APPENDIX 14a

South Galilee Coal Project
EIS Extracts

CONTENTS

FIGURES

TABLES

4. PROJECT DESCRIPTION

This Section provides a description of the proposed South Galilee Coal Project (SGCP).

4.1. LOCATION

4.1.1. Regional Context

The regional location of the SGCP is shown in **Figure 1-1** in **Section 1—Introduction**.

The SGCP is located within the Barcaldine Regional Council Local Government Area, approximately 12 kilometres (km) south-west from the centre of the township of Alpha. Alpha is situated approximately 170 km west of Emerald and 450 km west of Rockhampton in Central Queensland.

There are a number of proposed coal mines in the vicinity of the SGCP, including:

- Galilee Coal (Northern Export Facility), (also known as the China First Coal Project), proposed by Waratah Coal Pty Ltd
- Alpha Coal Mine, proposed by the GVK Group
- Kevin's Corner, proposed by the GVK Group
- Carmichael Coal Mine and Rail Project, proposed by Adani Mining Pty Ltd.

Figure 4-1 shows the location of mining tenements surrounding the SGCP.

4.1.2. Local Context

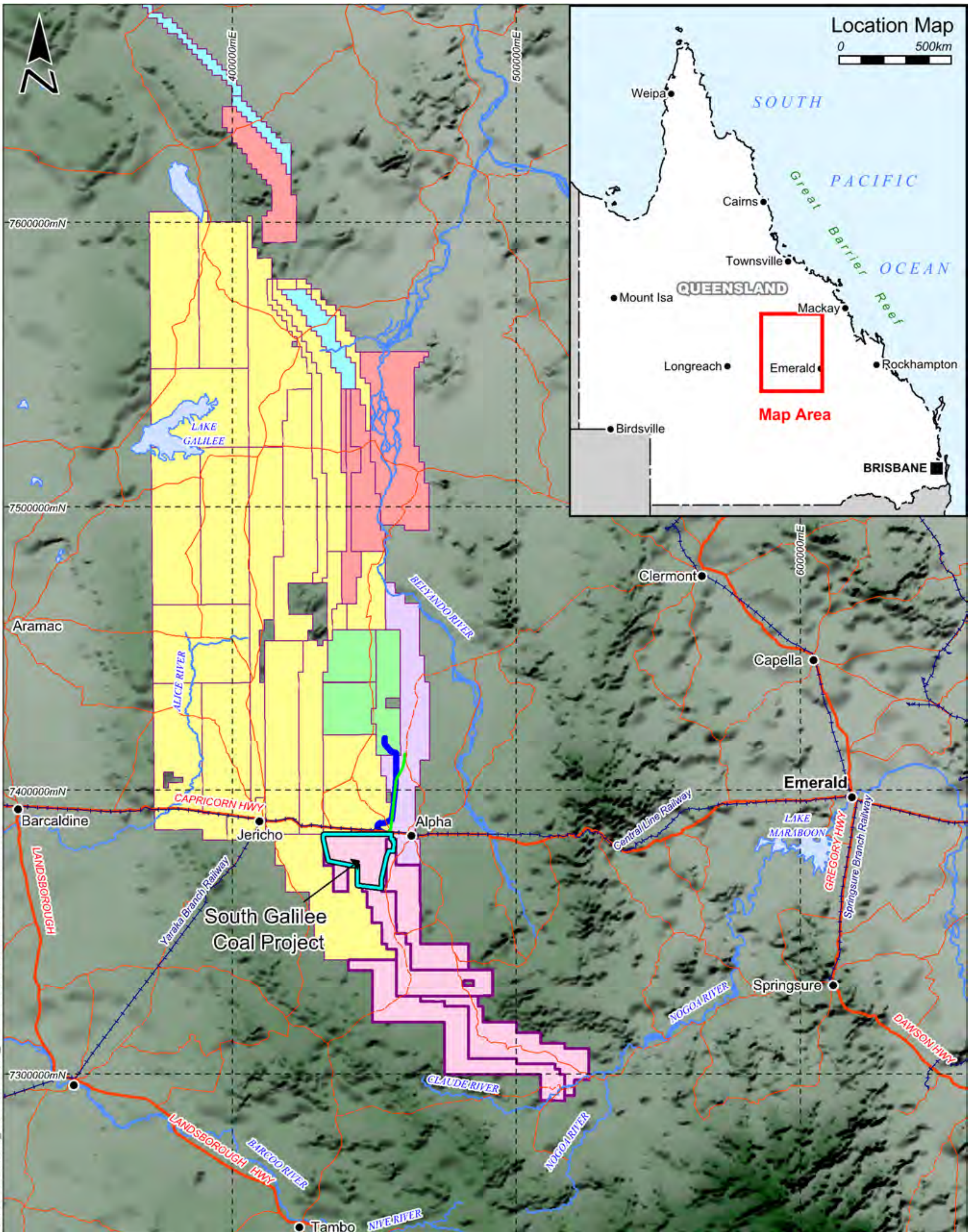
Figure 1-1 illustrates the SGCP's location in relation to the local area's existing infrastructure, such as roads, railways and geomorphic features such as waterways.

The conceptual layouts of the mine site and infrastructure components over the SGCP's life cycle are presented in **Figure 4-2** to **Figure 4-13**.

4.1.3. Tenements and Tenures

Table 4-1, **Figure 4-1** and **Figure 4-14** identify the mining tenements and land tenure in the SGCP area. As identified in **Table 4-1**, several properties within the SGCP area are also subject to other minerals and petroleum tenements.

The coal deposit for the SGCP has been defined by exploration activities undertaken in accordance with two Exploration Permits for Coal (EPCs), (1049 and 1180), held by Alpha Coal Pty Ltd (a subsidiary of Bandanna Energy). The SGCP will be located within MLA 70453 and the infrastructure corridor.



S:\PROJECTS\AM001 STH GALILEE EIS_MAPINFO\WORKSPACES\2012_WSPACE\AM001_FIG 1-4 SURROUNDING TENEMENTS.WOR

METSERVE Mining & Energy Technical Services Pty Ltd

SouthGalilee

LEGEND

- MLA70453
- SGCP infrastructure corridor
- SGCP power line
- Principal road
- Road (sealed)
- Road (unsealed)
- Railway
- River
- Population centre

Principal Tenement Holder

- Alpha Coal Pty Ltd
- Adani Mining Pty Ltd
- Hancock Coal Pty Ltd
- Qld Thermal Coal Pty Ltd
- Waratah Coal Pty Ltd
- Vale Exploration Pty Ltd

Data Source : Cambell Higginson Town Planning (2006)

Alpha Coal Pty Ltd

South Galilee Coal Project

Surrounding Tenements

25 0 25

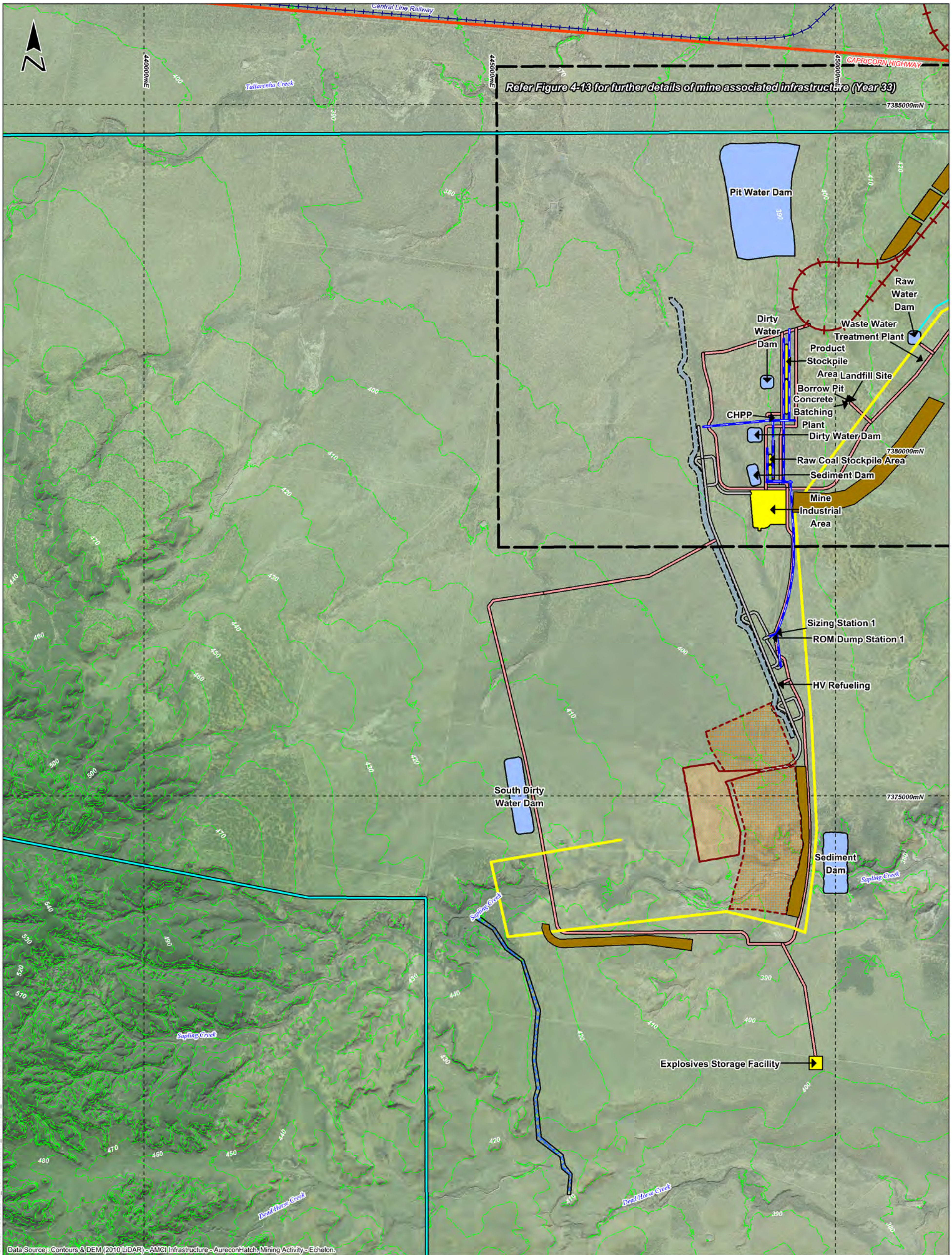
Kilometres

Scale: 1:1,500,000 (A4)

05/09/2012

Proj. : MGA Z55
Datum: GDA 1994

FIGURE 4-1



LEGEND

- MLA70453
- Principal road
- Contour AHD (10m)

Mining Activity
- Open pit
- Waste rock emplacement

Infrastructure
- Facility area
- Stream diversion
- Drainage channel
- Water storage dam
- Topsoil stockpile
- Topsoil spreading and rehabilitation
- Heavy vehicle road
- Light vehicle road
- On-site rail component
- Coal & rejects conveyor

Utilities
- 66kV overhead power line
- Raw water pipeline

METSERVE Mining & Energy Technical Services Pty Ltd

SouthGalilee

Alpha Coal Pty Ltd

South Galilee Coal Project

Conceptual Mine Stage Plan - Year 1

1 0 1
Kilometres

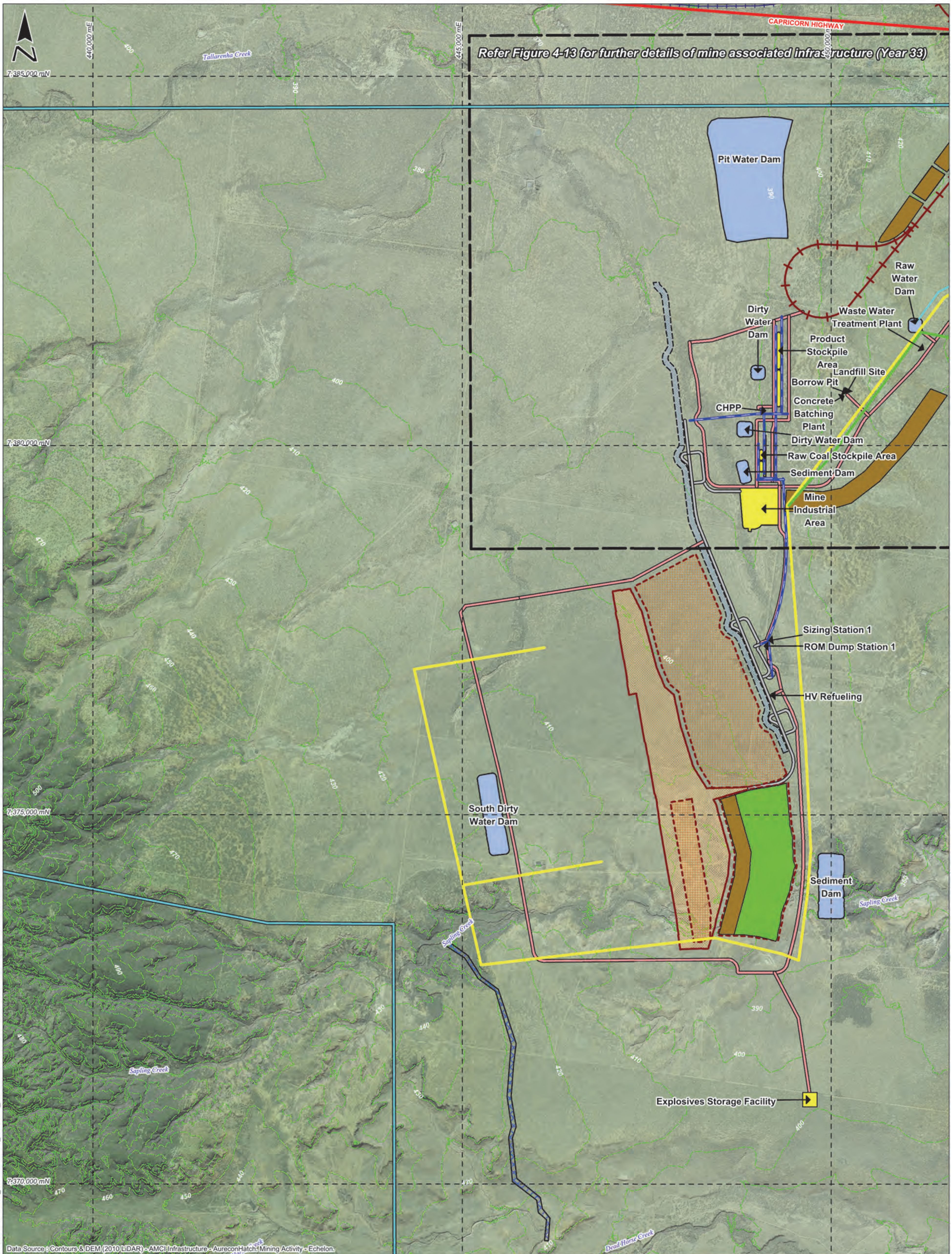
Scale: 1:50,000 (A3)

05/09/2012

Proj. : MGA Z55
Datum: GDA 1994

FIGURE 4-2

S:\PROJECTS\AM001 STH GALILEE EIS_MAPINFO\WORKSPACES\2012_WSPACE\SECT_04\AM001_M312B FIG 4-2 CONCEPTUAL MINE STAGE PLAN - YEAR 1.WOR



S:\PROJECTS\AM001 STH GALILEE EIS_MAPINFO\WORKSPACES\2012_WSPACE\SECT_04\AM001_M313A FIG 4-3 CONCEPTUAL MINE STAGE PLAN - YEAR 2.WOR

METSERVE Mining & Energy Technical Services Pty Ltd

SouthGalilee

LEGEND

MLA70453
Principal road
Contour AHD (10m)

Mining Activity
Open pit
Waste rock emplacement

Infrastructure
Facility area
Stream diversion
Drainage channel
Water storage dam
Topsoil stockpile
Topsoil spreading and rehabilitation
Heavy vehicle road
Light vehicle road
On-site rail component
Coal & rejects conveyor

Utilities
66kV overhead power line
11kV overhead power line
Raw water pipeline

Alpha Coal Pty Ltd

South Galilee Coal Project

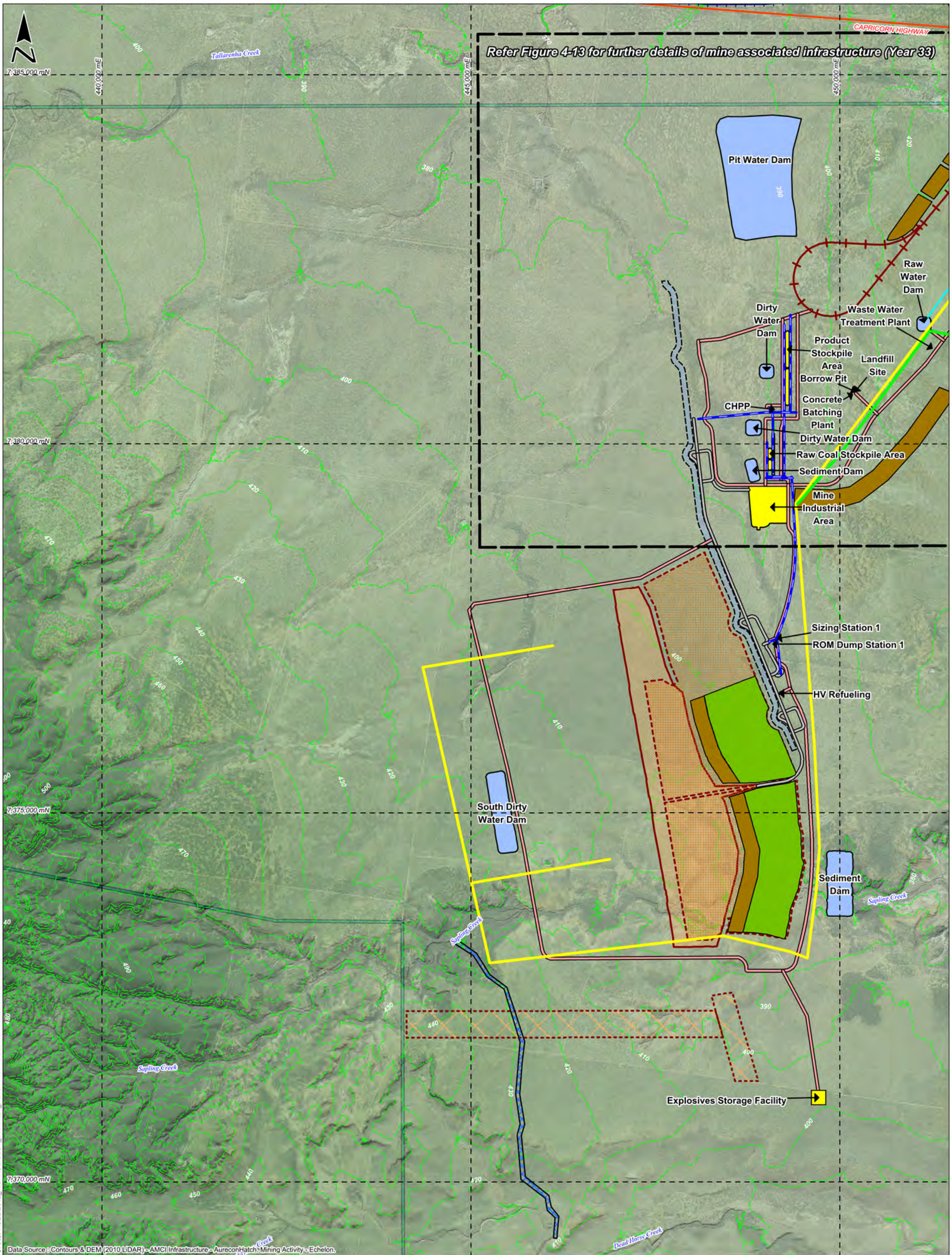
Conceptual Mine Stage Plan - Year 2

1 0 1
Kilometres
Scale: 1:50,000 (A3)

13/08/2012

Proj. : MGA Z55
Datum: GDA 1994

FIGURE 4-3



LEGEND

- MLA70453
- Principal road
- Contour AHD (10m)

Mining Activity

- Open pit
- Waste rock emplacement

Infrastructure

- Facility area
- Stream diversion
- Drainage channel
- Water storage dam
- Topsoil stockpile
- Topsoil spreading and rehabilitation
- Heavy vehicle road
- Light vehicle road
- On-site rail component
- Coal & rejects conveyor

Utilities

- 66kV overhead power line
- 11kV overhead power line
- Raw water pipeline

METSERVE Mining & Energy Technical Services Pty Ltd

SouthGalilee

Alpha Coal Pty Ltd

South Galilee Coal Project

Conceptual Mine Stage Plan - Year 3

1 0 1 Kilometres

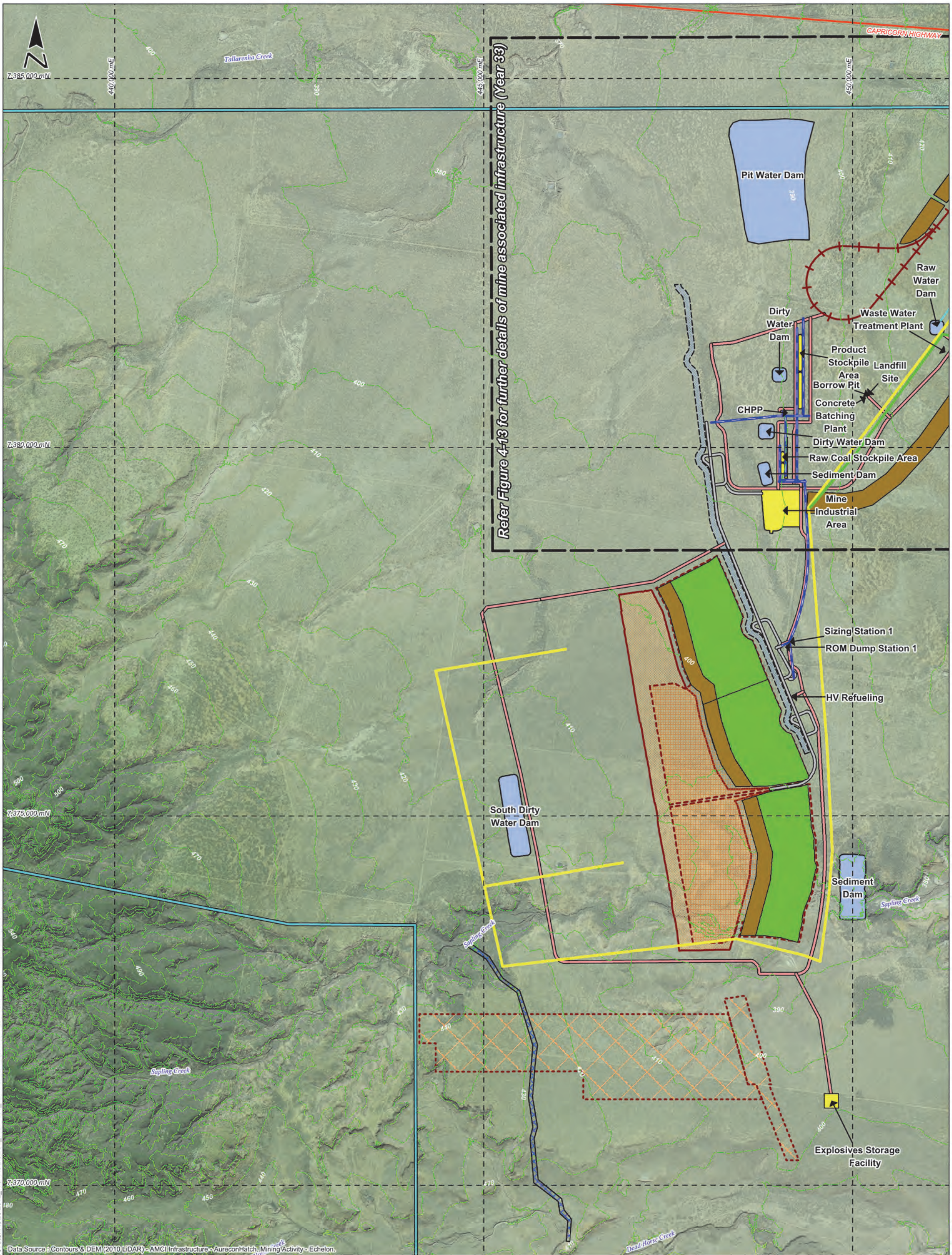
Scale: 1:50,000 (A3)

13/08/2012

Proj. : MGA Z55
Datum: GDA 1994

FIGURE 4-4

S:\PROJECTS\AM001 STH GALILEE EIS_MAPINFO\WORKSPACES\2012_WSPACE\SECT_04\AM001_M313A FIG 4-4 CONCEPTUAL MINE STAGE PLAN - YEAR 3.WOR



S:\PROJECTS\AM001 STH GALILEE EIS_MAPINFO\WORKSPACES\2012_WSPACE\SECT_04\AM001_M315A FIG 4-5 CONCEPTUAL MINE STAGE PLAN - YEAR 4.WOR

METSERVE Mining & Energy Technical Services Pty Ltd

SouthGalilee

LEGEND

- MLA70453
- Principal road
- Contour AHD (10m)

Mining Activity
- Open pit
- Waste rock emplacement

Infrastructure
- Facility area
- Stream diversion
- Drainage channel
- Water storage dam
- Topsoil stockpile
- Topsoil spreading and rehabilitation
- Heavy vehicle road
- Light vehicle road
- On-site rail component
- Coal & rejects conveyor

Utilities
- 66kV overhead power line
- 11kV overhead power line
- Raw water pipeline

Alpha Coal Pty Ltd

South Galilee Coal Project

Conceptual Mine Stage Plan - Year 4

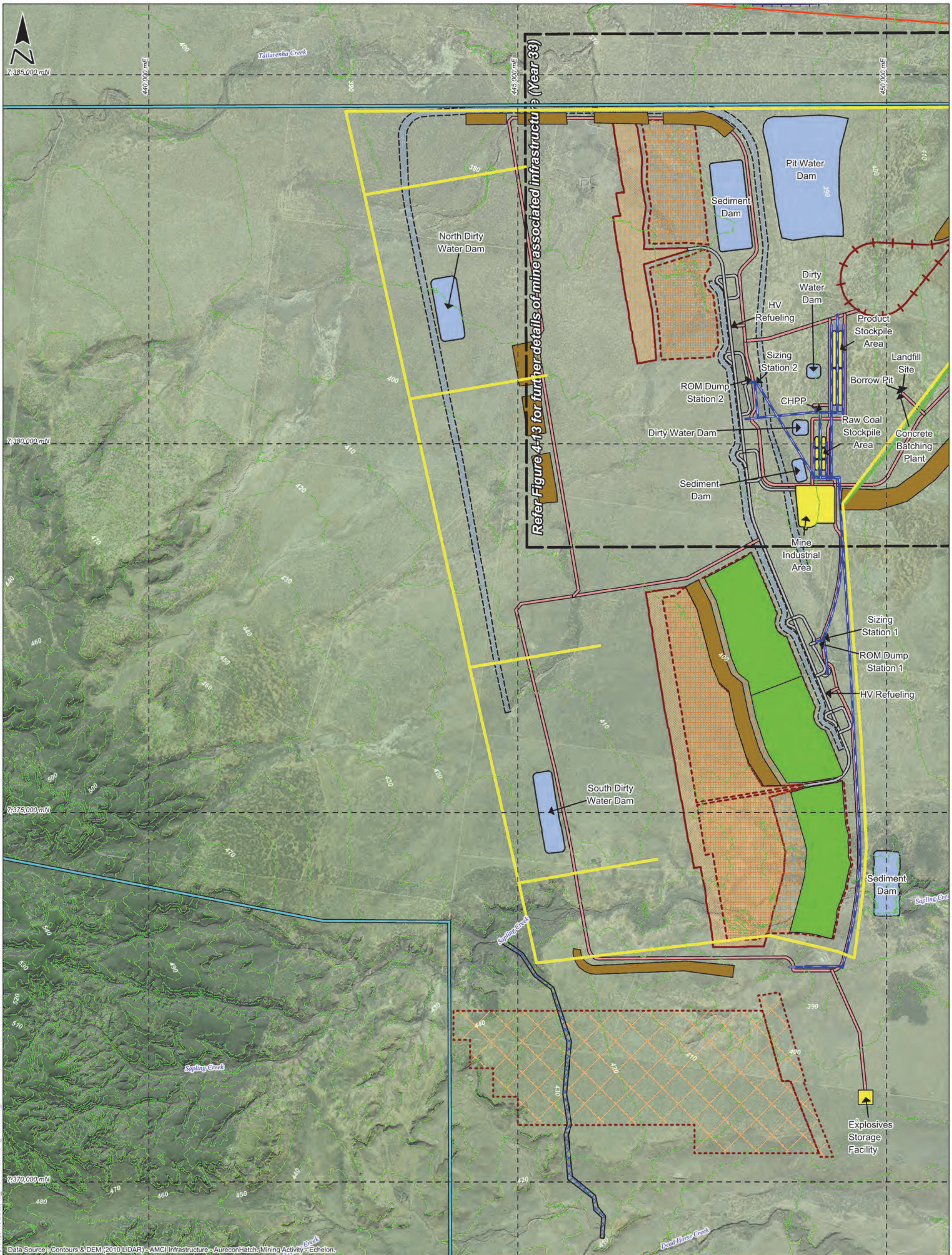
1 0 1
Kilometres

Scale: 1:50,000 (A3)

13/08/2012

Proj. : MGA Z55
Datum: GDA 1994

FIGURE 4-5



METSERVE Mining & Energy Technical Services Pty Ltd

SouthGalilee

LEGEND

MLA70453
Principal road
Contour AHD (10m)

Mining Activity
Open pit
Waste rock emplacement

Infrastructure
Facility area
Stream diversion
Drainage channel
Water storage dam
Topsoil stockpile
Topsoil spreading and rehabilitation
Heavy vehicle road
Light vehicle road
On-site rail component
Coal & rejects conveyor

Utilities
66kV overhead power line
11kV overhead power line
Raw water pipeline

Alpha Coal Pty Ltd

South Galilee Coal Project

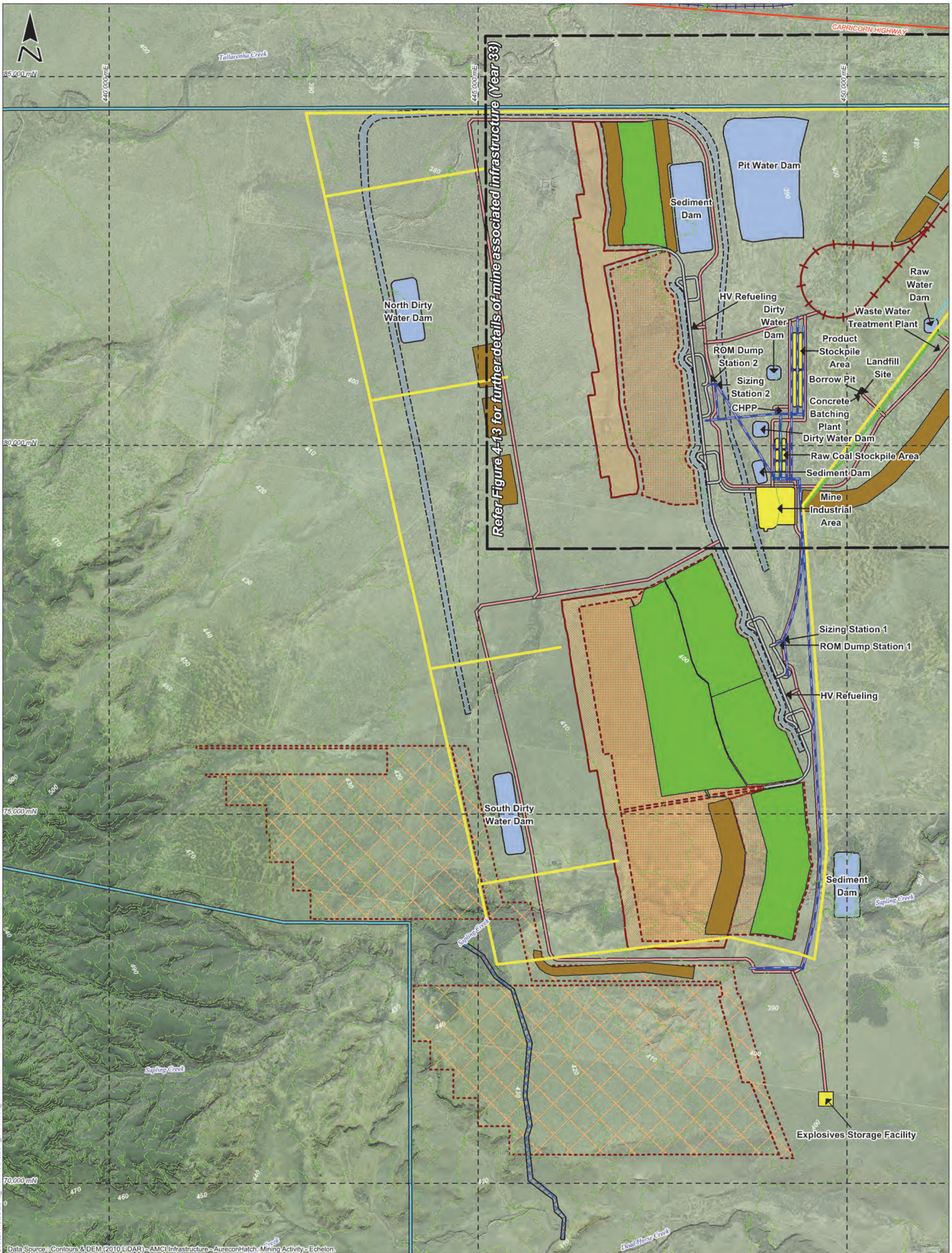
Conceptual Mine Stage Plan - Year 5

1 0 1
Kilometres
Scale: 1:50,000 (A3)

14/08/2012

Proj. : MGA Z55
Datum: GDA 1994

FIGURE 4-6



S:\PROJECTS\AM001 STH GALILEE EIS_MAPINFO\WORKSPACES\2012_WSPACE\SECT_04\AM001_M315A FIG 4-7 CONCEPTUAL MINE STAGE PLAN - YEAR 10.WOR

METSERVE Mining & Energy Technical Services Pty Ltd

SouthGalilee

LEGEND

- MLA70453
- Principal road
- Contour AHD (10m)

Mining Activity
- Open pit
- Waste rock emplacement

Infrastructure
- Facility area
- Stream diversion
- Drainage channel
- Water storage dam
- Topsoil stockpile
- Topsoil spreading and rehabilitation
- Heavy vehicle road
- Light vehicle road
- On-site rail component
- Coal & rejects conveyor

Utilities
- 66kV overhead power line
- 11kV overhead power line
- Raw water pipeline

Alpha Coal Pty Ltd

South Galilee Coal Project

Conceptual Mine Stage Plan - Year 10

1 0 1

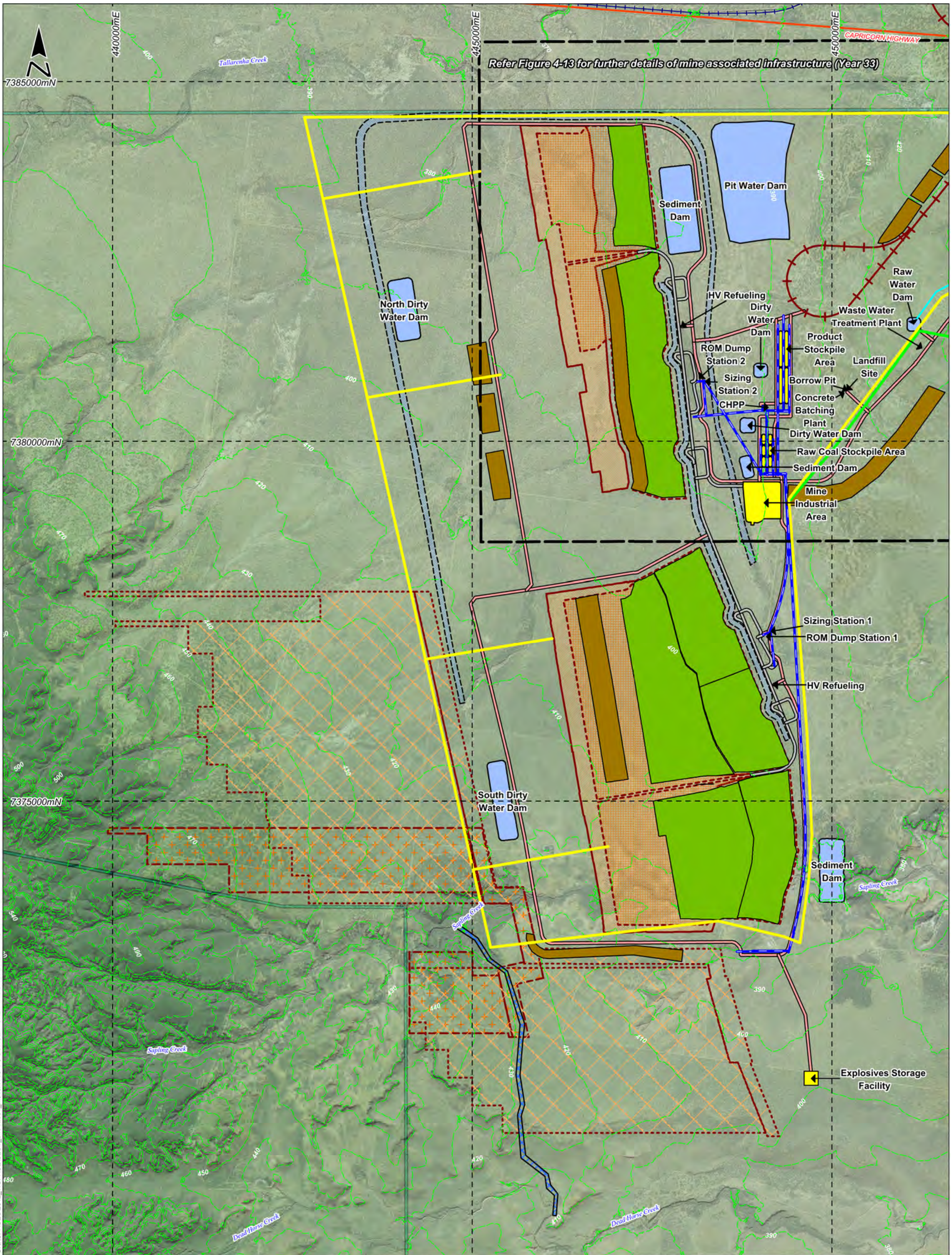
Kilometres

Scale: 1:50,000 (A3)

14/08/2012

Proj. : MGA Z55
Datum: GDA 1994

FIGURE 4-7



S:\PROJECTS\AM001 STH GALILEE EIS_MAPINFO\WORKSPACES\2012_WSPACE\SECT_04\AM001_M313A FIG 4-8 CONCEPTUAL MINE STAGE PLAN - YEAR 15.WOR

METSERVE Mining & Energy Technical Services Pty Ltd

SouthGalilee

LEGEND

- MLA70453
- Principal road
- Contour AHD (10m)

Mining Activity
- Open pit
- Waste rock emplacement
- D1 underground mining area
- D2 underground mining area

Infrastructure
- Facility area
- Stream diversion
- Drainage channel
- Water storage dam
- Topsoil stockpile
- Topsoil spreading and rehabilitation
- Heavy vehicle road
- Light vehicle road
- On-site rail component
- Coal & rejects conveyor

Utilities
- 66kV overhead power line
- 11kV overhead power line
- Raw water pipeline

Alpha Coal Pty Ltd

South Galilee Coal Project

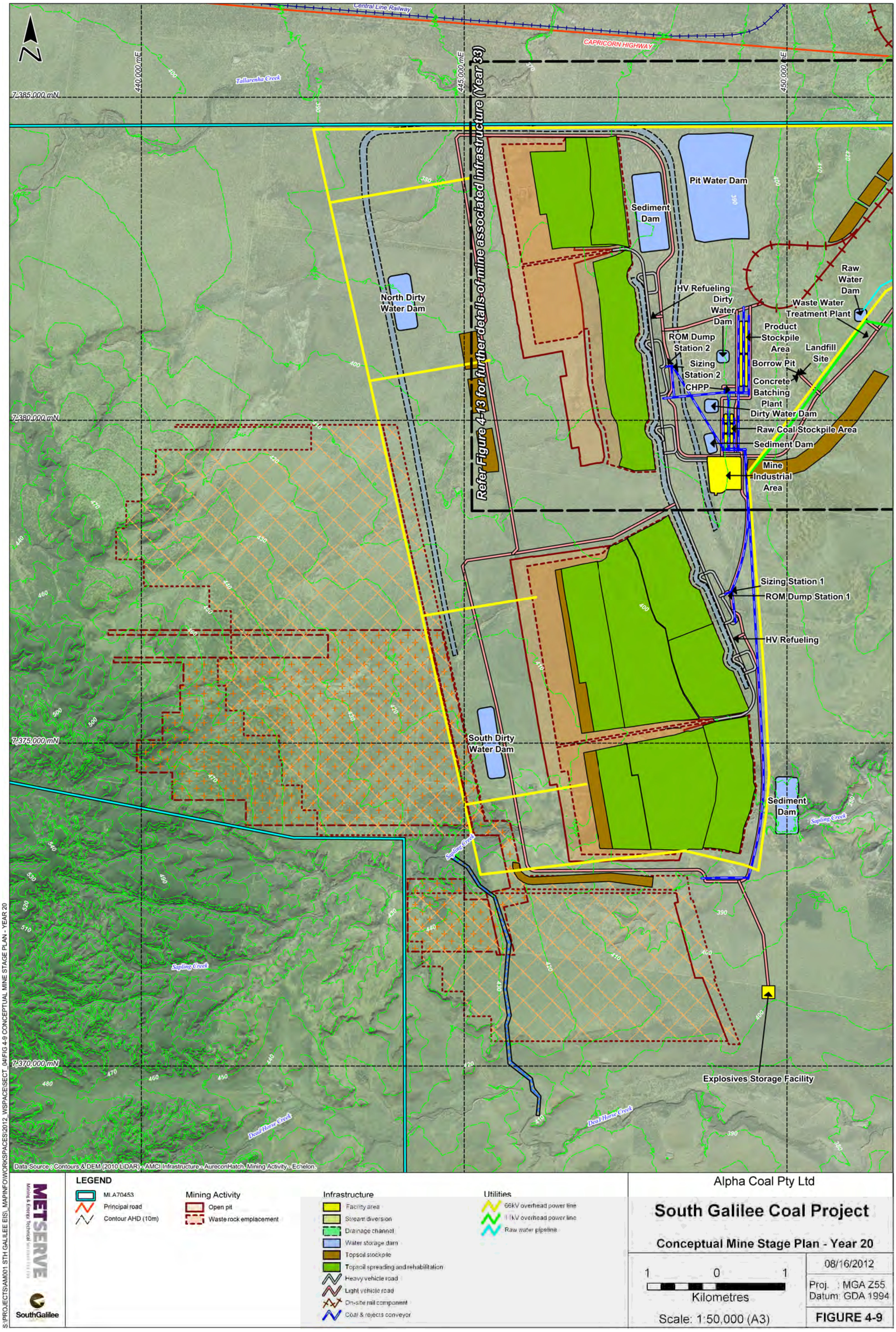
Conceptual Mine Stage Plan Year 15

1 0 1
Kilometres
Scale: 1:50,000 (A3)

04/09/2012

Proj. : MGA Z55
Datum: GDA 1994

FIGURE 4-8

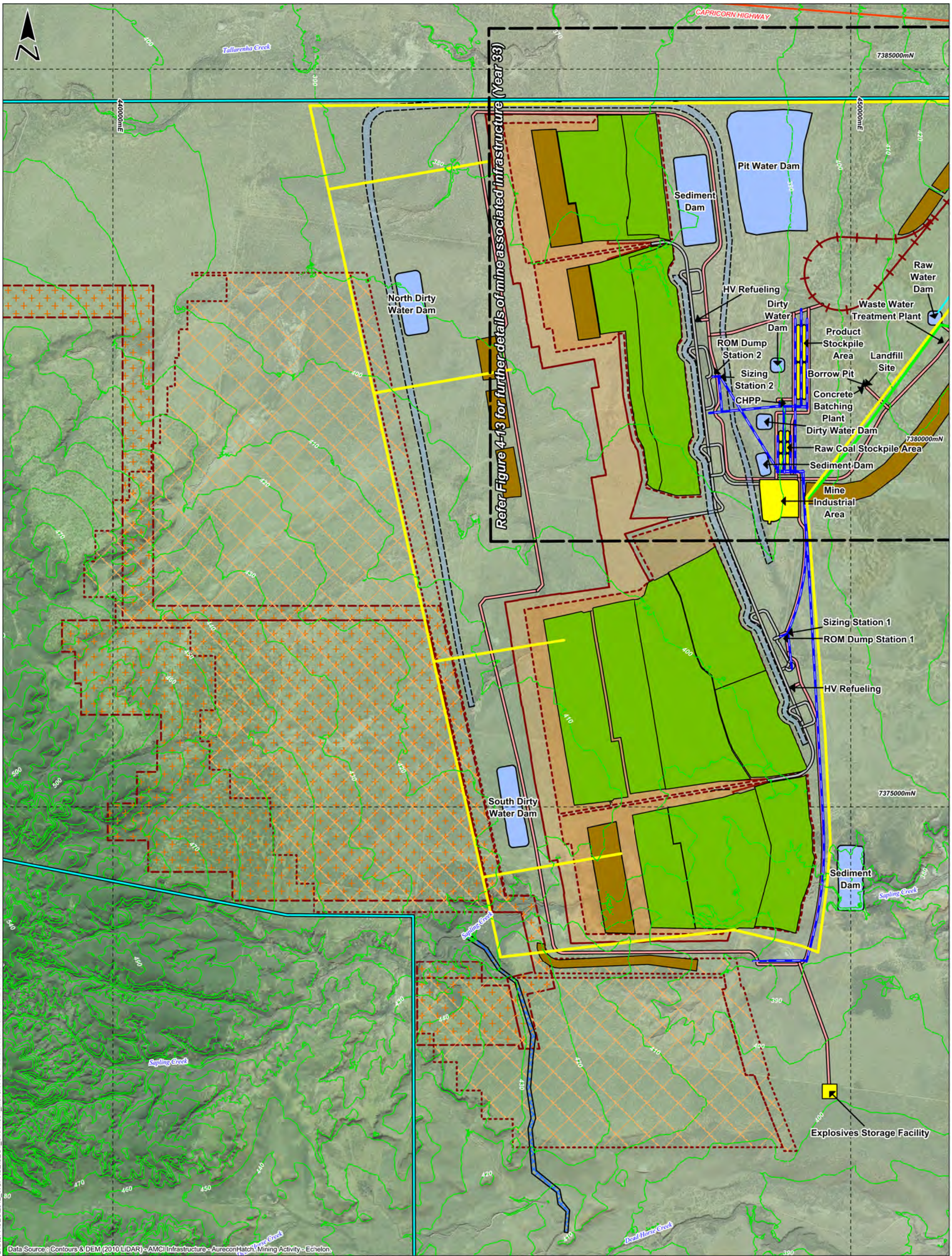


Alpha Coal Pty Ltd

South Galilee Coal Project

Conceptual Mine Stage Plan - Year 20

FIGURE 4-9



S:\PROJECTS\AM001 STH GALILEE EIS_MAPINFO\WORKSPACES\2012_WSPACES\SECT_04\AM001_M315A FIG 4-10 CONCEPTUAL MINE STAGE PLAN - YEAR 25

METSERVE Mining & Energy Technical Services

SouthGalilee

LEGEND

- MLA70453
- Principal road
- Contour AHD (10m)

Mining Activity
- Open pit
- Waste rock emplacement

Infrastructure
- Facility area
- Stream diversion
- Drainage channel
- Water storage dam
- Topsoil stockpile
- Topsoil spreading and rehabilitation
- Heavy vehicle road
- Light vehicle road
- On-site rail component
- Coal & rejects conveyor

Utilities
- 66kV overhead power line
- 11kV overhead power line
- Raw water pipeline

Alpha Coal Pty Ltd

South Galilee Coal Project

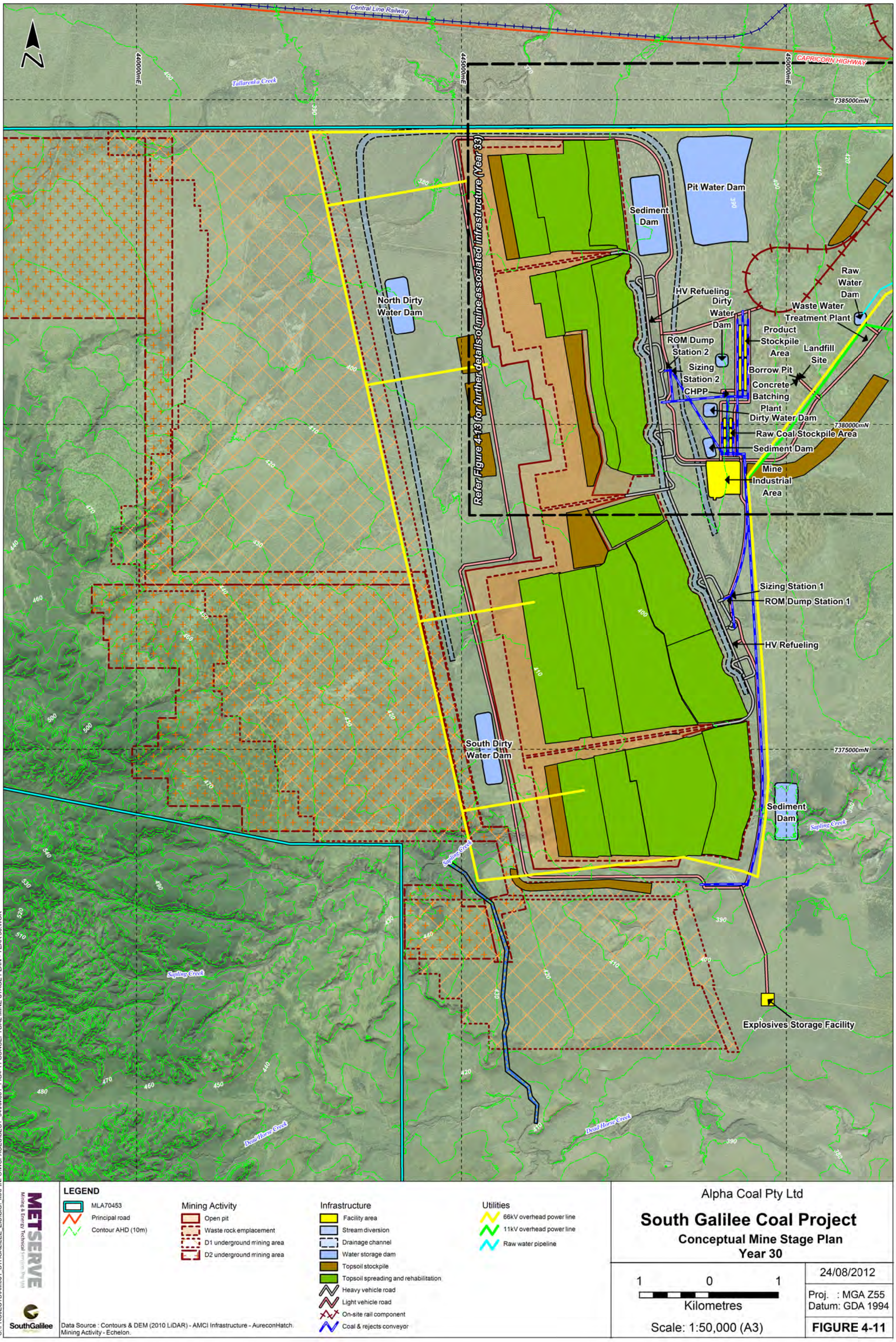
Conceptual Mine Stage Plan - Year 25

1 0 1
Kilometres
Scale: 1:50,000 (A3)

08/14/2012

Proj. : MGA Z55
Datum: GDA 1994

FIGURE 4-10



METSERVE Mining & Energy Technical Services Pty Ltd

SouthGalilee

Data Source : Contours & DEM (2010 LiDAR) - AMCI Infrastructure - AureconHatch. Mining Activity - Echelon.

Alpha Coal Pty Ltd

South Galilee Coal Project

Conceptual Mine Stage Plan
Year 30

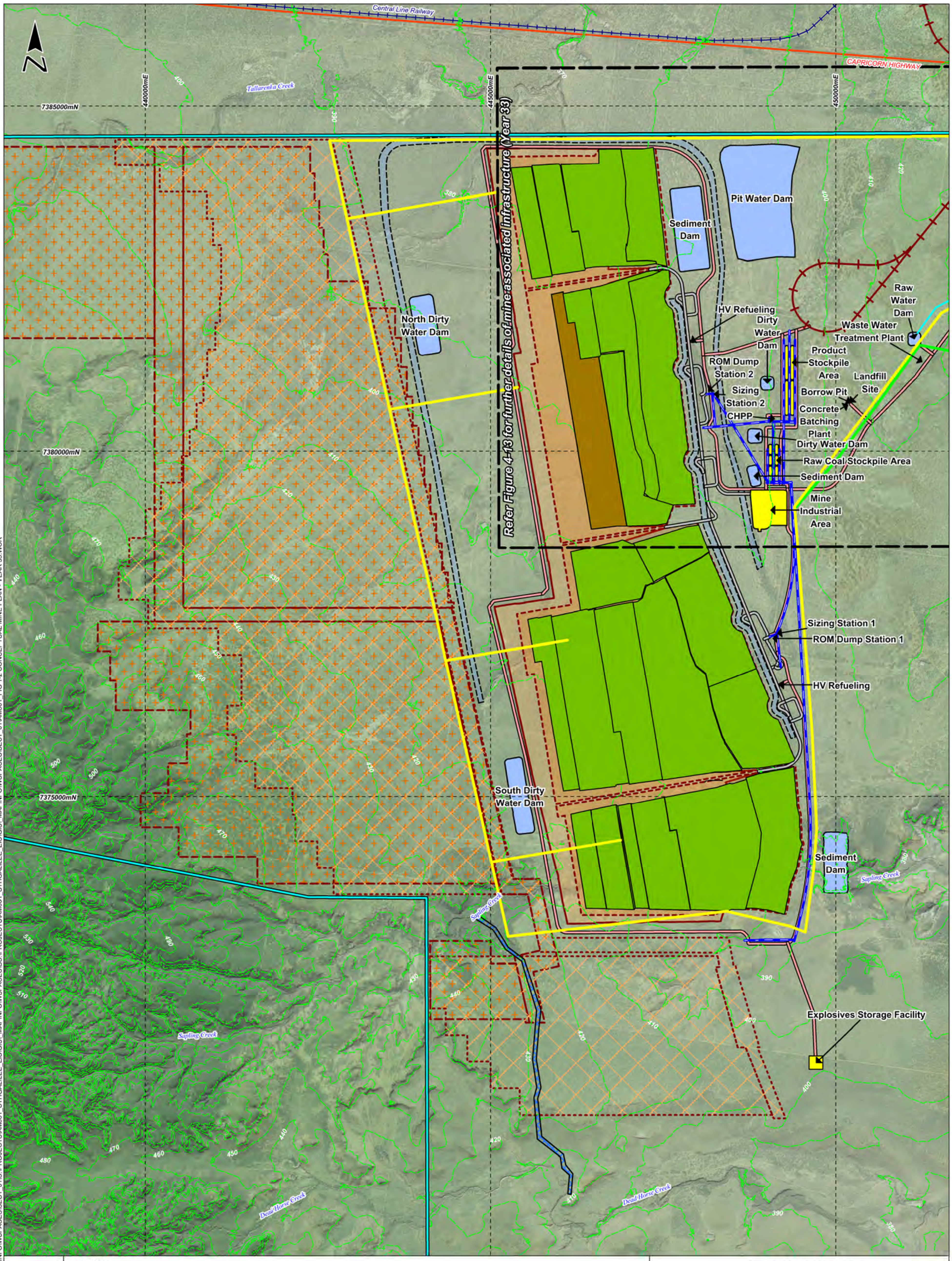
Scale: 1:50,000 (A3)

24/08/2012

Proj. : MGA Z55
Datum: GDA 1994

FIGURE 4-11

S:\PROJECTS\AM001_STHGALILEE_EIS\GIS_MAPINFO\WSPACES\SECT_04\AM001_FIG4-11 CONCEPTUAL MINE STAGE PLAN - YEAR 30.WOR



S:\PROJECTS\AM001_STHGALILEE_EIS\GIS_MAPINFO\WSPACES\SECT_01\S:\PROJECTS\AM001_STHGALILEE_EIS\GIS_MAPINFO\WSPACES\SECT_01\AM001_FIG 1-2 CONCEPTUAL MINE PLAN - YEAR 33.WOR

METSERVE Mining & Energy Technical Services Pty Ltd

SouthGalilee

LEGEND

- MLA70453
- Principal road
- Contour AHD (10m)

Mining Activity
- Open pit
- Waste rock emplacement
- D1 underground mining area
- D2 underground mining area

Infrastructure
- Facility area
- Stream diversion
- Drainage channel
- Water storage dam
- Topsoil stockpile
- Topsoil spreading and rehabilitation
- Heavy vehicle road
- Light vehicle road
- On-site rail component
- Coal & rejects conveyor

Utilities
- 66kV overhead power line
- 11kV overhead power line
- Raw water pipeline

Data Source : Contours & DEM (2010 LiDAR) - AMCI Infrastructure - AureconHatch. Mining Activity - Echelon.

Alpha Coal Pty Ltd

South Galilee Coal Project

Conceptual Mine Stage Plan

Year 33

1 0 1

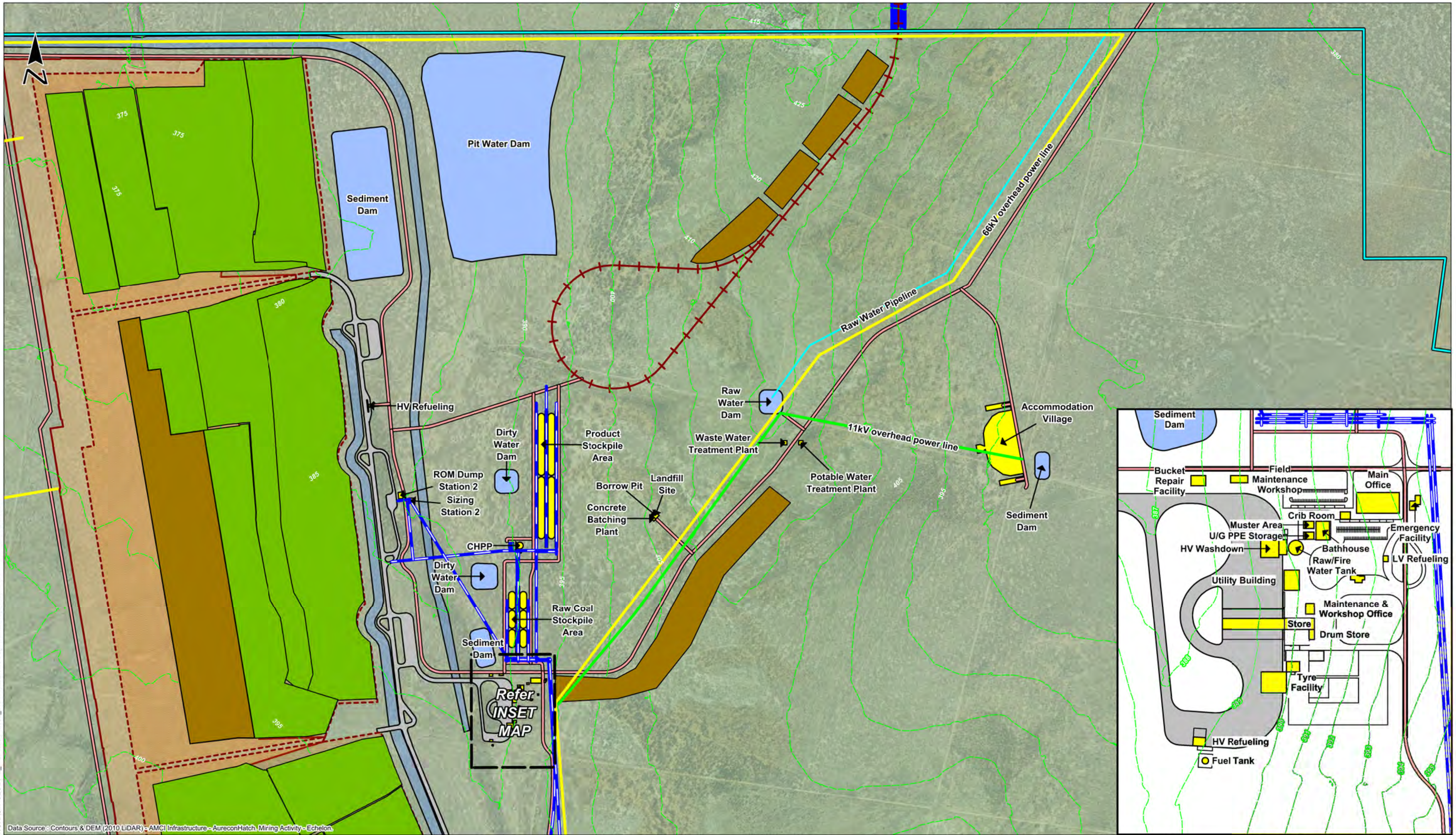
Kilometres

Scale: 1:50,000 (A3)

24/08/2012

Proj. : MGA Z55
Datum: GDA 1994

FIGURE 4-12



S:\PROJECTS\AM001 STH GALILEE EIS_MAPINFOWORKSPACES\2012_WSPACE\AM001_FIG4-13 CONCEPTUAL MINE ASSOCIATION INFRA-YEAR 33.WOR

METSERVE Mining & Energy Technical Services Pty Ltd

SouthGalilee

LEGEND

- MLA70453
- Principal road
- Railway
- Contour AHD (10m)

Mining Activity

- Open pit
- Waste rock emplacement

Infrastructure

- Facility area
- Stream diversion
- Drainage channel
- Water storage dam
- Topsoil stockpile
- Topsoil spreading and rehabilitation
- Heavy vehicle road
- Light vehicle road
- On-site rail component
- Coal & rejects conveyor

Utilities

- 66kV overhead power line
- 11kV overhead power line
- Raw water pipeline

Alpha Coal Pty Ltd

South Galilee Coal Project

Conceptual Mine Associated Infrastructure Year 33

1 0 1

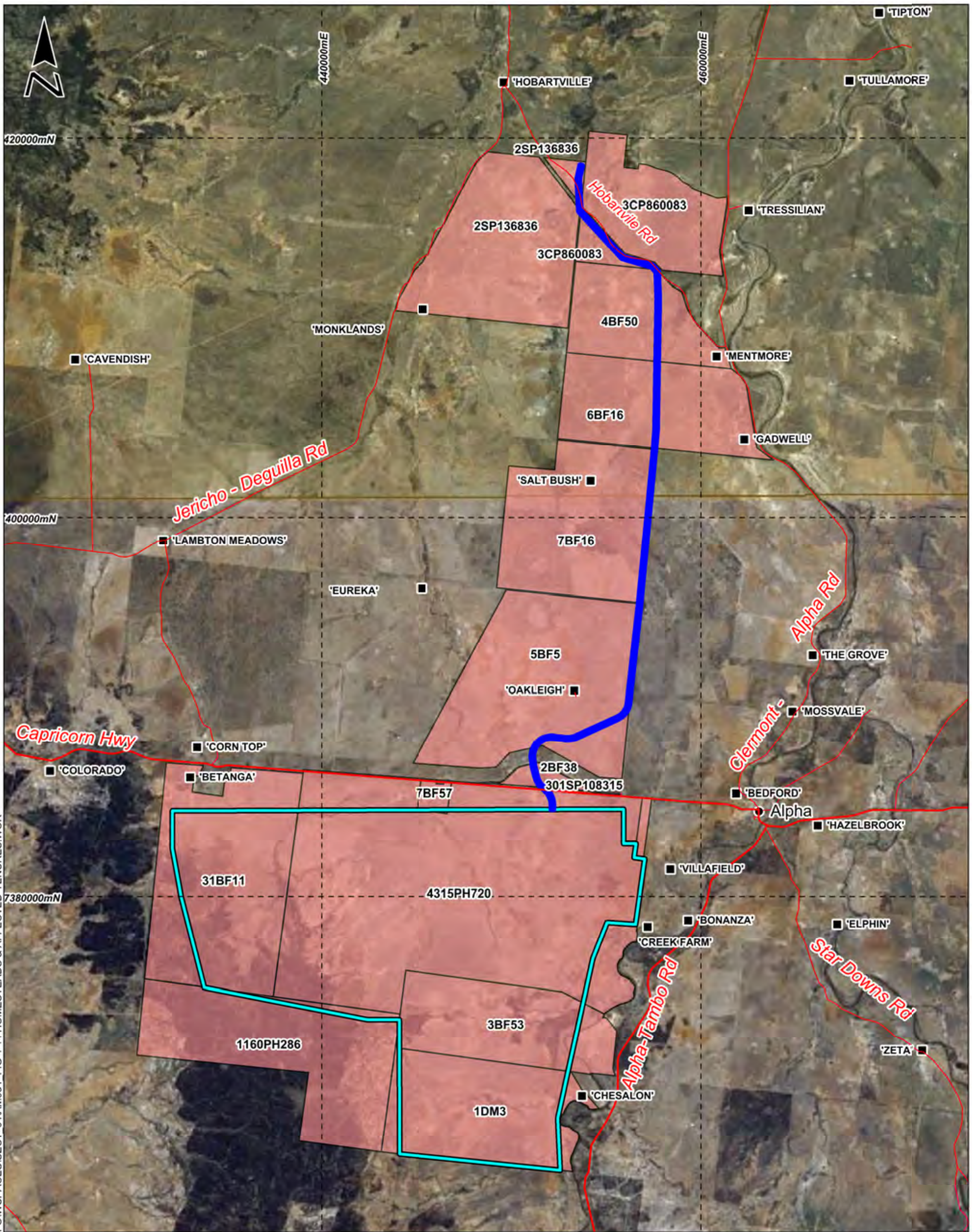
Kilometres

Scale: 1:50,000 (A3)

08/16/2012

Proj. : MGA Z55
Datum: GDA 1994

FIGURE 4-13



S:\PROJECTS\AM001_STHGALILEE_EIS\GIS_MAPINFOWSPACES\SECT_04\AM001_FIG 4-14 HOMESTEADS & AFFECTED TENURES.WOR

METSERVE Mining & Energy Technical Services Pty Ltd

SouthGalilee

LEGEND

- MLA70453
- Directly affected property
- SGCP infrastructure corridor
- Roads
- Population centre
- Homestead

Data Source:
Cadastral (Barcaldine May2010)-DERM. Topo (250k raster)-Geoscience Australia.

Alpha Coal Pty Ltd

South Galilee Coal Project

Directly Affected Land Tenure

5 0 5
Kilometres
Scale: 1:300,000 (A4)

24/08/2012

Proj. : MGA Z55
Datum: GDA 1994

FIGURE 4-14

Table 4-1 Real Property Description for Land Located Within or Partly Within MLA 70453 and Infrastructure Corridor

Tenure/Tenement[1]	Real Property Description	Property Name	Land Owner ID
MLA 70453			
EPC 1049, EPC 1180, EPC 1040 and EPP 668	4315PH720[2]	Creek Farm	A
EPC 1049, EPC 1180 and EPP 668	1DM3	Chesalon	B
EPC 1049, EPC 1040 and EPP 668	7BF57	Tallarenha	C
EPC 1049, EPC 1040, EPC 1155 and EPP 668	31BF11	Betanga	D
EPC 1049, EPC 1155 and EPP 668	1160PH286	Armagh	E
EPC 1049, EPC 1180, EPC 1155 and EPP 668	3BF53	Sapling Creek	F
Infrastructure Corridor			
EPC 1040, EPC 1263 and EPP 668	5BF5	Oakleigh	G
EPC 1210, EPC 1263 and EPP 668	3CP860083	Tresillian	H
EPC 1210, EPC 1040 and EPP 668	2SP136836	Monklands	I
EPC 1210, EPC 1263 and EPP 668	4BF50	Mentmore	J
EPC 1263 and EPP 668	6BF16	Gadwell	J
EPC 1263 and EPP 668	7BF16	Saltbush	K
EPC 1040 and EPP 668	301SP108315	N/A	L
EPC 1049, EPC 1180, EPC 1040 and EPP 668	4315PH720	Creek Farm	A
EPC 1040 and EPP 668	2BF38	Leased Reserve	A

1 EPC 1040 is held by Waratah Coal Pty Ltd
EPC 1155 is held by Waratah Coal Pty Ltd
EPC 1210 is held by the GVK Group
EPC 1263 is held by Queensland Thermal Coal Pty Ltd
EPP 668 is held by Australia Pacific LNG Pty Limited

2 4315PH720 is affected by MLA 70453 as well as the infrastructure corridor

4.2. RESOURCE BASE AND MINE LIFE

The indicative stratigraphy of the Project area is shown on **Figure 4-15**.

The SGCP is located in the south-eastern region of the Galilee Basin, an intracratonic basin covering an area of approximately 247,000 square kilometres (km^2). The Galilee Basin is comprised of Late Carboniferous to Middle Triassic sediments. The thickest Galilee Basin sequence has been recorded at 2,818 metres (m) within the Koburra Trough.

The Galilee Basin is unconformably overlain by the Jurassic Cretaceous Eromanga Basin. The eastern margin of the Galilee Basin is dominated by Permo-Triassic rocks, which outcrop in a long narrow gently curved belt. The Galilee Basin is divided into northern and southern sections by the east-west trending Barcaldine Ridge.

The primary geological units within the SGCP area can be divided into Quaternary, Tertiary, Triassic and Permian age sediments. The Quaternary-Tertiary stratigraphic unit has an average thickness of 21 m with a range of 3 to 52 m. Average depth to the base of weathering is 51 m with a range of 18 to 95 m. The Triassic units occur in the western part of the SGCP area, where the elevation rises into the Great Dividing Range.

The coal seams within MLA 70453 are interpreted to occur in the Late Permian Bandanna Formation. The primary target seams for the SGCP are the D1 and D2 seams. These seams are interpreted to consist of three plies varying in thickness from 0.5 to 4.5 m with raw ash ranging from 7.5 to 41 % on an air dried basis (AMCI and Bandanna Energy, 2011(b)). The coal is high volatile sub-bituminous, dull with abundant bright bands.

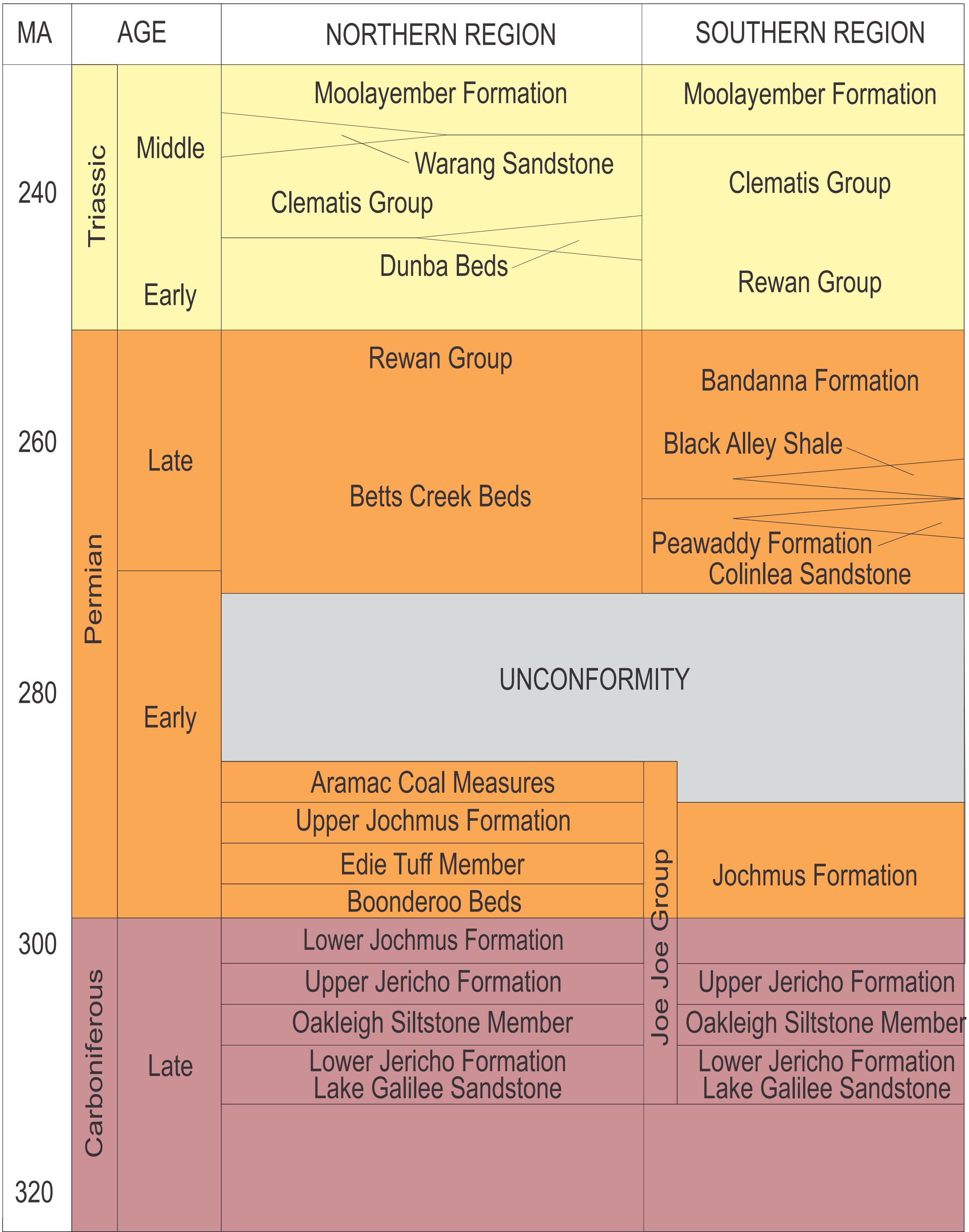
A summary of the Australasian Joint Ore Resource Committee (JORC) Code compliant resources is provided in **Table 4-2**.

Table 4-2 SGCP Resource Base

Seam	Resources (Million tonnes [Mt])			
	Measured	Indicated	Inferred	Total
D1	50.4	105.8	555.0	711.2
D2	116.3	100.5	251.0	467.8
Total	**166.7**	**206.3**	**806.0**	**1,179.0**

Source: AMCI and Bandanna Energy (2011) (b)

It is estimated that approximately 498 Mt of run-of-mine (ROM) coal will be mined, yielding approximately 447 Mt of product coal over the mine's 33 year operational life. Coal contained in underground pillars and development workings will be sterilised along with coal below Endangered Regional Ecosystems (ERE) which will be avoided for conservation purposes. A detailed description of exploration undertaken for the SGCP and a resource definition assessment is provided in **Section 7—Land**.



METSERVE Mining & Energy Technical Services Pty Ltd

SouthGalilee

Data Source: AMCI and Bandanna Energy (2011)

Alpha Coal Pty Ltd

South Galilee Coal Project

Stratigraphic Section of the Galilee Basin Geology

23/07/2012

FIGURE 4-15

S:\PROJECTS\AM001 STH GALILEE EIS_MAPINFOWORKSPACES\2012_WSPACE\SECT_04\SGCP DIAGRAMS.CDR

4.3. PROJECT TIMING

Construction activities are expected to commence in 2013, following granting of the required Environmental Authority. Construction will be staged over three phases as dictated by the mining schedule.

The commissioning process of mining and associated infrastructure will be undertaken at various times during the construction period.

Operations are expected to commence in 2015 with a scheduled mine life of 33 years until 2047. Product coal output is anticipated to ramp up to a peak of approximately 17 million tonnes per annum (Mtpa) when both open cut and underground components are operational. However, it is possible that there will be sufficient economic coal reserves to extend the operational life of the Project beyond the currently planned 33 years. The proposed Project sequencing is described further in **Section 4.5.2**.

Rehabilitation activities will be undertaken progressively throughout the mine life.

The Project's development timeframe will be dependent on the completion and access to third party rail and port infrastructure, as well as the availability of electricity and water supplies. As a result, some variation to the proposed development timeframe may occur.

Transport, waste management, accommodation, power and water supply, infrastructure and employment associated with these development phases are discussed in **Section 4.6** to **Section 4.12**.

4.4. CONSTRUCTION

The Project's construction phase is expected to commence in 2013 and extend over three stages as the ramp-up in coal production reaches its maximum level of approximately 17 Mtpa (refer to **Section 4.5.2** for further detail):

- construction required for Stage 1 (provisionally scheduled for 2013–2015)
- construction required for Stage 2 (provisionally scheduled for 2014–2017)
- construction required for Stage 3 (provisionally scheduled for 2017–2019).

Construction required for Stage 1 includes pre-construction activities such as land acquisition and clearing and all the major civil and capital works (e.g. infrastructure, accommodation village, rail spur and the initial box cut for the open cut mine). Construction required for Stages 2 and 3 involves extending the open cut mining area and constructing the underground mining areas.

Construction works and an indicative construction fleet are detailed in **Table 4-3** and **Table 4-4** respectively.

As construction works will be undertaken progressively, the number and type of equipment is expected to vary depending on the activity being undertaken.

A range of different construction materials and equipment will be required, most of which will be sourced from Brisbane, Gladstone or Mackay, with a small percentage sourced from local and regional areas. The transport of materials and equipment is detailed in **Section 14—Transport**. Construction inputs will be stored at designated laydown areas and temporary storage facilities within the area to be used for Mine Infrastructure Area (MIA) and Coal Handling and Preparation Plan (CHPP) in the operational phase. Ballast material for construction of the on-site rail component and the SGCP rail spur component will be stockpiled near the rail loop area within MLA 70453 and at the northern end of Saltbush Road.

The establishment costs for the SGCP are provided in **Section 18—Economic Environment**.

Table 4-3 Construction Works Program

Construction Component	Indicative Timing of Commencement
Mine Access Road, Accommodation Village Access Road, other on-site haul roads and light vehicle roads	2013
Construction access road for SGCP rail component	2013
Water Supply and Reticulation Infrastructure	2013
Water Management Infrastructure	2013
Stream Diversions	2013
Accommodation village	2013
Power Supply, Electrical and Telecommunications Infrastructure	2013
Dragline and Dragline Pad	2014
Initial Box-cut	2015
Continuous Miner, Longwalls 1 and 2	2017
ROM Dumps and Sizing Stations	2014
CHPP and Associated Equipment (e.g. CHPP feed surge bin, thickener, filter building)	2013
On-site Rail Component	2013
SGCP Rail Spur Component (to connect to Common User Rail Component)	2013
Upgrades of the Public Road Network	2013

Table 4-3 Construction Works Program (cont)

Construction Component	Indicative Timing of Commencement
Potable Water Treatment Plant	2013
Waste Water Treatment Plant	2013
Main Infrastructure Area (i.e. Administration Buildings, Bath House, Workshops, Hardstand Area, Warehouses etc.)	2014
Material Handling Infrastructure (e.g. conveyors, ROM and Product Stockpiles and Associated Equipment)	2014

Source: Aurecon (2011) and AMCI and Bandanna Energy (2011) (b)

Table 4-4 Indicative Surface Mobile Fleet for Construction Works

Fleet Component	Number
Crawler Crane (110 tonne)	1
All Terrain Crane (55 tonne)	1
Concrete Mixing Truck	2
Backhoe Loader	5
Cold Planer	1
Pneumatic Compactor	1
Vibratory Soil Compactor	1
Hydraulic Excavator	10
Motor Grader	2
Asphalt Paver	1
Pipelayer	1
Telehandler	2
Waste Handling Track Loader	1
Dozer (D9T)	5
Medium Wheel Dozer	5
Wheel Loader	1
Franna Crane (20 tonne)	4
B-Double	10
Articulated Truck	4
4x4 Landcruiser	11
4x4 Dual Cab Hilux	54
4x2 Dual Cab Hilux	43
Bus	6
Shovel (RH200)	1
Trucks (Cat 789)	6

Table 4-5 Indicative Surface Mobile Fleet for Construction Works

Fleet Component	Number
Dozer (D10)	2
Grader (16M)	1
Water cart	1
Dozer (RT)	1
Drill	1
Other (e.g. service trucks, support trucks, cranes, forklifts, etc.)	10

Construction activities will typically be undertaken during daylight hours, seven days a week. It is expected some construction activities, such as electrical installation, materials deliveries and plant and equipment commissioning may be required to occur over a continuous 24 hour period. Appropriate construction permits will be sought to cover both day and night time construction activities.

4.4.1. Pre-Construction

4.4.1.1. Land Acquisition

As described in **Section 4.1.3**, the SGCP will be located within MLA 70453 and the infrastructure corridor.

Where a substantial portion of land will be required for mining operations (e.g. the Creek Farm and Sapling Creek properties), the Proponent proposes to acquire land by negotiation, where practicable. Surface rights will also be required over part of the Chesalon and Betanga properties.

In the event that agreement cannot be reached with landholders, surface rights compensation will be determined by the Land Court of Queensland.

One petroleum tenement (EPP 668) overlies MLA 70453. In accordance with legislative requirements, the Mining Lease Application triggers a need to notify and consult with the EPP holder and enter into negotiations to ensure resource use is maximised.

The Proponent will finalise required land acquisitions and consent from other tenement holders prior to commencement of construction.

4.4.1.2. Land Clearing and Earthworks

Initial vegetation clearance and earthworks will be required to enable construction of site access and haul roads, water management works and associated mine infrastructure such as the accommodation village, administrative buildings and CHPP.

Land clearing will be undertaken progressively to minimise exposure of disturbed areas, degradation of topsoil and the spread of weeds. Topsoil will be removed and stockpiled in dedicated topsoil areas around the mine for later use in mine rehabilitation (refer to **Section 4.14**).

Stream diversion works will also be undertaken as described in **Section 4.10.1.5** and **Section 9—Water Resources**.

4.4.1.3. Site Access and Health and Safety

A site access road will be constructed from the Capricorn Highway to the construction office site. It is envisaged that this site access road will also serve as the Main Access Road during the SGCP operations.

A haul road will be constructed from the quarry on the Alpha-Tambo Road through MLA 70453, to connect with the proposed road alongside the SGCP rail line within the infrastructure corridor (refer to **Section 4.6.1**). These roads would be used to transport ballast material and provide access for rail line construction.

For road user safety, upgrades to State and local controlled roads will be required and are described further in **Section 4.6.1**.

Appropriate access restriction measures (e.g. construction of a security post at the site access road) will provide access control during the initial construction stage. Temporary fencing and signage will be installed to restrict access during construction activities and temporary works.

Temporary first aid, fire and emergency response facilities will be constructed where the MIA is proposed during the operations phase.

4.5. OPERATIONS

4.5.1. Geotechnical Assessment

A geotechnical assessment has been undertaken to identify any significant constraints to operations.

No impediments to open cut mining of the D1 and D2 seams have been identified, although economic constraints and highwall heights will limit the western down dip extent of mining. For low and highwall design parameters and profiles refer to **Table 7-11** and **Figure 7-12** (refer to **Section 7—Land**). A summary of the key geotechnical conditions and design parameters based on the geotechnical assessment is provided in **Section 7—Land**.

4.5.2. Mine Sequencing

The SGCP proposes to employ both open cut and underground mining methods. The SGCP execution will involve a staged ramp-up to the maximum production level of 17 Mtpa, as described in **Table 4-5**, **Table 4-6** and **Figure 4-2 to Figure 4-13**.

Table 4-6 SGCP Mine Sequencing

Element	Stage 1	Stage 2	Stage 3
Approximate Provisional Commencement Date of Mine Stage	2015	2017	2019
Product Coal	Up to 5 Mtpa	Up to 10 Mtpa	Up to 17 Mtpa
Mining Method	Open cut mining	Open cut and underground mining	Open cut and underground mining

The mine schedule presented in **Table 4-7** is based on the anticipated maximum level of production. The actual schedule will be influenced by final detailed mine planning and design, variations in the construction schedule, geological conditions, economic considerations and the availability of and access to third party infrastructure (e.g. rail and port infrastructure).

The mining methods are described in detail in **Section 4.5.3** and **Section 4.5.4.**

Table 4-7 Provisional Production Schedule

Year	Total ROM Coal (Mtpa)			Total Product Coal (Mtpa)	Total Waste Rock (million bank cubic metres [Mbcm])	Total Coal Reject (Mtpa)
	Open Cut	Underground	Total Combined			
1	5.61	-	5.61	5.40	19.40	0.21
2	5.74	-	5.74	5.42	26.52	0.32
3	7.35	3.04	10.39	9.66	55.29	0.72
4	4.79	7.09	11.88	10.71	18.34	1.17
5	7.19	6.99	14.18	12.99	51.78	1.20
6	6.58	7.43	14.01	12.70	46.57	1.31
7	6.08	9.34	15.42	13.86	31.22	1.56
8	5.78	12.20	17.98	16.07	31.47	1.91
9	5.05	12.14	17.19	15.32	25.29	1.87
10	5.04	13.59	18.63	16.58	24.88	2.04
11	4.37	13.22	17.59	15.63	23.90	1.97
12	4.43	13.21	17.64	15.66	24.67	1.97
13	4.76	13.17	17.93	15.94	20.56	1.99
	4.33	13.15	17.48	15.53	18.85	1.96
15	4.36	13.14	17.50	15.54	20.86	1.96
16	4.76	13.07	17.83	15.86	23.00	1.96
17	4.70	13.92	18.62	15.70	24.07	1.92
18	4.54	13.12	17.66	15.73	29.19	1.93
19	4.73	13.09	17.82	15.88	26.17	1.94
20	5.17	11.99	17.16	15.41	29.15	1.75
21	4.63	11.98	16.61	14.88	28.90	1.73
22	4.98	12.01	16.99	15.24	29.58	1.75
23	5.09	12.30	17.39	15.60	32.36	1.79
24	5.12	11.52	16.64	14.95	32.29	1.69
25	5.70	12.32	18.02	16.21	37.40	1.82
26	5.30	11.52	16.82	15.11	37.73	1.70
27	5.26	11.65	16.91	15.24	31.94	1.68
28	6.10	11.29	17.39	15.76	27.14	1.64
29	5.68	5.55	11.23	10.30	26.99	0.93
30	5.93	4.52	10.45	9.65	31.02	0.80
31	5.90	4.53	10.43	9.64	27.83	0.79
32	5.90	4.53	10.43	9.64	27.83	0.79
33	5.90	4.53	10.43	9.64	27.83	0.79
Total	**176.85**	**321.15**	**498**	**447.45**	**970.02**	**49.56**

Source: AMCI and Bandanna Energy (2011) (b)

4.5.3. Open Cut Operations

4.5.3.1. Mining Methods

Open cut mining at the SGCP will involve conventional strip mining using draglines with pre-stripping undertaken by conventional truck and shovel.

4.5.3.1.1. Clearing

Prior to the commencement of mining operations, vegetation will be cleared and topsoil will be removed and stockpiled separately for later use in mine rehabilitation (refer to **Section 4.14** and **Figure 4-2** to **Figure 4-12**). Live placement of topsoil will be employed where areas for rehabilitation become available. Topsoil stockpiles will be nominally no more than 2 m in height. Identification and treatment of topsoil contaminated by weed species is described in **Section 8—Nature Conservation**.

4.5.3.1.2. Drilling and Blasting

As described in **Section 7—Land**, drilling and blasting of overburden material will be required as part of mining operations. Drilling and blasting is expected to be required for the lower 20 % of the Permian overburden material in order to uncover coal economically.

Holes will be drilled into the overburden material at engineered intervals using a drill rig, charged with Ammonium Nitrate Fuel Oil (ANFO) and blasted.

Blasting will be undertaken in accordance with the conditions of the Environmental Authority.

4.5.3.1.3. Overburden Removal

A power shovel will be used to excavate the boxcut to allow dragline access. The overburden material will be dozed to provide a flat surface for the dragline to sit on. The dragline will be positioned adjacent to the overburden material to be moved, from where it will dig and dump overburden onto the spoil pile.

4.5.3.1.4. Overburden/Interburden Placement

A portion of the boxcut waste will be used for construction of flood prevention berms and the remainder will be placed within the waste rock emplacement facilities. Overburden removed by the draglines will be spoiled in previous strips.

All potentially acid forming (PAF) material will be selectively handled where practicable to ensure that the potential for acid rock drainage is limited.

The major potential source of PAF material will be the waste material that is found within 5 m of the coal seams. This can be split into the waste above the top seam (D1) or interburden (between the D1 and D2 seams). The waste above the D1 seam will be removed using draglines and will be mixed with non-acid forming (NAF) waste. This mixed waste would then be placed in the portion of the dump known as dragline spoil.

The interburden waste will be dumped in-pit where practicable. The remaining interburden that cannot be dumped in-pit shall be trucked to the waste dumps and tipped into voids between the dragline spoil piles. Reject material from washing the coal will also be dumped within the dragline spoil piles. Once all PAF material has been placed, a 10 m cover of NAF material will be applied over the entire waste rock emplacement area to ensure that the PAF waste is not exposed.

4.5.3.1.5. Coal Mining

In strip mining operations, the waste rock and coal are extracted in a series of 'strips', running parallel to each other. Each strip is mined then filled and rehabilitated progressively.

The SGCP will comprise four open cut pits, with a total strike length of approximately 14 km.

A truck and shovel fleet will be used for pre-stripping (i.e. removal of any overburden material deeper than the dragline cut-off depth of 65 m). A smaller truck and shovel operation will be utilised to mine coal and remove interburden.

Multiple mining areas for coal will allow for both the D1 and D2 seams to be mined concurrently in separate areas of the mine. This will allow blending of ROM coal from both seams to allow control of feed quality to the CHPP.

4.5.3.2. Major Equipment and Mobile Fleet

The indicative mine fleets required are shown in **Table 4-8** and **Table 4-9**.

Table 4-8 Indicative SGCP Open Cut Mine Fleet

Fleet Component	Use	Number		
		Stage 1	Stage 2	Stage 3
Drill Rig	Drilling holes before blasting Exploration drilling	1	2	2
Dragline (Marion 8750)*	Removing overburden	-	1	2
Shovel (RH200)*	Excavating overburden and interburden Excavating coal	1	3	3
Truck (Cat 789)*	Hauling waste rock and coal	6	10	10
Truck (Cat 793)*	Hauling waste rock and coal	-	12	12
Dozer (D11 CD)*	Removing overburden Mine work	-	2	2
Dozer (D10)*	Mine work Rehabilitation work	2	8	9
Grader (16M)*	Mine work	1	2	2
Water Cart	Dust suppression for mine work	1	3	3
Dozer (Rubber Tyred)	Mine work	1	3	3
Other	Mine work Support mine work	10	20	20

Source: AMCI and Bandanna Energy (2011) (b), * or equivalent

Table 4-9 Indicative SGCP Major Surface Fleet

Description	Peak Number
Crawler Crane	1
All Terrain Crane	1
Dozer (D9T)	5
Dozer (D10)	1
Water Cart	1
Dozer (Rubber Tyred)	1
Backhoe Loader (Cat 740)	5
Franna Crane	4
Fuel Truck	2
Articulated Truck (Cat 740)	2
4x4 Landcruiser (or similar)	12
4x4 Dual Cab Hilux (or similar)	57
4x2 Dual Cab Hilux (or similar)	21
Bus	6
Lighting Towers (3 Head)	10
Lighting Towers (6 Head)	15
Dewatering Vehicle	3
Ambulance	1
Fire Truck/Emergency Response Vehicles	4

4.5.3.3. Mine Dewatering

Open cut mining will result in groundwater inflow from the surrounding aquifers into the open cut pits. Dewatering volumes are anticipated to be less than 10 megalitres per day (ML/d) during the initial and final years of operations and up to 20 ML/d during peak years. Water management is discussed in further detail in **Section 4.10** and **Section 9—Water Resources**.

4.5.4. Underground Mining Operations

4.5.4.1. Mining Methods

As described in **Section 4.5.2**, the underground mining operations will commence in Stage 2 and will continue for the life of the SGCP. Underground operations will utilise the longwall mining method.

4.5.4.1.1. Development of Mains Headings and Gateroads

The southernmost open pit has been designed to facilitate access to the underground mine area via a boxcut. Seven headings have been designed from the boxcut to the D1 seam. Access to D2 seam will be by short inter-seam drifts from D1 to D2, initially for conveyor, personnel and material transport and return roadway. The inter-seam drifts will provide access to the D2 seam in coal and subsequently seven heading mains will be developed in the D2 seam.

Mains headings and gateroad panels will be developed by a full head single pass Continuous Miner unit. The design basis for underground mining of the D1 and D2 seams is outlined in **Table 4-10**. Roof and rib support will be installed utilising board bolting rigs as required.

Table 4-10 SGCP Underground Mine Design Parameters

Coal Seam	Mains Pillars	Gateroad Pillars	Roadways	Longwall Panel Width
D1 Seam	60 m x 30 m	125 m x 25 m	5.2 m x 3.3 m	350 m
D2 Seam	60 m x 30 m (outbye mains pillars are the same as D1 seam in order to achieve panel superimposition) 60 m x 35 m (western mains pillars provide allowance for mining under first D1 longwall block) 60 m x 30 m (inbye north-south mains pillars)	125 m x 25 m (outbye gateroad pillars are the same size as D1 seam in order to achieve panel superimposition) 125 m x 30 m (inbye pillars are wider for greater depth)	5.2 m x 3.0 m	350 m

Source: AMCI and Bandanna Energy (2011) (b)

The roadways will form the ventilation passages and provide access for personnel, machinery and other equipment.

A series of pillars will be left in place to support the overlying strata and protect the roadways as mining proceeds (refer to **Table 4-10**).

4.5.4.1.2. Coal Mining

Longwall coal mining machines use a shearer to cut a slice of coal from the coal face on each pass and the coal is transferred to the main gate conveyer via a face conveyor (Mine Subsidence Engineering Consultants [MSEC], 2007). A series of hydraulic roof supports are used in front of the coal face to provide a stable working area for the shearer, face conveyor and the machine operators. As each slice of coal is removed from the longwall face, the hydraulic roof supports are moved forward (MSEC, 2007). As the face retreats, the roof and a section of the overlying strata are collapsed behind the longwall machine (referred to as the 'goaf'), (MSEC, 2007).

The longwall face equipment is established at the end of the panel that is remote from the main headings and coal is extracted within the panel as the longwall equipment moves towards the main headings (MSEC, 2007). The longwall miner and drift conveyor systems operate at up to 4,500 tonnes per hour (tph) and 6,000 tph, respectively.

In order to start each new longwall panel, the longwall machine will be disassembled into components and re-assembled in the installation roadway of the next panel.

The underground mine will be a multi-seam operation, with the D1 seam mined first, followed by the D2 seam. The separation distance between the seams is approximately 9–17 m. In order to maximise pillar stability during mining of the D2 seam, the underground mine has been designed so that the D2 longwall panels directly underlie the D1 panels (where both exist together).

Coal will be extracted in panels 350 m wide, and up to 5,000 m in length. The minimum depth of cover will be 140 m.

4.5.4.2. Major Equipment and Mobile Fleet

One longwall machine will be required for Stage 2 and two for Stage 3. An indicative list of underground equipment and mobile fleet is provided in **Table 4-11**.

Table 4-11 Indicative Underground Mining Fleet

Element	Stage 1	Stage 2	Stage 3
Development			
Continuous Miner	N/A	3	3
Shuttle Cars		6	6
Longwall Mining			
Longwall Machine	N/A	1 x 1,000 tph	2 x 1,000 tph
Shearer		2	2
Bob Cat		1	1
Grader		1	1
Utility Vehicle (MPV)		4	4
LHD (Eimco)		5	5
Underground Transport (PJB)		5	5
Mobile Bolting Rig		1	1
Surface Substation			
Site Bus	N/A	3	2
Site 4x4's		5	5
Staff Vehicles		10	10
Site Forklift (Large)		1	-
Site Forklift (Small)		1	1

Source: AMCI and Bandanna Energy (2011) (b)

4.5.4.3. Ventilation Systems

Mine ventilation modelling has assumed negligible gas content with no significant additional mine ventilation required for gas dilution (refer to **Section 4.5.4.4** for further detail). The following ventilation design parameters have been assumed for the SGCP:

- Roadways to the D1 and D2 seams will provide intake and return ventilation (i.e. four intake roadways and three return roadways). The required intake ventilation for each drift will be of the order of 120 cubic metres per second (m^3/sec).
- Three drifts into each seam horizon allow for mine intake ventilation.
- Once the inter-seam drifts have been established and seven heading mains developed in the D2 seam, a shaft will be sunk to intersect both seams. This shaft will then act as a return shaft and the return roadways outbye of the shaft will be converted to intakes.
- With 70 % mine ventilation efficiency required, mine ventilation would be 365 m^3/sec.
- Dual return shafts of 6 m diameter have been provisioned. The first shaft will be in the pit bottom area and sunk to the base of the D2 seam (~150 m). The second shaft will be sunk in bye D1 and D2 blocks (to ~140 m depth).
- Both shafts will have substantial mine ventilation fans connected to the shaft collars operating in exhaust mode. It is envisaged that up to three fans of 450 kilowatt (kW) capacity will be connected to each shaft to provide the necessary mine flow and redundancy for maintenance.

Further detailed mine ventilation modelling will be conducted as part of the Definitive Feasibility Study (DFS).

4.5.4.4. Coal Seam Gas Management

No significant indications of gas have been reported during SGCP exploration activities. Work undertaken on the tenements located immediately north of the SGCP has not identified economically recoverable gas reserves, nor was methane considered to be a likely significant operational management issue (AMCI and Bandanna Energy, 2011(b)).

An in-seam gas assessment will be conducted as part of the DFS.

An automatic gas monitoring system will be designed and installed to comply with the *Coal Mining Safety and Health Act 1999* and *Coal Mining Safety and Health Regulation 2001*.

Any seam gas make, particularly at greater depths, will be managed by the ventilation system described in **Section 4.5.4.3**.

4.5.4.5. Mine Dewatering

Water inflow to underground workings will vary depending on the stage of development, although inflow is expected to be less than 10 ML/d during the initial and final years of operations and up to 20 ML/d during peak years. A dewatering system comprising electric and air operated pumps will be used to pump accumulated water through mains dewatering pipelines to storage facilities or dams on the surface.

Water management is described in further detail in **Section 9—Water Resources**.

4.5.5. Coal Reclaim and Preparation

The materials handling process is shown in **Figure 4-16**. The CHPP will operate 24 hours per day (hr/d), seven days per week with a ROM coal feed capacity of approximately 2,000 tph. Block and process flow diagrams for the CHPP are shown in **Figure 4-17** and **Figure 4-18**, respectively.

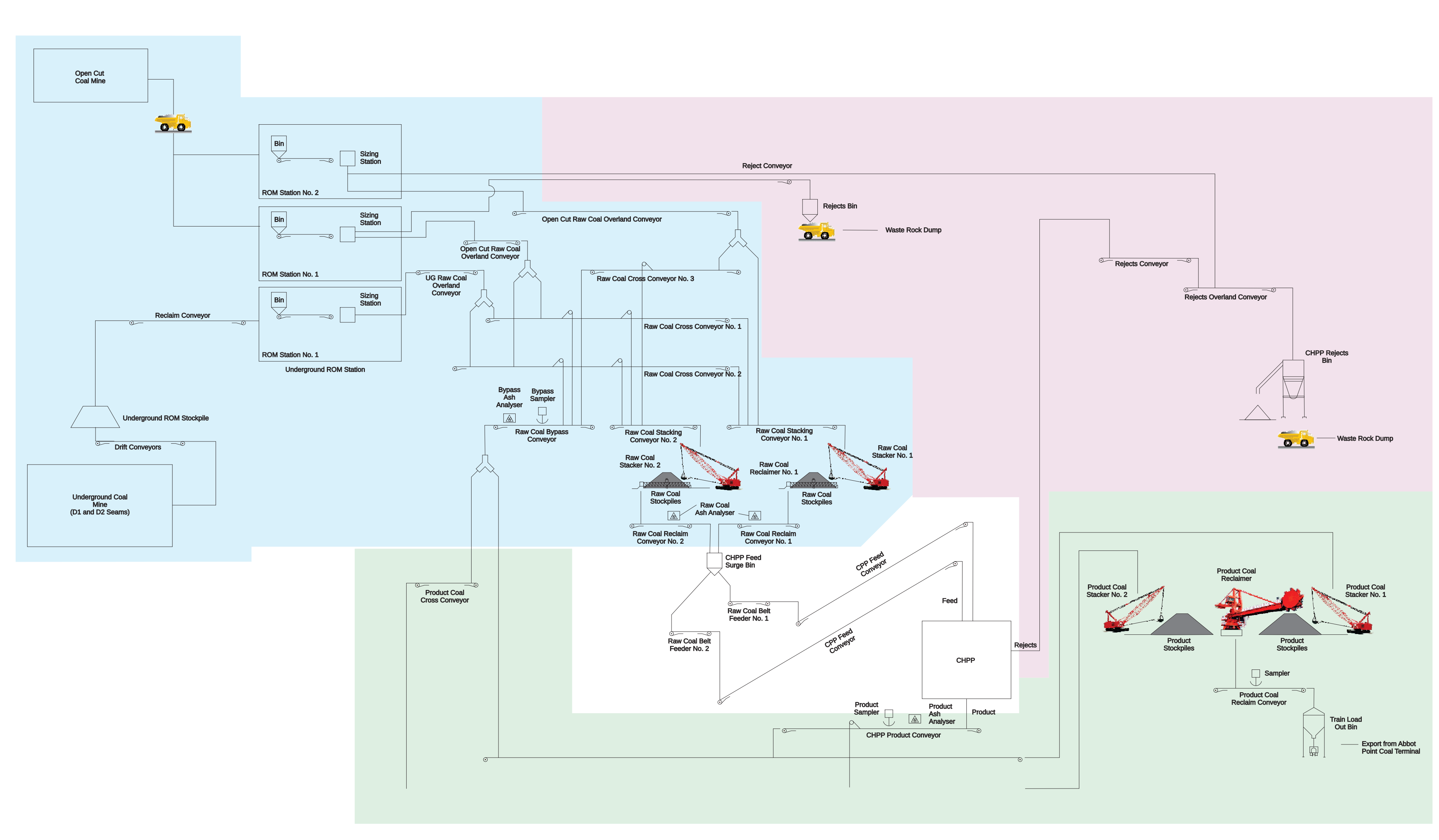
4.5.5.1. Coal Reclaim

ROM coal from open cut mining will be hauled by truck to one of two main ROM dump stations and placed into a 600 m^3 hopper. Transfer conveyors will transport coal to the sizing station, where it will be sized to meet the CHPP nominal topsize. Sizing screens will be used to separate undersize (< 50 millimetre [mm]) and oversize materials (50 to 300 mm). Oversize material will be fed to the rotary breaker to be crushed to < 50 mm before being transported by overland conveyor to the raw coal stockpiles located near the CHPP. Any material that is not sized to < 50 mm in the rotary breaker will be deemed to be reject and will report to the rejects conveyor.

ROM coal from the underground mining operations will be transferred via D1 and D2 drift conveyors to a centralised underground ROM stockpile located in the boxcut area (120,000 t capacity). ROM coal will be transported to the underground sizing station on a reclaim conveyor, where it will be sized to meet the CHPP nominal topsize. Sizing screens and sizers will be used to separate undersize (< 50 mm) and oversize (50 to 250 mm) materials. Oversize material will be crushed to > 50 mm and deposited on the underground overland conveyor. Coal will then be conveyed to the raw coal stockpile area located on the surface, near the CHPP.

The raw coal stockpile area will receive both open cut and underground ROM coal and will consist of four separate stockpiles (each with a capacity of 60,000 t) fed by two luffing stackers. Raw coal can bypass the raw coal stockpiles and CHPP and be conveyed directly to the product stockpiles, if the *in-situ* qualities are consistent with the product coal specifications.

Stockpiled ROM coal will be reclaimed by bridge bucket wheel reclaimers and conveyed to the CHPP feed surge bin. The design of the ROM coal reclaim and plant feed system will allow a controlled, blended feed to the CHPP.



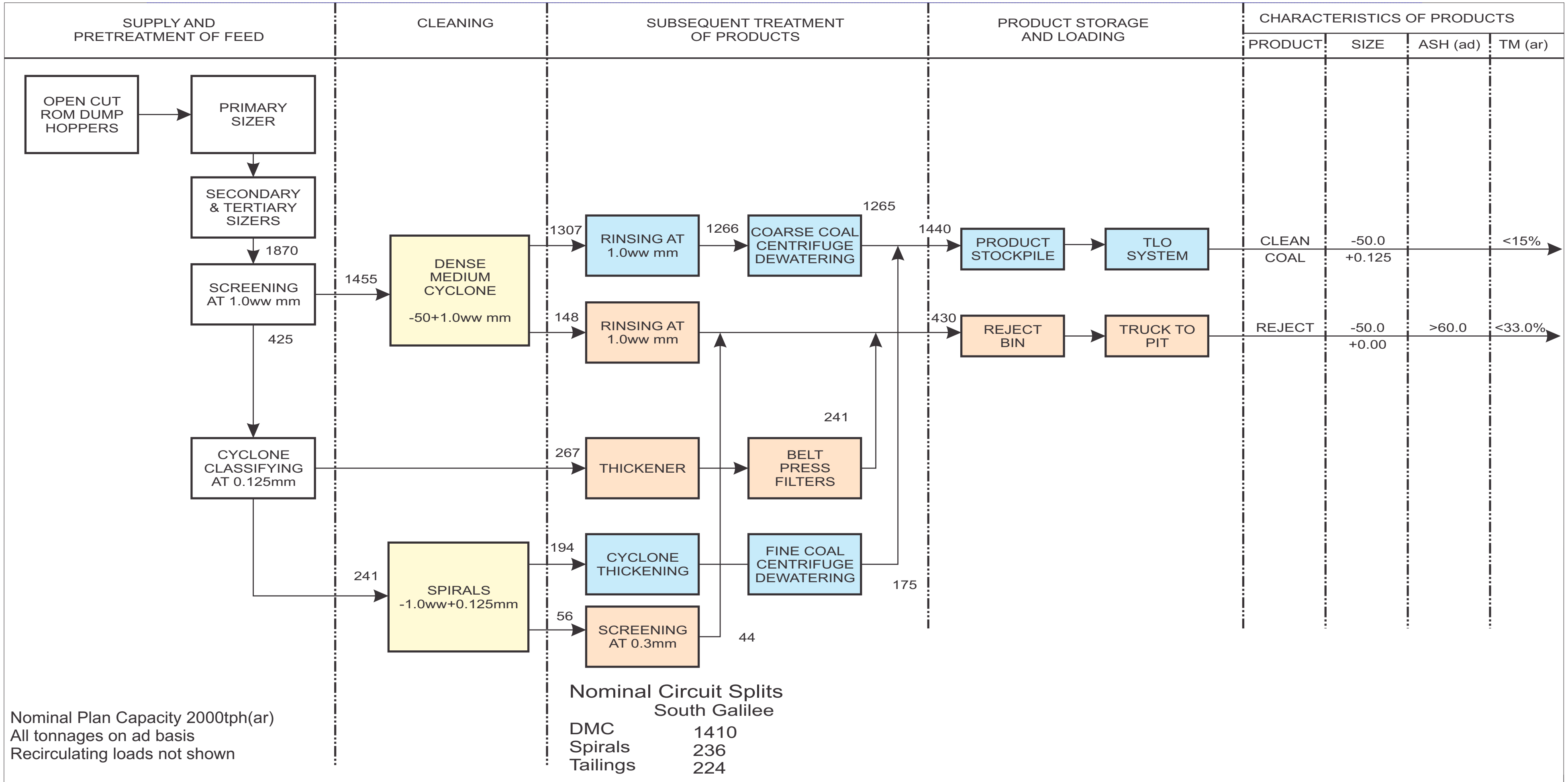
Alpha Coal Pty Ltd

South Galilee Coal Project

Indicative Materials Handling Flow Sheet

23/08/2012

FIGURE 4-16



METSERVE Mining & Energy Technical Services Pty Ltd

SouthGalilee

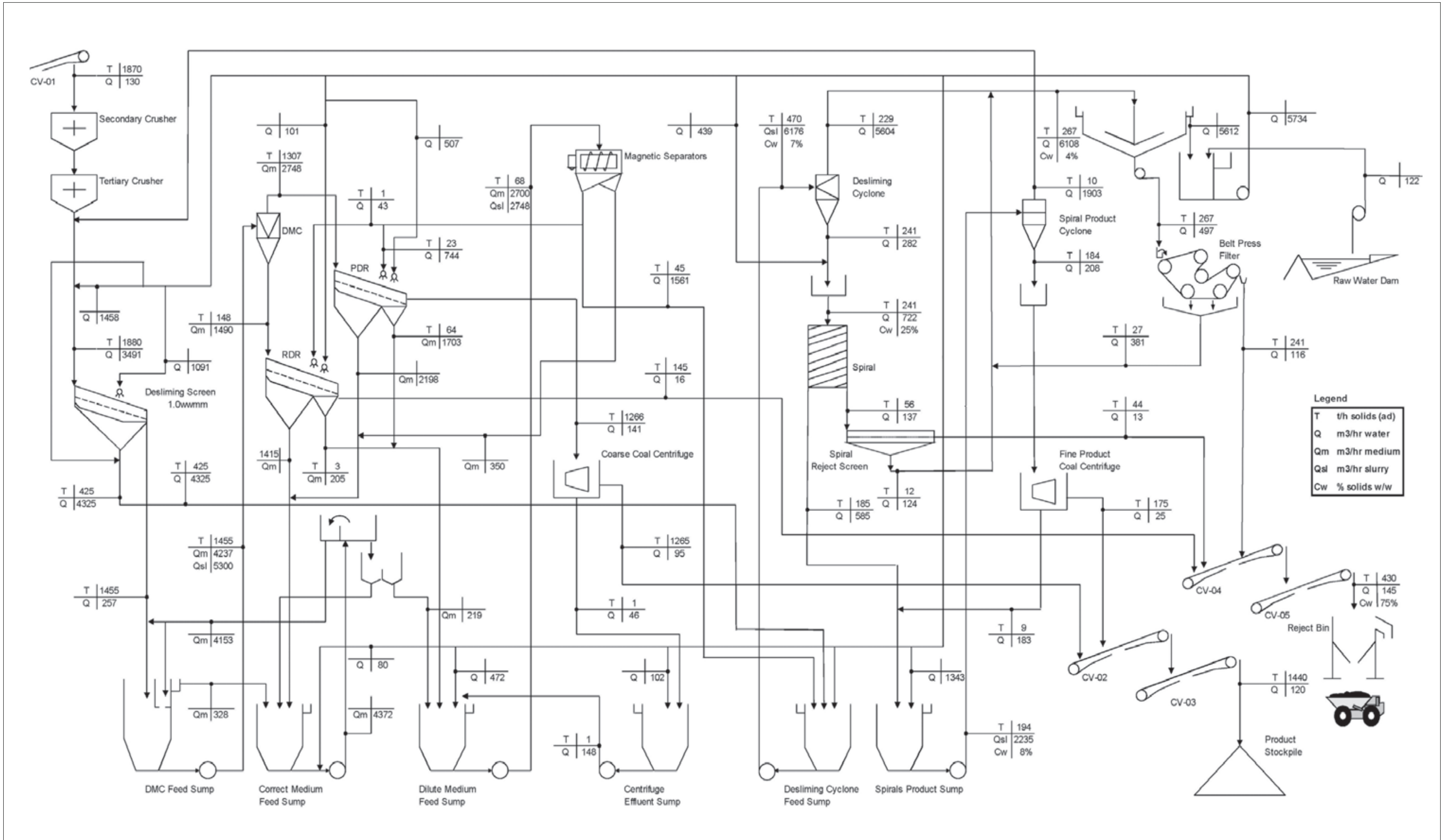
Alpha Coal Pty Ltd

South Galilee Coal Project

CHPP Block Diagram

23/07/2012

FIGURE 4-17



Alpha Coal Pty Ltd

23/07/2012

South Galilee Coal Project

CHPP Nominal Process Flow Diagram

FIGURE 4-18

4.5.5.2. Coal Handling and Preparation Plant

In Stage 1, coal will be processed in a wash plant or by dry beneficiation.

In Stages 2 and 3, the SGCP CHPP will use conventional wet beneficiation processes that are used extensively throughout the Australian coal industry.

The modular CHPP components will be constructed progressively to align with the mine plan coal production levels and the staged execution strategy (refer to **Section 4.5.2**). The +1.4 mm coarse coal fraction will be beneficiated in dense medium cyclones and the 1.4+0.125 mm fine fraction will be beneficiated using spirals. The 0.125 mm material will be discarded to rejects due to the high cost and low marginal value typically associated with coal in this coal fraction.

Two CHPP modules will be used, each with a nominal 1,000 tph capacity (i.e. nominal CHPP feed rate of 2,000 tph).

Coal will be processed and blended to produce a 13.5 % ash export thermal coal.

The CHPP will be supported by a CHPP workshop and office.

4.5.6. Product Handling

The product stockpile area will comprise four product coal stockpiles (each with a capacity of 230,000 t), fed by automated stackers. Both product coal from the CHPP and raw bypassed coal will report to the product stockpile area.

Product coal will be reclaimed via a single slewing bucket wheel reclaimer and conveyed to the train load-out system. The nominal load-out rate will be 8,000 tph. As described in **Section 4.6.2**, product coal will be transported by train to Abbot Point Coal Terminal (APCT), where it will be shipped to international customers. Further information regarding coal transport is provided in **Section 4.6**.

The product handling system will allow coal blending to achieve a consistent quality that meets product specification.

4.6. TRANSPORT

4.6.1. Road

The Capricorn Highway is the main road in the vicinity of the SGCP.

The Capricorn Highway is a state controlled road, connecting Rockhampton, Emerald and Longreach. Access to the SGCP will be from the Capricorn Highway via a turn-off approximately 12 km west of Alpha to the Mine Access Road. The Mine Access Road and Accommodation Village Access Road will be sealed 10 m wide (including shoulders), single carriageways (i.e. single lane for each direction of travel). The maximum speed limit will be 60 km/hr. On site, light vehicle roads and haul roads will be unsealed.

The following road upgrades will be required:

- removal and replacement of the seal on the Capricorn Highway between the Alpha Aerodrome and the intersection with the Mine Access Road (approximately 10.2 km)
- installation of a new auxiliary left turn lane on the Capricorn Highway for the mine access road turn-off.

As described in **Section 4.11.5**, road construction material will be sourced both on-site and externally. Ballast material sourced from the existing quarry on Alpha-Tambo Road will be transported on a haul road through MLA 70453, to connect with the proposed road alongside the SGCP rail line within the infrastructure corridor.

Road transport would be required for transport of the following during the construction period:

- road base, ballast and fill materials
- trucks and vehicles
- parts for construction of draglines and shovels
- diesel-powered generators and fuel
- CHPP construction equipment and materials
- workshops, warehouses and associated mine infrastructure building materials and equipment
- pre-fabricated accommodation buildings and site offices
- construction personnel
- other construction materials and equipment.

Road transport would also be used to transport personnel to site during operations and for delivery of some materials and equipment (e.g. equipment maintenance parts, food and supplies to the accommodation village, ANFO etc.).

A detailed description of the transport routes and potential impacts of the SGCP on the road network is provided in **Section 14—Transport**.

4.6.2. Rail

Product coal is proposed to be transported by rail to the APCT, located approximately 500 km north east of the Galilee Basin.

The Galilee Basin is currently not connected to a major coal haulage railway system. However, Waratah Coal Pty Ltd, the GVK Group and Adani Mining Pty Ltd have all proposed to construct railway systems from the Galilee Basin to the APCT. All of these proponents have indicated to the Proponent that their respective rail infrastructure will be open to third party access. On June 6, 2012, the GVK-Hancock Coal rail alignment was approved by state government to allow third party access for the transportation of coal from the Galilee basin to the APCT.

Irrespective of which proponent(s) ultimately establish rail infrastructure to the APCT, the line(s) will be a standard gauge rail system.

A standard gauge railway has considerable advantages over the existing narrow gauge rail network in Queensland in that it has a substantially higher carrying capacity (e.g. 24,000 t loads compared to 10,000 t loads on the Bowen Basin QR National Network).

The railway will have four components as outlined below and shown on **Figure 4-19**:

- **On-site rail component** – on-site rail will comprise track and signalling located within MLA 70453, including the loading loop, breakdown and fuel sidings.
- **SGCP rail spur component** – the SGCP rail spur connection will comprise track and signalling (including a passing loop and connecting turnout) to connect the on-site rail component and the common user rail component.
- **Common user rail component** – the common user rail component will link the Galilee Basin to the expanded APCT.
- **Unloading loop rail component** – the unloading loop rail component at the APCT will facilitate train unloading and subsequent movement of the coal to a stockpile. The layout of the unloading loop rail component is expected to be consistent with North Queensland Bulk Ports (NQBP) expansion master plan.

Design parameters, including the points of interface between the proposed SGCP rail components and existing road and rail infrastructure are described further in **Section 14—Transport** and **Appendix K—Transport Technical Report**.

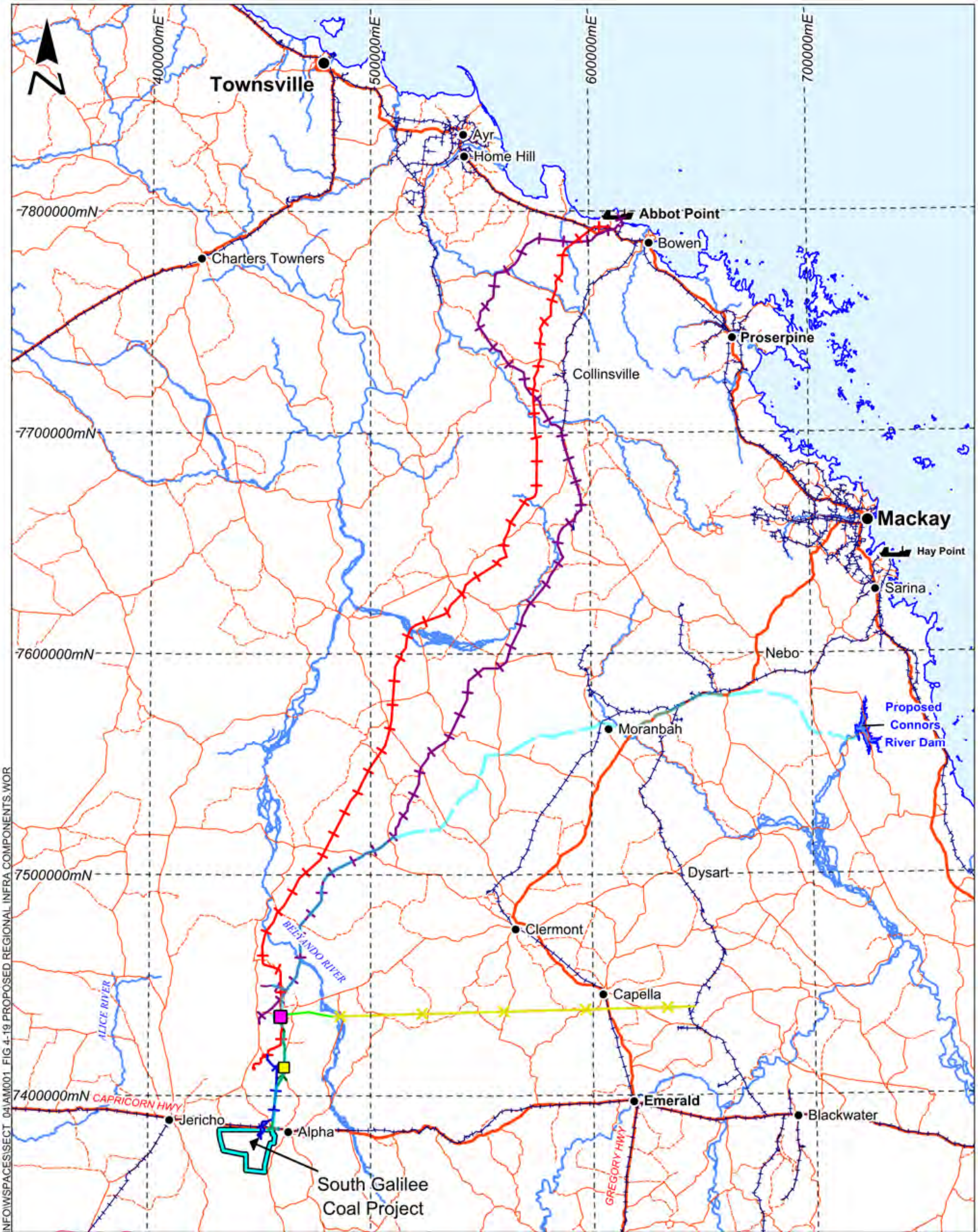
The following works will be required:

- construction of an underpass at the Capricorn Highway
- construction of a rail bridge over the Central Line Railway (single span bridge)
- construction of a level crossing at Hobartville Road.

The SGCP will also be required to provide capital to increase the capacity of common user rail infrastructure, where necessary.

The existing Central Line Railway will be used to transport the majority of the SGCP construction materials and equipment, where practicable.

Approximately two diesel trains per day would be required to transport product coal to the APCT. Each train would consist of four locomotives and 182 wagons (the Proponent and Bandanna Energy, 2011). Product coal trains will generally operate continuously, 24 hours per day, seven days per week for approximately 330 days each year. It is anticipated that the majority of bulk consumables and equipment required during operations would also be transported to site on the common user rail line.



S:\PROJECTS\AM001_STHGALILEE_EIS\GIS_MAPINFO\WSPACES\SECT_04\AM001_FIG 4-19 PROPOSED REGIONAL INFRA COMPONENTS.WOR

LEGEND

- MLA70453
- Principal road
- Road (sealed)
- Road (unsealed)
- Railway
- River
- SGCP Rail Spur Component
- Waratah Common User Rail Component
- Hancock Common User Rail Component
- Powerlink Galilee Basin Transmission Project
- SGCP Powerline
- Connors River Pipeline / Moranbah to Alpha Pipeline
- Proposed Powerlink substation
- Proposed Waratah / SGCP substation
- Population centre

Data Source: Topography - Geoscience Australia.

METSERVE Mining & Energy Technical Services Pty Ltd

SouthGalilee

Alpha Coal Pty Ltd

South Galilee Coal Project

Proposed Regional Infrastructure Components

100 0 100

Kilometres

Scale: 1:2,500,000 (A4)

28/08/2012

Proj. : MGA Z55
Datum: GDA 1994

FIGURE 4-19

4.6.3. Air

A contract fly-in-fly-out (FIFO) air service provider will be used to transport the SGCP workforce to and from the site. The Alpha Aerodrome will be upgraded as required, with upgrades expected to be undertaken by the air service provider.

4.6.4. Ship

As described in **Section 4.6.2**, product coal is proposed to be exported from the APCT, located approximately 500 km north-east of the Galilee Basin.

The APCT is currently undergoing significant expansion as part of the X50 project to increase capacity to 50 Mtpa.

In May 2011, the Queensland Government announced the 99 year lease of the X50 APCT to Mundra Port Pty Ltd. Under the lease, the State will retain ownership of the Port land and fixed infrastructure such as the jetty and the wharf (NQBP, 2011). The State will also continue to facilitate future private-sector funded expansion of export infrastructure within the broader port precinct, such as Terminal 2 and Terminal 3. The NQBP remains the port authority for the APCT.

The major expansion projects which are proposed for the APCT are the T2 and T3 projects. This will involve the development of two additional separate tranches of coal terminal capacity (Preferred Developers are the GVK Group and BHP Billiton Limited).

There is potential for the SGCP to secure interim and long-term port capacity at GVK's Abbot Point Terminal 3 (T3). Any long-term access would be subject to GVK obtaining approvals to T3 expansion.

The proposed APCT expansions will be subject separate environmental impact assessment and approvals processes, and as such, the port expansion component does not form part of this EIS.

4.7. WASTE MANAGEMENT

The proposed waste management strategies that will be implemented as part of the SGCP are detailed in **Section 13—Waste**.

4.7.1. Air Emissions

The SGCP is located in a rural setting which is subject to nuisance dust from unsealed roads, rural activities or natural events such as dust storms or bushfire.

The nearest homesteads to the SGCP surface disturbance activities are Chesalon, Creek Farm, 'Villafield' and 'Bonanza'.

Due to the location of the SGCP and the lack of any significant air pollution sources, air pollution from operations is expected to be confined to rising dust. Most rising dust will originate from overburden removal, coal preparation, haulage and rail loading, blasting and operation of large mobile equipment.

The potential for spontaneous combustion of stockpiled coal is considered minimal. In the event of coal fires developing, additional localised impacts on air quality due to the emission of smoke and gases would be expected.

Further details of the air quality impacts and mitigation measures are provided in **Section 10—Air Quality**.

4.7.2. Waste Rock

The total waste rock volume for the life of the SGCP is estimated to be approximately 970 Mbcm.

Waste rock characterisation, including geochemical analysis, indicates that (refer to **Section 7—Land**):

- the bulk of the overburden and interburden material is likely to be NAF
- the roof within 5 m of the D1 seam appears to be the main PAF horizon, with a number of other lower capacity PAF horizons associated with coal seams and also within interburden between seams D1 and D2
- PAF materials are likely to be fast reacting, with little or no lag time (days to weeks) once exposed to atmospheric conditions.

As described in **Section 4.5.3**, waste rock will be removed by the draglines and spoiled in previous mine strips. The roof horizon within 5 m of the D1 seam will be selectively placed away from the dump outer slopes and will be enclosed within a 10 m NAF cover. Interburden waste will be trucked into voids between dragline spoil peaks or trucked along the cut and dumped in the void after the D2 seam has been mined. PAF material will be selectively handled where practicable to minimise the potential for acid rock drainage.

The proposed handling and management of PAF materials is expected to be sufficient to manage potential environmental impacts as a result of acid mine drainage and salinity at the SGCP.

4.7.3. Coal Rejects

As described in **Table 4-6**, approximately 50 Mt of coal reject would be produced over the life of the SGCP.

A description of the geochemical and physical characteristics of the coal reject material is provided in **Section 7—Land**. Geochemical characterisation of the coal rejects indicates that this material is likely to be mainly PAF.

Coarse reject material from the CHPP will be transferred on the rejects conveyor to a 300 t reject surge bin located adjacent to the ROM Station 2. The reject bin will also receive rejects from the open cut sizing stations.

The rejects system will treat all < 0.125 mm material that enters the CHPP from the ROM stockpiles. The rejects system will consist of a 'high-rate' thickener coupled with a conventional clarified water return system, followed by belt press filters. Standard flocculant mixing and batching systems will be installed and dosing will be controlled by automated clarometer systems. The cake from the belt filter press will be deposited on the CHPP rejects conveyor as part of the combined CHPP reject.

The mining truck fleet will transport rejects to the waste rock emplacement facility, where they will be covered with a 10 m NAF cover. Coal reject material will not be placed at the base of any waste rock emplacements.

4.7.4. Solid and Liquid Waste Disposal

The objective of waste management will be to minimise waste generation and maximise opportunities for recycling. However, the facilities and equipment associated with mining and coal processing do generate a large amount of commercial and industrial wastes commensurate with the scale of operations. Waste streams generated during operation of the SGCP may include the following:

- general waste suitable for disposal to landfill
- re-usable or recyclable waste (e.g. paper, cardboard, wood, scrap metal, batteries and oils)
- sewage waste and waste water
- regulated waste (e.g. chemicals, engine coolant, gear lubricant, solvents, contaminated soil and tyres).

With the exception of recyclable waste which will be transported off-site by recycling contractors, the above wastes will be either treated on-site (e.g. sewage waste and waste water will be treated as described in **Section 4.11.3**) or disposed of in an on site landfill designed and managed to the appropriate legislative standards.

4.8. ACCOMMODATION

As described in **Section 4.12**, the SGCP will be a FIFO operation, with personnel housed in an accommodation village located within MLA 70453.

The construction workforce will be housed in the accommodation village and following the construction period, the village will be modified to form a permanent accommodation village. The village has therefore been sized for the peak construction and operations overlap of 1,600 personnel.

The accommodation village will be located in the north-eastern corner of MLA 70453 (refer to **Figure 4-13**), approximately 4 km from the mining operation.

The accommodation village will be accessed from the Capricorn Highway. Typical accommodation village facilities include the following:

- ensuite accommodation
- restaurant
- laundry facilities
- multi-purpose sports courts
- gymnasium
- swimming pool
- recreational lounge rooms
- theatre
- pool hall
- parking
- stores
- maintenance and service buildings.

4.9. POWER SUPPLY AND DISTRIBUTION

4.9.1. Construction Power

Estimated peak energy requirement during construction is approximately 1,950 kW per annum. Construction power will be supplied via stand-alone diesel powered generators.

4.9.2. Operations Power

The peak power supply required during operations is approximately 80 MV per annum.

4.9.2.1. Off-site

Given the projected growth in demand, Powerlink Queensland proposes to supply power to the Galilee Basin. The Galilee Basin Transmission Project proposes to extend the existing high voltage network into the Galilee Basin via a new 275 kilovolt (kV) transmission line between Powerlink Queensland's existing Lilyvale Substation near Emerald and a proposed 'hub' substation 50 km north of Alpha, to be known as the Surbiton Hill Substation. From the Surbiton Hill Substation, 132 kV electricity transmission lines will extend to Kevin's Corner and Alpha Coal Project. Powerlink Queensland plans to have the Galilee Basin Transmission Project completed by early 2014, subject to mining investment decisions. Powerlink's Galilee Basin Transmission Project is subject to a separate environmental impact assessment and approvals process, and as such, the electricity supply to the SGCP on-site reticulation system does not form part of this EIS.

The Proponent will be responsible for the construction of a 132 kV feed line from the proposed Waratah/SGCP Substation to the northern boundary of MLA 70453.

4.9.2.2. On-site

A conventional 132 kV switchyard will be constructed to support two 132/66 kV transformers and associated switchgear. The on-lease electricity reticulation system would comprise 66 kV overhead lines between the site switchyard and the high voltage distribution substations (1 and 2) and the open cut mining area. Where possible, the overhead power lines would be aligned parallel to roads and the number of road crossings will be minimised.

Viable options for utilising renewable energy sources will be incorporated into infrastructure planning and construction.

4.10. WATER MANAGEMENT

4.10.1. Water Management System

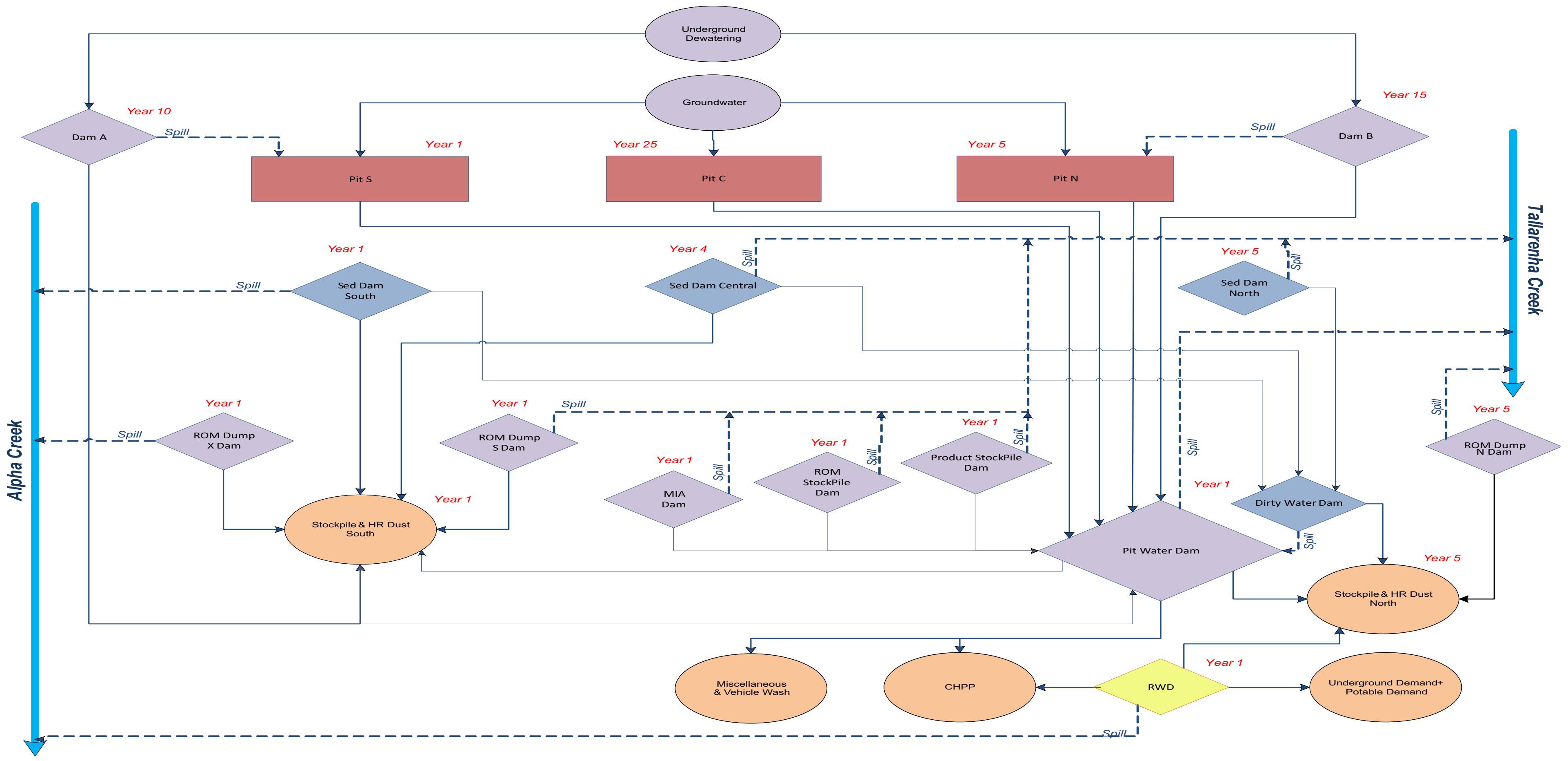
The water management system will be based on the following key principles:

- separation of clean runoff from mine affected water
- maximising the recirculation of process water to be utilised within the CHPP and for dust suppression
- implementing water efficient work practices and recycling in order to keep the consumption of raw water to a minimum.

A water management schematic is provided in **Figure 4-20**. **Figure 4-2** to **Figure 4-12** illustrate the SGCP water management system as it changes over the life of the mine. The conceptual SGCP water storage/management infrastructure components are described in **Section 4.10.1.1**. to **Section 4.10.1.6**. Additional surface water management infrastructure may be constructed over the life of the SGCP, if required.

The major water management infrastructure components include:

- sediment dams
- dirty water dams
- pit water dam
- raw water dam
- drainage channels
- stream diversion.



METSERVE Mining & Energy Technical Services Pty Ltd

SouthGalilee

Alpha Coal Pty Ltd

South Galilee Coal Project

Water Management Schematic

23/07/2012

FIGURE 4-20

4.10.1.1. Sediment Dams

Sediment dams will intercept runoff water and reduce the volume of suspended solids by reducing the flow energy and allowing water to stand. The proposed design criteria of the sediment dams are to:

- retain the flow from a 10 year ARI event, 24 hour storm to allow sufficient time for 0.05 mm diameter (coarse silt) particles to settle
- maximise the length of the dam relative to the width of the dam to maximise hydraulic retention time and deposition.

4.10.1.2. Saline Water Dams

Four saline water dams are proposed to store mine affected water.

For the purposes of this EIS assessment, water balance modelling indicates that it may be necessary for SGCP to undertake controlled releases from the water management system to the receiving environment in order to balance the mine water inventory during periods of high rainfall. If this is required, the controlled water releases will be undertaken in accordance with an approved procedure and in compliance with Environmental Authority conditions.

4.10.1.3. Pit Water Dam

Water from the open cut pits (as a result of rainfall events or groundwater inflow) will be transferred to the Pit Water Dam. The mine pit may be used to store excess runoff entering the pit during, and after, very large rainfall events. Water will be stored for a short period of time, subsequently being used in the CHPP or for dust suppression.

4.10.1.4. Raw Water Dam

The Raw Water Dam will store raw water for use during construction and operation (including use at accommodation village). The Raw Water Dam will accept and store water from the external water supply. The Raw Water Dam will be located south of the rail loop (refer to **Figure 4-2**). Water will be supplied via gravity-fed pipelines east to the accommodation village and west to the operations area. The water level in the Raw Water Dam will be maintained to ensure that a minimum of seven days storage is available at all times. Potable water will be supplied by the potable water treatment plant, located adjacent to the Raw Water Dam.

4.10.1.5. Drainage Channels

Drainage channels will be constructed to direct clean runoff around the open cut mining area into the natural steams. The drainage channels serve to minimise the inundation of the open pits with runoff (therefore minimising the amount of saline water) and maximise the volume of clean runoff remaining within the natural environment. The drainage channels will have a gradient and cross-sectional shape and size such that peak velocities do not lead to local erosion. The detailed engineering design of the drainage channels will be determined during the DFS process.

4.10.1.6. Stream Diversion

To maximise coal recovery within the proposed open cut mining area and to maintain Pit 4 in a safe condition, a diversion of Sapling Creek is proposed (refer to **Figure 4-2**). Sapling Creek is an ephemeral tributary of Alpha Creek.

The drainage line requiring diversion does not experience substantial or consistent flow, however, is classified as a watercourse under the *Water Act 2000.*

The diversion of Sapling Creek will be designed according to relevant legislation, policies and guidelines. Stream diversion stability and sustainability is to be achieved through a number of key processes, including:

- effective management of flood impacts
- short and long-term morphological and geotechnical stability
- hydro-geological sustainability
- ecological sustainability.

4.10.2. Water Consumption and Supply

Up to approximately 900 megalitres per annum (ML/a) of raw water is expected to be required for the SGCP during construction and a peak of approximately 5,172 ML/a during Year 10 of operations.

4.10.2.1. Construction

Raw water for construction activities will be sourced from groundwater bores located within MLA 70453. On-site raw water dams will be constructed to store water from these bores in order to maintain 7-day supply.

An on-site water treatment plant will be constructed to treat groundwater to supply up to approximately 225 ML/a of potable water for the construction workforce and accommodation facilities.

4.10.2.2. Operation

Operational raw water will be sourced from a combination of groundwater, dewatering, surface water harvesting and the external water supply to be determined during various stages of the SGCP.

Up to approximately 84 ML/a of potable water will be required for domestic and underground mining activities. A water treatment plant will be constructed near the Raw Water Dam (refer to **Figure 4-2**) to supply potable water. Potable water will be stored in two water tanks, one to supply the accommodation village and one to supply the mine site.

Should water for underground mining activities not be required to meet the same standards as potable water, a separate water treatment system may be constructed, provided it is economically and practically advantageous.

4.10.2.2.1. External water supply

It is estimated that a 3,000 ML/a allocation from the external water supply will be sufficient to meet SGCP water demand until the commencement of Stage 3 operations, after which an additional 470 ML/a will be sourced from rainwater, runoff from disturbed and undisturbed areas, and groundwater.

In the stages that the external water supply is operating, raw water requirements vary from approximately 658 ML/a to 1,138 ML/a.

Water resources are discussed in further detail in **Section 9—Water Resources**.

4.11. ASSOCIATED INFRASTRUCTURE

The infrastructure requirements proposed as part of the SGCP are outlined in **Section 4.11.1** to **Section 4.11.9** below. The surface infrastructure has been grouped in four main areas, including:

- the MIA acting as the central support hub
- the CHPP area to service the CHPP and stockpile facilities
- underground services area, located at the surface access for the underground mine
- accommodation village.

4.11.1. Mine Industrial Area

The MIA will contain the following:

- main office – air conditioned office to house workstations for staff and contractors and the main control and communications room
- training/inductions/emergency services building – demountable building to house first aid and emergency services personnel
- bath house – bathroom, locker room and change facilities for mine personnel
- cap lamp and self-rescuer storage area – storage area to house personnel equipment required for underground duties (e.g. cap lamps, self-rescues) and general PPE for open cut operations
- mine light vehicle car park
- bus drop-off/pick-up facility
- office and visitor car park
- heavy vehicle workshop
- medium vehicle/light vehicle workshop
- maintenance and workshop office – air conditioned demountable building for personnel closely related to the MIA workshops

- warehouse – secure unloading area and storage for parts and goods
- tyre facility – includes tyre removal, change and storage facilities
- bucket repair facility
- utilities/underground workshop – multi-purpose workshop used for welding and fabrication, sandblasting and painting, materials handling works/repairs, track replacement/repairs etc.
- heavy vehicle washdown – a drive through facility used to wash down heavy vehicles for maintenance, housekeeping and personnel safety
- medium vehicle/light vehicle washdown – a drive through facility used to wash down medium/light vehicles for maintenance, housekeeping and personnel safety
- heavy vehicle refuelling – split into four key areas (i.e. MIA refuelling, haul road refuelling, highwall refuelling and mobile refuelling)
- light vehicle refuelling – facility to service both on-site vehicles and external vehicles (e.g. delivery trucks), if required
- bulk lubricant facility
- controls and communications building
- field maintenance workshop – multi-purpose workshop used for performing maintenance of open cut field equipment.

4.11.2. Underground Services Area

The underground services area will be located beside the boxcut in the southern area of the mine.

Equipment to be transported underground will be disassembled at the MIA and transported via the main drift. Assembly will be undertaken in the underground workshop.

Underground access for SGCP personnel will be via the drift portal.

4.11.3. Sewage and Waste Water

A waste water treatment plant (WWTP) will be located on-site, near the Raw Water Dam (refer to **Figure 4-2**). Waste water and sewage (from the MIA, CHPP and accommodation village) will report to the WWTP for treatment. Facilities isolated from the sewage network (e.g. underground mine receiving centre) will operate on septic systems which will be collected periodically and transported by tanker to the STP. Approximately 10,000 kilolitres (kL) of treated waste water will be piped to the Sediment Dam per day.

4.11.4. Explosives Storage Facility

The explosives storage facility will be located south of the underground mining area (refer to **Figure 4-2**).

The explosives storage facility will include magazines for the storage of initiation products. The storage facility will be licensed to hold up to approximately 60 t of initiation products (i.e. detonators and primers).

Ammonium nitrate and emulsion will be stored near the rail loop. This facility will be licensed to hold 1,000 t of ammonium nitrate, 100 t of emulsion.

The explosives storage facility will be designed and constructed in accordance with relevant legislation and Australian Standards.

4.11.5. Quarry

The fill material for the majority of earthworks and road sub-base will be sourced from the rail cutting site and an on-lease borrow pit (refer to **Figure 4-2**), the exact location of which will be determined following geotechnical assessment. Road base and rail line ballast materials are proposed to be predominantly sourced off-lease due to the absence of high quality material on-lease. **Section 4.6.1** describes the transport of quarry materials.

4.11.6. Fuel Storage

A summary of the types and volumes of hazardous materials (including diesel) to be transported, stored and/or used on-site is provided in **Section 19—Hazard and Risk**. Diesel will be supplied to the site for the operation of mine equipment. The on-site fuel storage facilities will include:

- approximately 16,000 L medium/light vehicle refuelling facility
- two 100,000 L portable refuelling stations
- 1 ML tank located in the MIA
- two 1 ML heavy vehicle refuelling tanks
- two 1 ML tanks located at the rail unloading point.

All fuel storage facilities will be designed, constructed and operated in accordance with the requirement of *Australian Standard 1940 Storage and Handling of Flammable and Combustible Liquids*.

Regular inspections will be conducted and spill response and management procedures will be implemented. Repair and maintenance work will be completed on an as-needs basis.

4.11.7. Telecommunications

Two communication centres (primary centre located within the Administration and Mining Operations Offices and secondary centre adjacent to the CHPP offices) will be constructed to house the networking and electronic equipment required for the site, including the following:

- Wide Area Network (WAN) Routers and Firewalls
- WAN Accelerators
- corporate IT Servers
- corporate Storage Area Network (SAN)
- corporate Data Backup
- corporate IP Telephony
- closed-circuit television equipment (CCTV) and IP CCTV network video storage
- Voice Over Internet Protocol (VOIP) phones to be connected to Power Over Ethernet capable Ethernet switches
- rail network equipment
- radio network equipment:
  - UHF (Analog) construction radio will be provided for the construction phase and repeater base stations will be utilised to provide coverage across the site
  - UHF (Digital) mobile radio system will be used for site communications during operations
- production network servers.

4.11.8. Compressed Air Distribution

Compressed air will be required to service underground and surface operations. The compressed air system will be located at the underground services area and comprise compressors, oil separators, dryers, valving and receivers.

A second compressed air system will be located at the heavy vehicle workshop.

4.11.9. Other Buildings/Facilities

Other buildings/facilities located outside the MIA include the following:

- control room
- CHPP lab—laboratory for routine plant analysis and general quality control analysis
- concrete batching plant – concrete batching plant will be located between the Raw Water Dam and the CHPP
- water truck refill – two water truck refill points will be located on the main haul road, close to the heavy vehicle refuelling facilities
- dragline assembly facility – pad for use by contractor(s) during construction/assembly of the draglines and other ultra-heavy equipment requiring on-site assembly
- heavy vehicle go-lines – three go-lines to fit the heavy vehicle fleet during major shut downs (i.e. northern, central and southern go-lines)
- security/site access outpost – demountable building housing security personnel and an electronic boom gate to regulate traffic flow to and from the mine site
- brake testing ramp – facility where brakes on underground vehicles can be proven prior to entering the mine
- mobile crib facilities – crib huts containing toilet facilities for use by operators working in the open cut pits
- ballast dump – storage of gravel and stones ballast for use in underground roadways
- stone dust system – shed for the storage of stone dust.

4.12. EMPLOYMENT ARRANGEMENTS

4.12.1. Construction

The construction workforce for the SGCP will be employed on a contract basis. The construction workforce is anticipated to be up to approximately 1,600 personnel, although numbers will fluctuate with the staffing requirements of the various construction components. In addition to the mine personnel, support personnel would be required for operating the accommodation village and there would be periodic increases of maintenance contractors for shutdown work on the major plant and infrastructure. As described in **Section 4.4**, construction will be undertaken during daylight hours, seven days a week.

The accommodation facility for the construction workforce is described in **Section 4.8**.

The construction workforce for the SGCP will operate on a 21 days on, 7 days off roster with 12 hour shifts.

4.12.2. Operations

A breakdown of the approximate anticipated operational workforce is provided in **Table 4-12** and a summary for each stage of the SGCP (including contractors and employees) is outlined below:

- Stage 1 – 507 personnel
- Stage 2 – 886 personnel
- Stage 3 – 1,288 personnel.

Table 4-12 Operational Workforce Breakdown

Position/Role	Workforce Numbers		
	Stage 1	Stage 2	Stage 3
Management	11	12	12
Technical Services	25	35	49
Underground Operation	0	310	619
Open Cut Operation	214	214	214
CHPP and Maintenance	174	194	214
Safety Department	20	23	28
Human Resources Department	18	18	18
Commercial	23	26	28
FTE Contractors	0	21	21
Miscellaneous (e.g. cooks, cleaners, gardeners/maintenance)	22	33	85
Total	**507**	**886**	**1,288**

Source: AMCI and Bandanna Energy (2011) (b)

The SGCP will be a FIFO operation. However, employment of people who reside locally will not be discouraged.

The operational workforce for the SGCP will operate on a 7 days on, 7 days off roster with 12 hour shifts.

The accommodation facility for the operational workforce is described in **Section 4.8**.

4.12.3. Decommissioning

The decommissioning workforce will be determined in detail prior to the decommissioning phase when sufficient information regarding the required activities is obtained. However, it is estimated that a peak of approximately 300 personnel will be required in this phase.

The accommodation facility for the decommissioning workforce is described in **Section 4.8**.

4.13. ONGOING EXPLORATION AND EVALUATION ACTIVITIES

Exploration and evaluation activities will be ongoing and may involve in-seam and surface-to-seam drilling. All exploration and evaluation activities will be undertaken in accordance with industry standards, particularly the Department of Environment and Heritage Protection's (DEHP) *Code of Environmental Compliance for Exploration and Mineral Development Permits*.

Exploration activities will be undertaken with contract drill rigs to supply geological data and coal samples for analysis. Geological information and coal samples will be used to inform detailed mine planning and provide coal quality data.

For all exploration and evaluation activities, established access tracks will be utilised wherever practicable. Where this is not practicable, clearing of access to the selected drill sites will be required. Clearing of an access path generally involves grading a track at surface level. Land and vegetation disturbance will be minimised. A permit to clear/disturb will be submitted and signed off by the Environmental Advisor for each proposed drill site. If drilling is required in a mapped ERE area, control strategies will be implemented in accordance with the EM Plan (refer to **Section 21—Environmental Management Plan**). After the completion of any exploration activities, all drill hole sites and access tracks will be rehabilitated.

4.14. REHABILITATION AND DECOMMISSIONING

4.14.1. Rehabilitation

The primary rehabilitation objective is to reconstruct disturbed lands to a safe, non polluting, stable and self-sustaining state.

The site will be rehabilitated to enable two post-mining land uses, native bushland and grazing (refer to **Section 5 – Rehabilitation and Decommissioning**).

Rehabilitation works will include:

- reshaping disturbed areas (e.g. construction areas, waste rock emplacement facilities) to allow for drainage while minimising erosion potential

- placement of topsoil at a specified depth over the reshaped disturbance areas
- seeding with an appropriate species mix for the proposed final land use
- on-going monitoring to measure rehabilitation works against agreed success criteria.

Rehabilitation of any significant subsidence effects (e.g. surface cracking, erosion etc.) may include:

- filling and/or repairing of any significant subsidence-induced surface cracking
- installation of sediment controls (e.g. sediment fences) or stabilisation techniques (e.g. rocks, vegetation etc.).

4.14.1.1. Topsoil Management

Topsoil will be stripped from disturbance areas associated with the SGCP (refer to **Section 4.4.1** and **Section 4.5.3**). The availability and suitability of topsoil reserves is detailed in **Section 7—Land**.

Current reserves show availability of sufficient topsoil to rehabilitate all SGCP disturbance areas as per the proposed rehabilitation strategy (refer to **Section 5—Rehabilitation and Decommissioning**).

Topsoil stockpiles (refer to **Figure 4-2** to **Figure 4-12**) will be clearly signposted to ensure integrity and protection. To prevent topsoil deterioration during storage:

- an up-to-date inventory of topsoil material including the volume and location of stockpiles will be maintained by mine planning and surveying personnel
- live placement of topsoil will be desirable but will depend on rehabilitation backlog – topsoil will be reused as soon as practicable
- soil will be stockpiled nominally no more than 2 m in height
- the establishment of a vegetative cover will be encouraged to minimise erosion, perpetuate nutrient cycling and maintain a viable seed bank where practicable
- stockpiles will be located where they will not be disturbed by future mining
- stockpiles will, as far as practicable, be located for minimal exposure to wind erosion and runoff.

Some soil stockpiles may require relocation during the life of the SGCP.

4.14.2. Decommissioning

A Mine Closure Plan will be developed in advance of closure and decommissioning. This plan will document how disturbed areas will be rehabilitated to meet closure and relinquishment requirements. It will be developed in consultation with appropriate stakeholders and regulatory agencies. The objectives of the post-mine land use are to ensure that:

- post-mine areas are self-sustaining and require no ongoing maintenance, while protecting the physical and biological integrity of the surrounding environment after mining activities have ceased
- existing and potential beneficial uses of the area are preserved where practicable after mining activities have ceased.

4.14.2.1.1. Waste Rock Emplacements

The waste rock emplacement facilities will be progressively rehabilitated and decommissioned once the final rehabilitation success criteria have been achieved.

4.14.2.1.2. Final Voids

The final void remaining at the end of the SGCP life will cover approximately 329 ha with a depth of approximately 140 m (refer to **Section 5—Rehabilitation and Decommissioning**).

4.14.2.1.3. Infrastructure

Contractors will be required to decommission temporary construction equipment and plant in accordance with a Construction Environmental Management Plan.

SGCP infrastructure will be located on land owned by the miner. Final landform designs for the infrastructure areas will be based on decommissioning, dismantling and/or disposing of the plant and equipment and re-profiling the base to match the original pre-mining landform where practicable. Contour ripping, topsoiling and revegetation will be undertaken to encourage a vegetative cover. Detailed rehabilitation plans will be developed and refined over the life of the SGCP.

Unless determined to be suitable and requested by the landowner, water storages will be removed in a similar manner and rehabilitated to a waterbody or grazing post-mine land use.

4.14.2.1.4. Subsidence Areas

The post-mine land use of the subsidence areas will be native bushland.

CONTENTS

FIGURES

PLATES

TABLES

7. LAND

7.1. LEGISLATION/GUIDELINES

This Section considers the Queensland Government's *State Planning Policy 1/92: Development and the Conservation of Agricultural Land* (SPP 1/92), which is implemented under the *Sustainable Planning Act 2009* in order to protect good quality agricultural land (GQAL).

Due to the absence of Queensland or Australian guidelines for the assessment of landscape and visual impact for mining or similar developments, the *United Kingdom's Landscape Institute - Institute of Environmental Management and Assessment Guidelines* were used for this assessment. It is recognised that not all elements of these guidelines are relevant to Australia and/or the mining industry, however, the standard approach and identified landscape and visual amenity were both relevant and applicable. By using the assessment and classification tables from these guidelines, conclusions have been drawn as to the visual impacts from the South Galilee Coal Project (SGCP). The SGCP is located within the Barcaldine Regional Council Local Government Area (LGA), an amalgamation of the previous Aramac, Barcaldine and Jericho Shires. The Jericho Shire Planning Scheme (Campbell Higginson Town Planning, 2006) was consulted for any relevant visual amenity requirements. The Jericho Shire Planning Scheme stipulates that ridgelines and escarpments must be maintained in a natural state to protect rural character and landscape values. A separation distance of at least 50 metres (m) is required for all Rural Zone "buildings" and "structures" from ridgelines or escarpments.

The Jericho Shire Planning Scheme also requires that the design of lighting does not prejudice the amenity of the Rural Zone through poorly directed lighting, lighting overspill or lighting glare. To achieve this, direct lighting or lighting should not exceed 8.0 lux at 1.5 m beyond the boundary of the site.

7.2. EXISTING ENVIRONMENT

7.2.1. Land Use and Tenure

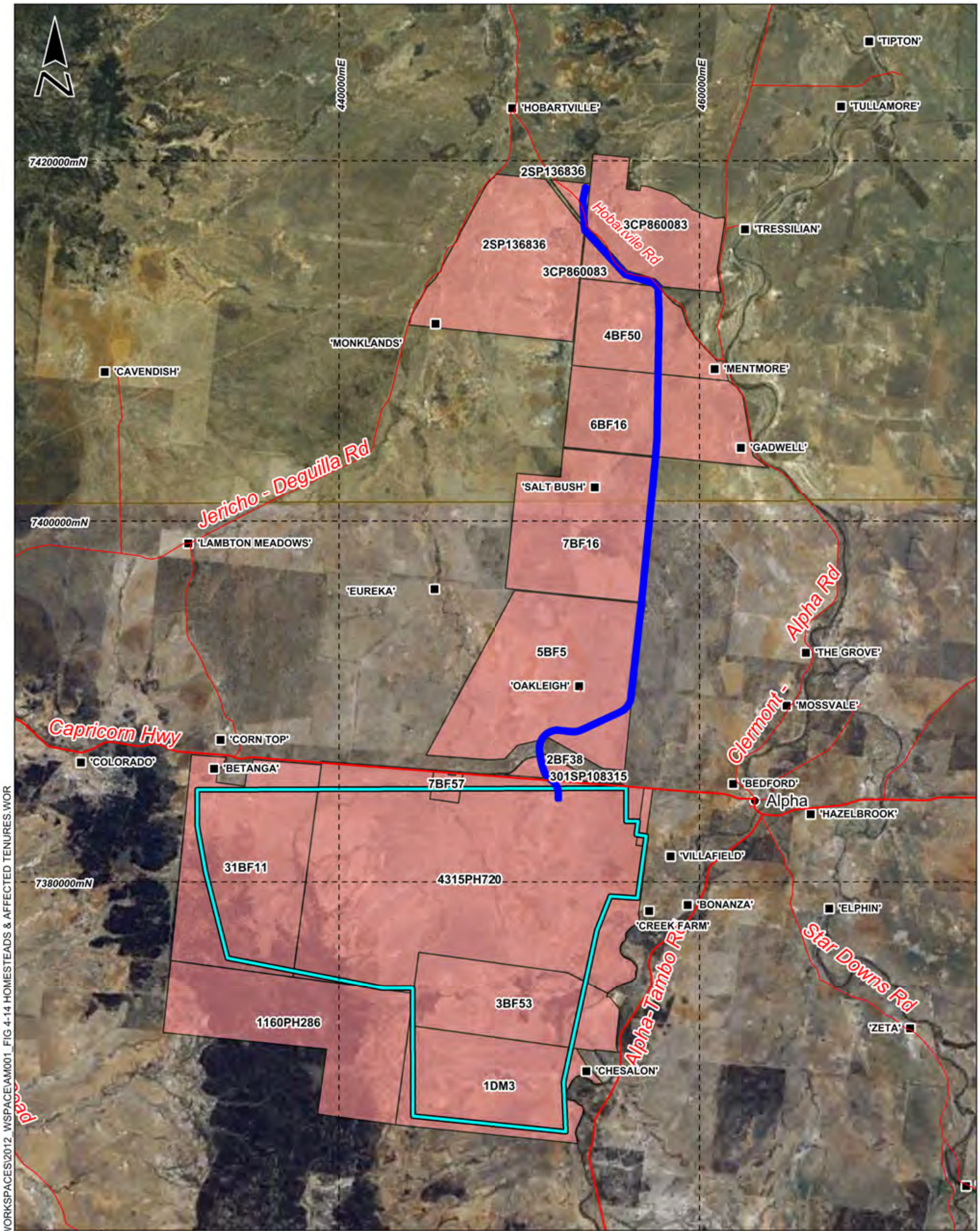
7.2.1.1. Tenure

The SGCP is situated within Mining Lease Application (MLA) 70453, approximately 12 kilometres (km) south-west of the township of Alpha in Central Queensland (refer to **Figure 7-1**). Background land tenures and tenure holders are indicated in **Table 7-1** and shown on **Figure 7-1**. The predominant tenure type is leasehold.

Surrounding mine tenements are shown on **Figure 7-2.**

7.2.1.2. Native Title

As described in **Section 15—Indigenous Cultural Heritage**, the SGCP is located within the Native Title claim of the Wangan and Jagalingou People (Tribunal Number QUD85/04) (refer to **Figure 15-1**). The claim covers an area of approximately 43,722 square kilometres (km^2) in Central Queensland (Commonwealth of Australia, 2011).



LEGEND

- MLA70453
- Directly affected property
- SGCP infrastructure corridor
- Roads
- Population centre
- Homestead

Data Source:
Cadastral (Barcaldine May2010)-DERM. Topo (250k raster)-Geoscience Australia.

METSERVE Mining & Energy Technical Services Pty Ltd

SouthGalilee

Alpha Coal Pty Ltd

South Galilee Coal Project

Directly Affected Land Tenure

5 0 5

Kilometres

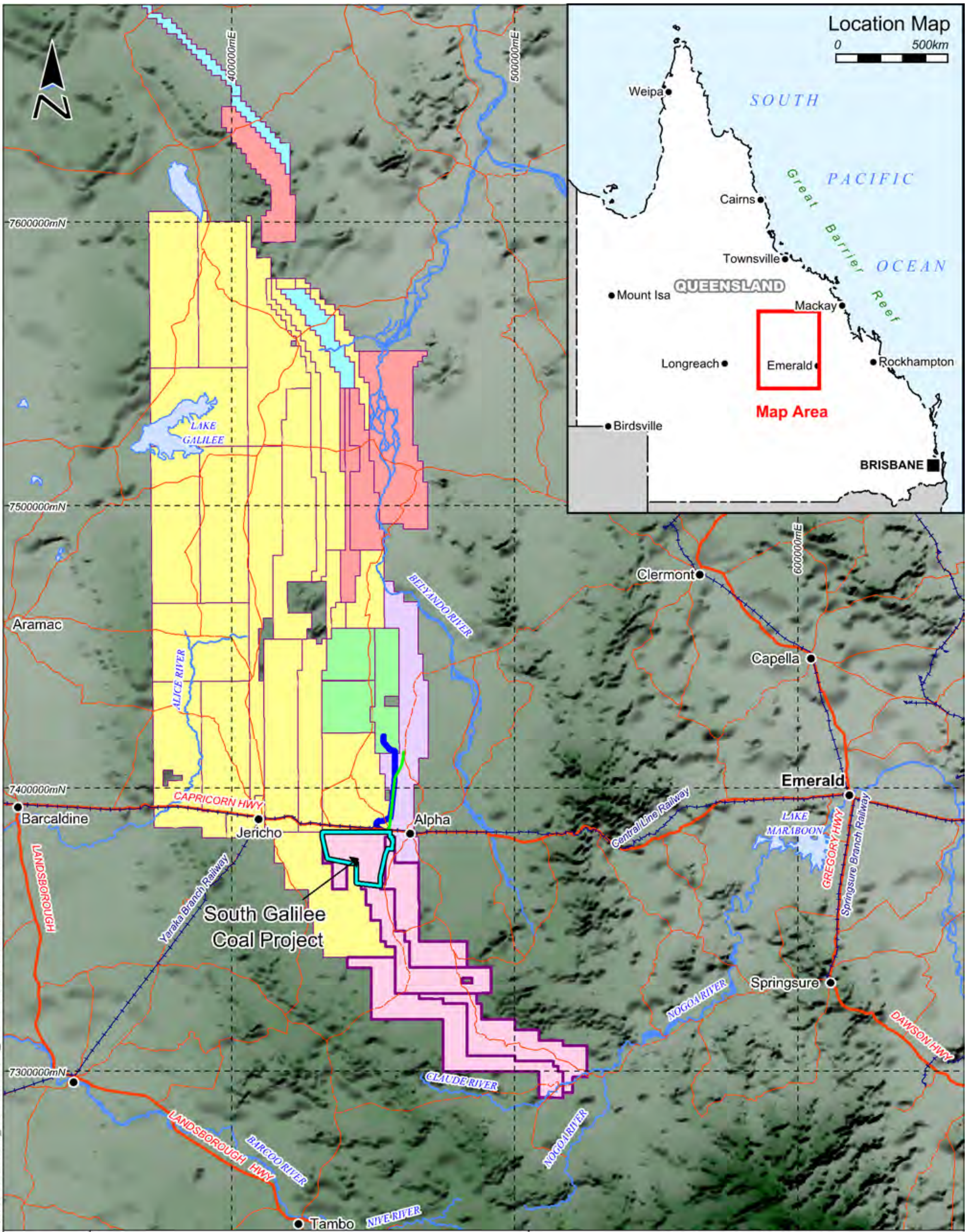
Scale: 1:300,000 (A4)

08/17/2012

Proj. : MGA Z55
Datum: GDA 1994

FIGURE 7-1

S:\PROJECTS\AM001 STH GALILEE EIS_MAPINFO\WORKSPACES\2012_WSPACE\AM001_FIG 4-14 HOMESTEADS & AFFECTED TENURES.WOR



LEGEND

- MLA70453
- SGCP infrastructure corridor
- SGCP power line
- Principal road
- Road (sealed)
- Road (unsealed)
- Railway
- River
- Population centre

Principal Tenement Holder

- Alpha Coal Pty Ltd
- Adani Mining Pty Ltd
- Hancock Coal Pty Ltd
- Qld Thermal Coal Pty Ltd
- Waratah Coal Pty Ltd
- Vale Exploration Pty Ltd

Data Source : Cambell Higginson Town Planning (2006)

METSERVE Mining & Energy Technical Services Pty Ltd

SouthGalilee

Alpha Coal Pty Ltd

South Galilee Coal Project

Surrounding Tenements

25 0 25
Kilometres

Scale: 1:2,000,000 (A4)

05/09/2012

Proj. : MGA Z55
Datum: GDA 1994

FIGURE 7-2

S:\PROJECTS\AM001 STH GALILEE EIS_MAPINFO\WORKSPACES\2012_WSPACE\AM001_FIG 1-4 SURROUNDING TENEMENTS.WOR

Table 7-1 Real Property Description for Land Located Within or Partly Within MLA 70453 and Infrastructure Corridor

Tenure/Tenement[1]	Real Property Description	Property Name	Landholder
MLA 70453			
EPC 1049, EPC 1180, EPC 1040 and EPP 668	Lot 4315 PH720[2]	Creek Farm	A
EPC 1049, EPC 1180 and EPP 668	Lot 1 DM3	Chesalon	B
EPC 1049, EPC 1040 and EPP 668	Lot 7 BF57	Tallarenha	C
EPC 1049, EPC 1040, EPC 1155 and EPP 668	Lot 31 BF11	Betanga	D
EPC 1049, EPC 1155 and EPP 668	Lot 1160 PH286	Armagh	E
EPC 1049, EPC 1180, EPC 1155 and EPP 668	Lot 3 BF53	Sapling Creek	F
Infrastructure Corridor			
EPC 1040, EPC 1263 and EPP 668	Lot 5 BF5	Oakleigh	G
EPC 1210, EPC 1263 and EPP 668	Lot 3 CP860083	Tresillian	H
EPC 1210, EPC 1040 and EPP 668	Lot 2 SP136836	Monklands	I
EPC 1210, EPC 1263 and EPP 668	Lot 4 BF50	Mentmore	J
EPC 1263 and EPP 668	Lot 6 BF16	Gadwell	J
EPC 1263 and EPP 668	Lot 7 BF16	Saltbush	K
EPC 1040 and EPP 668	Lot 301 SP108315	N/A	L
EPC 1049, EPC 1180, EPC 1040 and EPP 668	Lot 4315 PH720[2]	Creek Farm	A
EPC 1040 and EPP 668	Lot 2 BF38	Leased Reserve	A

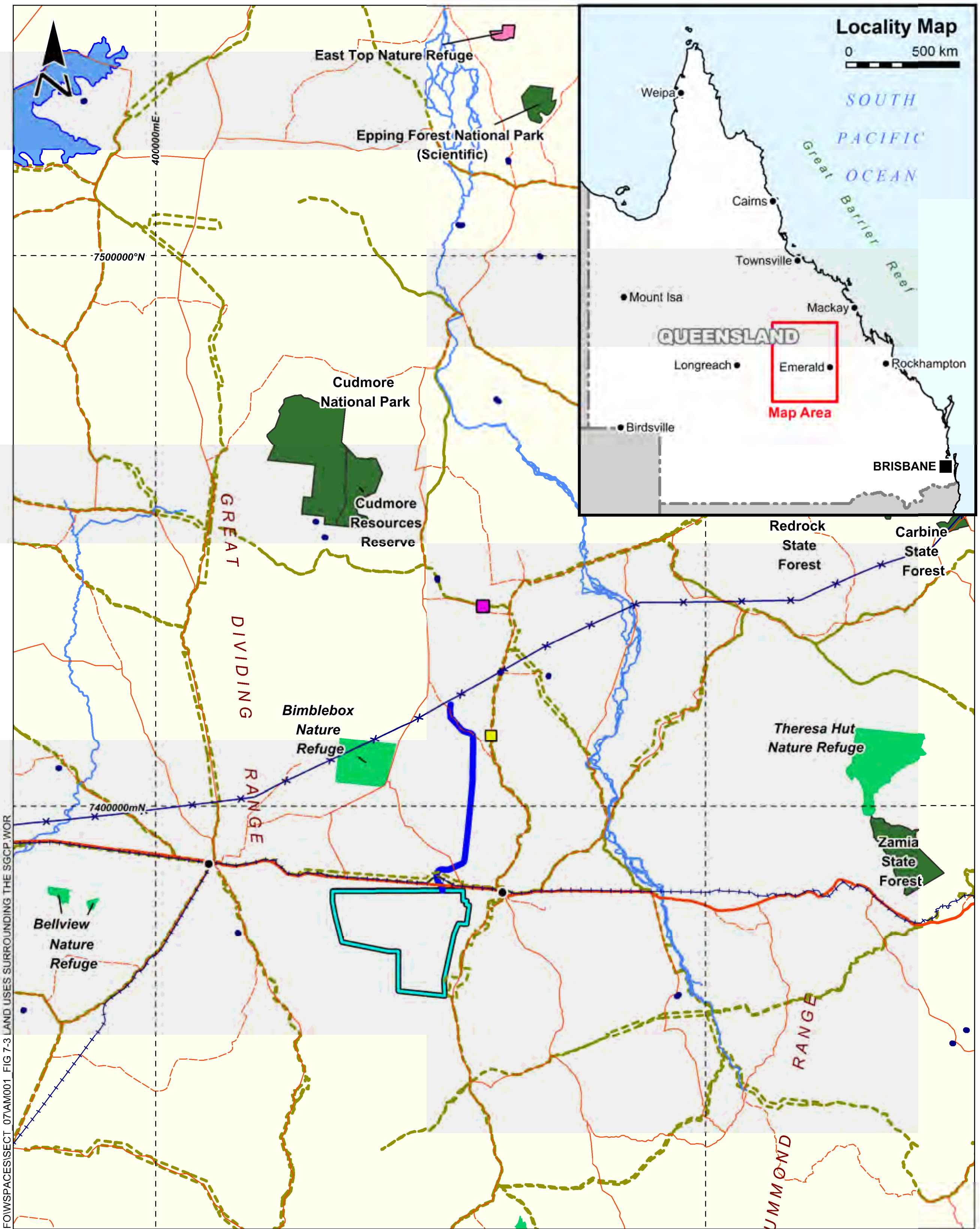
1 EPC 1040 is held by Waratah Coal Pty Ltd
EPC 1155 is held by Waratah Coal Pty Ltd
EPC 1210 is held by the GVK Group
EPC 1263 is held by Queensland Thermal Coal Pty Ltd
EPP 668 is held by Australia Pacific LNG Pty Limited

2 4315PH720 is affected by MLA 70453 as well as the infrastructure corridor

7.2.1.3. Land Use

Land within the SGCP area is primarily used for low intensity beef cattle grazing. The majority of the area has been cleared for improved pasture. There is no evidence of any cropping in the area.

As shown on **Figure 7-3**, there are no protected areas (e.g. National Park, State Forest, Reserve, Conservation Park, Nature Refuge etc.) within the SGCP area.



LEGEND

- MLA70453
- SGCP infrastructure corridor
- Principal road
- Road (sealed)
- Road (unsealed)
- Railway
- Powerline
- River
- Dam
- Stockroute
- Population centre
- Proposed Waratah/SGCP substation
- Proposed Powerlink/SGCP substation
- Nature Refuge
- Protected Area (National Park, State Forest, Reserve, Conservation Park etc)

Data Source: Tenement - DEEDI. Topography (250k) - Geoscience Australia. Protected Areas, Nature Refuges, Stockroutes - QGIS

METSERVE Mining & Energy Technical Services Pty Ltd

SouthGalilee

Alpha Coal Pty Ltd

South Galilee Coal Project

Landuses Surrounding the SGCP

20 0 20

Kilometres

Scale: 1:1,000,000 (A4)

24/08/2012

Proj. : MGA Z55
Datum: GDA 1994

FIGURE 7-3

S:\PROJECTS\AM001_STHGALILEE_EIS\GIS_MAPINFOWSPACES\SECT_07\AM001_FIG 7-3 LAND USES SURROUNDING THE SGCP.WOR

The SGCP is located adjacent to the Capricorn Highway and the Central Line Railway, which run parallel in an east-west direction to the north of MLA 70453. A number of unsealed access roads are located within MLA 70453. A detailed description of the local road network is provided in **Section 14—Transport** and **Appendix K—Transport Technical Report**.

No water, gas or high voltage electricity services have been identified within MLA 70453. An existing high voltage powerline runs in a south-west to north-easterly direction north of the SGCP (refer to **Figure 7-3**). The proposed regional infrastructure is shown on **Figure 4-20**.

The Alpha Aerodrome, owned and operated by the Barcaldine Regional Council is located east of MLA 70453.

The SGCP infrastructure corridor intersects a stock route which runs parallel and to the north of the Central Line Railway. A stock route is also present to the east of MLA 70453 (refer to **Figure 7-3**).

The SGCP is not located within any declared water storage catchment area administered by the Department of Environment and Heritage Protection (DEHP), (DERM, 2010).

Land clearing, grazing and track construction have affected the vegetation communities at the SGCP site. The levels of disturbance vary across the area. No Category A, B or C Environmentally Sensitive Areas (ESAs), as designated in DEHP-certified mapping, are located within the SGCP area, with the exception of regional ecosystems with an Endangered biodiversity status. **Figure 7-4** shows the location of ESAs within and nearby the SGCP. Endangered regional ecosystems are discussed in further detail in **Section 8—Nature Conservation** and **Section 20—Matters of National Environmental Significance**.

7.2.1.3.1. Land Use Suitability

The *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland – Land Suitability Techniques* (DME, 1995) provide criteria for the assessment of land use suitability. Land use suitability is described according to a five rank class system, including:

- Class 1 – suitable land with negligible limitations
- Class 2 – suitable land with minor limitations – land which is suited to a proposed use but which may require minor changes to management to sustain use
- Class 3 – suitable land with moderate limitations – land which is moderately suited to a proposed use but which requires significant inputs to ensure sustainable use
- Class 4 – land which is marginally suited for a proposed use and would require major inputs to ensure sustainability; these inputs may not be justified by the benefits to be obtained in using the land for the particular purpose and is hence considered presently unsuited
- Class 5 – unsuitable land with extreme limitations – land which is unsuited and cannot be sustainably used for a proposed use.

The SGCP area comprises of land suitability Class 4, which correlates to Class C GQAL (**Section 7.2.1.3.2**).

7.2.1.3.2. Agricultural Land Class

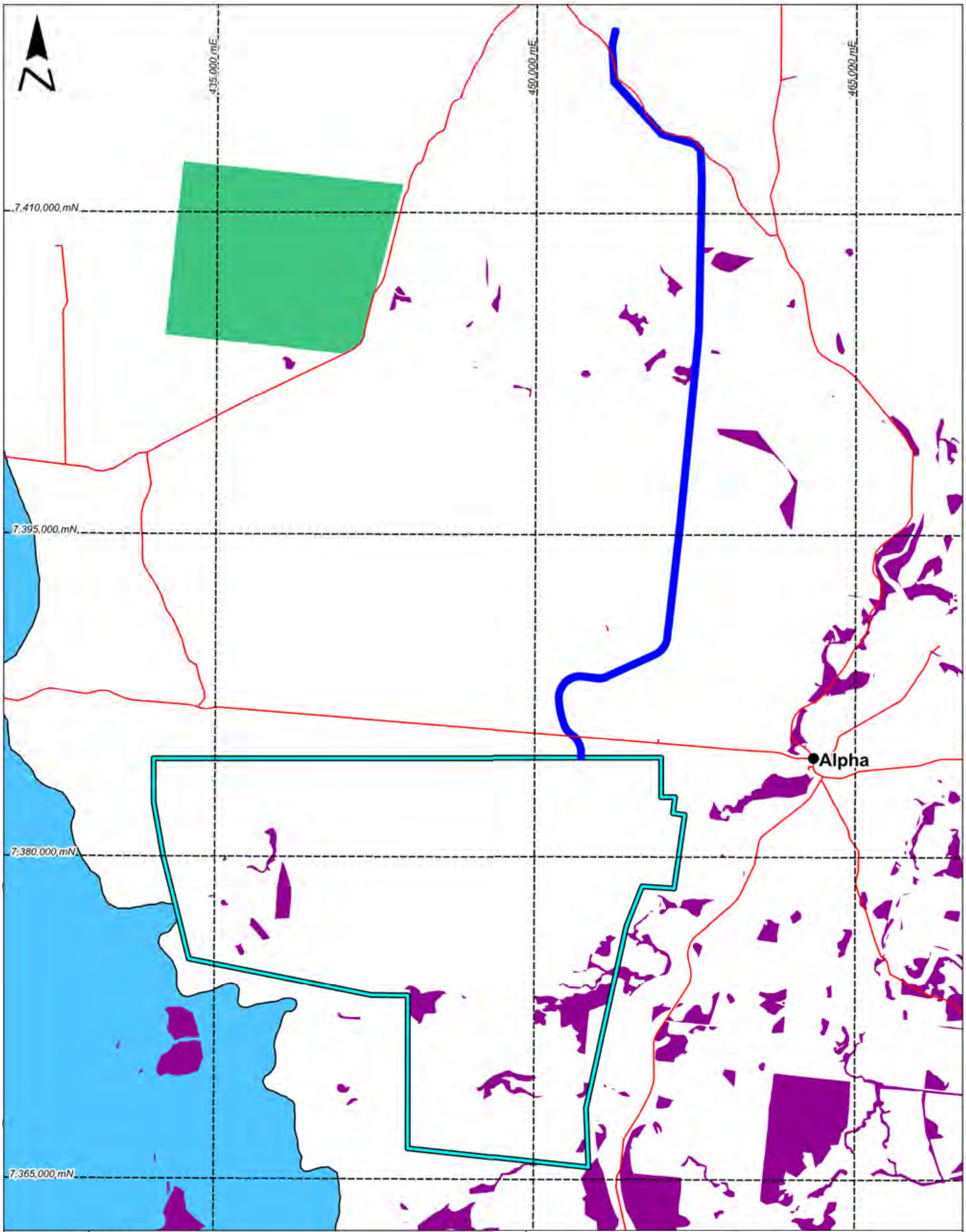
SPP 1/92 defines four classes of agricultural land for Queensland. Class A land in all areas is considered to be GQAL. In some areas, Class B land (where agricultural land is scarce) and better quality Class C land (where pastoral industries predominate) may also be considered GQAL. The description of the classes is as follows:

- Class A: Crop Land – land that is suitable for current and potential crops with limitations to production which range from none to moderate levels
- Class B: Limited Crop Land – land that is marginal for current and potential crops due to severe limitations and suitable for pastures. Engineering and/or agronomic improvements may be required before the land is considered suitable for cropping
- Class C: Pasture Land – land that is suitable only for improved or native pastures due to limitations which preclude continuous cultivation for crop production, but some areas may tolerate a short period of ground disturbance for pasture establishment
- Class D: Non-agricultural Land – land not suitable for agricultural uses due to extreme limitations. This may be undisturbed land with significant habitat, conservation and/or catchment values or land that may be unsuitable because of very steep slopes, shallow soils, rock outcrop or poor drainage.

The land suitability assessment undertaken by Land Resources Assessment and Management Pty Ltd (LRAM) in July 2011 (refer to **Appendix J—Soils and Land Suitability Technical Report**) found that the SGCP area is comprised of approximately 97.5 % Class C2 pasture land and 2.5 % Class C1 land. These two subclasses of pasture land are described below:

- Class C1 – higher productivity pasture land based on high quality native pastures or on pastures that can be readily improved (represents GQAL)
- Class C2 – lower productivity pasture land based on low quality native pastures on which pasture improvement is not economically viable (does not constitute GQAL).

Approximately 780 hectares (ha) of GQAL are located within the SGCP area. The distribution of GQAL within the SGCP area is shown on **Figure 7-5**.



METSERVE Mining & Energy Technical Services Pty Ltd

SouthGalilee

LEGEND

- MLA70453
- SGCP infrastructure corridor
- Principal road
- Nature Refuge
- Endangered Regional Ecosystems (Biodiversity Status)
- Wild River Preservation Areas
- Population centre

Data Source : DERM (2012)

Alpha Coal Pty Ltd

South Galilee Coal Project

Environmentally Sensitive Areas

5 0 5

Kilometres

Scale: 1:250,000 (A4)

23/08/2012

Proj. : MGA Z55
Datum: GDA 1994

FIGURE 7-4

In the former Jericho Shire, DEHP mapping identified the presence of GQAL in the SGCP area. According to this DEHP mapping, approximately 929 ha of GQAL are located within the SGCP. However, this classification is not consistent with the land suitability findings of the soil survey and could be the result of the mapping scale used by the DEHP. The more detailed scale of the mapping developed by the soil survey indicates that the classification described by LRAM is more accurate.

The Queensland Government's Strategic Cropping Land (SCL) framework identifies five nominated cropping zones (DERM, 2011). As the SGCP is located outside of all five zones, the SCL framework does not apply and the SGCP does not need to be assessed under the SCL policy.

7.2.2. Topography

The natural topography is dominated by very gently undulating plains and rises of low relief, as shown on **Figure 4-2** to **Figure 4-13**. The plains in the east and north-east generally decline from more elevated low hills located along the western portion of MLA 70453. The topography of the region ranges from 350 to 600 m Australian Height Datum (AHD) on the eastern flanks of Great Dividing Range.

The major topographical features in the broader landscape are the Drummond Range located approximately 60 km to the east of the SGCP and the Great Dividing Range, located approximately 10 km to the west of the SGCP.

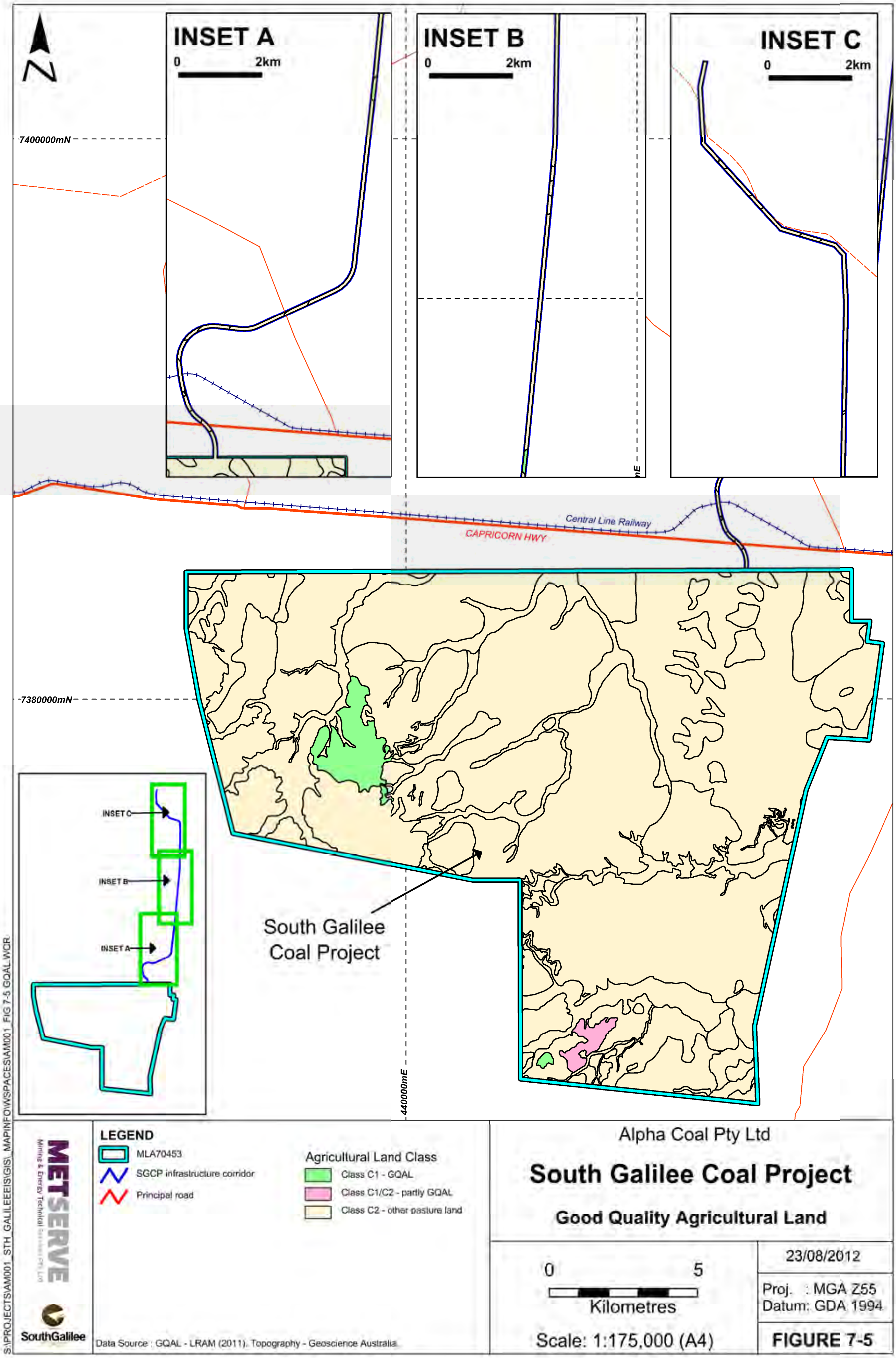
7.2.3. Geology

The Late Carboniferous-Middle Triassic Galilee Basin is a large scale intracratonic basin with predominantly fluvial sediment infill. The Galilee Basin has an area of approximately 247,000 km^2. It can be divided into northern and southern regions with a boundary in the vicinity of the Barcaldine Ridge extension of the Maneroo Platform.

The northern Galilee Basin is divided into two depositional environments. The Koburra Trough is located on the eastern side of the northern region of the Galilee Basin, and overlies the Drummond Basin. The Koburra Basin is also the Galilee Basin's thickest recorded sequence, with up to 2,818 m of strata recorded. On the western side of the northern Galilee Basin is the Lovelle Depression.

The southern Galilee Basin is divided by the Pleasant Creek Arch into two depositional centres; the Powell Depression to the west and the Springsure Shelf to the east.

The regional geology surrounding the SGCP is presented in **Figure 7-6**. **Figure 7-7** provides a stratigraphic section for the northern and southern regions of the Galilee Basin. A summary of the regional stratigraphic sequence (from oldest to youngest) in the southern Galilee Basin is provided in **Section 7.2.3.1** to **Section 7.2.3.5**.



INSET A
0 2km
INSET B
0 2km
INSET C
0 2km
7400000mN
7380000mN
440000mE
Central Line Railway
CAPRICORN HWY
South Galilee Coal Project
INSET C
INSET B
INSET A
LEGEND
MLA70453
SGCP infrastructure corridor
Principal road
Agricultural Land Class
Class C1 - GQAL
Class C1/C2 - partly GQAL
Class C2 - other pasture land
METSERVE
Mining & Energy Technical Services Pty Ltd
SouthGalilee
Data Source : GQAL - LRAM (2011). Topography - Geoscience Australia.
Alpha Coal Pty Ltd
South Galilee Coal Project
Good Quality Agricultural Land
0 5
Kilometres
Scale: 1:175,000 (A4)
23/08/2012
Proj. : MGA Z55
Datum: GDA 1994
FIGURE 7-5
S:\PROJECTS\AM001_STH_GALILEE\EIS\GIS_MAPINFO\WSPACES\AM001_FIG 7-5 GQAL.WOR

7.2.3.1. Carboniferous

7.2.3.1.1. Lake Galilee Sandstone

Deposition of the Galilee Basin began with the Late Carboniferous Lake Galilee Sandstone which lies unconformably on the Ducabrook formation of the Drummond Basin in the northern region of the Galilee Basin. In the southern region of the Basin, the Lake Galilee Sandstone is believed to overlie various Devonian basement units.

7.2.3.1.2. Jericho Formation

The Jericho Formation is fluvio-deltaic, with some glacial influence, and conformably overlies the Lake Galilee Sandstone. It consists of mudstone, siltstone and sandstone units including the Oakleigh Siltstone Member.

7.2.3.1.3. Jochmus Formation

The Jochmus Formation in turn conformably overlies the Jericho Formation and is similarly fluvio-deltaic, with minor glacial influence. The Jochmus Formation consists of sandstone, mudstone, siltstone, tuff and conglomerate units.

7.2.3.2. Permian

7.2.3.2.1. Aramac Coal Measures

The Jochmus Formation is conformably overlain by the Early Permian Aramac Coal Measures which consist of fluvial sandstone and siltstone units with major coal beds.

7.2.3.2.2. Colinlea Sandstone

The Early to Middle Permian Colinlea Sandstone unconformably overlies the Jochmus formation in the eastern and southern central Galilee Basin. Deposition of the unit occurred in an alluvial environment dominated by peat swamps and easterly and southerly flowing rivers. Sediments were derived from volcanic and metamorphic provinces to the north of the Basin’s margins. Strata range from light-medium grey carbonaceous, highly argillaceous siltstone to shale interbedded with minor white to light grey, very fine to fine grained, angular to sub-rounded micaceous quartzose sandstone and coal.

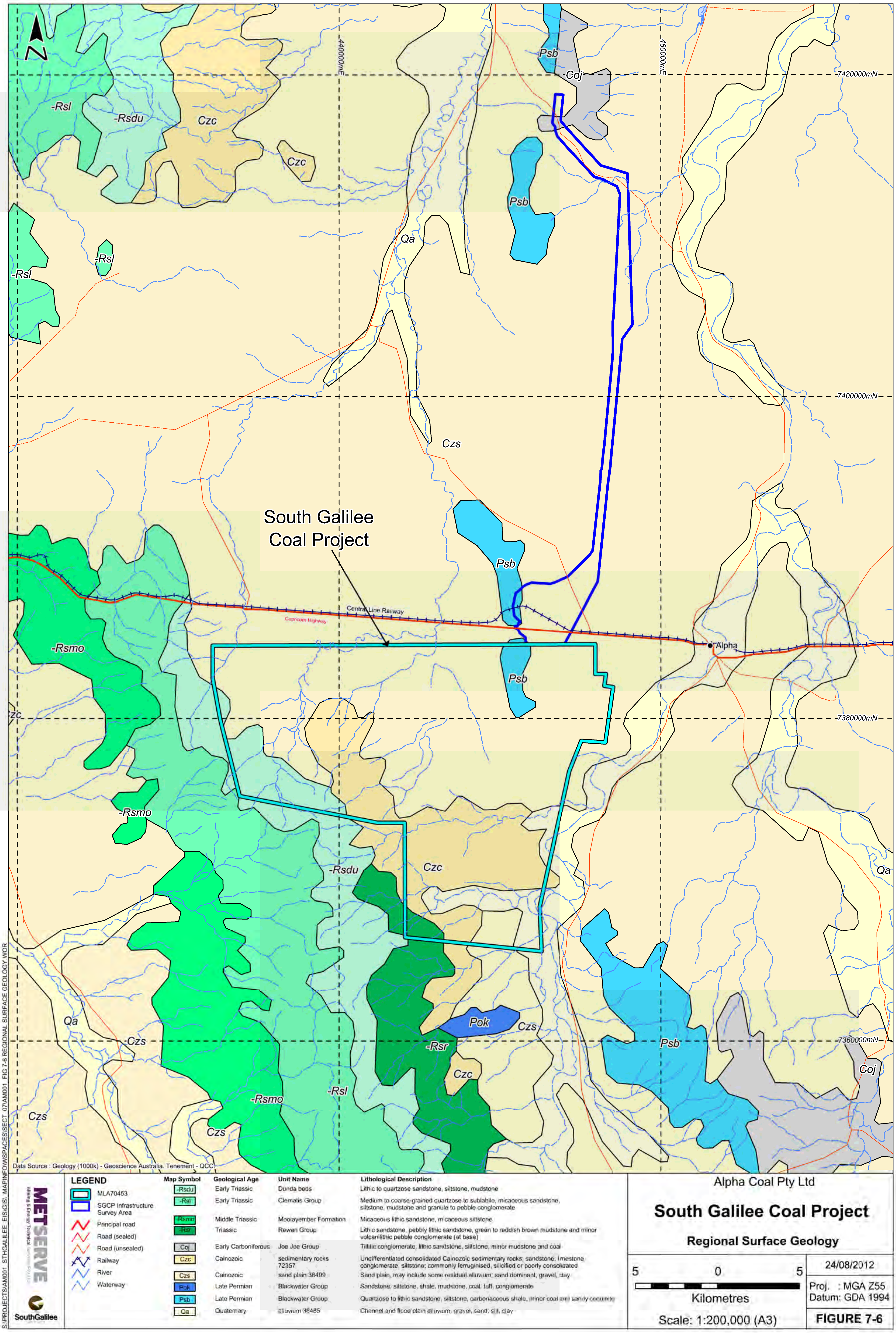
7.2.3.2.3. Peawaddy Formation

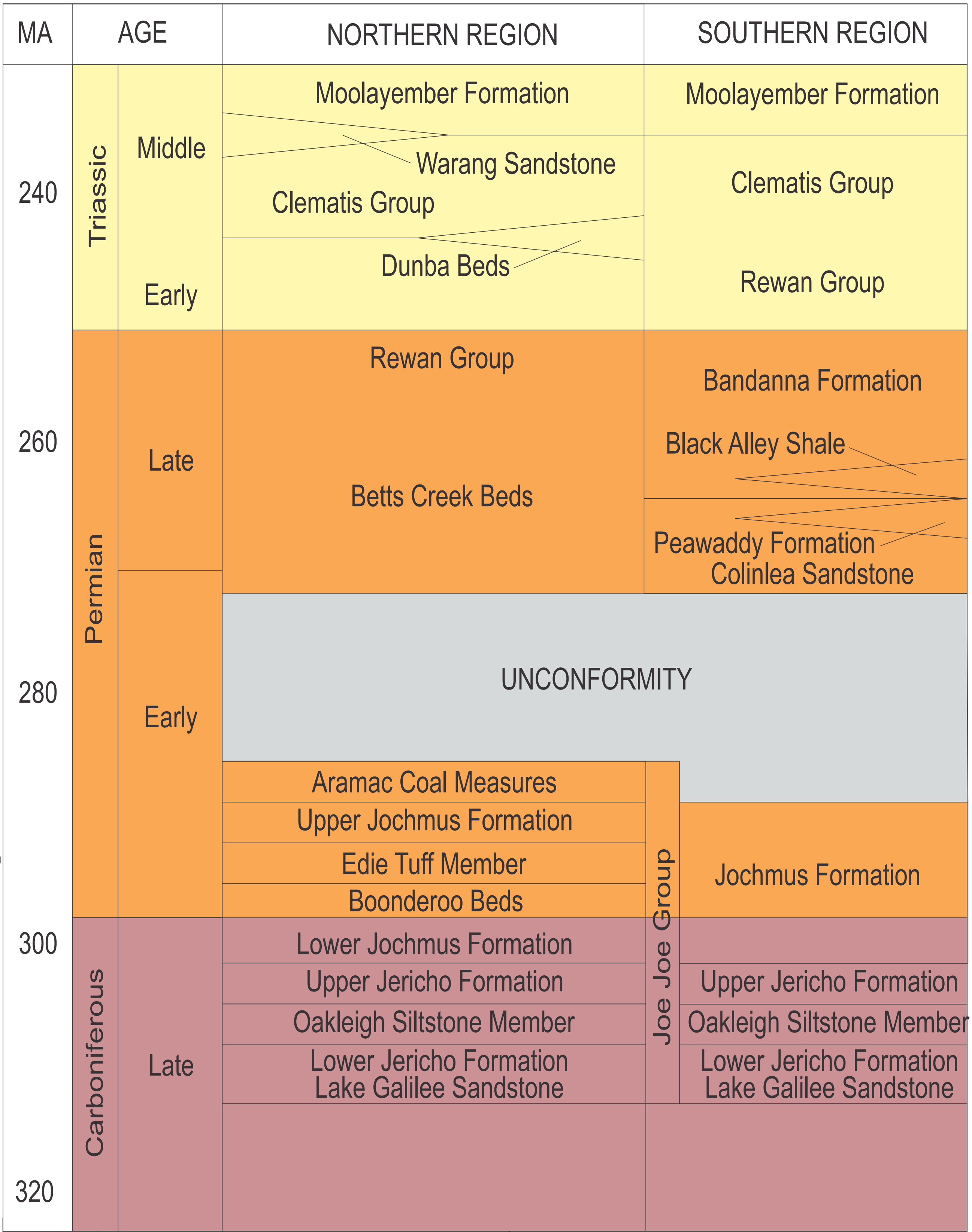
The marine paralic Peawaddy Formation was deposited in a low-energy environment, associated with reduction in stream gradients caused by marine incursion into southern and central regions of the Galilee Basin due to a rise in sea level.

7.2.3.2.4. Black Alley Shale

As for the Peawaddy Formation, the Black Alley Shale was deposited in a reduced energy environment associated with marine incursion in the southern and central regions of the Galilee Basin. The unit is comprised of dark grey to black shale and siltstone with interbedded light green-grey tuff and fine to very fine, labile sandstone.

This page intentionally left blank


South Galilee Coal Project
Central Line Railway
Capricorn Highway
Alpha
-Rsl
-Rsdu
Czc
Qa
Czs
Psb
Coj
-Rsmo
-Rsr
Pok
440000mE
460000mE
-7420000mN
-7400000mN
-7380000mN
-7360000mN
N
Data Source : Geology (1000k) - Geoscience Australia. Tenement - QCC
S:\PROJECTS\AM001_STHGALILEE_EIS\GIS_MAPINFOWSPACES\SECT_07\AM001_FIG 7-6 REGIONAL SURFACE GEOLOGY.WOR
LEGEND
MLA70453
SGCP Infrastructure Survey Area
Principal road
Road (sealed)
Road (unsealed)
Railway
River
Waterway
Map Symbol | Geological Age | Unit Name | Lithological Description
-Rsdu | Early Triassic | Dunda beds | Lithic to quartzose sandstone, siltstone, mudstone
-Rsl | Early Triassic | Clematis Group | Medium to coarse-grained quartzose to sublabile, micaceous sandstone, siltstone, mudstone and granule to pebble conglomerate
-Rsmo | Middle Triassic | Moolayember Formation | Micaceous lithic sandstone, micaceous siltstone
-Rsr | Triassic | Rewan Group | Lithic sandstone, pebbly lithic sandstone, green to reddish brown mudstone and minor volcanilithic pebble conglomerate (at base)
Coj | Early Carboniferous | Joe Joe Group | Tillitic conglomerate, lithic sandstone, siltstone, minor mudstone and coal
Czc | Cainozoic | sedimentary rocks 72357 | Undifferentiated consolidated Cainozoic sedimentary rocks; sandstone, limestone conglomerate, siltstone; commonly ferruginised, silicified or poorly consolidated
Czs | Cainozoic | sand plain 38499 | Sand plain, may include some residual alluvium; sand dominant, gravel, clay
Pok | Late Permian | Blackwater Group | Sandstone, siltstone, shale, mudstone, coal, tuff, conglomerate
Psb | Late Permian | Blackwater Group | Quartzose to lithic sandstone, siltstone, carbonaceous shale, minor coal and sandy coquinite
Qa | Quaternary | alluvium 38485 | Channel and flood plain alluvium, gravel, sand, silt, clay
METSERVE
Mining & Energy Technical Services Pty Ltd
SouthGalilee
Alpha Coal Pty Ltd
South Galilee Coal Project
Regional Surface Geology
5 0 5
Kilometres
Scale: 1:200,000 (A3)
24/08/2012
Proj. : MGA Z55
Datum: GDA 1994
FIGURE 7-6



S:\PROJECTS\AM001 STH GALILEE EIS_MAPINFO\WORKSPACES\SECTION 4 - PROJECT DESCRIPTION\AM001_M373E SECTION 4 DIAGRAM FIGURES.CDR

METSERVE Mining & Energy Technical Services Pty Ltd

SouthGalilee

Data Source: AMCI and Bandanna Energy (2011)

Alpha Coal Pty Ltd

South Galilee Coal Project

Stratigraphic Section of the Galilee Basin Geology

05/07/2012

FIGURE 7-7

7.2.3.2.5. Bandanna Formation

The Late Permian Bandanna Formation ranges from a lacustrine/paludal to a fluvial deposit in the southern region of the Galilee Basin, conformably overlying the Colinlea Sandstone and inter-fingering with the Black Alley Shale. The unit is the target formation of the SGCP and is composed of:

- grey slightly micaceous and silty, carbonaceous sub-fissile shale
- grey argillaceous and carbonaceous siltstone
- grey fine to medium grained fused, micaceous quartz, feldspathic sandstone
- coal.

The Bandanna Formation contains multiple coal seams which are generally known as Seam A to Seam F.

7.2.3.2.6. Rewan Formation

The Late Permian to Early Triassic Rewan Group unconformably overlies the Bandanna Formation. The formation is composed of terrestrial alluvial sediments including meandering channel deposits and flood-basin siltstone and sandstone units.

7.2.3.3. Triassic

7.2.3.3.1. Dunda Beds

The Dunda beds consist of quartz labile sandstone and interbedded lutite and are a transitional unit between the Early Triassic members of the Upper Rewan Formation and the Clematis Sandstone. They have been described as light grey, olive grey and yellow grey in colour and fine to coarse grained.

7.2.3.3.2. Clematis Sandstone

Late to Middle Triassic in age, the Clematis Sandstone is a poorly sorted, fine to coarse grained, angular to sub-angular quartzose sandstone with minor red siltstone and mudstone and rare conglomerate and thin interbeds of variegated shale.

7.2.3.3.3. Moolayember Formation

The Moolayember Formation is a Late to Middle Triassic fluvio-lacustrine deposit consisting of light grey-green, yellow and brown, argillaceous siltstone, sandstone and mudstone units with slight interbedded mica. It is the uppermost unit of the Galilee Basin.

7.2.3.4. Tertiary

Tertiary deposits overlie the Galilee Basin and comprise consolidated siltstone and sandstone typically 5 to 15 m thick and are thickest in the northern and central region of the SGCP.

7.2.3.5. Quaternary

Quaternary deposits in the SGCP are mostly alluvial and consist of gravel, sand and poorly consolidated clayey sandstone. Thickness of the Quaternary sediments varies over the Project area, but generally thickens to the east.

7.2.3.6. Mineral Resource Geology

The SGCP exploration program undertaken over the last four years has focussed on the northern portion of EPC 1049. The initial objective of the program was to delineate a sufficient resource to support a large-scale long-life operation. Subsequently, exploration has involved in-fill drilling to convert previously 'inferred' resource into the 'measured' and 'indicated' JORC categories. Over 36,000 m of drilling has been undertaken to date over a 100 km^2 area, including 163 chip holes and 129 cored holes.

Coal resources within the SGCP are contained in the Permian Bandanna Formation. The Bandanna Formation contains multiple coal seams, which are generally known as Seam A through to Seam F.

The primary target seams for the SGCP, the D1 and D2 seams, are interpreted to consist of three plies varying in thickness from 0.5 to 4.5 m (AMCI and Bandanna Energy, 2011).

Current estimates of the resource indicate that approximately 498 million tonnes (Mt) run-of-mine (ROM) thermal coal will be extracted from the SGCP open-cut and underground mining areas. Of this, approximately 177 Mt ROM coal will be mined in the open-cut operation and approximately 321 Mt ROM coal will be mined in the underground operation.

Figure 4-2 to **Figure 4-13** indicates the conceptual layout of the SGCP over the life of the Project. The boundaries of MLA 70453 are shown on **Figure 7-1**.

7.2.3.6.1. Coal Quality

Analytical results obtained from the exploration program show that the SGCP coal is high volatile sub-bituminous coal. Indicative coal quality is shown in **Table 7-2.**

Table 7-2 Coal Quality Characteristics

Typical Coal Properties	SGCP Coal
Inherent Moisture (mass % ad)	6.5
Ash (PA) (mass % ad)	13.0
Volatile Matter (% ad)	34.0
Total Sulfur (% ad)	0.9
Fixed Carbon (% ad)	46.5
Gross Calorific Value (kcal/kg ad)	6,250

ad = air dried

Source: AMCI and Bandanna Energy (2011)

7.2.3.6.2. Coal Quantity

Current estimates of the resource indicate that approximately 480 Mt of ROM thermal coal will be extracted from the SGCP open-cut and underground mining areas.

A summary of the Australasian Joint Ore Resource Committee (JORC) Code compliant resources contained in the D1 and D2 seams is provided in **Table 7-3**.

Table 7-3 SGCP Resource Base

Seam	Resources (Mt)			
	Measured	Indicated	Inferred	Total
D1	50.4	105.8	555.0	711.2
D2	116.3	100.5	251.0	467.8
Total	166.7	206.3	806.0	1,179.0

Source: AMCI and Bandanna Energy (2011)

7.2.3.7. Geochemistry Assessment

This Section provides the findings of the geochemical investigation carried out on waste rock material from the SGCP.

The specific objectives of this study are to:

- determine the acid forming potential of the waste rock and coal rejects, as well as evaluate the acid rock drainage (ARD), salinity and sodicity risks associated with the material from the SGCP area
- determine the chemical composition of the waste rock and coal rejects in order to identify any toxicity concerns for revegetation
- identify the potential geochemical implications for waste rock and coal reject disposal and mine operations, and provide preliminary recommendations for environmental management.

7.2.3.7.1. Geochemical Testwork Program

A geochemical testwork program was undertaken to characterise the overburden, interburden and coal and provide a basis for assessing potential environmental issues associated with the handling of these materials.

Initial geochemical testing was undertaken in early 2009 to provide a broad indication of ARD potential. This testing involved collecting 54 samples from open holes BH99C and BH100C. Samples were collected from chip piles collected each metre and combined into composites according to lithological boundaries. The parameters testing included the following:

- pH and Electrical Conductivity (EC) of deionised water extracts
- total sulfur (S)

- acid neutralising capacity (ANC)
- single addition net acid generation (NAG).

A total of 186 samples were collected from fully cored holes CK162, CK165C and SP142, drilled as part of the 2010 geotechnical drilling program. Continuous samples were collected from the available core for each hole from the base of the weathered Permian through to the D2 floor.

Samples were analysed for total S, which was used to select a smaller subset for the following testing:

- ANC
- single addition NAG.

In addition, specialised testing was carried out on selected samples, including:

- extended boil and calculated NAG testing
- sulfur speciation
- kinetic NAG testing
- acid buffering characteristic curve
- multi-element testing of solids
- multi-element testing of deionised water extracts.

7.2.3.7.2. Geochemical Characterisation Results

The pH, EC in decisiemens per metre (dS/m) and acid forming characteristics (total sulfur, maximum potential acidity (MPA), ANC, net acid producing potential (NAPP) and NAG) test results are summarised in **Table 7-4**.

Table 7-4 Geochemical Characterisation Results

	pH[1]	EC (dS/m)[1]	Total %S[2]	MPA[2]	ANC[2]	NAPP (kg H_2SO_4/t)[2]	NAG pH[2]
Min	2.4	0.04	0.01	0	0	-294	1.8
Mean	5.4	0.52	0.23	7	19	-11	4.4
Max	7.8	3.13	3.49	107	294	107	8.5

Source: **Appendix I—Geochemistry Technical Report**

1 Data obtained from samples collected in early 2009 from holes BH99C and BH100C

2 Data obtained from samples collected in early 2009 (from holes BH99C and BH100C) and in 2010 (from holes CK162, CK165C and SP142)

pH and EC

The analysis of the pH and EC provides an indication of the inherent acidity and salinity of the material when it is initially exposed to the surface. The results of the initial geochemical test-work undertaken in early 2009 indicate that the $pH_{1:5}$ (i.e. suspension comprising a ratio of one part soil and five parts deionised water) ranges from 2.4 to 7.8, with approximately half the samples showing no inherent salinity with a pH greater than six.

$EC_{1:5}$ values (i.e. suspension comprising a ratio of one part soil and five parts deionised water) ranged from 0.04 to 3.13 dS/m, with approximately half the samples falling within the non-saline to slightly saline range with an EC of 0.3 dS/m or less. Environmental Geochemistry International Pty Ltd (2011) suggest that the lower $pH_{1:5}$ and higher $EC_{1:5}$ values are the result of partial pyrite oxidation occurring between sample collection and sample testing.

The results indicate a general lack of immediately available acidity and salinity in the samples except where partial oxidation of pyrite has occurred. Pyrite oxidation would therefore be the main source of salinity in overburden material.

The relationship between sodicity and salinity is important when considering the dispersive nature of the material. Highly sodic soils can lead to weak aggregate stability, clay dispersion, surface crusting and poor drainage due to a decrease in the hydraulic conductivity of the soil. High salinity soils are generally non-dispersive and can result in flocculation as the high salinity counteracts the high sodicity. The Exchangeable Sodium Percentage (ESP) values for the two surface Tertiary soil samples were non sodic, but the weathered and fresh Permian samples were mainly sodic to very strongly sodic.

Acid Forming Characteristics

Total sulfur testing was carried out of 240 samples, with results ranging from below detection to 3.49 %. Total sulfur testing found that Tertiary and weathered Permian samples had low total sulfur values of less than 0.05 % and a negligible risk of acid formation. The fresh Permian samples show a broad range of sulfur values, with approximately 75 % of samples having relatively low values of 0.2 % or less. Coal samples are significantly more enriched in sulfur (i.e. median sulfur content of 1.2 %) than other lithologies, which have medians of less than 0.2 %.

ANC testing was conducted on 196 samples and ranged up to 294 kg H_2SO_4/t. ANC values were mostly low with median values of 5 kg H_2SO_4/t or less. Coal samples had low ANC of close to 10 kg H_2SO_4/t or less. Other lithologies did not show strong associations with ANC.

The NAPP value is an acid-base account calculation which uses sulfur and ANC values. It represents the balance between the maximum potential acidity and ANC. Samples that plot above the ANC:MPA = 1 (NAPP = 0) line (refer to **Figure 7-8**) are NAPP negative, indicating an excess in acid buffering capacity over potential acidity. These samples may have sufficient ANC to prevent acid generation. Conversely, a positive NAPP value indicates that the material may be acid generating. Approximately half the samples tested were NAPP positive and half NAPP negative.

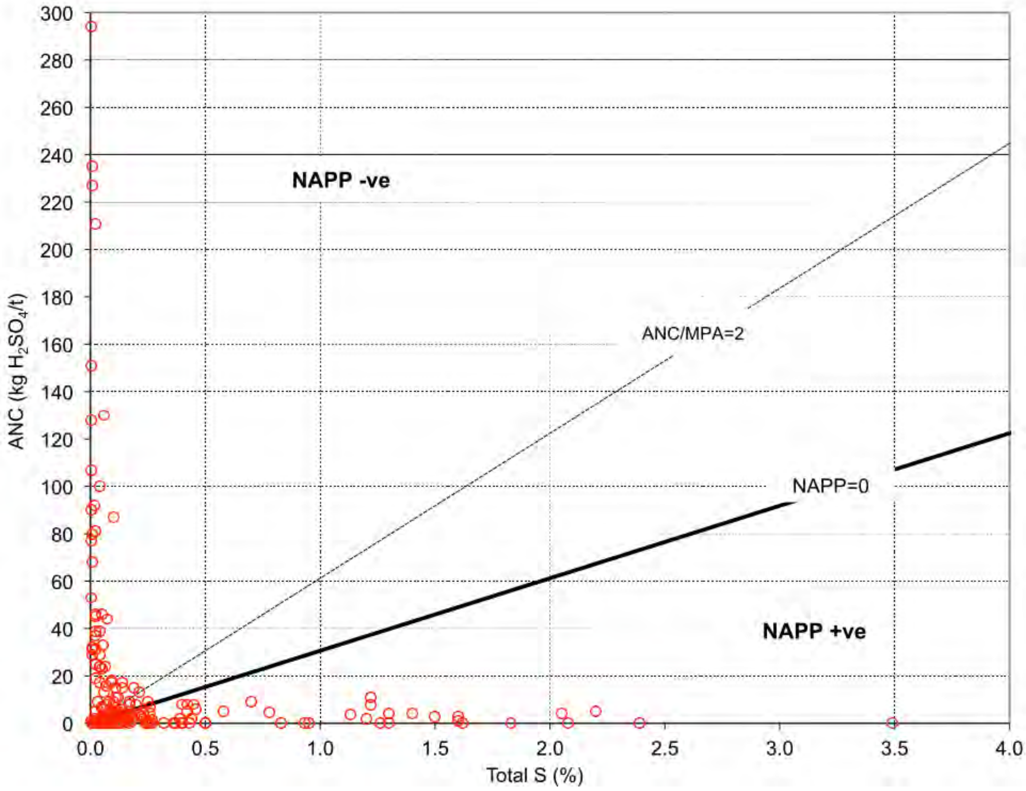


Figure 7-8 Acid-Base Account Plot for Waste Rock Samples

Acid Buffering Characteristic Curve (ABCC) testing was carried out on 11 fresh Permian samples to evaluate the availability of the ANC measured. The ABCC results indicated that the availability of the ANC in the SGCP overburden/interburden materials may be significantly less than the total ANC measured.

Kinetic NAG tests provide an indication of the kinetics of sulfide oxidation and acid generation for a sample. Results indicated that pyritic PAF materials represented by the samples tested were likely to exhibit rapid pyrite reaction rates after exposure to atmospheric oxidation and short lag times of days to weeks before low pH conditions develop.

Water extract testing indicates that once acid conditions develop, elevated concentrations of dissolved Al, Co, Cu, Fe, Mn, Ni, SO_4 and Zn are likely to occur. However, the solubility of metals/metalloids will be largely determined by pH and control of ARD is expected to also control metal/metalloid release.

Figure 7-9 is a plot of the NAPP values compared to the NAG values. Samples with negative NAPP values and NAG greater than 4.5 are non-acid forming (NAF). Samples with a positive NAPP value and a NAG value less than 4.5 are considered potentially acid forming (PAF). All other regions of the figure are classified as uncertain.

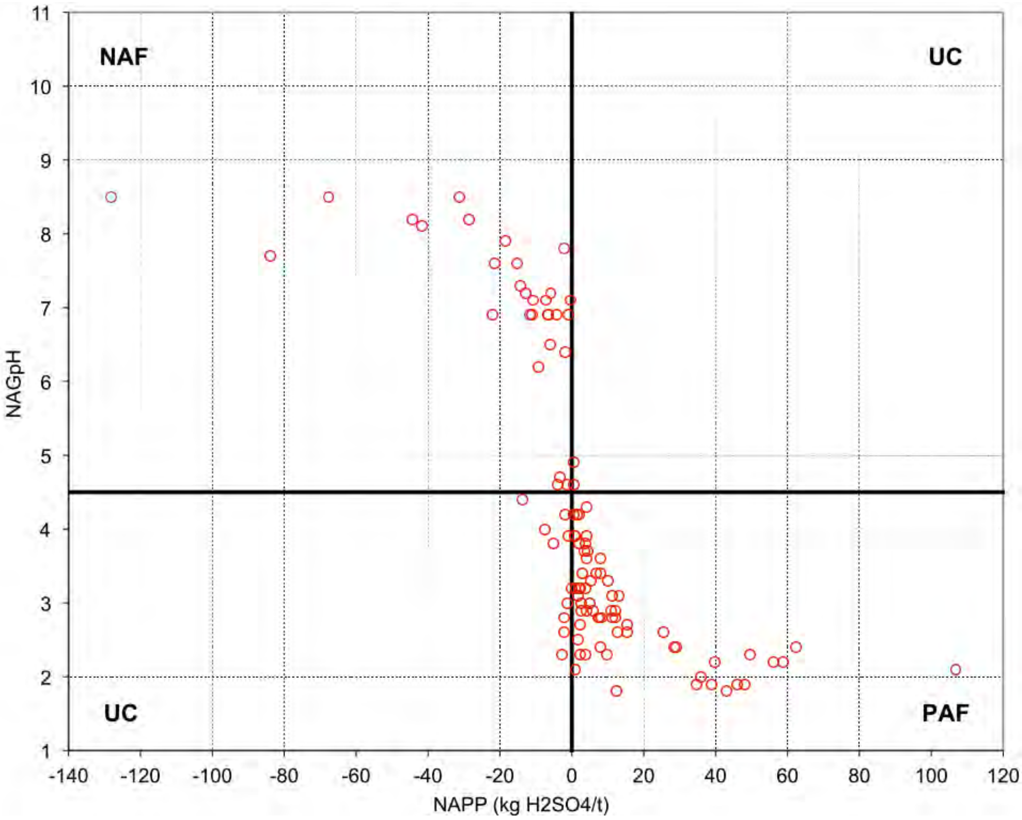


Figure 7-9 ARD Classification for Fresh Permian Waste Rock Samples

Results of geochemical characterisation undertaken to date suggest that the bulk of the overburden and interburden material is likely to be NAF, and suggest the presence of a large continuous section of NAF material from the surface down to the upper portion of the fresh Permian. Permian is likely to be dominated by NAF materials (approximately 65 %) but will also include PAF and potentially acid forming low capacity (PAF LC) materials.

The roof within 5 m of the D1 seam appears to be the main PAF horizon of concern, having sulfur values of >1 %. There are a number of other lower capacity PAF horizons associated with coal seams and also within interburden between seams D1 and D2. Final pit floor material will mainly comprise D2 floor, which is likely to be PAF LC. ROM coal and coal rejects are also likely to be mainly PAF.

Coal stockpiles may also be sources of ARD, depending on reaction rates and stockpile residence times.

7.2.3.8. Geotechnical Assessment

The SGCP mining operations will cut through the Bandanna Formation, targeting the D1 and D2 seams. The maximum mining depth for the proposed open-cut will be 140 m. The mining depth for the underground is between 140 m and 450 m.

A geotechnical assessment has been undertaken to identify any significant constraints to operations. The principal source of data for the geotechnical assessment has been samples obtained from 16 fully cored geotechnical drill holes, which:

- were spread along strike of the D1 seam sub-crop in the northern part of EPC 1049
- were generally concentrated on the Creek Farm and 'Sapling' properties in the area proposed for initial open-cut mining
- extended down dip (to the west) to the approximate B1 seam sub-crop of the open pit areas near the Creek Farm and 'Sapling' properties.

No impediments to open-cut mining of the D1 and D2 seams have been identified in these initial areas, although economic constraints and high wall heights will limit the western down dip extent of mining.

7.2.3.9. Fossil Potential

The age and depositional sequence of the SGCP geology indicate that fossils may be present. Fossil specimens of plant leaves and stems have been recorded in drill cores during exploration activities undertaken to date.

7.2.4. Soils

A soil survey and land suitability assessment of the SGCP area was undertaken by Land Resources Assessment and Management Pty Ltd (LRAM) in July 2011 (refer to **Appendix J—Soils and Land Suitability Technical Report**).

7.2.4.1. Methodology

The methodology used in the soil survey is described in detail in **Appendix J—Soils and Land Suitability Technical Report** and a summary is provided below.

A land system represents a unique landscape pattern that contains a distinctive combination of geology, landform, soil and vegetation features. As land systems are based on distinctive soil patterns, they can be used to develop a separate map of soil distribution.

Land systems across the Nogoa-Belyando area have been mapped and described by CSIRO (Gunn *et. al*., 1967) and the Queensland Environmental Protection Agency (EPA) (Lorimer, 2005). Existing CSIRO land system mapping and EPA land unit mapping was reviewed to obtain an understanding of the anticipated land resources within the study area.

Following a review of existing data, a detailed soil survey of the proposed disturbance area was undertaken in July 2011. The soil survey was conducted at 1:100,000 scale across the Project area, except in areas of expected high disturbance, where a mapping scale of 1:50,000 was used.

The soil survey described the major profile and topographic attributes so that soils could be classified and major observable limiting factors could be identified.

Soil profile and landscape features were recorded at 102 sites. Detailed soil profiles were collected to a maximum depth of 1.8 m at a total of 32 sites, using a vehicle mounted sampling tool, hand auger or pits and cuttings.

Fifty eight soil samples from 13 profiles representing the main soils within the SGCP area were submitted for laboratory analysis. A further four surface samples were collected to test general fertility and one subsoil sample was taken to test soil erodibility.

The surface soil samples submitted for laboratory analysis were analysed for the following parameters:

- soil pH
- electrical conductivity (EC)
- chloride (Cl^-)
- exchangeable cations (e.g. calcium, magnesium, sodium, potassium and aluminium)
- cation exchange capacity (CEC)
- total nitrogen (Total N)
- organic matter content
- available phosphorous
- moisture content
- clouding and slaking.

The subsoil samples submitted for laboratory analysis were analysed for the following parameters:

- soil pH
- EC
- Cl^-
- exchangeable cations
- CEC
- moisture content
- clouding and slaking.

The survey methodology met the requirements described by DME (1995) and Schoknect *et. al*. (2008). All site descriptions used the standard terminology of the Australian Soil and Land Survey Field Handbook (The NCST, 2009).

7.2.4.2. Soil Mapping Units and Descriptions

As described in **Table 7-5**, eleven soil types were identified within the SGCP area. Mapping units (refer to **Figure 7-10**) were determined on the basis of similarity in morphological and topographic attributes. Boundaries were gradually refined from the initial aerial photogrammetry boundaries by the use of field observations and GPS instruments. The soil scheme of Isbell (1998) was used to classify types and the Australian Soils and Land Survey Handbook (McDonald *et al*., 1990) was also referenced.

Table 7-5 Soil Mapping Units and Area within the SGCP

Soil Type	ASC Suborder[1]	Terrain Unit[2]	General Description	Area (ha)
Rocky sands and sandy loams	Clastic Rudosols and Leptic Tenosols	Steep to rolling low hills on little weathered sedimentary rocks	Shallow soil with many large pebbles to stones and frequent rock outcrop and thin, grey, loamy sand or sandy loam that either directly overlies weathered rock or grades into a paler subsurface layer of similar texture which then overlies rock; weathered rock at <150 to 300 millimetres (mm) depth.	1,960
Ironstone sands and sandy loams	Clastic Rudosols and Leptic Tenosols	Scarps on strongly weathered sedimentary rocks	Shallow soil with iron-stained medium pebbles to stones common and red sandy loam of variable thickness that either directly overlies weathered rock or grades into a similarly coloured subsurface layer of loamy sand which then overlies ferricrete; weathered rock at <100 to 400 mm depth.	245
Shallow red-yellow earths	Red and Yellow Kandosols	Level plains to undulating rises on strongly weathered sedimentary rocks	Gradational soil with thick, grey or brown sandy loam merging into red or yellow subsoil increasing in texture with depth from sandy loam to sandy clay loam and occasionally to sandy light clay; clear change into gravelly, mottled (yellow-grey and some red), gravelly clay loam, sandy medium clay between 400 mm and 1 m depth.	20,535
Deep red-yellow earths	Red and Yellow Kandosols	Level plains to undulating rises on strongly weathered sedimentary rocks	Gradational soil with thick, grey or brown sandy loam merging into red or yellow subsoil increasing in texture with depth from sandy loam to sandy clay loam and occasionally to sandy light clay; clear to gradual change into mottled (yellow-grey and some red), gravelly clay loam, sandy to sandy medium clay below 1 m depth.	3,370
Shallow red-grey texture contrast (TC) soils	Red and Grey Sodosols	Gently undulating plains and rises on strongly weathered sedimentary rocks	Red sandy loam of variable thickness over conspicuously bleached sandy loam to sandy clay loam that rapidly changes into mottled, red and grey sandy light clay to sandy medium clay; strongly weathered rock usually at 400 to 750 mm depth.	40

Table 7-5 Soil Mapping Units and Area within the SGCP (cont)

Soil Type	ASC Suborder[1]	Terrain Unit[2]	General Description	Area (ha)
Deep red-grey TC soils	Red, Brown and Grey Sodosols	Gently undulating rises on strongly weathered sedimentary rocks	Thin, brown or dark grey, sandy loam to clay loam, sandy over occasionally thick subsurface layer of similar texture but paler colour with rapid change into mottled (red to brown and grey) sandy light clay to medium heavy clay; strongly weathered rock below 1 m and usually below 1.5 m depth.	660
Deep yellow-grey TC soils	Yellow and Grey Sodosols	Level plains to undulating rises on strongly weathered sedimentary rocks	Grey sandy loam to clay loam, fine sandy of variable thickness usually over conspicuously bleached subsurface layer of similar texture and thickness that rapidly changes into mottled (yellow, grey and red) sandy light medium clay to heavy clay between 100 mm and 1.1 m depth; strongly weathered rock below 1 m and usually below 1.5 m depth.	1,415
Alluvial red TC soils	Red Chromosols	Alluvial plains on recent alluvium	Thick, dark sandy loam over paler, red subsurface layer of similar texture that rapidly changes into red sandy light clay which may contain grey mottles often overlying a buried layer of mottled (red, yellow and grey) sandy clay loam often; total profile depth including buried layer at least 1.5 m.	1,120
Alluvial yellow-grey TC soils	Yellow and Grey Sodosols	Alluvial plains and drainage depressions on recent alluvium	Grey to dark surface layer of sandy loam, sandy clay loam or clay loam and variable thickness often over a thick, sporadically or conspicuously bleached paler subsurface layer of similar variable texture with a rapid change into mottled (grey, yellow and red) sandy light clay to sandy medium heavy clay; total profile depth including buried layer at least 1.5 m.	1,875
Alluvial sands and sandy loams	Stratic Rudosols and Leptic Tenosols	Alluvial plains and drainage on recent alluvium	Thin, grey or brown, loamy coarse sand to sandy loam grading into a slightly browner or redder subsurface layer then into brighter coloured, red or brown subsoil of similar texture; soil profile depth at least 1.5 m but buried layers of coarse sand may occur below this depth.	nd[3]
Alluvial loams and earths	Stratic Rudosols, Grey Dermosols and Red and Yellow Kandosols	Alluvial plains and drainage depressions on recent alluvium	Either: stratified loams with a moderately thick, dark sandy clay loam over buried layers of varied texture, colour and thickness; or loamy gradational soils similar to the *Deep red-yellow earths* but overlying buried layers of varied texture, colour and thickness rather than a mottled, gravelly layer.	nd[3]

Source: **Appendix J—Soils and Land Suitability Technical Report**

1 ASC suborder represents the soil taxonomic classification (to its second or suborder level) using the Australian Soil Classification (Isbell, 2002)

2 A terrain unit is based on weathering history of the underlying rocks and resultant regolith cover

3 The 'Alluvial sands and sandy loams' and 'Alluvial loams and earths' only occur as minor soils associated with other dominant soils and therefore their areas could not be readily determined (nd)

7.2.4.3. Soil pH

The majority of soils have a predominantly medium acid to moderately alkaline pH in the surface layer, however surface pH is strongly acid in the Rocky sands and sandy loams soil type. **Table 7-6** shows the pH results.

The data indicates that there is no potential within the top 1.8 m of all soil profiles for acid generation by disturbance of PAF materials.

Table 7-6 Soil Analytical Results

Soil Type[1]	pH	CEC (milliequivalents per 100 g soil)[2]
Rocky sands and sandy loams	4.3	2
Ironstone sands and sandy loams	5.9	3
Shallow red-yellow earths	6.5 - 8.3	4 – 32
Deep red-yellow earths	5.7 – 7.2	3 – 6
Deep red-grey TC soils	6.4 – 6.5	4 – 15
Deep yellow-grey TC soils	5.5 – 6.0	4
Alluvial red TC soils	6.1	5
Alluvial yellow-grey TC soils	5.0 – 6.0	2 - 5
Alluvial sands and sandy loams	6.9	4

Source: **Appendix J—Soils and Land Suitability Technical Report**

1 Shallow red-grey TC soils were not sampled for laboratory analysis as they cover only 40 ha and should have the same chemical and physical properties as the Deep red-grey TC soils. Alluvial loams and earths were not sampled as they represent only a very minor soil on the alluvial plains and drainage depressions

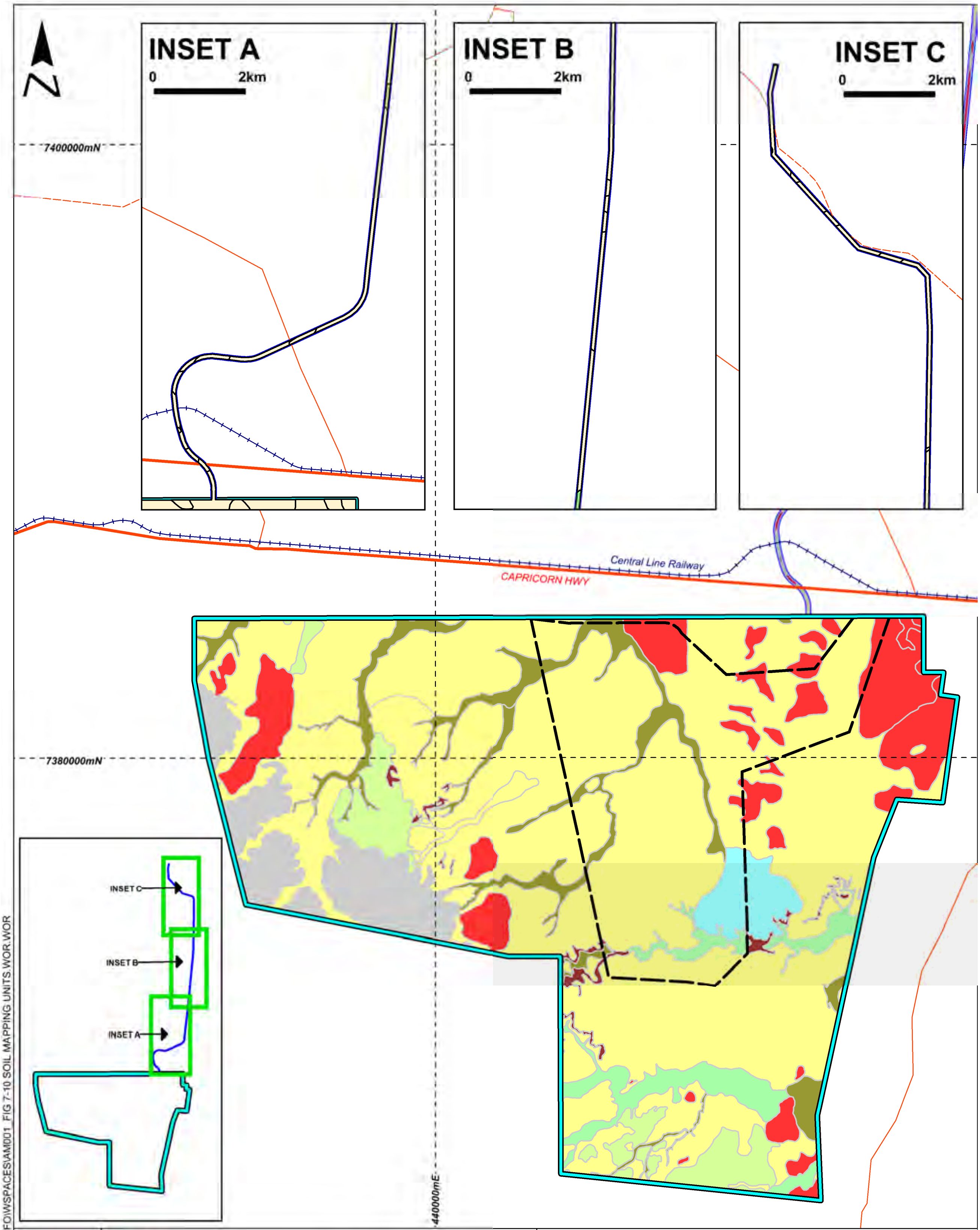
2 CEC is a measure of the soil ability to retain positively charged nutrients (e.g. calcium, magnesium, potassium, ammonium) for use by plant roots, as well as sodium and aluminium

7.2.4.4. Cation Exchange Capacity

The CEC results for the soils within the SGCP area are provided in **Table 7-6**.

7.2.4.5. Soil Salinity

Salinity refers to the concentration of soluble salts in the soil water. Elevated soil salinity within the root zone can retard plant growth. Salinity at or near the surface is not a significant constraint within the SGCP area as approximately 87 % of the area has no salinity hazard. In those soils with salinity constraints, typically the salinity increases with depth through the subsoil. Any activity that disturbs saline subsoil and brings it to the surface can impact on rehabilitation and may result in soluble salts being leached from the soil material and moved downslope.



LEGEND

- MLA70453
- SGCP infrastructure corridor
- Area of direct disturbance
- Principal road
- Road (sealed)
- Railway

Soil Types

- Alluvial red TC soils
- Alluvial yellow-grey TC soils
- Deep red-grey TC soils
- Deep red-yellow earths
- Deep yellow-grey TC soils
- Ironstone sands and sandy loams
- Rocky sands and sandy loams
- Shallow red-grey TC soils
- Shallow red-yellow earths

Data Source: Soils - LRAM. Topography (250k raster) - Geoscience Australia.

METSERVE Mining & Energy Technical Services Pty Ltd

SouthGalilee

Alpha Coal Pty Ltd

South Galilee Coal Project

Soil Mapping Units Within the SGCP

0 5

Kilometres

Scale: 1:175,000 (A4)

23/08/2012

Proj. : MGA Z55

Datum: GDA 1994

FIGURE 7-10

S:\PROJECTS\AM001_STH_GALILEE\EIS\GIS_MAPINFO\WORKSPACES\AM001_FIG 7-10 SOIL MAPPING UNITS.WOR.WOR

7.2.4.6. *Soil Sodicity and Dispersion*

Soil sodicity is used as an indicator of dispersion. Sodic soil (ESP 6 to 14) is usually considered as being dispersive and strongly sodic soil (ESP ≥15) is nearly always dispersive.

All soil samples from the surface and subsurface layers are non-sodic (ESP <6), except for one subsurface sample from the *Alluvial yellow-grey TC soil*, which had an ESP of six.

Subsoil in the *Shallow red-yellow earths, Deep red-grey TC soils, Deep yellow-grey TC soils and Alluvial yellow-grey TC soils* was sodic or strongly sodic and represent dispersive texture contrast soils. All other subsoils were non-sodic.

7.2.4.7. *Erosion Potential*

Soil erosion is governed by the inherent erosion potential of the soil profile, the topography of the site, volume and intensity of the incident rainfall and the land use practices which determine the amount of vegetative cover and condition of the ground surface.

The wind erosion hazard in the SGCP area is negligible due to rainfall levels and groundcover. Approximately 41 % of the SGCP has a minor water erosion hazard and 46 % has a moderate water erosion hazard. Only 9.5 % of the SGCP area has a severe or extreme water erosion hazard.

The erosion potential of soils, determined by the rate of infiltration at the surface, permeability of the profile and coherence of the soil particles, is presented in **Table 7-7**. Whilst many of the soils are highly erodible, the grazing practices and generally gentle slopes have restricted erosion to relatively few areas (generally along drainage lines).

7.2.4.8. *Soil Fertility*

Soil fertility is a prime determinant of the ability to successfully re-vegetate disturbed areas.

All soils have a low to very low level of at least one of the major nutrients, and approximately 96 % of the SGCP area has a moderate or greater soil fertility constraint, typically a combination of low organic matter and low available phosphorous.

Table 7-7 Inherent Soil Erodability

Soil	Erodability Rating	Factors
Rocky sands and sandy loams	Moderate	Incoherent to weakly coherent sandy material which is quite permeable but can be easily detached by flowing water
Ironstone sands and sandy loams	Moderate	Incoherent to weakly coherent sandy material which is quite permeable but can be easily detached by flowing water
Shallow red-yellow earths	Moderate	Sandy profiles with incoherent to weakly coherent surface layer and quite permeable profile though the mottled, gravelly layer below the subsoil may be partly dispersive
Deep red-yellow earths	Moderate	Sandy profile with incoherent to weakly coherent surface layers and quite permeable profile though the mottled, gravelly layer below the subsoil may be partly dispersive
Shallow red-grey TC soils	Very high	Coherent, permeable surface layer overlying very slowly permeable subsoil causing water to pond then seep along the top of the very dispersive subsoil
Deep red-grey TC soils	Very high	Coherent, permeable surface layer overlying very slowly permeable subsoil causing water to pond then seep along the top of the very dispersive subsoil
Deep yellow-grey TC soils	High	Coherent, permeable surface layer overlying very slowly permeable subsoil causing water to pond then seep along the top of dispersive subsoil
Alluvial red TC soils	Low	Weakly coherent surface layer and quite permeable profile
Alluvial yellow-grey TC soils	Very high	Coherent, permeable surface layer overlying very slowly permeable subsoil causing water to pond then seep along the top of the very dispersive subsoil
Alluvial sands and sandy loams	Moderate	Incoherent to weakly coherent sandy material which is quite permeable but can be easily detached by flowing water

Source: **Appendix J—Soils and Land Suitability Technical Report**

7.2.4.9. Topsoil Resources

Topsoils will be stripped prior to any excavation works for later use in the rehabilitation and revegetation of the SGCP. Approximately 80 % of the SGCP area has very thick layer(s) suitable for topsoil and therefore has no topsoil depth constraint. The recommended topsoil stripping depths have been determined by a soil survey (refer to **Appendix J—Soils and Land Suitability Technical Report**) and are summarised in **Table** 7-8.

Table 7-8 Recommended Topsoil Stripping Depths

Soil Type	Recommended Soil Stripping Depth (mm)
Rocky sands and sandy loams	100
Ironstone sands and sandy loams	50–100
Shallow red-yellow earths	300
Deep red-yellow earths	300
Shallow red-grey TC soils	250–400
Deep red-grey TC soils	100–350
Deep yellow-grey TC soils	100–300
Alluvial red TC soils	300
Alluvial yellow-grey TC soils	150–300

Source: **Appendix J—Soils and Land Suitability Technical Report**

7.2.5. Land Contamination

Searches of the Queensland Environmental Management Register (EMR) and the Contaminated Land Register (CLR) were conducted for all lots covered by MLA 70453 and the infrastructure corridor. No sites on the properties relating to the SGCP are included on either register. A copy of the search results are provided in **Annexure A**.

In the past, the SGCP site has been used for cattle grazing and contamination may have occurred through the use of agricultural chemicals (e.g. dips, drenches and herbicides), however, no such facilities have been identified within MLA 70453 or the infrastructure corridor.

7.2.6. Scenic Amenity and Lighting

This Section provides an assessment of the visual qualities and character of the land surrounding the SGCP area and any potential impact on the visual quality and character that may occur as a result of the SGCP.

This Section addresses the methodology used, the existing landscape and visual characteristics, potential effects and impact generators and provides an assessment of the visual impact both during the life of the SGCP and from a residual perspective.

The environmental values to be maintained are the existing landscape character and scenic amenity.

7.2.6.1. Methodology

The guidelines used in this assessment are described in **Section 7.1**. It is acknowledged that, despite using an approach designed to minimise the subjective nature of visual impact assessments, some subjectivity is inherent and unavoidable in the visual impact assessment process.

7.2.6.1.1. Desktop Study and Field Observations

An initial desktop study was conducted and involved an analysis of topographic maps and aerial imagery for the SGCP and immediate surrounding areas. The locations of the known surrounding homesteads, roads and the township of Alpha were identified to determine potential viewpoints.

Viewpoints that were identified from the desktop analysis were visited in the field on the 17 and 19 May 2011 and assessed for sensitivity to the proposed development (refer to **Figure 7-11**). The weather conditions were favourable for conducting the assessment, characterised by sunshine with very little cloud. Digital photos were taken at a number of viewpoints.

7.2.6.1.2. Local Council Designations

The SGCP is located within the boundary of the Barcaldine Regional Council LGA, therefore the applicable former Jericho Shire Planning Scheme was referenced. Under that plan, the SGCP is located within the Rural Zone (refer to **Figure 3-1**).

As described in **Section 7.1**, in the rural context, the relevant planning scheme requires that ridgelines and escarpments be maintained in a natural state to protect rural character and landscape values. A separation distance of at least 50 m is required for all Rural Zone "buildings" and "structures" from ridgelines or escarpments.

The Jericho Shire Planning Scheme also requires that the design of lighting does not prejudice the amenity of the Rural Zone through poorly directed lighting, lighting overspill or lighting glare. To achieve this, direct lighting or lighting should not exceed 8.0 lux at 1.5 m beyond the boundary of the site.

The SGCP will not impact on the visual amenity of ridgelines and escarpments or significantly impact on the amenity of the Rural Zone through lighting impacts.

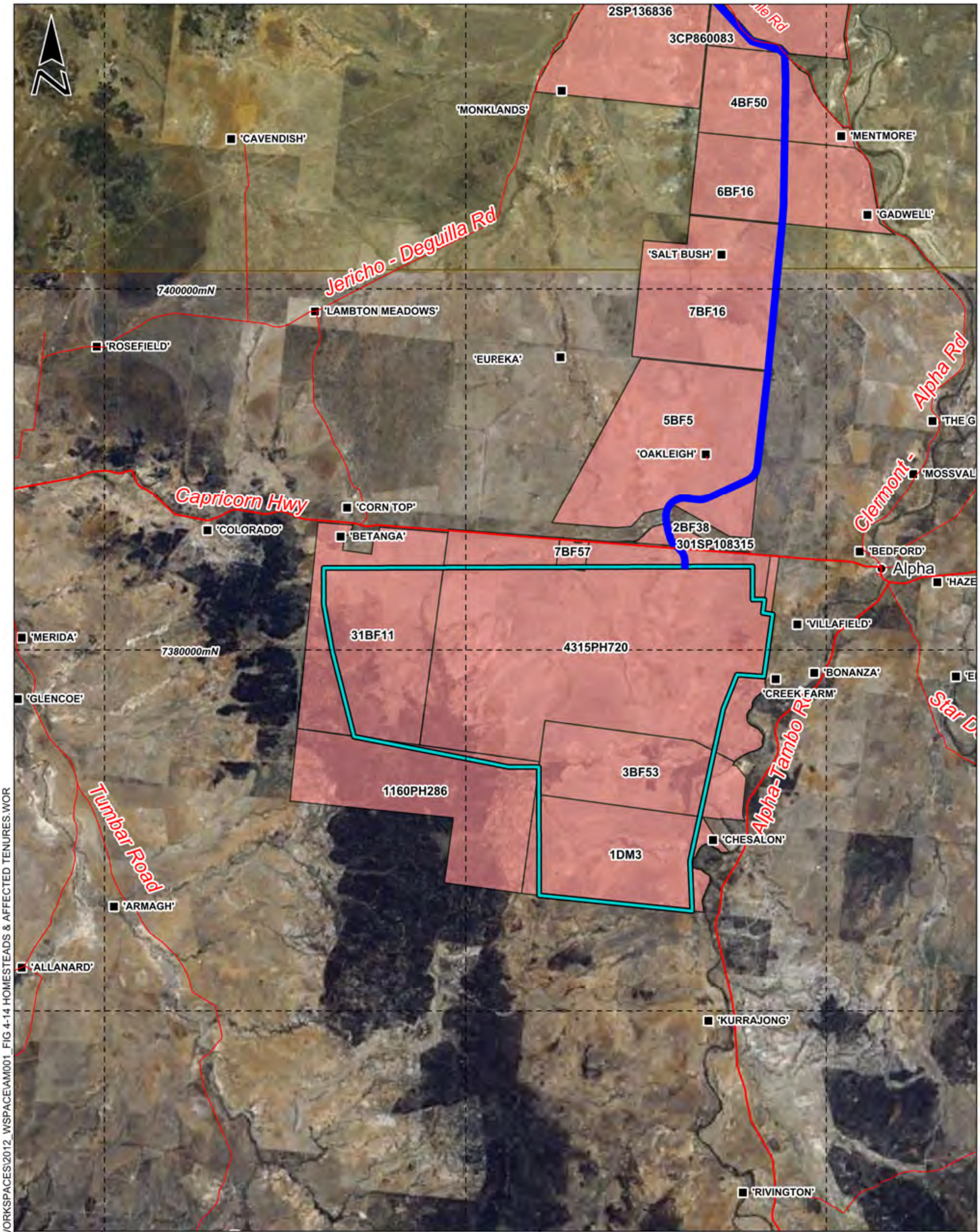
7.2.6.1.3. Development of Photographic Montages with Predicted Mine Contours

Photographs from potentially sensitive viewpoints towards the SGCP were taken, along with data such as elevation, GPS position and bearing. A geo-referenced 3-D computer model of the mine plan was developed.

The location information was digitally combined with the photographic image and the 3-D model of the conceptual final mine plan landforms, to produce a visualisation of the predicted mine impacts on the visual envelope from the viewpoint in the field. These photographic montages give a visual representation of the proposed impacts from the SGCP.

7.2.6.1.4. Landscape and Visual Assessment

The term 'landscape assessment' describes the existing character, features and quality of the landscape surrounding the SGCP area. 'Visual assessment' relates to the changes to the surrounding scenic values as a result of changes to the landscape. It also considers people's responses to the changes, and to the overall effects with respect to visual amenity or aesthetic condition. For the purposes of the landscape and visual assessment, visual amenity is assessed for areas both within and peripheral to the SGCP.



LEGEND

- MLA70453
- Directly affected property
- SGCP infrastructure corridor
- Roads
- Population centre
- Homestead

METSERVE Mining & Energy Technical Services Pty Ltd

SouthGalilee

Data Source:
Cadastral (Barcaldine May2010)-DERM. Topo (250k raster)-Geoscience Australia.

Alpha Coal Pty Ltd

South Galilee Coal Project

Homesteads in the Vicinity of the SGCP

5 0 5

Kilometres

Scale: 1:300,000 (A4)

08/20/2012

Proj. : MGA Z55
Datum: GDA 1994

FIGURE 7-11

S:\PROJECTS\AM001 STH GALILEE EIS_MAPINFO\WORKSPACES\2012_WSPACE\AM001_FIG 4-14 HOMESTEADS & AFFECTED TENURES.WOR

The characterisation of the SGCP has been based on an assessment of the natural, cultural, social, and aesthetic factors as they exist today compared to the predicted landscape character following the completion of proposed mining and post mining rehabilitation activities.

7.2.6.2. Landscape Assessment

7.2.6.2.1. Existing Land Use

The land use in the region surrounding the SGCP consists of beef cattle production and associated activities, primarily on pastoral leases.

A number of other mining developments have been proposed in the Galilee Basin, situated to the north of the SGCP (refer to **Section 1.3**).

7.2.6.2.2. Natural Features

The natural topography is dominated by gently undulating plains and rises of low relief. The plains in the east and north-east generally decline from more elevated low hills located along the western portion of MLA 704543. The topography of the region ranges from 350 to 600 m AHD on the eastern flanks of the Great Dividing Range.

The major regional topographic features are the Drummond Range located approximately 60 km east of the SGCP and the Great Dividing Range, which runs in a north to south direction approximately 10 km west of the SGCP.

Vegetation in the region is typical of the bioregion and is primarily open acacia forest and eucalypt woodland. The majority of the area has been cleared for improved pastures for cattle grazing.

7.2.6.2.3. Social and Cultural Factors

The SGCP and surrounding area comprises land used for cattle grazing. The SGCP is located within a new coal basin, the Galilee Basin, and a number of new coal mines are proposed to the north.

The SGCP is located approximately 12 km south-west of the township of Alpha. There is little residential development in the region outside of the town centre, with only isolated homesteads surrounding the SGCP, as shown on **Figure 7-1**.

Cultural heritage associated with both Indigenous and non-Indigenous use of the land in the region is discussed in **Section 15—Indigenous Cultural Heritage** and **Section 16—Non-Indigenous Cultural Heritage**. The existing social environment and associated social impact assessment is included in **Section 17—Social**.

7.2.6.2.4. Landscape Sensitivity

Landscape sensitivity is categorised as high, medium, low or negligible according to the degree to which a particular landscape or area can accommodate change arising from a particular development without detrimental effects on its character. The classification of sensitivity is based on:

- the existing land use
- the pattern and scale of the landscape
- visual enclosure/openness of the views and the distribution of visual receptors
- scope for mitigation measures that will be in character with the existing landscape
- the value placed on the landscape.

The landscape within the vicinity of the SGCP is considered to have a moderate sensitivity to landscape changes arising from the SGCP, given that it currently primarily supports rural activities.

7.2.6.3. Visual Assessment

7.2.6.3.1. Existing Visual Elements

As there are no existing mines in the immediate vicinity of the SGCP, the key existing visual elements of the area are predominantly grazing lands and natural vegetation.

In the broader context, the Great Dividing Range to the west of the SGCP is a key visual element of the natural landscape.

7.2.6.3.2. Viewpoint Sensitivity

Viewpoint sensitivity is determined by a number of factors including:

- viewing distance
- viewing frequency
- viewpoint importance
- viewing duration
- viewing angle and focus.

In general, sensitivity increases with frequency, importance, duration, angle and focus of the view, but decreases with distance.

Using the factors above, the most sensitive viewpoints were identified as surrounding homesteads and public views from Hobartville Road. These viewpoints have been assessed as Primary Viewpoints and are discussed further in this Section.

The more distant views of less significance have been discussed as Secondary Viewpoints and are also discussed in this Section. The other public viewpoint in the area will be from the Capricorn Highway. Views from the Capricorn Highway are anticipated to be transitory, and the location is therefore classified as a less significant viewpoint.

This view, along with a number of private homesteads, is assessed as a Secondary Viewpoint.

The desktop search did not identify any viewpoints deemed to be of community or cultural significance (e.g. those included in guidebooks or tourist maps).

7.2.6.3.3. Primary Viewpoints

The Primary Viewpoints surrounding the SGCP are comprised mostly of surrounding homesteads as well as the view from the town of Alpha and a point on Hobartville Road. Residential properties are considered to be potentially sensitive to visual impacts as residents can be exposed on a regular and/or prolonged basis. **Table 7-9** provides an assessment of the sensitivity of the Primary Viewpoints to the visual features of the SGCP.

Table 7-9 Assessment of Primary Viewpoint Sensitivity

Viewpoint Location	Distance (approx) (km)[1]	Frequency	Importance	Duration	Angle/ Focus	Overall Sensitivity
Betanga Homestead	16	Medium	High	High	Low	Medium
Creek Farm Homestead	10	High	High	High	Medium	High
Chesalon Homestead	11	High	High	High	Medium	High
Oakleigh Homestead	14 (from MLA 70453) 4 from infrastructure corridor	Medium	High	Low	Low	Medium
Hobartville Road	0.3 from infrastructure corridor	Medium	Medium	Low	Low	Medium
Alpha	16	Low	Medium	Low	Low	Low

1 Distance calculated from a point located centrally within MLA 70453, rather than to the closest point of the lease boundary

The Betanga homestead is located north-west of MLA 70453. As the closest homestead on the north-western side of the SGCP, Betanga homestead is conservatively considered to be representative of homesteads in this vicinity (e.g. Colorado, Rosefield, Lambton Meadows, etc.). The view is partially obstructed by trees and stockyards.

The Creek Farm homestead is located to the east of MLA 70453. Due to the proximity to the SGCP and the mine infrastructure in that part of MLA 70453, the frequency of this view is expected to be high. The view towards the SGCP is partially screened by vegetation. As the closest homestead on the eastern side of the SGCP, the Creek Farm homestead is conservatively considered to be representative of viewpoints located east of the Project (e.g. Bonanza, Villafield, Bedford etc.).

The Chesalon homestead is located to the south-east of MLA 70453. Due to the proximity of the homestead to the southern open pit and waste rock emplacement, the frequency and duration of views are expected to be high. The importance of the view is expected to be high. The existing view is partially obscured by vegetation.

The Oakleigh homestead is located west of the infrastructure corridor and north of MLA 70453. As the closest homestead on this side of the infrastructure corridor, Oakleigh homestead is considered to be conservatively representative of the Saltbush, Monklands and Eureka homesteads. The principal impact on visual amenity for this location is expected to be the infrastructure corridor. The frequency and duration of views towards the infrastructure corridor are expected to be of a medium range due to the distance and the scale of the infrastructure itself. The view towards the infrastructure corridor is expected to be predominantly screened by vegetation.

The infrastructure corridor alignment is proposed to run south of and parallel to Hobartville Road for approximately 7 km. Along this section of Hobartville Road, intermittent views to the infrastructure corridor may be possible. The duration and angle/focus of this view is predicted to be low as the infrastructure corridor will be at right angles to the direction of travel (with the exception of the rail crossing point), which means that it will not be part of the main field of view of people using the road. Along this section of the road, there will be a distance of approximately 200 to 400 m between Hobartville Road and the infrastructure corridor. The view to the infrastructure corridor is expected to be predominantly obscured by vegetation (refer to **Plate 7-1**). The importance of this view is expected to be medium as a significant portion of the traffic using the Hobartville Road is expected to be mine workers from other proposed projects in the area.

Plate 7-1 View South Towards SGCP Infrastructure Corridor from Hobartville Road

The view from the Alpha township is expected to be restricted by the topography of the area, intervening distance to the SGCP and the vegetated landscape. The frequency of the view is expected to be very low as the residential areas of the township are located below the highest elevation point (shown in **Plate 7-2**). The duration of views and focus towards the SGCP are expected to be low.

Plate 7-2 View Towards SGCP from Alpha Township

An assessment of the visual impacts of the SGCP on these viewpoints is provided in subsequent sections.

7.2.6.3.4. Secondary Viewpoints

The Secondary Viewpoints are considered to have lower sensitivity and will be less likely to be impacted by visible features of the SGCP. These are identified in **Table 7-10**.

Table 7-10 Assessment of Secondary Viewpoint Sensitivity

Viewpoint Location	Distance (approx) (km)	Frequency	Importance	Duration	Angle/ Focus	Overall Sensitivity
Gadwell Homestead	2	Low	High	Low	Low	Low
Capricorn Highway (east of Tallarenha Creek crossing)	7 (from MLA 70453)[1]	Medium	Medium	Low	Low	Medium
Corn Top Driveway	16[1]	Low	Medium	Low	Low	Low

The Gadwell homestead is located east of the infrastructure corridor. The visual impact of the corridor is expected to be diminished by the infrequent and short duration views as well as the topography and vegetation. The Gadwell homestead is considered to be conservatively representative of other homesteads located east and north-east of the infrastructure corridor (e.g. Mentmore, Tresillian, Mossvale and The Grove homesteads).

The Capricorn Highway runs parallel to the northern boundary of MLA 70453. The views towards the SGCP are expected to be infrequent, of low duration and low importance. Views towards MLA 70453 are at right angles to the direction of travel along the highway and therefore will not form part of the main field of view for people travelling along the highway. Views from the Capricorn Highway will generally be screened by vegetation. Although this section of the road is considered the most likely to have views of the SGCP, it still contains tall trees in the foreground. The distance to the SGCP will further diminish the impacts on visual amenity.

Corn Top Homestead is not expected to have a view to the SGCP due to vegetation, topography and distance. The start of the driveway into the property is expected to have some view of the SGCP, albeit of low overall sensitivity. The frequency, duration and angle of this view are low due to vegetation screening as well as the Capricorn Highway and Central Line Railway.

7.3. POTENTIAL IMPACTS AND MITIGATION MEASURES

7.3.1. Land Use and Tenure

7.3.1.1. Tenure

As described in **Section 7.2.1**, the SGCP will be located within MLA 70453 and the infrastructure corridor.

Where a substantial portion of land will be required for mining operations (e.g. the Creek Farm and Sapling Creek properties), SGCP proposes to acquire land by negotiation, where practicable. Surface rights will also be required over part of the Chesalon and Betanga properties.

In the event that agreement cannot be reached with landholders, surface rights compensation will be determined by the Land Court of Queensland.

One petroleum tenement (Exploration Permit Petroleum 668) overlies MLA 70453. In accordance with legislative requirements, the mining lease application triggers a need to notify and consult with the EPP holder and enter into negotiations to maximise resource use.

SGCP will finalise required land acquisitions and consent from other tenement holders prior to commencement of construction.

SGCP will continue to undertake stakeholder consultation as described in **Section 17—Social** and **Appendix R—Social Impact Management Plan**.

7.3.1.2. Native Title

The SGCP has undertaken the appropriate engagement with the identified Aboriginal Party as required by the Commonwealth *Native Title Act 1993*. SGCP has developed a Cultural Heritage Management Plan (refer to **Section 15—Indigenous Cultural Heritage**).

7.3.1.3. Land Use

The SGCP will alter land use in the local area, by reducing the availability of land for agricultural purposes during the operational phase. Grazing may continue to be undertaken in areas not subject to direct disturbance as a result of the SGCP.

The impacts on rural land uses will be offset by the economic benefits of the SGCP described in **Section 18—Economic Environment** and **Appendix S—Economic Technical Report.**

The potential impacts of the SGCP on directly affected and adjacent landholders will be mitigated by the implementation of a Landholder Management Plan (refer to **Section 17—Social** and **Appendix R—Social Impact Management Plan**).

As shown on **Figure 7-3**, the SGCP infrastructure corridor will intersect a stock route which runs parallel and to the north of the Central Line Railway. Consultation with the DEHP's Stock Route Management Unit indicates that the objective of mitigation measures for affected stock routes should be to maintain connectivity. The Proponent will undertake detailed design of the infrastructure corridor in consultation with the DEHP Stock Route Management Unit and design concessions may include provision for an underpass or overpass.

SGCP will continue to undertake stakeholder consultation as described in **Section 17—Social** and **Appendix R—Social Impact Management Plan**.

7.3.1.3.1. Land Use Suitability

Factors influencing changes in land suitability include changed physical, chemical and biological properties of the soil, changes in slope and slope length and soil depth.

Final land use criteria for the SGCP include a mix of cattle grazing and native vegetation. The limitations to cattle grazing of the post mining landforms within the SGCP site are based on slope.

Steep sloping areas such as the slopes of the waste rock emplacements, ramps and the final void are unlikely to sustain grazing without erosion unless regrading work is done. These areas are constrained by slope angle, the nature of soil cover and altered soil moisture profile. Consequently, no parts of the final waste rock emplacements, ramps or final void are proposed to be grazed. These landforms will be rehabilitated to areas of native bushland. Further information is provided in **Section 5—Rehabilitation and Decommissioning**.

Activities associated with the SGCP do not propose to limit the land use suitability of the areas surrounding the SGCP.

The land within MLA 70453 is not likely to become part of a Protected Area Estate nor is it likely to be protected as part of any treaty.

7.3.1.3.2. Agricultural Land Class

As described in **Section 7.2.1.3.2**, the SGCP area contains approximately 780 ha of GQAL.

The construction and operation of the SGCP has the potential to impact upon GQAL by:

- reducing the productive area
- impeding optimal paddock layout and stock management practices for efficient production
- modifying overland flow patterns, potentially increasing erosion and sedimentation of the local waterways
- introducing weed species, or increasing their distribution.

SPP 1/92 provides a framework for considering the value of GQAL in development assessment. SPP 1/92 acknowledges that there will be developments that can legitimately alienate GQAL because they represent an overriding benefit to the community.

The SGCP is considered to provide the following overriding community benefits:

- it allows for utilisation of the coal resources of the State
- it will provide substantial employment within Queensland
- it will facilitate the establishment of a locally/regionally significant industry that provides substantial export income to the State
- there is no alternative location on land of lesser agricultural quality, as the SGCP location is dictated by the location of coal reserves
- the land is typical of grazing land in the region.

Information regarding the economic productivity of the SGCP area is provided in **Section 18—Economic Environment**.

The SGCP is expected to have a minor impact on GQAL as only approximately 5 ha of GQAL are likely to be subject to direct disturbance. The potential impacts of the SGCP on directly affected and adjacent landholders will be mitigated by the implementation of a Landholder Management Plan (**Section 17—Social** and **Appendix R—Social Impact Management Plan**).

7.3.2. Topography

By the manner of its operation, open-cut mining will result in significant alteration of the existing topography (e.g. removal of topography and creation of a new topographic surface at the waste rock emplacements). Open-cut mining will also require the diversion of Sapling Creek and alteration of surface drainage. Further information on the diversion of overland flows is provided in **Section 9—Water Resources**.

These impacts are typical of open-cut mining methods. However, there are also significant mitigation and management measures implemented progressively over the life of the mine to minimise both the degree and extent of these impacts.

Section 5—Rehabilitation and Decommissioning details the progressive and final rehabilitation plans and ultimate rehabilitation success criteria for the SGCP. As a minimum, all areas significantly disturbed by mining activities will be rehabilitated to a stable landform with self-sustaining vegetation cover.

Coal resources are also proposed to be mined by underground mining techniques once open-cut mining has progressed sufficiently. The conceptual layout of the underground mining operations is presented in **Figure 4-3** to **Figure 4-12**.

Underground mining at the SGCP is likely to result in surface expressions of subsidence. After coal has been extracted from a longwall panel, the roof over the area from which the coal has been removed is allowed to collapse or "goaf" (ACA, 2008). Subsidence occurs when the strata located above the goaf zone bends into the void, resulting in vertical fractures and bed separation (Mine Subsidence Engineering Consultants (MSEC), 2007).

The degree of subsidence is dependent on a number of factors, including the thickness of coal extracted, the extent of the area mined, width of chain pillars, the depth of the seam below the surface, the nature of overburden present above the coal seam and other geological factors (University of Wollongong, undated b).

Subsidence typically involves a gradual lowering of the surface strata leading to compressive strain in the centre of the subsided area and tilts and tensile strains around the edges of the subsided area which may result in the formation of cracks at the surface (University of Wollongong, undated b).

A subsidence assessment was conducted for the SGCP by Seedsman Geotechnics Pty Ltd and is presented in **Appendix H—Subsidence**.

Subsidence predictions for the SGCP, detailed discussion of the potential impacts associated with subsidence and proposed mitigation and management measures are provided in **Section 20—Matters of National Environmental Significance** .

7.3.3. Geology

7.3.3.1. Resource Utilisation

As described in **Section 2—Project Rationale and Alternatives**, detailed mine planning and Pre-Feasibility Assessment indicate that the target coal seams can be most economically extracted using the mining methods proposed.

The conceptual mine plan has been developed on the basis of standard mining assumptions and the geological model. The design of the underground mining area includes a stand-off to avoid the identified Threatened Ecological Communities (refer to **Section 8—Nature Conservation**).

7.3.3.2. Geochemical Impacts

As described in **Section 7.2.3.7**, geochemical characterisation undertaken to date suggests that the bulk of the overburden and interburden material is likely to be NAF, with a large continuous section of NAF material from the surface down to the upper portion of the fresh Permian. Permian is likely to be dominated by NAF materials (approximately 65 %) but will also include PAF and PAF-LC materials.

The roof within 5 m of the D1 seam appears to be the main PAF horizon of concern, having sulfur values of >1 %. There are a number of other lower capacity PAF horizons associated with coal seams and also within interburden between the D1 and D2 seams. Final pit floor material will mainly comprise D2 floor, which is likely to be PAF-LC. ROM coal and coal rejects are also likely to be mainly PAF.

Coal stockpiles may also be sources of ARD, depending on reaction rates and stockpile residence times.

Waste rock from the open pit mining operations and coal rejects from the CHPP will be placed in the waste rock emplacements.

Environmental conditions for development of acid sulfate soils (ASS) were not observed within the SGCP area and it is extremely unlikely that ASS are present. Although the Rocky sands and sandy loams soil type has an extremely acid pH, its minimal clay content means it has a limited capacity to generate acid and it is located outside of the direct disturbance area for the SGCP.

As indicated in **Section 7.2.4.3**, the data indicates that there is no potential within the top 1.8 m of all soil profiles for acid generation by disturbance of PAF materials during earthworks and construction.

An Acid Mine Drainage Management Plan (AMDMP) will be developed to outline appropriate management measures. The AMDMP will be prepared in accordance with the Assessment and Management of Acid Drainage guideline of the Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland series (DME, 1995) and any other applicable best practice guidelines.

To reduce the risk of ARD, enriched metal concentration and potential release to vegetation (plant uptake), atmosphere (dusting) or water resources (leaching), the following waste rock emplacement management measures will be considered and/or implemented:

- dust suppression (watering) during emplacement construction
- selective handling of PAF material overburden and interburden materials
- selective placement or encapsulation of material in the 5 m above seam D1 (e.g. deep burial away from the outer slopes of the waste rock emplacement)

- PAF waste rock and rejects will be surface treated with crushed limestone and/or lime water treatment of drainage to control ARD
- the final pit floor will be treated with limestone, high ANC NAF and/or water treatment depending on the ARD reaction rates and acid loads
- selective placement or encapsulation of coal rejects
- exposure time of PAF and dispersive material to the surface will be minimised to reduce the potential formation of acid leachate and soil dispersion
- the waste rock emplacement will be contoured so that runoff is shed from the landform
- the final landform will incorporate engineered cover systems at closure (e.g. soil covers, designed to adequately protect the waste rock emplacement from potential wind/surface water erosion and moisture infiltration)
- drainage works will be designed to maintain long-term stability of the engineered cover.

Portions of the lower capacity PAF/PAF-LC zones may be amenable to ARD control through mixing with high ANC NAF materials and/or addition of limestone. Further investigation and testing will be undertaken to determine the effectiveness of mixing lower capacity PAF horizons with higher ANC NAF materials in order to control ARD.

Coal stockpile drainage will be collected and treated with lime, if required, depending on ARD reaction rates and stockpile residence time.

Drilling and geochemical test work will continue to be undertaken to:

- further investigate the occurrence of PAF and PAF-LC material across the deposit
- better define the variation and continuity of the zone of higher ANC fresh Permian overburden intercepted in hole SP142
- assess the NAF/ANC overburden material for acid buffering potential
- better assess the sodicity potential of overburden materials
- construct an ARD model suitable for predicting the distribution of these zones during operations
- conduct leach column testing on a range of material types to help assess reaction kinetics and leachate compositions
- conduct additional ARD testing of coal and coal rejects to better define the acid potentials.

Results of these ongoing investigations will be used to validate and, if necessary, revise the methods for handling and storage of overburden and interburden material to minimise the potential for adverse environmental impact.

A geochemical monitoring program will be established to routinely sample and test waste materials during operations. The program will monitor variation in acid potential, reconcile the ARD prediction model and check ARD rock type materials handling and placement.

Surface water and groundwater monitoring will also be undertaken as described in **Section 9—Water Resources**. Field observations and pit water quality monitoring will be undertaken in order to identify the potential development of low pH conditions or ARD within the active pit surface or runoff ponds on the waste rock emplacement (refer to **Section 9—Water Resources**).

7.3.3.3. Geotechnical Impacts

As described in **Section 7.2.3.8**, no impediments to open-cut mining of the D1 and D2 seams have been identified, although economic constraints and high wall heights will limit the western down dip extent of mining.

Based on the assessment undertaken to date, the following key geotechnical conditions will apply to the SGCP open-cut mining:

- Pit wall stability – application of the pit wall design parameters detailed in **Table 7-11** are expected to maintain adequate levels of stability for the low walls and highwalls formed during progressive mining. Provision of pre-split drill and blast for the highwalls is considered mandatory in this regard but will not avoid the effects of adversely oriented faults that are likely to be encountered at various stages. Wall stability will be further enhanced by good operational scaling practice.
- Material excavatability – overburden removal should be readily accomplished through all Tertiary materials and to approximately 80 % of the depth of weathered Permian by large excavation equipment in face shovel or backhoe configuration. The remaining approximately 20 % of weathered Permian and all fresh Permian will require drill and blast to uncover coal economically.
- Trafficability – trafficability on the D2 seam floor will be affected to some degree by the predominance of siltstone and carbonaceous mudstone over sandstone in this stratigraphic position. However, most floor rock is medium strength and only one of the 16 geotechnical drillholes contained carbonaceous mudstone which would be classified as low strength rock.
- In-pit waste rock emplacement – instability is unlikely to be an issue at SGCP through a combination of low floor dip and the apparent absence of bedding parallel shears in the floor rock types.

Design parameters based on the geotechnical assessment are provided in **Table 7-11**.

The design parameters outlined in **Table 7-11** are illustrated in **Figure 7-12**.

SGCP proposes to extend the geotechnical drilling programme to cover the northern part of the Creek Farm property as well as the underground mining area.

7.3.3.4. Fossils

As described in **Section 7.2.3.9**, plant fossil specimens have been recorded in drill cores during exploration activities undertaken to date.

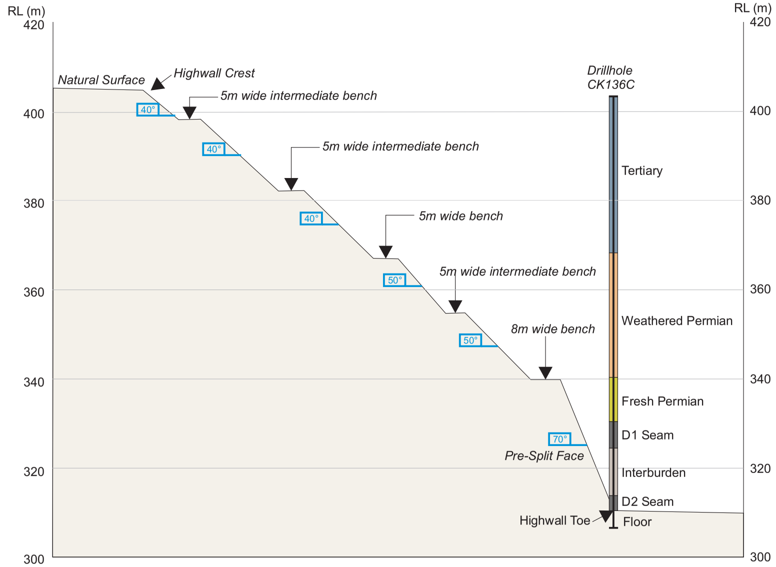
In the event of a significant fossil find, the find will be demarcated and the Queensland Museum will be alerted.

Table 7-11 Open-cut Low Wall, Highwall and Waste Rock Emplacement Design Parameters

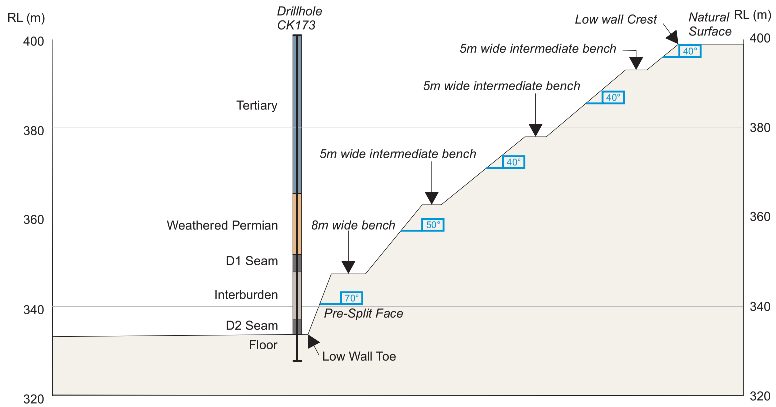
Geotechnical Unit	Design Parameter
Tertiary	15 m (vertical) face height at 40 degrees (°) (from horizontal) with 5 m wide intermediate benches at 15 m vertical spacing
Weathered Permian	Maximum 15 m (vertical) face height at 50° (from horizontal) with 5 m wide intermediate benches at 15 m vertical spacing and an 8 m wide bench at top of fresh rock
Fresh Permian overburden, interburden and coal seams	A 15 m wide bench at top of fresh rock then a 70° pre-split face to the floor of D2 seam with a maximum vertical face height of 65 m above the floor of D2 seam A 15 m wide intermediate bench is to be incorporated into the highwall face when 65 m vertical height is exceeded
Non-coal material types from all of above units as feed for waste rock emplacements	Set-back from crest of box cut low wall to toe of waste rock emplacement should be the same as the vertical height from the low wall crest to the D1 or D2 seam floor – whichever is the lower unit being mined Allow 25° angle of repose for Tertiary and 35° for all Permian materials with 20 m maximum vertical height between 10 m wide benches in emplacement

Source: AMCI and Bandanna Energy (2011)

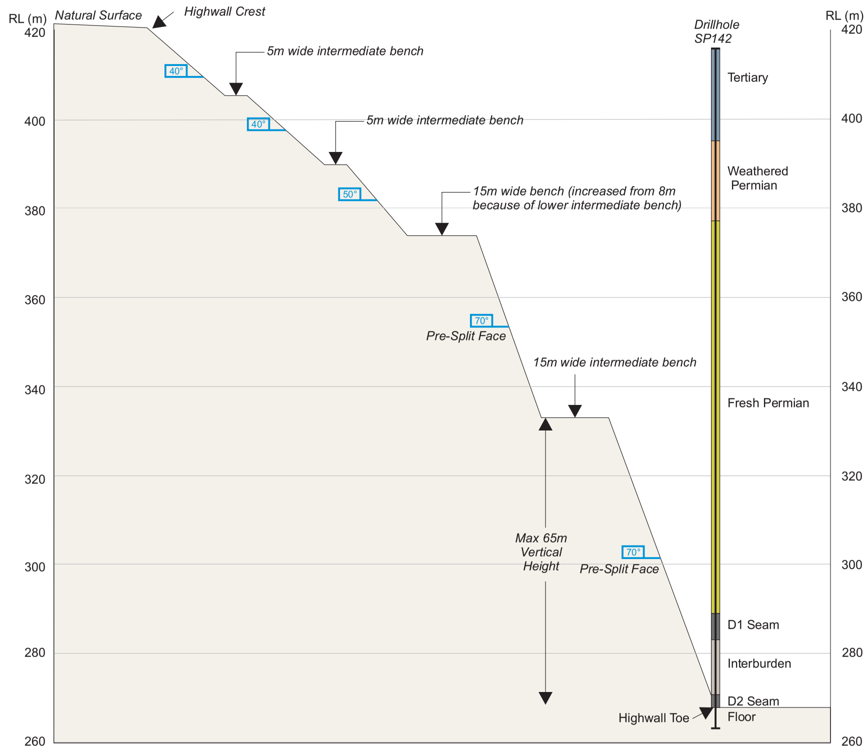
INTERMEDIATE HIGHWALL PROFILE



LOW WALL PROFILE



ULTIMATE HIGHWALL PROFILE



METSERVE Mining & Energy Technical Services Pty Ltd

SouthGalilee COAL PROJECT

Alpha Coal Pty Ltd

South Galilee Coal Project

Low Wall and Highwall Design Profiles

23/08/2012

FIGURE 7-12

7.3.4. Soils

7.3.4.1. Topsoil Management

Topsoil resources directly impacted by mining activities will be stripped ahead of mining for reuse in the rehabilitation program. To maintain the integrity of vegetation in areas adjacent to disturbed areas, appropriate erosion, sediment and dust controls will be established prior to and during soil disturbance.

Prior to stripping the soil, vegetation on areas to be disturbed will be cleared and windrowed. The windrowed material may be retained for fauna habitat, shipped or burned on-site.

Topsoil stripping depths are provided in **Table 7-8**. Where there is variation in recommended stripping depths, detailed field checking will be undertaken prior to stripping to confirm appropriate stripping depth.

Care will be taken to ensure that dispersive clay subsoils are not stripped and mixed with topsoil. Designated topsoil stockpiling areas will be suitably prepared to minimise topsoil losses. Where practicable, topsoil stockpiles will be constructed with dozers in a manner that will minimise compaction and create a rough surface to reduce erosion and maximise storage of rainfall.

The duration of topsoil stockpiling will be minimised where practicable to reduce soil deterioration and weed colonisation. Where stockpiles are to remain in place until the decommissioning phase, they will be sown with an appropriate seed mix to maintain an adequate groundcover.

Topsoil stockpile heights will be kept to a minimum and, depending on topsoil structure, will be no greater than 2 m high mounds, where practicable.

SGCP soils are typically lacking in at least one soil nutrient, so a nitrogen phosphorous-potassium fertiliser and composted organics will be added to topsoil prior to use in rehabilitation.

7.3.4.2. Soil Erosion

The potential impacts of erosion and landform instability include:

- impacts on water quality (suspended solids)
- impacts on surface water channels (sedimentation)
- rehabilitation failure
- loss of structural ability
- compromise of water material capping
- increased infiltration and potential for leaching.

An Erosion and Sediment Control Plan (ESCP) will be developed and implemented prior to the commencement of construction. The ESCP will be developed in accordance with the EPA Guideline—*EPA Best Practice Urban Stormwater Management: Erosion and Sediment Control* and the *Soil Erosion and Sediment Control – Engineering Guidelines for Queensland Construction Sites* (Institute of Engineers Australia (Qld Division) 1996)). The ESCP will contain standard erosion control measures as well as specific measures applicable to particular areas/processes. The ESCP will also detail the monitoring and reporting program for erosion and sediment control structures and practices. An indicative erosion monitoring program is attached to **Appendix J—Soils and Land Suitability Technical Report**.

The standard erosion control measures will include the following:

- major earth works will be scheduled to avoid the high rainfall period of December to March, where practicable
- the following erosion control measures will be implemented for all works that disturb the land surface where slopes exceed 1 %:
    - access and disturbance will be minimised to essential areas only
    - all bare earth areas will be surrounded with a berm to divert upslope stormwater runoff from around the site
    - runoff control devices (e.g. 'whoa boys', berms, temporary sediment fencing, straw bale banks or geotextile socks filled with coarse filter media) will be installed to reduce slope length on access tracks and other disturbed ground
    - stripping and stockpiling of topsoil will be undertaken immediately prior to the commencement of bulk earthworks, where practicable
    - topsoil and subsoil stockpiles will be constructed on the contour and will be protected from runoff with diversion banks (or similar) upslope, and formed with runoff control devices immediately downslope
    - disturbed areas will be rehabilitated following the completion of works, where practicable
    - channels/drains and inlet/outlet works will be designed to convey water at least up to the design peak flow
    - rock filter dams, sediment traps and/or sediment basins will be incorporated into the design of stormwater runoff controls for all major disturbance areas
    - energy dissipaters will be installed at drainage outlets
    - with the exception of stream diversions and diversion drains, all water control structures will be located above the riparian zone.

The ESCP will include specific mitigation measures for areas of dissected terrain, areas with dispersive texture contrast soils, areas with severe subsoil salinity, waste rock emplacements, subsidence areas, borrow pits and minor stream crossings. A summary of these specific measures is provided in **Table 7-12**.

Specific details of water management infrastructure (including sediment control dams, diversions and channels) are provided in **Section 9—Water Resources**.

Table 7-12 Summary of Specific Erosion Controls

Area	Control Measure
Dissected terrain	• exclude these areas from development, where practicable • avoid location of ancillary facilities within this area • minimise the number of access tracks • locate any essential access tracks on gentle grades diagonally across the slope • minimise drainage to line crossings, where practicable • incorporate general all-purpose fertilisers into local topsoil material used as planting media during rehabilitation • implement all erosion control measures applicable to sloping areas with dispersive texture contrast soils (below)
Sloping areas with dispersive texture contrast soils	• avoid inverting the soil or leaving clay subsoil exposed during clearing and/or grubbing • treat any exposed clay subsoil as soon as practicable through amelioration and capping with planting media and/or impermeable material • leave at least 100 mm of undisturbed soil material on top of clay subsoil during grubbing operations • level and lightly compact the land surface as soon as practicable following the completion of clearing/grubbing operations in a manner that spreads runoff water away from the disturbed area • fill any holes with soil material so clay subsoil is not exposed • reshape the land surface on top of pipelines and adjacent service tracks in a manner that spreads runoff water away from the disturbed area • cap pipeline mounds with at least 100 mm of ameliorated topsoil and seed • where pipelines or access tracks are not mounded, reduce slope length by installing runoff control devices at regular intervals (e.g. 'whoa boys', sediment fences, straw bale banks or geotextile socks)
Areas with severe subsoil salinity	• bury excavated subsoils deep or cap with at least 300 mm of suitable topsoil following completion of construction activities • if saline subsoil is required to be stockpiled for a short period, the stockpile will be surrounded with a berm to prevent water running onto the stockpile from further upslope and to detain runoff water within the stockpile area
Waste rock emplacements	• design the final surface topography to adequately control surface water runoff • maximum slope of external batters should be 33 % (1V:3H) • cap emplacement with a minimum of 100 mm of suitable topsoil • if there is insufficient topsoil, mulch with rock fragments of at least 60 mm diameter • revegetate with appropriate plant species

Table 7-12 Summary of Specific Erosion Controls (cont)

Area	Control Measure
Subsidence areas	• rehabilitate areas with significant subsidence-induced surface cracks by ripping to a minimum 300 mm depth, regrading and seeding
Borrow pits	• implement standard erosion control measures and erosion control measures applicable to sloping areas with dispersive texture contrast soils (above) • careful location of borrow pits in dissected terrain • surround any pits that expose saline subsoil with a berm • implement runoff control devices to prevent water running over the cut faces from further upslope and to detain runoff water within the disturbed area • minimise erosion due to rainfall splash by leaving final cut faces as close to vertical as practicable
Minor stream crossings	• stream crossings will avoid sections of active, unstable stream flow with a potential high risk of stream bank erosion • minimise disturbance to stream banks • restabilise crossing points as soon as practicable following disturbance by refilling and slightly compacting, capping with at least 100 mm suitable topsoil and revegetating

Source: **Appendix J—Soils and Land Suitability Technical Report**.

7.3.4.3. Erosion Monitoring

An indicator of landform stability is the extent of soil loss from rehabilitation sites relative to background rates of soil loss. Selected final slopes on rehabilitation sites will be monitored to identify any exceedence of background soil loss rates.

An erosion monitoring program will be implemented and will include the following:

- the monitoring of rainfall and climatic conditions
- regular monitoring of temporary and permanent erosion and sediment control structures during construction, operations and decommissioning
- an assessment of vegetation cover at permanent, representative monitoring locations
- documenting evidence of failure or instability on rehabilitated slopes at permanent, representative monitoring sites
- maintaining photographic records at permanent, representative photographic stations, taken on a regular basis
- reporting as part of annual environmental reporting requirements.

Qualitative surveying (described above) will be undertaken to indicate excessive sediment loss from landforms. If necessary, sediment traps may also be utilised as an indicator of soil loss. Where monitoring identifies the need for corrective action to be implemented, alternative strategies will be investigated with reference to best practice guidance and appropriate industry standards.

7.3.5. Land Contamination

Under the *Environmental Protection Act 1994 (EP Act)*, landholders and Local Government must notify the DEHP that land has been, or is being used for a notifiable activity. Land that has been or is being used for notifiable activities is recorded on the EMR, which is maintained by the DEHP.

A number of activities associated with the SGCP will be classified as notifiable activities under Schedule 3 of the *EP Act*. The Proponent has a duty to notify the DEHP should potentially contaminating activities be carried out on-site.

The potential land contamination risks associated with the SGCP include:

- storage and use of fuel and chemicals
- landfill
- waste rock and reject handling and storage.

The above activities proposed at the SGCP pose a limited risk of contamination for the following reasons:

- all chemicals and fuels will be appropriately stored in accordance with relevant Australian Standards
- facilities and procedures will be implemented to minimise the risk of land contamination and appropriately manage wastes at the SGCP (refer to **Section 13—Waste**).

Waste rock geochemistry and potential for contamination from the waste rock emplacements is discussed in **Section 7.3.3.2** and **Section 13—Waste**.

Waste management measures will be implemented to minimise the risk of land contamination at the site, as described in **Section 13—Waste**. Waste management will aim to promote sustainable waste management practices in accordance with the *Waste Reduction and Recycling Act 2011*.

Strategies for the prevention of land contamination due to the storage, spillage or disposal of hazardous materials will include:

- where practicable, hazardous chemicals will be replaced with less harmful alternatives
- Material Safety Data Sheets (MSDS) for all chemicals used on-site will be kept in a central register and be available to all staff at all times
- construction of appropriate spill containment facilities for all areas where process reagents and petroleum products are stored and used
- establishing and maintaining a register of location and quantities of hazardous substances including their storage, use and disposal, which will be updated annually

- training of operators and implementation of safe work practices for minimising the risk of spillage
- induction of employees and contractors including environmental protection responsibilities
- validation sampling of any remediated area to establish the site as uncontaminated as per the *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*
- preparation of a site map detailing the location of all potential contamination sources and sites that could potentially become contaminated
- development of remediation plans for any contaminated sites. The plans will be dependent on the contaminant type and contaminant levels. The remediation plan will include the details of the contaminated land investigation that form the basis of the remediation plan
- emergency plans in the event of a spill.

The key planning document to prevent or minimise land contamination will be the Waste Management Plan. Following completion, remediation and rehabilitation of the SGCP, no areas within MLA 70453 are anticipated to require inclusion on the CLR.

7.3.6. Scenic Amenity and Lighting

7.3.6.1.1. Impact Generators

The visual elements that require assessment are the:

- open-cut mining areas
- waste rock emplacements
- coal handling, stockpiling and processing areas
- accommodation village
- mine lighting requirements
- rail loop
- associated ancillary infrastructure
- infrastructure corridor
- mine rehabilitation areas.

Considering all views of notable sensitivity are a considerable distance from the SGCP, the primary features likely to impact on scenic amenity of the SGCP area are the proposed waste rock emplacements. The majority of sensitive views towards the waste rock emplacements are screened by topography and vegetation and therefore the impact of the waste rock emplacements is reduced.

Direct lighting is unlikely to be visible outside of the SGCP, however indirect lighting or the flow from the operations at night is likely to be visible from a number of viewpoints. The lighting associated with the SGCP mine site is likely to comprise:

- flood lighting for active operational areas
- lighting on conveyors
- lighting on work areas (e.g. CHPP and workshops)
- elevated flood lighting in the vicinity of the active waste rock emplacements
- vehicle lights.

The post-mining rehabilitation objective is to rehabilitate above ground disturbance areas to a native bushland use or grazing where practicable. This approach will result in the waste rock emplacement having a similar appearance to the existing undulating landform and will blend in with the surrounding landscape to some degree. The only residual disturbance will comprise the final void, which is unlikely to be visible from ground level outside MLA 70453.

7.3.6.2. Scenic Amenity

In order to determine the likely visual impacts on the primary sensitive receptors, a number of photoview simulations were undertaken from representative viewpoints. The representative viewpoints utilised for the simulations were:

- Betanga homestead
- Chesalon homestead
- Creek Farm homestead
- Oakleigh homestead.

The location of these viewpoints is provided on **Figure 7-13** to **Figure 7-24**.

The view from the Betanga homestead was taken from the front of the homestead. In the foreground of the view is a powerline, stockyards and scattered vegetation. The horizon line is partially obscured by vegetation.

The view from the Chesalon homestead is largely obscured by vegetation.

The view from the Creek Farm homestead is taken from the western side of the homestead. The view towards the SGCP is largely obscured by vegetation.

The view from the Oakleigh homestead towards the SGCP is taken from the southern side of the homestead looking towards the SGCP. The foreground of the view contains stockyards and a stand of trees. The horizon line is obscured by dense vegetation.

Views from the remaining Primary Viewpoints are considered to be influenced by the SGCP to a similar/lesser extent than those selected for the simulations.

Figure 7-13 - Photoview Simulation, Existing Conditions
Betanga Homestead

South Galilee Coal Project, Queensland
View looking south-east to SGCP from Betanga homestead
View Location 013 - Betanga
Existing Conditions, photographed 17 May 2011

Prepared 7 November 2011

S:\Projects\AM001 Sth Galilee EIS_MapInfo\Workspaces\Section 7 - Land\AM001_M438.CDR

Figure 7-14 - Photoview Simulation, Year 15
Betanga Homestead

S:\Projects\AM001 Sth Galilee EIS_MapInfo\Workspaces\Section 7 - Land\AM001_M438.CDR

S:\Projects\AM001 Sth Galilee EIS_MapInfo\Workspaces\Section 7 - Land\AM001_M438.CDR

Figure 7-16 - Photoview Simulation, Existing Conditions
Chesalon Homestead

METSERVE Mining & Energy Technical Services Pty Ltd

South Galilee Coal Project, Queensland
View looking north-west to SGCP from Chesalon homestead
View Location 103 - Chesalon
Existing Conditions, photographed 19 May 2011

Prepared 7 November 2011

SouthGalilee COAL PROJECT

S:\Projects\AM001 Sth Galilee EIS_MapInfo\Workspaces\Section 7 - Land\AM001_M439 Chesalon Homestead.CDR

Figure 7-17 - Photoview Simulation, Year 15
Chesalon Homestead

S:\Projects\AM001 Sth Galilee EIS_MapInfo\Workspaces\Section 7 - Land\AM001_M439 Chesalon Homestead.CDR

Figure 7-18 - Photoview Simulation, Year 33
Chesalon Homestead

S:\Projects\AM001 Sth Galilee EIS_MapInfo\Workspaces\Section 7 - Land\AM001_M439 Chesalon Homestead.CDR

S:\Projects\AM001 Sth Galilee EIS_MapInfo\Workspaces\Section 7 - Land\AM001_M440 Creek Farm Homestead.CDR

S:\Projects\AM001 Sth Galilee EIS_MapInfo\Workspaces\Section 7 - Land\AM001_M440 Creek Farm Homestead.CDR

Figure 7-21 - Photoview Simulation, Year 33
Creek Farm Homestead

S:\Projects\AM001 Sth Galilee EIS_MapInfo\Workspaces\Section 7 - Land\AM001_M440 Creek Farm Homestead.CDR

Figure 7-22 - Photoview Simulation, Existing Conditions
Oakleigh Homestead

METSERVE
Mining & Energy Technical Services Pty Ltd

South Galilee Coal Project, Queensland
View towards closest part of infrastructure and SGCP from Oakleigh homestead
View Location 043 - Oakleigh
Existing Conditions, photographed 17 May 2011

Prepared 7 November 2011

SouthGalilee
COAL PROJECT

S:\Projects\AM001 Sth Galilee EIS_MapInfo\Workspaces\Section 7 - Land\AM001_M441 Oakleigh Homestead.CDR

Figure 7-23 - Photoview Simulation, Year 15
Oakleigh Homestead

South Galilee Coal Project, Queensland
View towards closest part of infrastructure and SGCP from Oakleigh homestead
View Location 043 - Oakleigh
3D overlay showing Proposed Conditions - Year 15

Prepared 7 November 2011

S:\Projects\AM001 Sth Galilee EIS_MapInfo\Workspaces\Section 7 - Land\AM001_M441 Oakleigh Homestead.CDR

Figure 7-24 - Photoview Simulation, Year 33
Oakleigh Homestead

METSERVE Mining & Energy Technical Services Pty Ltd

South Galilee Coal Project, Queensland
View towards closest part of infrastructure and SGCP from Oakleigh homestead
View Location 043 - Oakleigh
3D overlay showing Proposed Conditions - Year 33

Prepared 7 November 2011

SouthGalilee COAL PROJECT

S:\Projects\AM001 Sth Galilee EIS_MapInfo\Workspaces\Section 7 - Land\AM001_M441 Oakleigh Homestead.CDR

The photoview simulations from the Betanga, Chesalon, Creek Farm and Oakleigh homesteads are provided in **Figure 7-13** to **Figure 7-24**. The photoviews provide a representation of existing conditions followed by a simulation of the photoview at Year 15 and Year 33.

Based purely on elevation and orientation (derived from the digital elevation model (DEM) for the Project), at Year 33 the Betanga Homestead will potentially have views to the infrastructure corridor, parts of the on-site rail and several topsoil stockpiles north of the on-site rail. However, these views will be screened by the intervening vegetation and topographical features and the sensitivity will be greatly reduced by through distance (refer to **Figure 7-13, Figure 7-14, Figure 7-15** and **Figure 7-25**).

As shown on **Figure 7-16, Figure 7-17, Figure 7-18** and **Figure 7-26**, at Year 33 the Chesalon Homestead is not predicted to have any views of the SGCP surface disturbance areas.

As shown on **Figure 7-19, Figure 7-20, Figure 7-21** and **Figure 7-27**, at Year 33 the Creek Farm Homestead is not predicted to have any views of the SGCP.

Although based on the DEM at Year 33, the Oakleigh Homestead is predicted to have views of the southern portion of the infrastructure corridor (**Figure 7-28**), in reality, these potential views will be screened by thick intervening vegetation (**Plate 7-3**). The Oakleigh Homestead is not predicted to have views of any SGCP visual elements within MLA 70453 (refer to **Figure 7-22**).

Plate 7-3 View Towards Infrastructure Corridor from Oakleigh Homestead

It is evident that there are no significant scenic amenity impacts at these Primary Viewpoints.

7.3.6.3. Landscape Character and Scenic Amenity

The existing scenic amenity value of the SGCP in the context of the surrounding region is considered low-moderate (common) given the lack of any significant or unusual visual elements and the large areas of land throughout Central Queensland that display similar landscape characteristics. There is substantial evidence of alteration to natural features resulting from agriculture. Therefore, the views are not considered to be pristine.

Views of agriculture and mining activities may appeal to some parts of the community and not to others. While in visual assessments, these activities are generally accepted as reducing the landscape character and scenic amenity, to some people they may increase these values. The limited views towards the SGCP from public vantage points may appeal to these people.

The proposed final landforms associated with the SGCP are similar in landscape character to the existing undulating nature of the regional landscape. However, given that there are currently no large-scale mining operations in the Galilee Basin, the impact of the SGCP on landscape character is expected to be moderate-high. Measures to shape and contour the final landform are described in **Section 5—Rehabilitation and Decommissioning**. Mitigation measures are described in **Section 7.3.6.5**.

7.3.6.4. Visual Impact

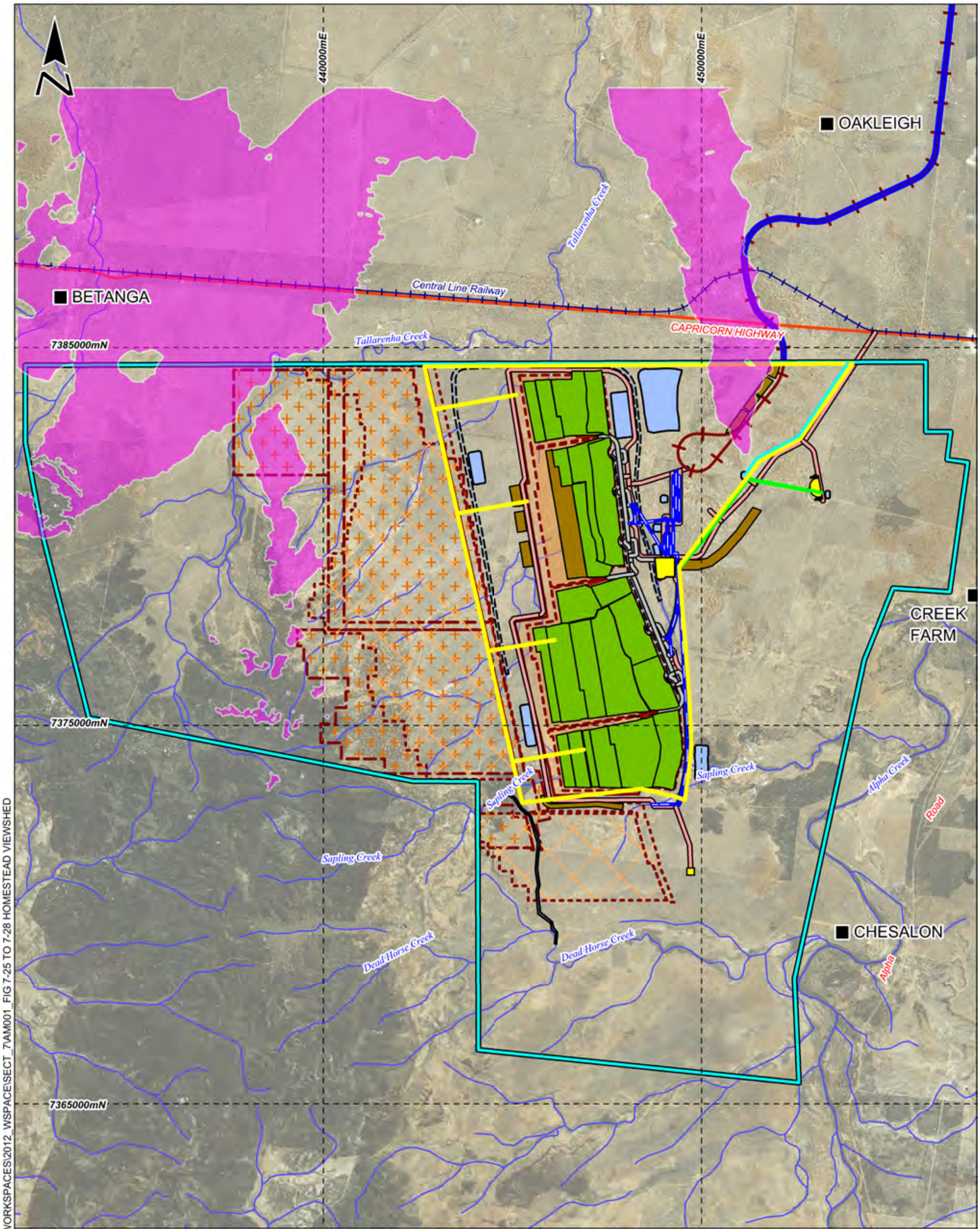
To assess the magnitude of the visual impact of the SGCP on the visual resource both on its own and from a cumulative perspective, five main factors were considered, namely visual intrusion, visibility, exposure, sensitivity and lighting.

7.3.6.4.1. Visual Intrusion

The SGCP has been assessed on the nature of its likely intrusion (physical characteristics) on the visual quality of the surrounding environment and its compatibility/discord with the landscape and surrounding use. Intrusion includes both the removal of existing visible landscape features and the creation of new ones.

The SGCP operations will involve the construction of waste rock emplacements that will become new elevated landforms in addition to the local landscape. The waste rock emplacements are likely to be visible in some parts of the local area and along some sections of the surrounding network.

The primary rehabilitation objective for the site upon decommissioning is to return areas disturbed by mining activities to self-sustaining native vegetation and/or grazing, in accordance with the land suitability objectives. The rehabilitation of areas disturbed by activities associated with the SGCP will be progressively undertaken as described in **Section 5—Rehabilitation and Decommissioning** and will involve the removal of infrastructure upon completion of mining. Some infrastructure may remain at the request of landowners (e.g. roads, dams).



S:\PROJECTS\AM001 STH GALILEE EIS_MAPINFO\WORKSPACES\2012_WSPACE\SECT_7\AM001_FIG 7-25 TO 7-28 HOMESTEAD VIEWSHED

METSERVE Mining & Energy Technical Services Pty Ltd

SouthGalilee

LEGEND

- MLA70453
- Infrastructure corridor
- Principal road
- River / Creek

Viewshed

- View from homestead

Mining Activity

- Open pit
- Waste rock emplacement
- D1 underground mining area
- D2 underground mining area

Infrastructure

- Facility area
- Stream diversion
- Drainage channel
- Water storage dam
- Topsoil stockpile
- Topsoil spreading & rehabilitation
- Heavy vehicle road
- Light vehicle road
- On-site rail component
- Coal & rejects conveyor

Utilities

- 66kV overhead power line
- 11kV overhead power line
- Raw water pipeline

Alpha Coal Pty Ltd

South Galilee Coal Project

Viewshed from Betanga Homestead - Year 33

2.5 0 2.5

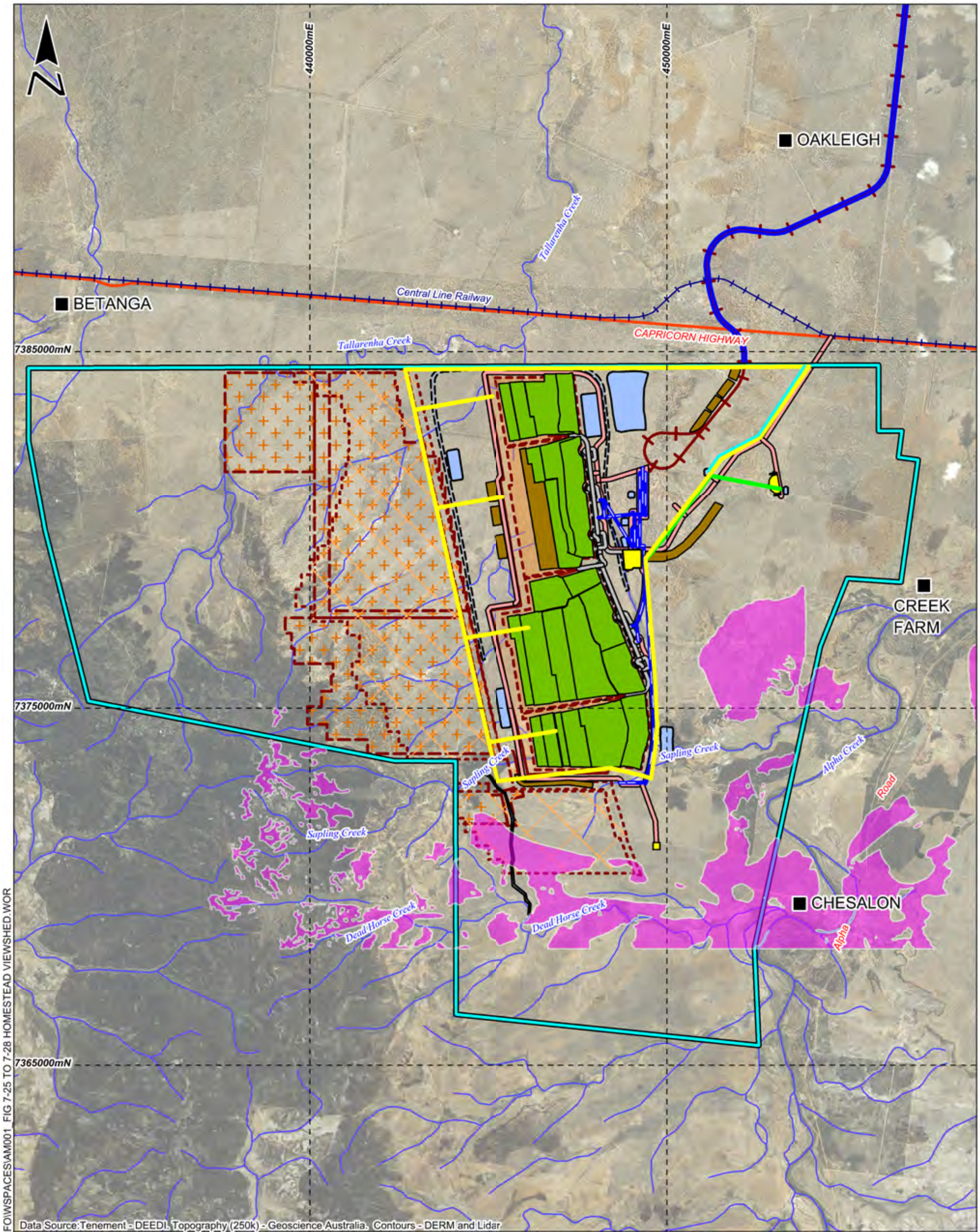
Kilometres

Scale: 1:150,000 (A4)

08/21/2012

Proj. : MGA Z55
Datum: GDA 1994

FIGURE 7-25



S:\PROJECTS\AM001_STH_GALILEE\EIS\GIS_MAPINFO\WSPACES\AM001_FIG 7-25 TO 7-28 HOMESTEAD VIEWSHED.WOR

METSERVE Mining & Energy Technical Services Pty Ltd

SouthGalilee COAL PROJECT

LEGEND
- MLA70453
- Infrastructure corridor
- Principal road
- River / Creek

Viewshed
- View from homestead

Mining Activity
- Open pit
- Waste rock emplacement
- D1 underground mining area
- D2 underground mining area

Infrastructure
- Facility area
- Stream diversion
- Drainage channel
- Water storage dam
- Topsoil stockpile
- Topsoil spreading & rehabilitation
- Heavy vehicle road
- Light vehicle road
- On-site rail component
- Coal & rejects conveyor

Utilities
- 66kV overhead power line
- 11kV overhead power line
- Raw water pipeline

Alpha Coal Pty Ltd

South Galilee Coal Project

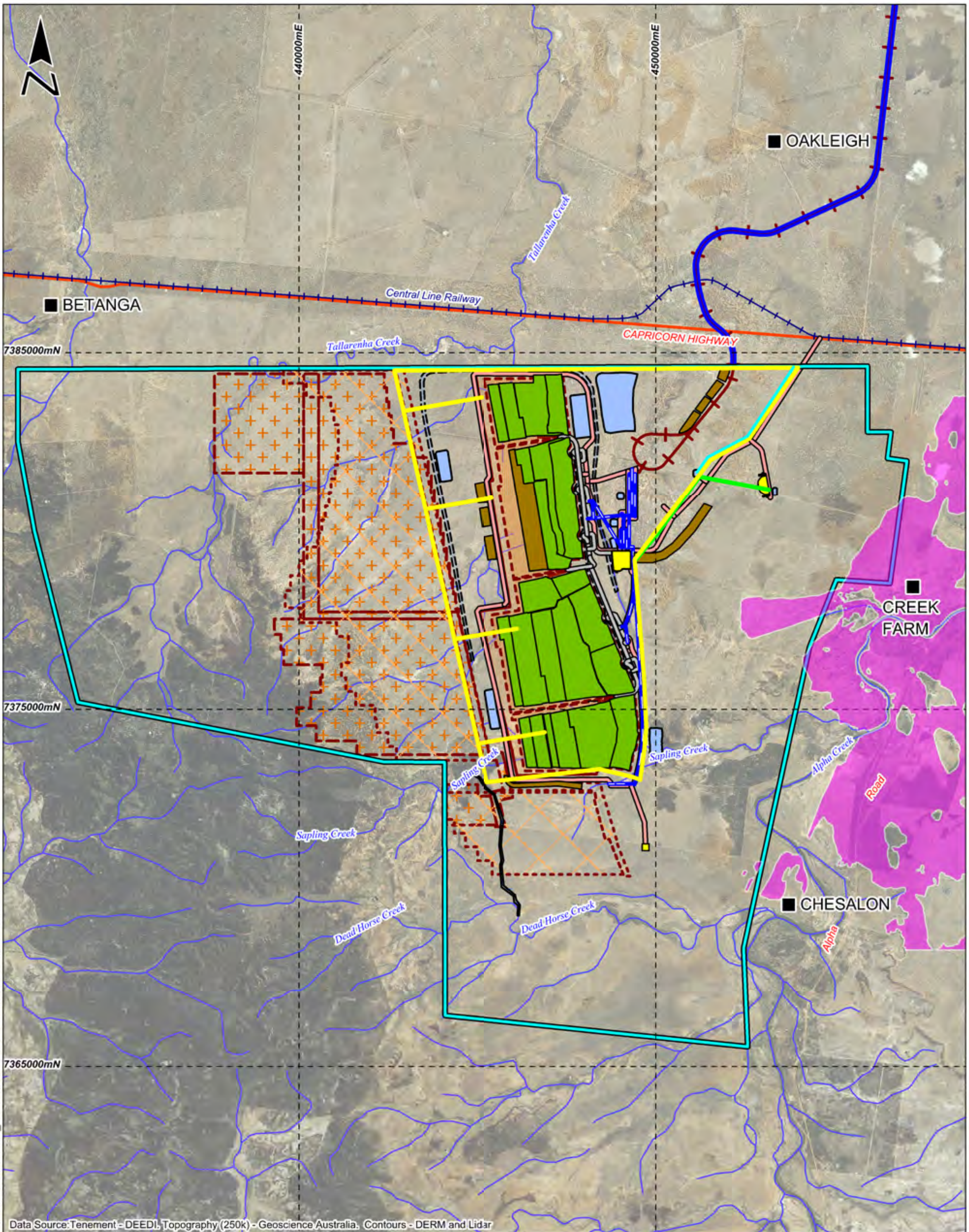
Viewshed from Chesalon Homestead Year 33

2.5 0 2.5
Kilometres
Scale: 1:150,000 (A4)

08/20/2012

Proj. : MGA Z55
Datum: GDA 1994

FIGURE 7-26



LEGEND

- MLA70453
- Infrastructure corridor
- Principal road
- River / Creek

Viewshed

- View from homestead

Mining Activity

- Open pit
- Waste rock emplacement
- D1 underground mining area
- D2 underground mining area

Infrastructure

- Facility area
- Stream diversion
- Drainage channel
- Water storage dam
- Topsoil stockpile
- Topsoil spreading & rehabilitation
- Heavy vehicle road
- Light vehicle road
- On-site rail component
- Coal & rejects conveyor

Utilities

- 66kV overhead power line
- 11kV overhead power line
- Raw water pipeline

METSERVE Mining & Energy Technical Services Pty Ltd

SouthGalilee COAL PROJECT

Alpha Coal Pty Ltd

South Galilee Coal Project

Viewshed from Creek Farm Homestead
Year 33

2.5 0 2.5
Kilometres

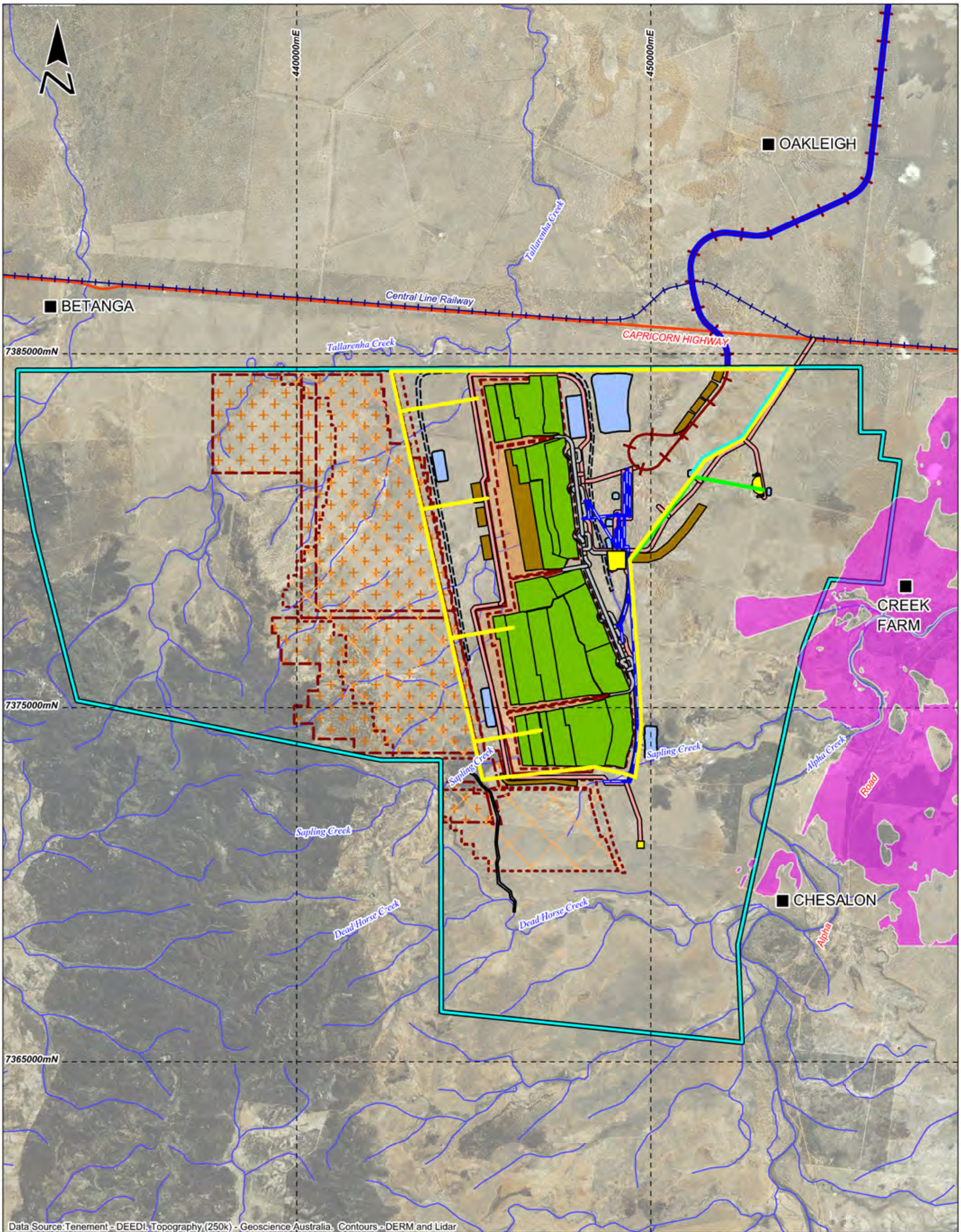
Scale: 1:150,000 (A4)

08/20/2012

Proj. : MGA Z55
Datum: GDA 1994

FIGURE 7-27

S:\PROJECTS\AM001_STH_GALILEEEIS\GIS_MAPINFO\WSPACES\AM001_FIG 7-25 TO 7-28 HOMESTEAD VIEWSHED.WOR



S:\PROJECTS\AM001_STH_GALILEE\EIS\GIS_MAPINFO\WSPACES\AM001_FIG 7-25 TO 7-28 HOMESTEAD VIEWSHED.WOR

LEGEND

- MLA70453
- Infrastructure corridor
- Principal road
- River / Creek

Viewshed
- View from homestead

Mining Activity
- Open pit
- Waste rock emplacement
- D1 underground mining area
- D2 underground mining area

Infrastructure
- Facility area
- Stream diversion
- Drainage channel
- Water storage dam
- Topsoil stockpile
- Topsoil spreading & rehabilitation
- Heavy vehicle road
- Light vehicle road
- On-site rail component
- Coal & rejects conveyor

Utilities
- 66kV overhead power line
- 11kV overhead power line
- Raw water pipeline

METSERVE

SouthGalilee

Alpha Coal Pty Ltd

South Galilee Coal Project

Viewshed from Oakleigh Homestead
Year 33

2.5 0 2.5
Kilometres

Scale: 1:150,000 (A4)

25/07/2012

Proj. : MGA Z55
Datum: GDA 1994

FIGURE 7-28

The rehabilitated waste rock emplacements will be generally consistent with the existing disturbed and undulating landform. Consequently, residual visual intrusion is assessed as low as few features in the landscape will change, and the proportion of the existing view that will change is very low. No sensitive receptors will be significantly affected by the change in the view. Progressive rehabilitation of the waste rock emplacements will also minimise adverse visual impacts throughout the mine life.

7.3.6.4.2. Visibility

As demonstrated in the photoview simulations (refer to **Figure 7-13** to **Figure 7-24**), the waste rock emplacements and other physical features of the SGCP will not be visible from the sensitive receptors within the local area. Whilst there may be vantage points from within the properties surrounding the SGCP that enable clear views towards the SGCP, these locations are considered to have very low sensitivity and as such, are unlikely to be impacted by the SGCP. Similarly, views from the surrounding road network have low sensitivity and are unlikely to be significantly impacted by the SGCP.

7.3.6.4.3. Exposure and Sensitivity

Visual exposure relates to the distance of the view (i.e. it is recognised that the impact of an object diminishes as the distance from the observer increases). The visual sensitivity of the Primary Viewpoints is assessed as ranging from low to high as the most sensitive receptors considered in this assessment are the residences in the areas of the proposed mining activities. The Primary Viewpoints are located between 0.3 and 16 km of the SGCP, and the views are largely screened by vegetation and intervening landforms.

The visual sensitivity of the Secondary Viewpoints is assessed as ranging from low to medium. The Secondary Viewpoints are located between 2 and 16 km of the SGCP, and the views are largely screened by vegetation and intervening landforms.

The impact significance on visual exposure is regarded as low as views towards the SGCP will generally be distant. Where views towards the SGCP are obtained at a short distance (primarily from the surrounding properties and within the mine operations) the impacts are likely to be low due to the low sensitivity of the view and the short duration of the views. Therefore potential impacts on places of work are expected to be low.

7.3.6.4.4. Lighting Impacts

Mining operations at the SGCP will be also undertaken at night. Therefore, lighting associated with operational areas is likely to be visible at night as a glow in the sky. While no significant direct impacts to sensitive viewpoints is predicted, mitigating measures such as retention or planting of vegetation between sensitive viewpoints and the mine will be assessed for effectiveness to minimise any lighting impact if complaints are received.

The waste rock emplacements and associated infrastructure are likely to be the most obvious elements of the SGCP, with lighting on the waste rock emplacements visible at night from some viewpoints. Lighting on the waste rock emplacements will be minimised to that required for safe operations. As described in **Section 7.3.6.5**, effective lighting strategies will be implemented on elevated infrastructure to ensure safe working environments and minimise light spillage to surrounding homesteads.

Artificial lighting regimes can result in changed habitat conditions for nocturnal fauna and associated impacts. Fauna known from within MLA 70453 that may be potentially affected by lighting associated with SGCP activities are nocturnal birds, reptiles and microbat species (refer to **Appendix N—Terrestrial Ecology Technical Report**). Artificial lighting tends to attract insects, and may therefore increase foraging opportunities for some nocturnal insectivores (e.g. microbats). All of these species are highly mobile and have abundant habitat outside of the proposed disturbance area. The potential impacts of lighting on fauna will be minimised by directing lights away from fauna habitats, where practicable.

The potential impacts of increased vehicle lighting are not expected to be significant as the sensitive receptors have limited exposure to the transport routes to be utilised by the SGCP. Therefore the increases in traffic are unlikely to have a significant impact on amenity.

The handling of coal product at the port facility is unlikely to have a significant impact on amenity surrounding the port. The sensitivity to additional industrial activity in the already heavily industrialised port area is likely to be low. Matters related to the port facility are subject to a separate approvals process.

7.3.6.5. Scenic Amenity Impacts Mitigation and Management

The magnitude of impact or degree of change as a consequence of the proposed activities associated with the SGCP is expected to be low to moderate due to the presence of limited vantage points providing views of the SGCP infrastructure. The magnitude of impact on decommissioning is regarded as low and beneficial due to vegetative rehabilitation and the creation of a final landform that will conform to the existing undulating landscape and the establishment of native vegetation in a sparsely vegetated area.

The primary indirect impact will be lighting from the mine infrastructure, particularly in the vicinity of the active waste rock emplacements. Lighting impacts at sensitive receptors are likely to be associated with a ‘glow’ from the operation rather than direct light impacts.

Where direct light impacts could potentially occur, appropriate mitigation measures will be implemented, including the installation of light fixtures in accordance with *AS 4282:1997 Control of the obtrusive effects of outdoor lighting*. This Australian Standard provides strategies to reduce light spillage beyond the immediate surrounds of the working area. For example, a screen or louvre attached to the light fitting to control light flux for all angles above 10 degrees below the horizontal will effectively reflect light onto the ground and improve lighting levels.

Other mitigation measures to reduce impacts on the visual amenity of the area include:

- use of high pressure sodium lights where practicable
- consideration of appropriate colour selection and finishes for mine infrastructure to reduce visual contrast
- dust suppression
- consideration of the orientation of lighting emitting infrastructure
- establishment of buffer vegetation between the proposed new surface infrastructure and sensitive receptors
- retaining existing vegetation on-site wherever practicable.

Based on the above assessment, the SGCP is assessed as having a low to moderate visual impact on the surrounding area.

7.3.7. Cumulative Impacts

The SGCP site and the locality have primarily been used for grazing and much of the SGCP site will be suitable for grazing post mining. The post mining land use is proposed to comprise a mosaic of self-sustaining vegetation communities and grazing land, using appropriate native tree, shrub and grass species, and improved pasture species where suitable.

The cumulative impacts on land use in the region will be relatively high during mining operations; however, for the end of mine life, the majority of mines have a rehabilitation plan that includes grazing and native vegetation in various proportions. While there will be changes in the land use and reductions in land suitability during mining, once mine decommissioning is completed and as much land as practicable is returned to the pre-existing land use, the final cumulative impact will be significantly reduced.

The cumulative impact on visual amenity is difficult to quantify. The region has few significant visual elements and there are large areas of land in Central Queensland that display similar landscape characteristics. While mining has definite visual impacts, how an individual perceives these impacts can vary significantly.

The cumulative impact of the SGCP, when added to the visual impact of the proposed mines in the surrounding region, is minimal.

Due to the mitigation and management measures proposed for the SGCP, cumulative impacts on final land use, land contamination and scenic amenity are not expected to increase significantly.

ANNEXURE A QUEENSLAND CONTAMINATED LAND REGISTER AND ENVIRONMENTAL MANAGEMENT REGISTER SEARCH RESULTS

Level 8, 400 George St • Brisbane, Queensland • GPO Box 2454 • Brisbane • QLD 4001 • AUSTRALIA
Telephone (07) 3330 5685 • Facsimile (07) 3330 5754 •
www.derm.qld.gov.au/environmental_management/land/contaminated_land

SEARCH RESPONSE
ENVIRONMENTAL MANAGEMENT REGISTER (EMR)
CONTAMINATED LAND REGISTER (CLR)

Jessie Keast
PO 306
Fortitude Valley Post Office
Fortitude Valley QLD 4006

Transaction ID: 1320305 EMR Site Id: 15 June 2011
Cheque Number:
Client Reference: 15429277

This response relates to a search request received for the site:
Lot: 7 Plan: BF57
null CAPRICORN HIGHWAY
DRUMMONDSLOPE

EMR RESULT

The above site is NOT included on the Environmental Management Register.

CLR RESULT

The above site is NOT included on the Contaminated Land Register.

ADDITIONAL ADVICE

EMR/CLR Searches may be conducted online through www.smartservice.qld.gov.au or Citec Confirm www.confirm.com.au.

If you have any queries in relation to this search please phone (07) 3330 5685.

Darryl Byers
Registrar, Contaminated Land Unit

Queensland Government

Level 8, 400 George St • Brisbane, Queensland • GPO Box 2454 • Brisbane • QLD 4001 • AUSTRALIA
Telephone (07) 3330 5685 • Facsimile (07) 3330 5754 •
www.derm.qld.gov.au/environmental_management/land/contaminated_land

SEARCH RESPONSE
ENVIRONMENTAL MANAGEMENT REGISTER (EMR)
CONTAMINATED LAND REGISTER (CLR)

Jessie Keast
PO 306
Fortitude Valley Post Office
Fortitude Valley QLD 4006

Transaction ID: 1320306 EMR Site Id: 15 June 2011
Cheque Number:
Client Reference: 15429277

This response relates to a search request received for the site:
Lot: 4315 Plan: PH720
null NO STREET ADDRESS
UNABLE TO VALIDATE (SEARCH MAY PROCEED)

EMR RESULT

The above site is NOT included on the Environmental Management Register.

CLR RESULT

The above site is NOT included on the Contaminated Land Register.

ADDITIONAL ADVICE

EMR/CLR Searches may be conducted online through www.smartservice.qld.gov.au or Citec Confirm www.confirm.com.au.

If you have any queries in relation to this search please phone (07) 3330 5685.

Darryl Byers
Registrar, Contaminated Land Unit

Level 8, 400 George St • Brisbane, Queensland • GPO Box 2454 • Brisbane • QLD 4001 • AUSTRALIA
Telephone (07) 3330 5685 • Facsimile (07) 3330 5754 •
www.derm.qld.gov.au/environmental_management/land/contaminated_land

SEARCH RESPONSE
ENVIRONMENTAL MANAGEMENT REGISTER (EMR)
CONTAMINATED LAND REGISTER (CLR)

Jessie Keast
PO 306
Fortitude Valley Post Office
Fortitude Valley QLD 4006

Transaction ID: 1320307 EMR Site Id: 15 June 2011
Cheque Number:
Client Reference: 15429277

This response relates to a search request received for the site:
Lot: 31 Plan: BF11
null NO STREET ADDRESS
UNABLE TO VALIDATE (SEARCH MAY PROCEED)

EMR RESULT

The above site is NOT included on the Environmental Management Register.

CLR RESULT

The above site is NOT included on the Contaminated Land Register.

ADDITIONAL ADVICE

EMR/CLR Searches may be conducted online through www.smartservice.qld.gov.au or Citec Confirm www.confirm.com.au.

If you have any queries in relation to this search please phone (07) 3330 5685.

Darryl Byers
Registrar, Contaminated Land Unit

Queensland Government

Level 8, 400 George St • Brisbane, Queensland • GPO Box 2454 • Brisbane • QLD 4001 • AUSTRALIA
Telephone (07) 3330 5685 • Facsimile (07) 3330 5754 •
www.derm.qld.gov.au/environmental_management/land/contaminated_land

SEARCH RESPONSE
ENVIRONMENTAL MANAGEMENT REGISTER (EMR)
CONTAMINATED LAND REGISTER (CLR)

Jessie Keast
PO 306
Fortitude Valley Post Office
Fortitude Valley QLD 4006

Transaction ID: 1320308 EMR Site Id: 15 June 2011
Cheque Number:
Client Reference: 15429277

This response relates to a search request received for the site:
Lot: 3 Plan: BF53
null NO STREET ADDRESS
UNABLE TO VALIDATE (SEARCH MAY PROCEED)

EMR RESULT

The above site is NOT included on the Environmental Management Register.

CLR RESULT

The above site is NOT included on the Contaminated Land Register.

ADDITIONAL ADVICE

EMR/CLR Searches may be conducted online through www.smartservice.qld.gov.au or Citec Confirm www.confirm.com.au.

If you have any queries in relation to this search please phone (07) 3330 5685.

Darryl Byers
Registrar, Contaminated Land Unit

Queensland Government

Level 8, 400 George St • Brisbane, Queensland • GPO Box 2454 • Brisbane • QLD 4001 • AUSTRALIA
Telephone (07) 3330 5685 • Facsimile (07) 3330 5754 •
www.derm.qld.gov.au/environmental_management/land/contaminated_land

SEARCH RESPONSE
ENVIRONMENTAL MANAGEMENT REGISTER (EMR)
CONTAMINATED LAND REGISTER (CLR)

Jessie Keast
PO 306
Fortitude Valley Post Office
Fortitude Valley QLD 4006

Transaction ID: 1320309 EMR Site Id: 15 June 2011
Cheque Number:
Client Reference: 15429277

This response relates to a search request received for the site:
Lot: 1 Plan: DM3
null NO STREET ADDRESS
UNABLE TO VALIDATE (SEARCH MAY PROCEED)

EMR RESULT

The above site is NOT included on the Environmental Management Register.

CLR RESULT

The above site is NOT included on the Contaminated Land Register.

ADDITIONAL ADVICE

EMR/CLR Searches may be conducted online through www.smartservice.qld.gov.au or Citec Confirm www.confirm.com.au.

If you have any queries in relation to this search please phone (07) 3330 5685.

Darryl Byers
Registrar, Contaminated Land Unit

Level 8, 400 George St • Brisbane, Queensland • GPO Box 2454 • Brisbane • QLD 4001 • AUSTRALIA
Telephone (07) 3330 5685 • Facsimile (07) 3330 5754 •
www.derm.qld.gov.au/environmental_management/land/contaminated_land

SEARCH RESPONSE
ENVIRONMENTAL MANAGEMENT REGISTER (EMR)
CONTAMINATED LAND REGISTER (CLR)

Jessie Keast
PO 306
Fortitude Valley Post Office
Fortitude Valley QLD 4006

Transaction ID: 1320310 EMR Site Id: 15 June 2011
Cheque Number:
Client Reference: 15429277

This response relates to a search request received for the site:
Lot: 1160 Plan: PH286
null NO STREET ADDRESS
UNABLE TO VALIDATE (SEARCH MAY PROCEED)

EMR RESULT

The above site is NOT included on the Environmental Management Register.

CLR RESULT

The above site is NOT included on the Contaminated Land Register.

ADDITIONAL ADVICE

EMR/CLR Searches may be conducted online through www.smartservice.qld.gov.au or Citec Confirm www.confirm.com.au.

If you have any queries in relation to this search please phone (07) 3330 5685.

Darryl Byers
Registrar, Contaminated Land Unit

SEEDSMAN GEOTECHNICS PTY LTD

ACN 082 109 082
Telephone 0417279556
Facsimile 0248722535

SOUTH GALILEE COAL PROJECT

LIFE OF MINE SUBSIDENCE DEFORMATIONS

metservesgcp-01 MARCH 2012

SEEDSMAN GEOTECHNICS PTY LTD

ACN 082 109 082
Telephone 0417279556
Facsimile 0248722535

Wednesday, 28 March 2012

REF: metservesgcp-01

Mr R Currie
Senior Consultant – Environment
Metserve
PO Box 306
Fortitude Valley QLD 4006

Dear Russell,

Re: Subsidence – South Galilee Coal Project

We are pleased to submit this report outlining subsidence prediction methods and our assessment of the likely subsidence to develop above the proposed longwall concept plans for the South Galilee Coal Project. Digital files of the predicted subsidence have been forwarded electronically.

Please contact the undersigned if you require further details.

Yours truly

Ross Seedsman

EXECUTIVE SUMMARY

This report addresses the modelled subsidence deformations predicted to develop above the proposed South Galilee Coal Project longwall mining area. It is understood that the conceptual longwall plan is based on limited specific geological and geotechnical information and provides an indication of a plan that will achieve maximum resource recovery.

Longwall extraction at the South Galilee Coal Project (SGCP) is proposed to extract both the D1 and D2 seams. At this early stage of concept planning, the longwall extraction voids are 360m wide with intervening chain pillar widths of 25m. The depth of cover to the D1 seam ranges from 50m to 240m. The D2 seam lies 12-15m below th3e D1 Seam

Subsidence engineering is based primarily on back analysis of subsidence outcomes in similar rock masses. As this information is not available for the Galilee Basin, the predictions are based on experience in the Bowen Basin which is assessed to be adequately similar. There is very little information available on the subsidence above multiple seam extraction so a greater level of engineering judgement is required for this aspect.

For the D1 seam in isolation, the maximum vertical subsidence is 2.55m, the maximum tilt is 78 mm/m, and the maximum strains are 24 mm/m. For the D2 seam in isolation, the values are 1.5m, 44mm/m and 14 mm/m respectively. For the combined layout of both the D1 and D2 seams, the predicted maximum vertical subsidence is 4.2m, the maximum tilt is 112 mm/m, and the maximum strain is 35 mm/m (tensile or compressive).

When apply the predicted deformations in a risk assessment context, the values should be increased by 20%. Recognising the uncertainties in the predictions, specific values of the various deformation parameters should not be used as constraints: any constraints to the mine design should be based on recognition of unacceptable consequences.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

Longwall extraction at the South Galilee Coal Project (SGCP) is proposed to extract both the D1 and D2 seams (Figure 1). At this early stage of concept planning, the longwall extraction voids are 360m wide with intervening chain pillar widths of 25m. The depth of cover to the D1 seam ranges from 50m to 240m. This report addresses the predicted subsidence outcomes of this proposed layout. The report does not address the mining conditions that may be associated with these panel and pillar widths. It is assumed for this subsidence analysis that the pillars will be stable during longwall retreat.

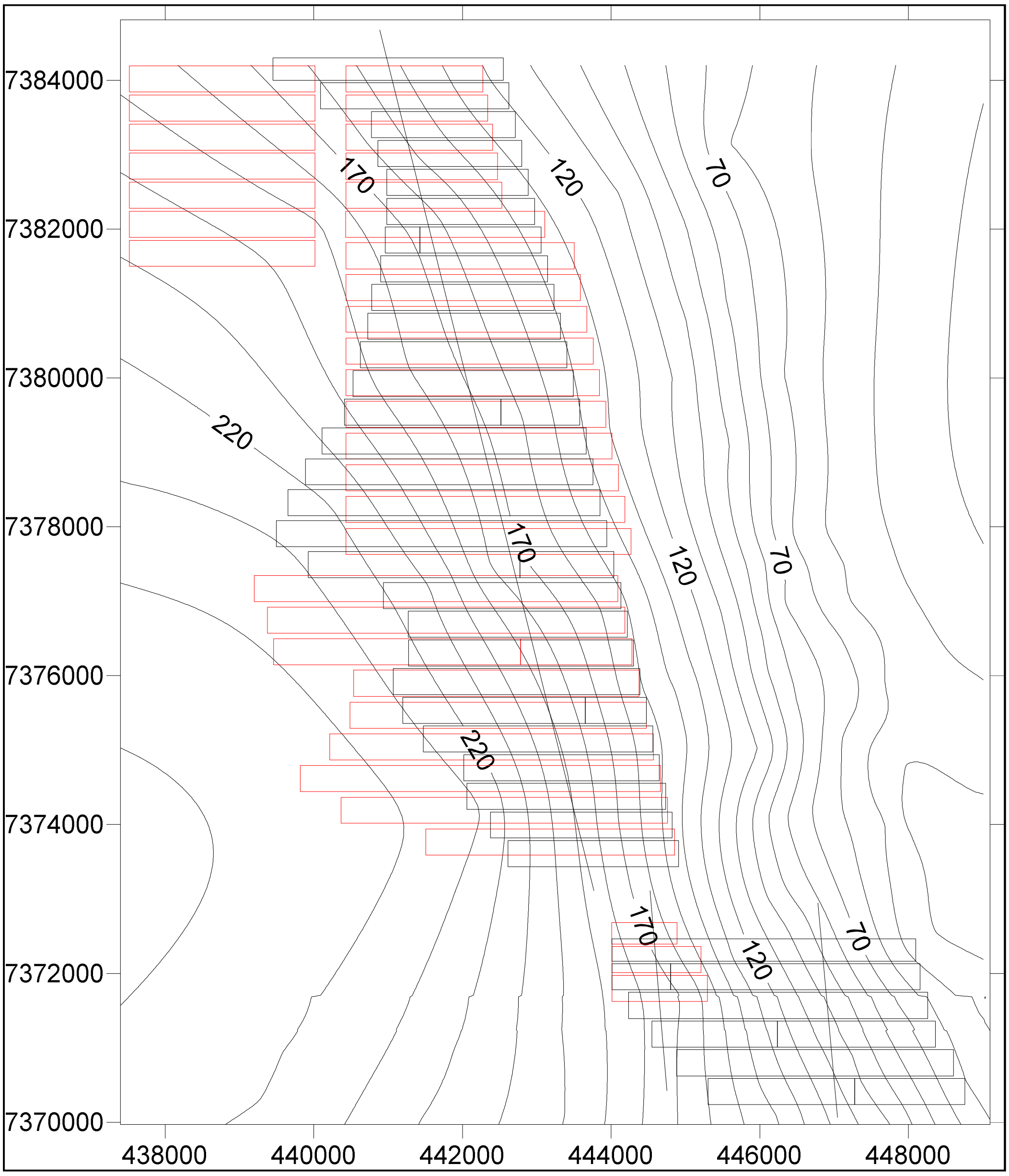


Figure 1 Outline of concept longwall extraction panels (D1 seam – black, D2 seam – red) and depth of cover to D1 seam.

2 SITE CONDITIONS

2.1 TOPOGRAPHY

The natural topography in the SGCP area is dominated by very gently undulating plains and rises of low relief. The plains in the east and north-east generally decline from more elevated low hills located along the western portion of MLA 70453. The elevation ranges from 350 to 600 metres Australian Height Datum (AHD) (Figure 2). The surface slopes are typically less than 1^{o} (17mm/m).

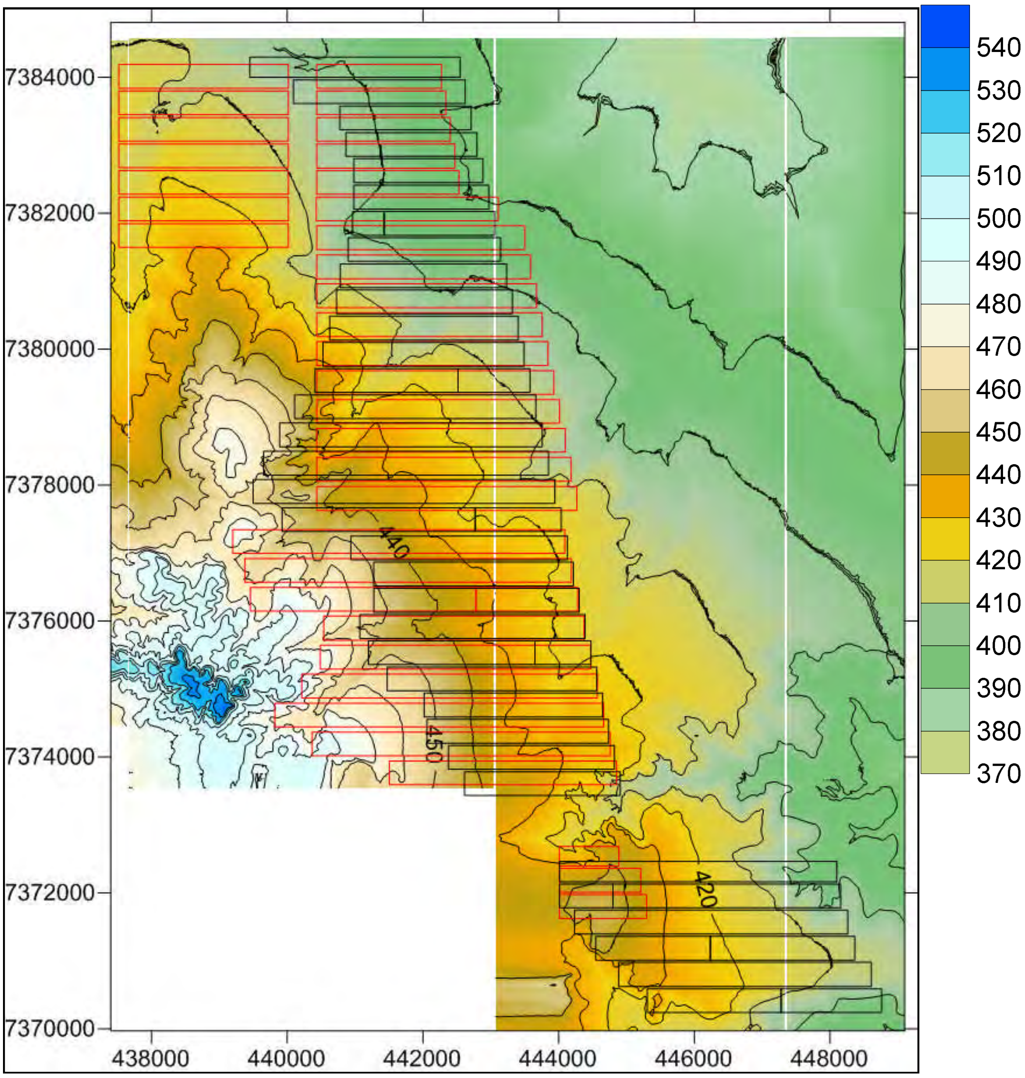


Figure 2 Surface elevation (AHD)

2.2 OVERBURDEN GEOLOGY

The D1 and D2 seams are contained within the Late Carboniferous-Middle Triassic Galilee Basin. The Late Permian age Bandanna Formation unit is the target formation of the SGCP and is composed of:

- grey slightly micaceous and silty, carbonaceous sub-fissile shale;
- grey argillaceous and carbonaceous siltstone;

- grey fine to medium grained fused, micaceous quartz, feldspathic sandstone; and
- multiple coal seams which are generally known as Seam A to Seam F.

The Rewan Group unconformably overlies the Bandanna Formation. The formation is composed of terrestrial alluvial sediments including meandering channel deposits and flood-basin siltstone and sandstone units. The Dunda beds are a transitional unit between the Early Triassic members of the Upper Rewan Formation and the Clematis Sandstone and consist of quartz labile sandstone and interbedded lutite. The Clematis Sandstone is a poorly sorted, fine to coarse grained, angular to sub-angular quartzose sandstone with minor red siltstone and mudstone and rare conglomerate and thin interbeds of variegated shale. The Moolayember Formation is a Late to Middle Triassic fluvio-lacustrine deposit consisting of light grey-green, yellow and brown, argillaceous siltstone, sandstone and mudstone units with slight interbedded mica. It is the uppermost unit of the Galilee Basin.

Tertiary deposits overlie the Galilee Basin and comprise consolidated siltstone and sandstone typically 5-15m thick and are thickest in the northern and central region of the SGCP area.

Quaternary deposits in the SGCP area are mostly alluvial and consist of gravel, sand and poorly consolidated clayey sandstone. Thickness of the Quaternary sediments varies over the Project area, but generally thickens to the east.

2.3 Engineering geology

The depth of cover to the D1 and D2 seams varies between approximately 50m and 240m (Figure 1). The D1 seam thickness is typically 4.0m to 4.5m and the D2 seam thickness is in the range of 2.4m - 2.8m. Structure contours on the roof of the D2 seam generally strike approximately 340-350^0 over the area. The structure roof contours on the D1 seam are very similar, situated about 12-15m above D2. Based on the geological and geophysical logging conducted to date, it is assessed that there are no very low strength roof or floor units that may adversely impact on pillar stability.

The overburden sequence consists of sandstones, mudstones and claystone with minor coal seams (Figure 3). From observations of the geological core and a review of the regional geology, it is assessed the overburden sequence does not contain massively bedded units (>10m thick) and consequently it is anticipated that it will cave readily during longwall operations.

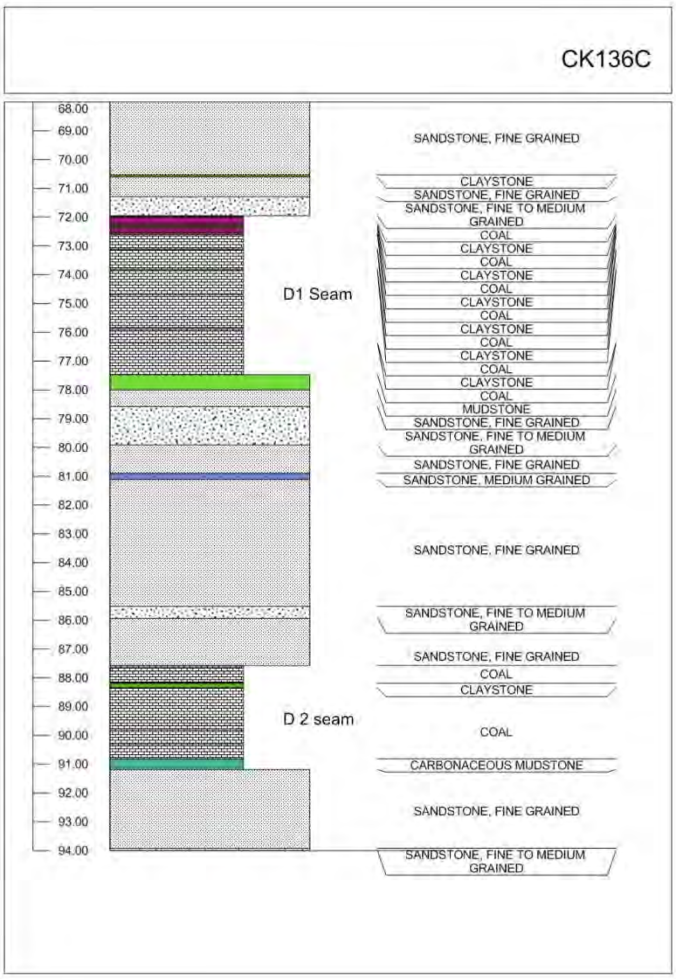


Figure 3 Detail of coal seams and immediate roof and floor

Exploration drilling within the proposed longwall mining area is still at an early stage and the drill hole spacing is in the order of 1500m. This spacing is not adequate to confidently identify faults at the coal seam level which will ultimately determine the layout of the longwall. As a rule of thumb in high production Australian longwall operations, faults with a throw more than half the seam thickness (i.e. throws of approximately 2m) can represent barriers to longwalls. As a frame of reference, experience in the Bowen Basin is that a drill hole spacing of about 250m is required before a longwall can be adequately planned. It is not known if the same spacing will be required for the Galilee longwall mines. Importantly, the mine plan being assessed is conceptual only at this stage– it is a mine plan that seeks to maximise resource recovery; the final mine layout will be one that optimises resource recovery with safety and productivity.

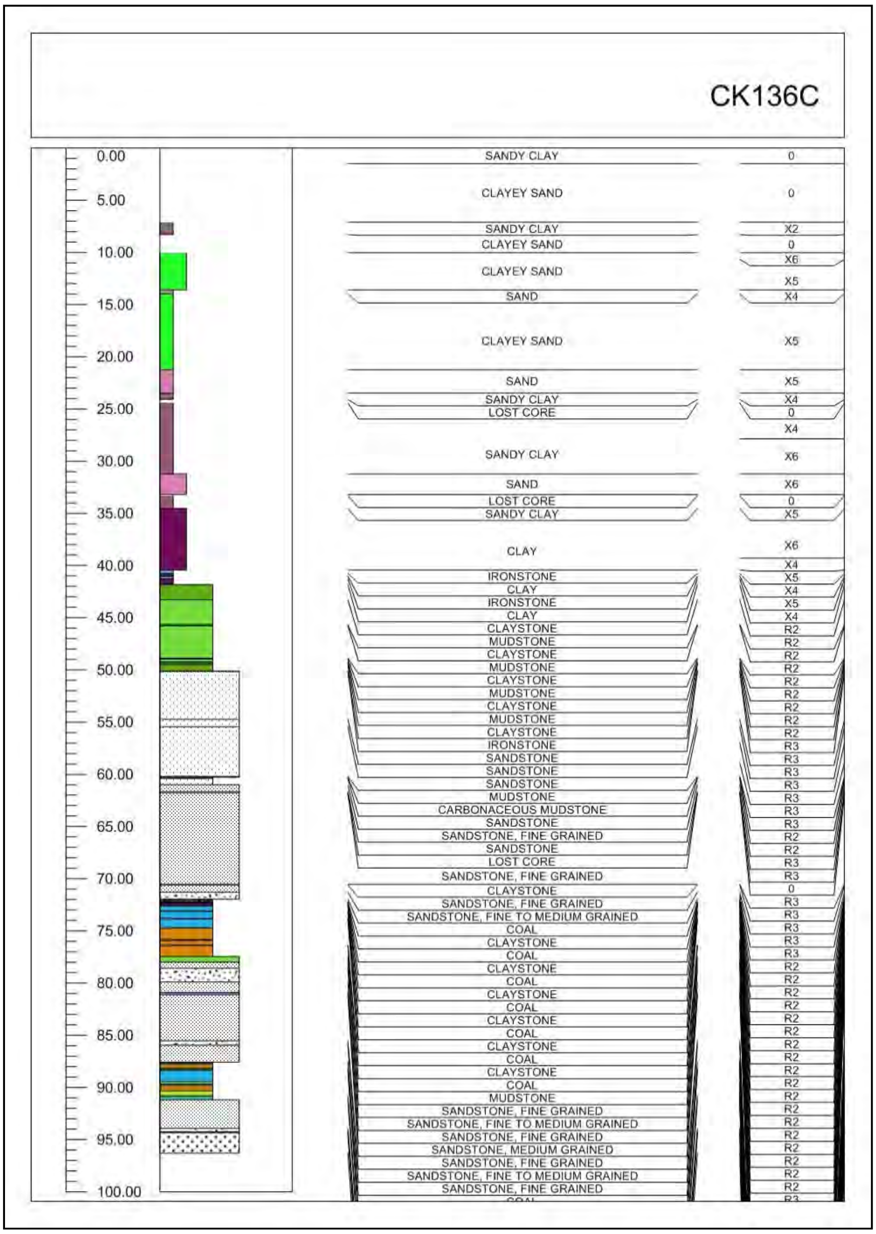
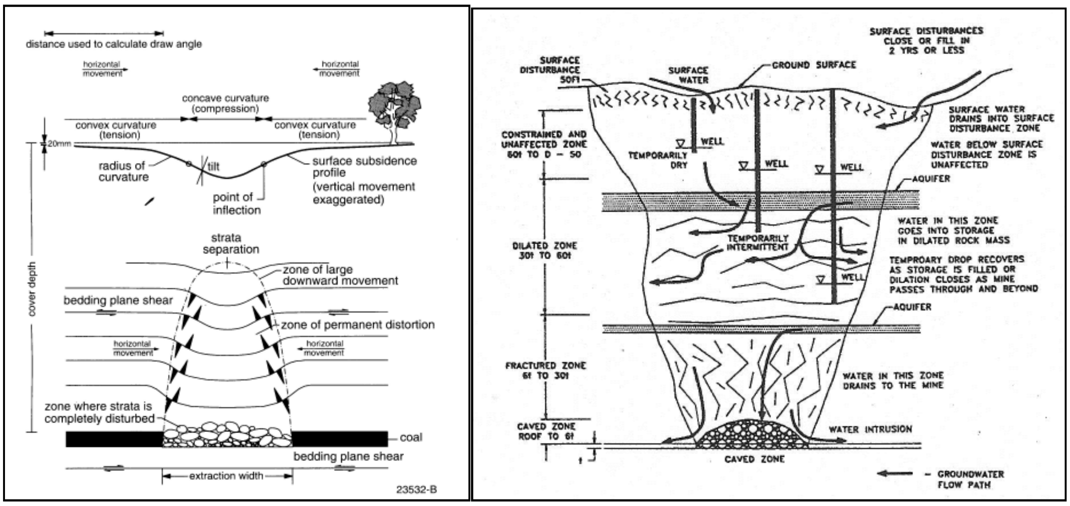


Figure 4 Typical overburden sequence

3 SUBSIDENCE PREDICTION AND VISUALISATION

A characteristic of longwall mining is the collapse of the overburden behind the mining front. This collapse may continue to the surface and result in a range of surface deformations (collectively known as subsidence). There are numerous diagrammatic representations of the deformations and fracturing that develop in the overburden and at the surface which differ in detail depending on the concepts being communicated (Figure 5). All the diagrams for the overburden used by subsidence engineers are derived by inductive reasoning from a limited set of observations – it is not possible to excavate a sufficient number of deep longwalls to examine the actual fracture and deformation patterns. Subsidence engineering is very much based on extrapolation from back analyses of what are perceived to be similar geological conditions.

Close to the extracted seam, there is a zone where the overburden rock is completely disturbed – this is typically considered to be 10m to 20m thick. Above this is a progressively narrower zone where the overlying beds remain generally intact with fracturing along the sides of the zone (Figure 5a). The height of this zone is a function of the width of the extraction and the presence of massive rock units in the overburden. In hydrogeological models (Figure 5b), this is the fractured zone: the reported thickness of this zone (6 to 30 times the extraction thickness) gives an indication of the possible variability in its dimensions. Above the fractured zone, the overburden rocks sag and bedding may separate in the dilated and constrained zones: there are changes in horizontal transmissivity but negligible changes in vertical transmissivity. The presence of dilated and constrained zones prevents water flowing from the surface to the mine. At greater depths the overburden rocks may span with only small deflections.



(a) Deformations and fracturing[1] **(b)** hydrogeological[2]

Figure 5 General models for subsidence behaviour

To characterise the surface deformations and to provide context to resulting impacts, subsidence engineers make reference to a number of parameters:

- Vertical movement: change in the relative level of the surface. This may be significant in terms of flooding low lying areas
- Tilt – differential vertical movement. This may alter the direction of flow in drainage channels.
- Horizontal movements associated with the sagging. By themselves, these typically have no impact.
- Strains – how the surface is stretched or compressed by relative horizontal movement. High levels of tensile strain can cause cracking in either the overburden rocks or the surface soils.

3.1 GENERAL SHAPE OF A SUBSIDENCE BOWL

The surface above a longwall extraction panel subsides in the form of a trough or a bowl (Figure 5a). The depth of the bowl is less than the thickness of the coal that is extracted and the width of the bowl

[1] Holla, L and Barclay, E. 2000 Mine subsidence in the Southern Coalfield, NSW, Australia. NSW Department of Mineral Resources.
[2] Bai, M. and Kendorski, FS. 1995. Chinese and North American High-Extraction Underground Coal Mining Strata Behaviour and Water Protection Experience and Guidelines. 14th Conference on Ground Control in Mining, 209-217.

is greater than the width of the extraction. The general shape of a cross section through a subsidence bowl (Figure 6) reveals the following key features that are used to quantify subsidence deformations:

- The areal extent of subsidence is defined by the angle of draw. Conventionally the angle of draw is drawn to 20mm of vertical subsidence (not zero). It would be better if the term "angle of critical deformation" was used to make this distinction clear.
- The location of the maximum tilt corresponds with zero strain (inflexion point).
- The subsidence at the inflexion point should be half the maximum vertical movement.
- Offset of the inflexion point from the edge of the extraction or the edge of the goaf.
- The locations of the maximum tilts or strains do not necessarily correspond with the edge of the extraction.

As panels become wider with respect to depth, the maximum subsidence trends to a maximum percentage of the extraction thickness. The proposed SGCP panels are within this range. This is termed supercritical subsidence to differentiate it from subcritical behaviour for narrow panels with respect to depth. A feature of supercritical panels is that as well as no increase in maximum vertical subsidence, the maximum tilt and maximum strain also do not increase with increasing panel width (Figure 7). Supercritical subsidence infers more rock breakage at the surface, with the result the subsidence profile can deviate significantly from the smooth curves that are produced by any prediction method.

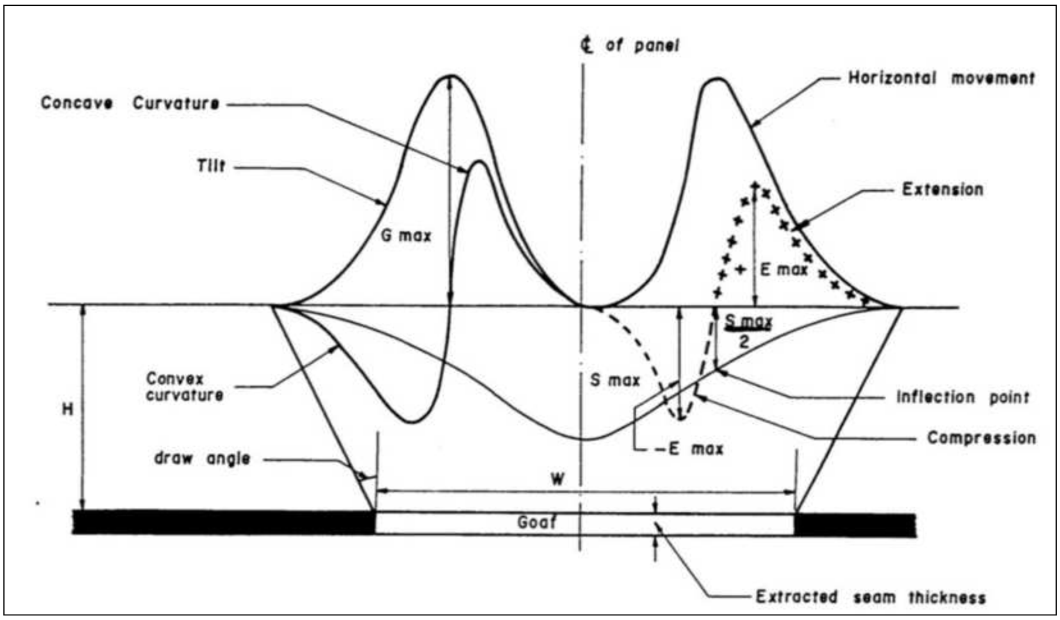


Figure 6 General characterisation of a subsidence cross line

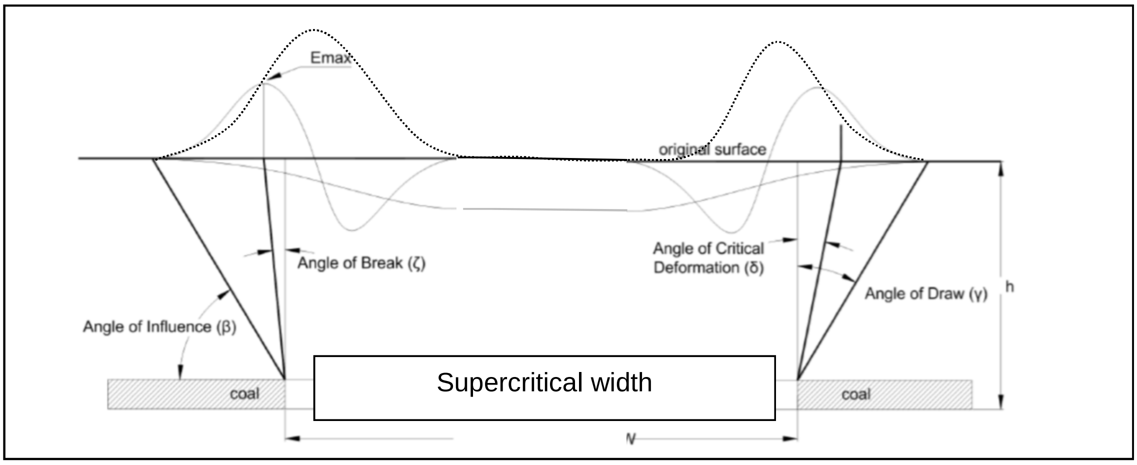


Figure 7 Maximum values do not change with increasing width of supercritical panels

3.2 PREDICTION METHODS

As subsidence deformations are spatially distributed, prediction is complex and requires estimates of values (vertical movement, tilt, strain) at a very large number of specific eastings and northings. For the SGCP, predictions have been conducted at 1.7 million points at 10m centres. In addition, subsidence engineers are dealing with a rock mass, which may behave as a blocky material such that a smooth continuous behaviour will not present (rocks break and do not deform like plastic). The available prediction methods assume a continuous surface.

“Accuracy” in a scientific measurement sense is therefore not an appropriate concept: subsidence engineers have developed various approaches to supply adequately reliable predictions to address the prediction uncertainties and allow engineering responses.

3.2.1 Ordered movements

By assuming a smooth continuous subsidence bowl and a horizontal surface, there are a number of prediction methods available. It is emphasised all of these methods require calibration/back analysis as subsidence engineering is empirically based rather than deterministic.

3.2.1.1 Discrete points

Subsidence prediction in New South Wales began last century by using local databases to predict maximum vertical movement, maximum vertical movement at the edge of the panel, maximum tilt, maximum strain, and the locations of the points of 20mm vertical movement. Smooth curves could then be drawn by hand through these points. It was found that separate datasets and recommendations were required for different coalfields and could only be determined after substantial mining experience.

A simplified version of this approach has been used by Waratah Coal for the Galilee Coal Project. Waratah Coal has assumed the maximum vertical subsidence will be 67% of the extracted thickness and has not sought to predict strains or tilts.

3.2.1.2 Profile functions

The profile function approach fits an arithmetic curve to subsidence data. Various functions have been used in the technical literature (exponential, trigonometric, hyperbolic) with possibly the most efficient one being the hyperbolic tangent[3]:

$S(x) = 1/2 * S_{max} * (1 - \tanh(cx/B))$

Where $S(x)$ = subsidence at x,
x = distance from the inflection point,
S_{max} = maximum subsidence of the profile,
B = distance from the inflection point to point of S_{max}, and
c = constant.

In New South Wales, there is an advanced version of the profile function method – the Incremental Profile Method[4]. The form of this profile function is a complex 5th order polynomial with 10 coefficients, the values of which and the methods to determine them are held confidential by the consultant. Consequently, the Incremental Profile Method is not available for engineering peer review.

In their EIS for Kevin's Corner, Hancock Coal uses an unpublished profile function method developed by their consultant based on extensive manipulation of a 3-order polynomial fit. Its application requires in-house developed subroutines and similarly the method is not available for engineering peer review.

3.2.1.3 Influence functions

Influence function methods are somewhat similar to profile functions and are based on incrementing the deformation of the surface for each element of the extraction of the seam. This allows complex and irregular mining layouts to be analysed and the results presented as surfaces instead of cross sections. Mathematical functions used have included trigonometric and exponential types. The readily available SDPS (Surface Deformation Prediction System)[5] uses a form of the Gaussian curve:

$g(x, s) = S_o(x)/r * \exp[-\pi * (x-s)^2/r^2]$

where:
r = the radius of principal influence = H/ tan(B),
H = the overburden depth,
B = the angle of principal influence,
s = the coordinate of the point, P(s), where subsidence is considered,
x = the coordinate of the infinitesimal excavated element, and
$S_o(x)$ = the convergence of the roof of the infinitesimal excavated element.

SDPS version 6.x was developed under a contract from the Office of Surface Mining, Reclamation and Enforcement, US Department of Interior. It appears to be a defacto standard for regulatory approval in the US. It is available for full engineering peer review. SDPS is the method used in this SGCP study and is described further in Section 5.

[3] Brady, BHG. and Brown, ET. 2004. Rock Mechanics for Underground Mining, 3rd Edition. George Allen and Unwin, London.
[4] www.minesubsidence.com
[5] www.carlsonsw.com

3.2.1.4 Analytical and numerical methods

For subcritical panels, analysis and prediction by way of the elastic deformation of blocky rock beams is possible. This can be done analytically (using voussoir beams) or numerically using discrete element codes such as UDEC. To justify the sophistication of these approaches a detailed site characterisation is necessary and at much greater level than is available at this stage of the SGCP. Like all numerical and analytical methods, the applications to engineering design are certainly not deterministic – once again they require calibration to mining in similar geotechnical environments.

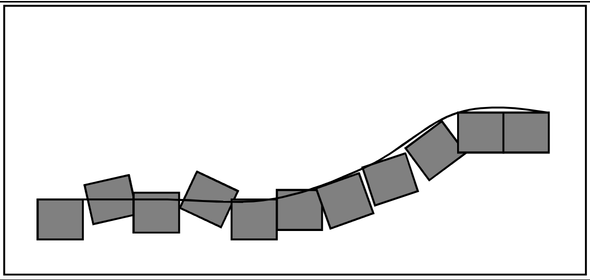
It is possible to analyse the subsidence that develops above the chain pillars between the longwall panels by assuming that they behave as rigid elastic footings. There is an empirical approach to allow consideration of the yield of the coal pillars.

3.2.2 Disordered movements

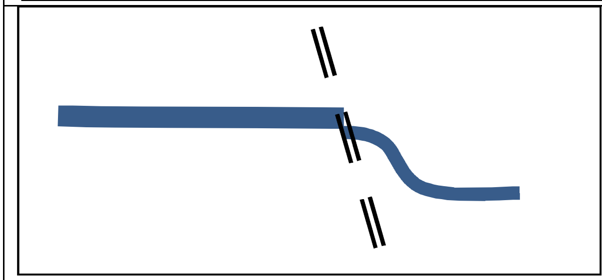
The readily available prediction methods do not address the “disordered” movements that are well known to be present (i.e. the departures from the smooth continuous assumption required for the prediction). In terms of the total deformation field, these represent a very small fraction but they tend to receive a large degree of attention because of their “novelty” and unpredictability. Although they can be validly anticipated, the absolute movements are not predictable before the event: it is possible to build a database after the event to provide ongoing guidance. The appropriate strategy is to manage perceived unacceptable impacts with additional offsets to the extraction panels.

When the near-surface rocks break, the resulting blocks of rock interact and can produce localised movements (Figure 8a). This is particularly the case with supercritical extraction and thin soil cover. If there are faults or dykes in the overburden sequence, these can localise displacements near the surface (Figure 8b). This is relatively rare because longwalls are typically only deployed in large blocks of unfaulted coal. In the vicinity of valleys and any topographically dissected surface, the lack of sideways confinement to the surface rocks may allow lateral movement (Figure 8c): the lateral movements can be large if the longwall is directly below: outside the angle of critical vertical deformation the lateral movements are relatively small.

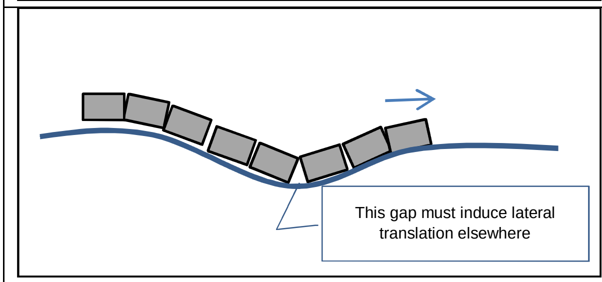
There is another set of disordered movements that relate to the definition of the subsidence footprint as being the onset of 20mm of vertical subsidence. The 20mm threshold was chosen to define the onset of subsidence partly because of the recognition of no damage to the surface and partly because of the resolution of survey techniques used at the time. As the resolution of survey methods has improved, it is now known the meteorological shrink and swell of the surface may be much greater than this. It is now possible to resolve vertical and horizontal movements much more precisely (to approximately 2-3mm). Subsidence engineers now regularly measure very small horizontal movements even when the vertical movements are less than 20mm – these have always been present and without adverse impact. Ongoing research into these movements is focussed on the possible disruption to the horizontal stresses in near-surface rocks.



(a) Bending of a layer of blocks will result in individual blocks rotating. Anomalous strains and tilts may be recorded.



(b) Fault or dyke localises deformations. Longwall mining seeks to avoid the larger of the known faults and dykes.



(c) Bending of a layer of blocks can induce lateral movement into a free face

Figure 8 Sources of disordered movements

4 SUBSIDENCE PREDICTION IN AUSTRALIA

4.1 ISOLATED PANELS

The starting point for all the published prediction methods is an estimation the maximum vertical subsidence above a single longwall panel. In empirical methods, this estimate (Figure 9) is based on a cross plot of the maximum vertical subsidence (normalised to the extraction thickness) versus the panel width (normalised to the depth of cover).

As longwalls were introduced into Australia longwalls, it was soon found that the plot from the British coal fields was not applicable to Australian conditions, and separate plots were published for the Southern, Newcastle, Western coalfields (Figure 9)[6,7,8]. There is no published curve for the Bowen Basin - possibly because the extraction is mostly supercritical. No data has been collated for the Galilee Basin. In each of the plots, a line was drawn to represent the maximum expected maximum subsidence. The significant differences in the plots are at low values of the width to depth ratio and these differences were inferred to be related to the presence massive overburden layers that could

[6] Holla Mine Subsidence in the Southern Coalfield, NSW, Australia. Department of Mineral Resources, 2000.
[7] Holla Mining Subsidence in New South Wales 3. Surface Subsidence Prediction in the Western Coalfield. Department of Minerals and Energy, January 1991
[8] Holla Mining Subsidence in New South Wales 2. Surface Subsidence Prediction in the Newcastle Coalfield. Department of Mineral Resources, January 1987

span. Note that the maximum subsidence for wide panels (supercritical) tends towards a constant value of around 60% in all three coalfields.

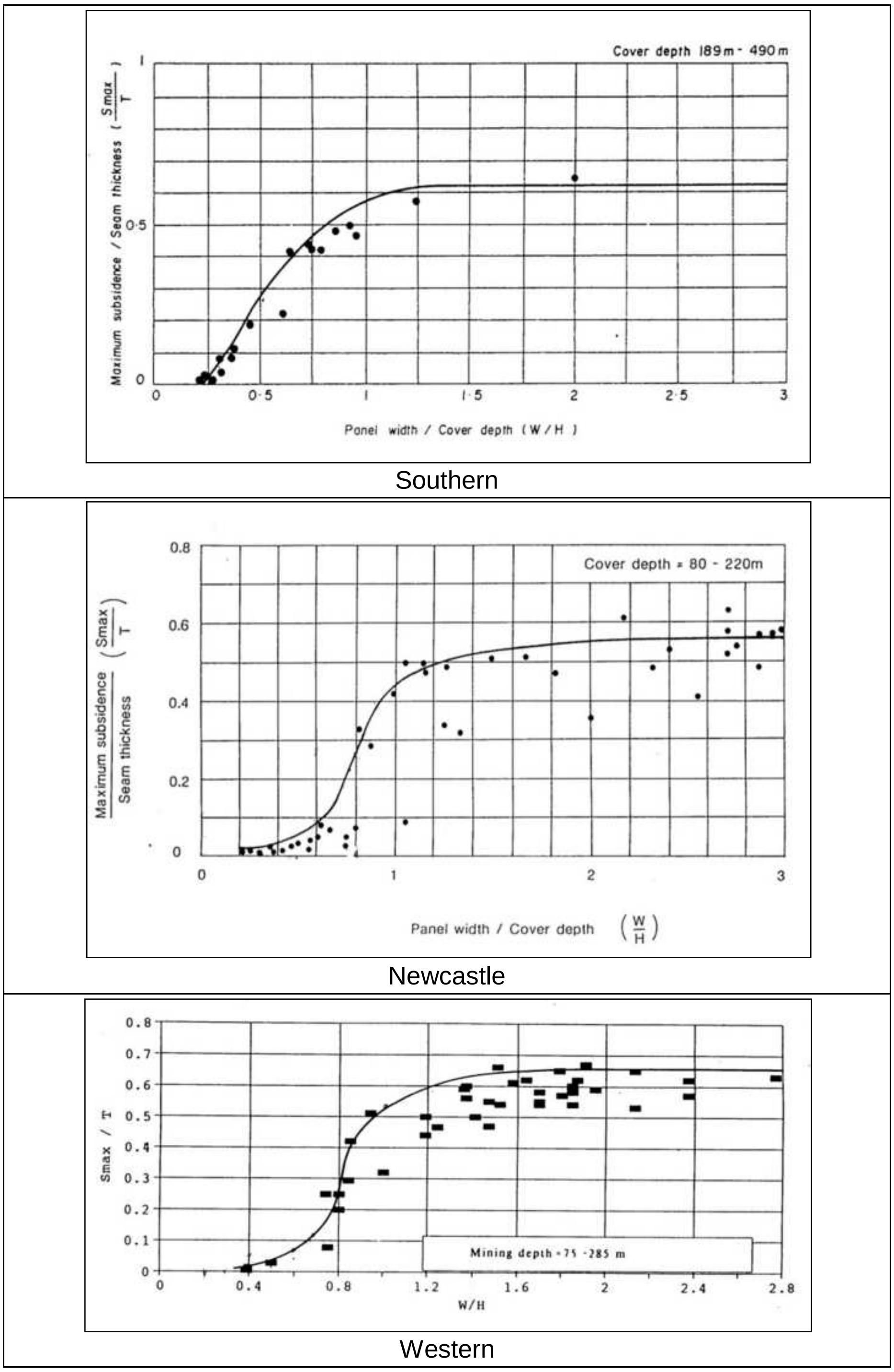


Figure 9 Prediction of maximum vertical subsidence in NSW coalfields

A weakness with the empirical methods is the reliance on a relatively small database compared to the variability that may be found in a rock mass. As more longwalls were extracted in the Newcastle coalfield it was found that the initial recommended line was not valid and one that approached the Southern coalfield was more appropriate (Figure 10)[9].

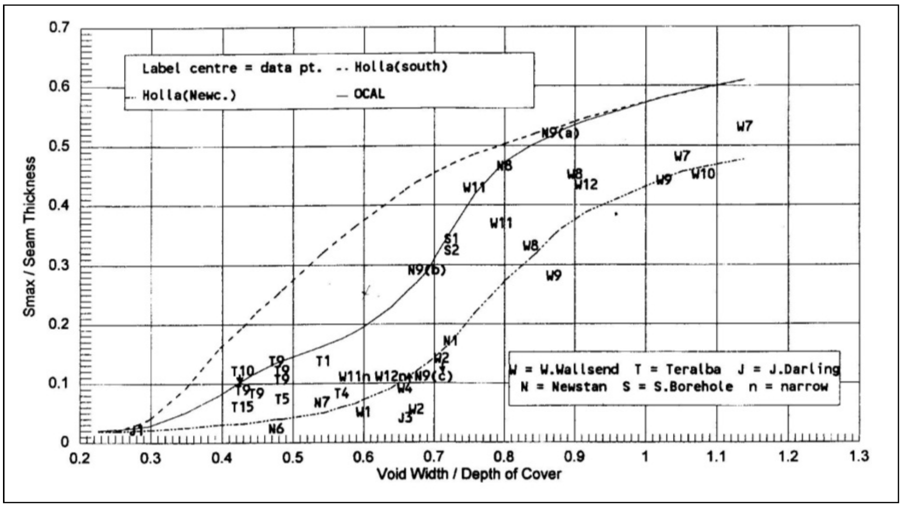


Figure 10 Changes to the Newcastle curve over time

The plots do give an indication of the achievable precision of subsidence prediction – in the range of 10% - 20%.

Close inspection of the Newcastle curve (Figure 9) reveals a number of subsidence outcomes that fall below the drawn maximum expected maximum subsidence line (for example a panel width/depth ratio of 1.05 and a normalised maximum subsidence of 0.10). In the redesign of Mandalong Mine[10], an analytical method (fractured rock beams) was used to investigate the deflection of massive rock beams. It was found that very thick beams can deflect up to 10% of the span without breaking. Mandalong has extracted longwall panels with a width to depth ratio of 1.0 and an equivalent deflection of about 50mm - 100mm for a 5m thick extraction (0.01 to 0.02). Such overburden rocks are not present at SGCP.

In the last 10 years, wider longwall panels have become technically and economically attractive. The larger width to depth ratios have resulted in a realisation that panels with subsidence normalised to depth of cover in the range of 0.4 may have been spanning and not fully supercritical.

Figures 9 and 10 highlight the variability in measured vertical subsidence and how this impacts on subsidence prediction. Predicting the shape of the subsidence bowl, through the prediction of maximum tilts and maximum strains introduces further uncertainty. The prediction of maximum values is by way of the relationship:

Maximum value = 1000 * Kn * Smax/H (n=1,2,3),

Where Smax is derived from Figures 9 or 10, H is the depth of cover, and K1 is a tensile strain factor, K2 is a compressive strain factor, and K3 is a tilt factor. Empirically derived values for K are provided as a function of panel width/depth ratio for Southern and Newcastle coalfield (Figure 11). They are not available for the Bowen Basin or for the Galilee Basin. In this case the recommended lines are

[9] Tobin C. 1998. A review of the Newcastle Coalfield subsidence prediction curve. The AusIMM proceedings,303(1), 59-63.
[10] Seedsman, RW. 2006. An analytical subsidence prediction method to maximize underground coal extraction under tight environmental constraints. *In* AMIREG 2006, Advances in Mineral Resources Management and Environmental Geotechnology, 2nd International Conference, 25-27 September, Hania, Greece.

“best fit”, not maximum expected. High variability is apparent with possible values ranging +/-50% of the recommendation.

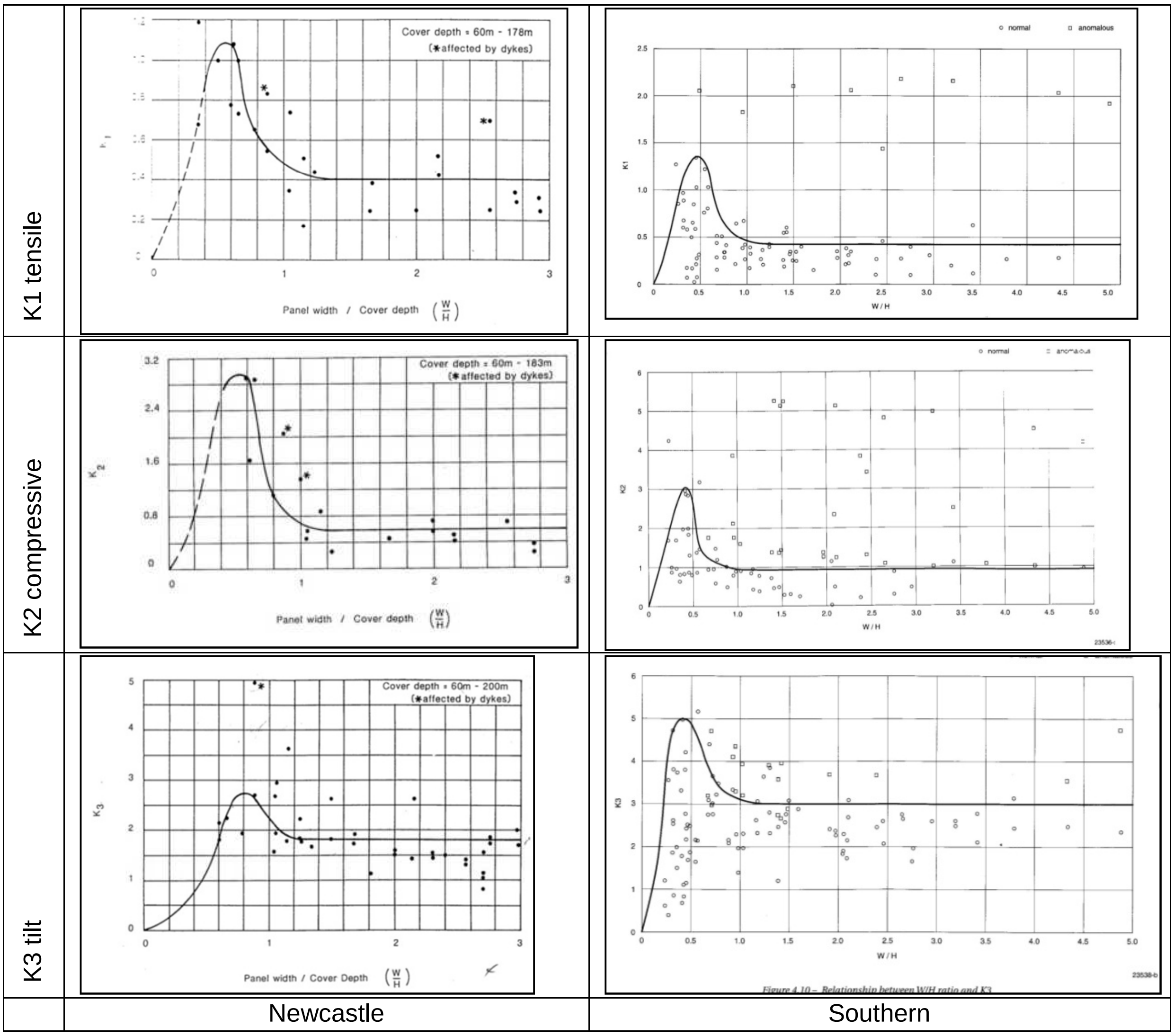


Figure 11 K values for the Newcastle and Southern coalfields

High variability is also a characteristic of the angle of critical deformation to 20mm of vertical subsidence (Figure 12) with values between 0^{o} and 60^{o} having been recorded. Much of this spread may be related to survey precision and failure to identify shrink/swell of the surface soils. A value of 26.5^{o} has been found to be a useful value for early mine planning: this implies the limit of subsidence deformations is located at a distance from the any longwall extraction equal to half the depth of cover.

Inspection of the curves in the previous figures leads to the inevitable conclusion that scientific “accuracy” is not a realistic outcome of subsidence prediction. As mentioned earlier, the goal is to derive appropriate predictions in order to allow appreciation of the potential environmental hazards so that risk strategies involving elimination, substitution, and engineering controls can be designed.

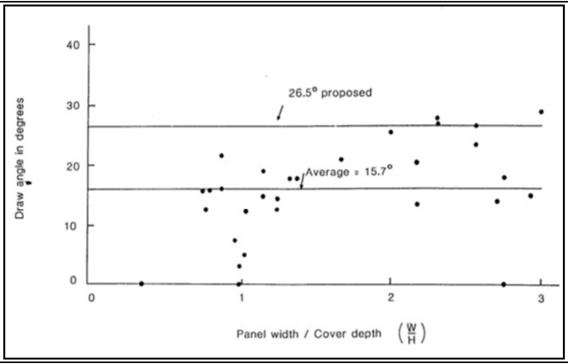
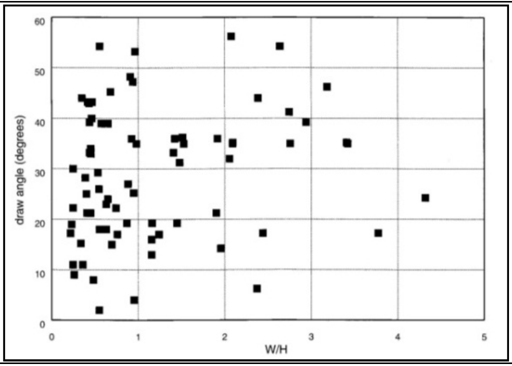
	
Newcastle	Southern

Figure 12 Variation in the angle of critical deformation for the Newcastle and Southern coalfields

For the SGCP, information in the various figures presented above, together with experience from the Bowen Basin, has been used to derive appropriate input values for the SDPS influence function program.

4.2 ADJACENT LONGWALLS AND THE INTERVENING PILLARS

The subsidence developed above a set of longwalls, separated by what are known as chain pillars, can be more than the addition of the subsidence of each panel (Figure 13). This is particularly the case at large depths of cover or where the roof and floor strata are particularly low strength and stiffness.

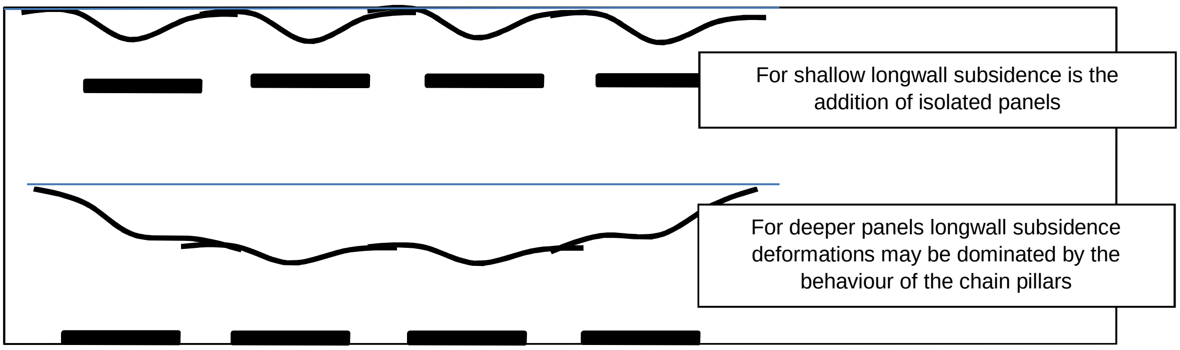


Figure 13 Sketch showing different way in which subsidence can develop above a chain pillar

The subsidence above a chain pillar results from the increase in the stresses applied to the pillars as the longwall extraction proceeds. The increased stresses cause compression of the immediate roof and floor rocks, compression of the coal seam and particularly any yielding of the coal pillars. In the Southern Coalfield, an empirical approach has been developed to predict pillar subsidence as a function of panel width, pillar width, and depth. At Mandalong, an analytical approach was adopted, exploiting detailed knowledge of the seam and the surrounding rocks[11]. There has been no specific examination of how strains and tilts differ when the pillar subsidence if the major part of the deformation field.

[11] Seedsman, R.W. 2010. Calibrated parameters for the prediction of subsidence at Mandalong Mine. COAL 2010 – Coal Operators Conference, AusIMM Illawarra Branch.

For most of the SGCP, the relatively shallow depths of cover allow a prediction based on the cumulative addition of isolated panels. An analysis of pillar compression has not been conducted for SGCP as there is insufficient geotechnical data and the design of the chain pillars has not been finalised.

4.3 MULTIPLE SEAMS

There has been very little multiple seam longwall mining in Australia to date, although many operations are being planned or are in the early stages of development. A recent paper[12] combined the limited Australian information with some international data and advocated applying a normalised vertical subsidence factor of 80% to both seams (compared to 60%) although the paper also referenced other confidential data which does not fit their model. This model omitted reference to other work on the importance of the thickness of the rocks between the coal seams.

Counter to the recent paper, it has been common practice to add the subsidence from each seam and recognise/manage the uncertainty until more data are available. This is the approach which has been adopted for the SGCP.

4.4 DISORDERED MOVEMENTS

Disordered movements have been intensively examined in the Southern Coalfield[13] where the steeply dissected topography is developed in a rock sequence which is conformable with the coal measures. When longwall extraction passed under drainage courses there were instances of buckling and cracking of rock bars. In addition, there are major items of surface infrastructure that could be considered "brittle" and not tolerant of differential horizontal movement (dams, bridges).

For the SGCP, the flat terrain and the nature of the weathered surface rocks mitigate against the likelihood of far field horizontal movements and valley closure effects.

4.5 SUBSURFACE

Experience in the NSW and Bowen Basin coalfields indicate that the hydrogeology model (Figure 5b) is appropriate for longwall panels up to 200m-250m wide. The author uses a value of 115m as the default height of the fractured zone above such longwall panels in single seams, which for seams with thicknesses of 3m - 3.5m implies a ratio of about 40.

Gale[14] provides a nomogram that relates water inflow rates to maximum subsidence and depth of cover (Figure 14). This chart is based on extrapolating from UK experience that surface tensile strains less than 10mm/m are required to prevent unacceptable inflows (from an underground safety and productivity perspective)

[12] Li , G., Steuart, P., Paquet, R., and Ramage, R. 2010. A case study on mine subsidence due to multi-seam longwall extraction. 2nd Australasian Ground Control in Mining Conference, Sydney. 23-24 November.
[13] Waddington Kay and Associates. 2002. ACARP Management Information Handbook on the undermining of Cliffs, Gorges, and River Systems – Version 1.
[14] Gale, W. 2008. Aquifer inflow prediction above longwall panels. ACARP Project No C13013

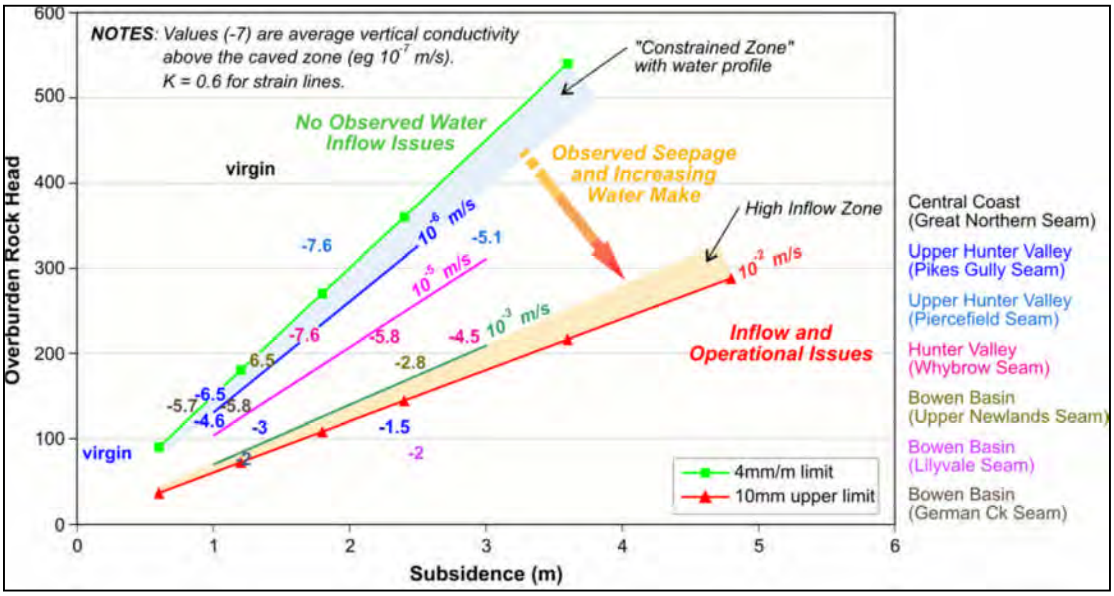


Figure 14 Water inflow nomogram

The height of the fractured zone may also be a function of the panel width and not just the extraction thickness as implied by Figure 5b [15]. In Figure 15, the fractured zone may be defined by Category 1 cracks which are defined by the angle of full subsidence. If this is the case, higher fractured zones may develop for wider longwall panels.

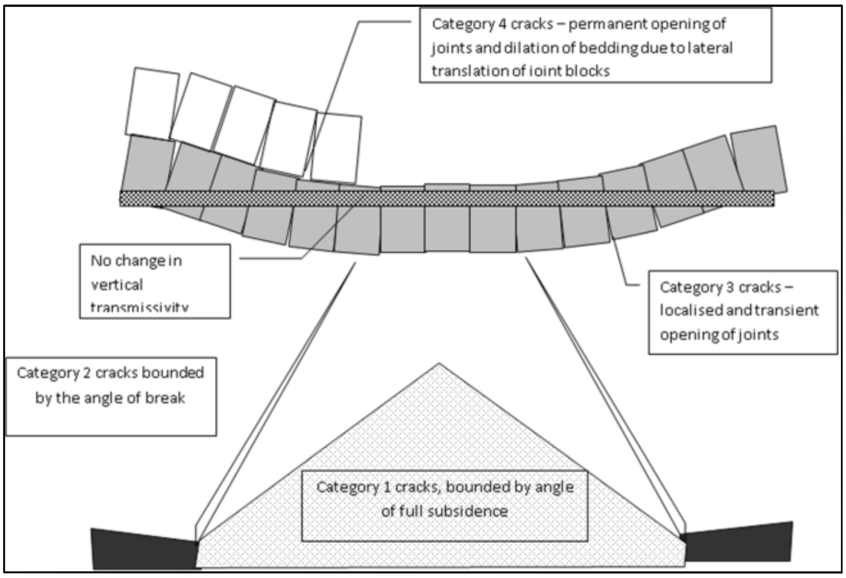


Figure 15 Composite model for fracturing above a longwall panel

[15] Seedsman, R.W. and Dawkins, A. 2006. Techniques to predict and measure subsidence and its impacts on the groundwater regime above shallow longwalls. ACARP Project No C23020

5 SGCP LIFE OF MINE PREDICTIONS

5.1 OVERVIEW

From the preceding discussion, it is apparent that a substantial amount of engineering judgement is required to predict subsidence in the first underground mine in a new coalfield. Reviewing subsidence outcomes from other Australian coalfields reveals a degree of variability. The lack of a precedent in the Galilee Basin and the preliminary nature of geotechnical information mean that the subsidence predictions for the SGCP should be used as an indication of likely deformations only. The influence function method is assessed an appropriate way of visualising the deformations.

5.2 SDPS - INFLUENCE FUNCTION METHOD

SDPS has been applied extensively to coal mines in the Bowen Basin[16] and after calibration has been found to produce very good predictions of subsidence.

The input parameters for SDPS are:

- Maximum vertical subsidence – derived from seam thickness and the subsidence factor.
- Goaf edge offset - the distance of the point of inflexion from a vertical projection of the edge of the longwall extraction.
- The tangent of the influence angle (Tan B) – a parameter that controls the maximum tilt that develops on a subsidence crossline. TanB is the same parameter as K3. The complement of this angle can be considered to be generally similar, but not exactly, to the angle of critical deformation (20mm of vertical subsidence).
- A strain coefficient – a value that is used to convert curvature to strain.

A key point to highlight is that none of these parameters can be determined analytically from the overburden geology. The state of the art is based on empirically-derived values – values measured from longwall mines in what are assessed to be appropriately similar. Obviously, there is no precedent in the Galilee Basin, so engineering judgement is required.

Figure 16 highlights the variations in the shape of the subsidence bowls for different selections of parameters. A lower tanB value results in a wider subsidence bowl with a lower maximum tilt; a higher strain factor results in higher strains. Note how a similar maximum strain value can be obtained for a combination of tanB=2.3 and a strain coefficient = 0.35 as for a combination of 4.4 and 0.20 respectively; of course the overall shape of the bowl is different.

[16] Byrnes R. 2003. Case studies in the application of influence functions to visualising surface subsidence. COAL2003 - 4th Underground Coal Operators Conference. AusIMM Illawarra Branch.

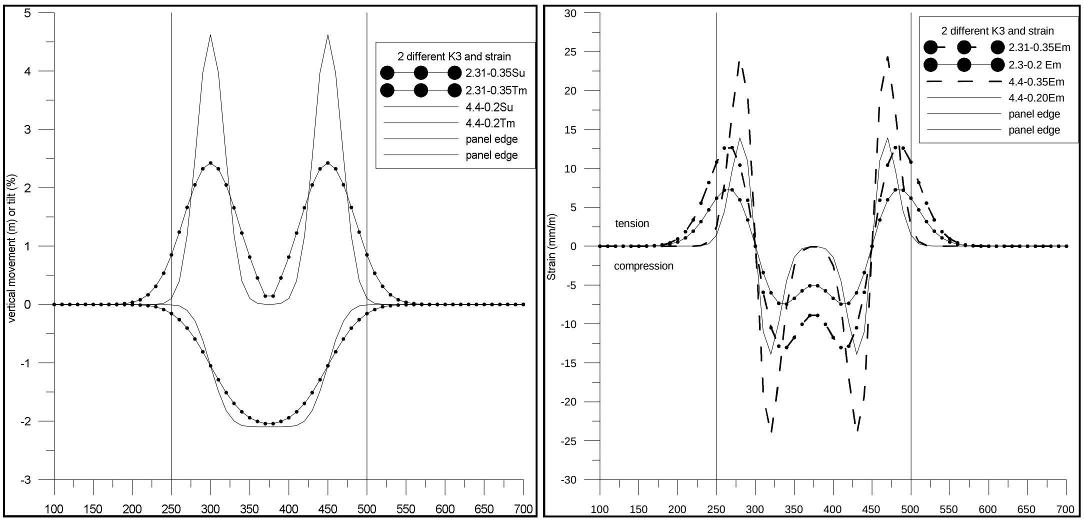


Figure 16 Variations in vertical subsidence (Su as m), tilt (Tm as %), and strain (Em as mm/m) for different tanB and strain coefficient values (250m wide panel, 200m depth, 3.5m thick seam, 60% subsidence factor)

SDPS was developed in the USA and provides a set of default input values based on experience in their Eastern coalfields. These default values have been found not to apply in Australia. Instead, values published for the NSW coalfields and values used in the Bowen Basin are presented in Table 1. In terms of depths and overburden geology, the mines of the Bowen Basin are more similar to those proposed in the Galilee Basin than the New South Wales examples. Conversely, there is more published information on the NSW mines than the Bowen Basin ones.

Table 1 Selection of SDPS parameters

	Smax/T	Offset	Tan B = K3	Strain coefficient
USA	0.19-0.76	0.20 conservative 0.25 average	2.31	0.35
NSW – Southern	0.5-0.64	0.20	3.0	na
NSW – Western	0.65	0.35	3.4	na
NSW- Newcastle	0.56	0.4	1.8	na
Bowen Basin	0.60	0.20	4.4	0.2
Galilee – this study	0.60	0.20	4.4	0.2

5.3 SELECTED PARAMETERS

By drawing an analogy to the Bowen Basin, the input parameters used for the SGCP predictions are:

- Subsidence factor – 60%.
- Goaf edge offset. From back analysis of Bowen Basin data, this is 0.20 of the depth of cover.
- Bowen Basin subsidence profiles suggest a typical value for tanB of 4.4. This gives an influence angle of 77^{o}. The complement of this angle (13^{o}) can be considered to be generally similar, <u>but not exactly</u>, to the angle of critical deformation (20mm of vertical subsidence). An angle of critical deformation of 26.5^{o} should be used.

- A strain coefficient – a value of 0.20 has been found to give reasonable estimates of the maximum strain. Note this is a relatively low value and part of this is the need to correct for the high curvatures that result from the use of a high Tan B value to maximise the tilts. Experience in the NSW fields suggests the maximum tensile strains are typically about half the maximum compressive strains – this observation cannot be directly incorporated in the current SDPS formulation.
- No specific analysis of pillar deformations.
- Multiple seam deformations based on the simple addition of the two seams.

It should be noted that the precision of the arithmetic in SDPS cannot be used to infer anything about the validity or accuracy of the predictions themselves.

The visualisation was conducted on 10m centres with a total of 1,738,935 calculation points. It is stressed that the visualisations generated by SDPS do not (cannot) include the small-scale disordered variations.

5.4 SUBSIDENCE BOWLS

5.4.1 Separate seams

Figure 17 and 18 illustrate the distribution of vertical subsidence for the D1 and D2 seams in isolation. At this scale, the plans do not reveal much of the detail: to provide some more information on how the various parameters are distributed, Figures 19 and 20 show the distribution of subsidence, tilts and strains along the north south AA' crossline.

For the D1 seam in isolation, the maximum vertical subsidence is 2.55m, the maximum tilt is 78 mm/m, and the maximum strains are 24 mm/m (Table 2). For the D2 seam in isolation, the values are 1.5m, 44mm/m and 14 mm/m respectively. For the combined layout of both the D1 and D2 seams, the predicted maximum vertical subsidence is 4.2m, the maximum tilt is 112 mm/m, and the maximum strain is 35 mm/m (tensile or compressive).

Table 2 Maximum subsidence parameters

Layout	Maximum vertical (m)	Maximum tilt (mm/m)	Maximum strain (mm/m)	Depth (m)
D1	2.55	78	24	60-240
D2	1.5	44	14	
D1 and D2	4.2	112	35	

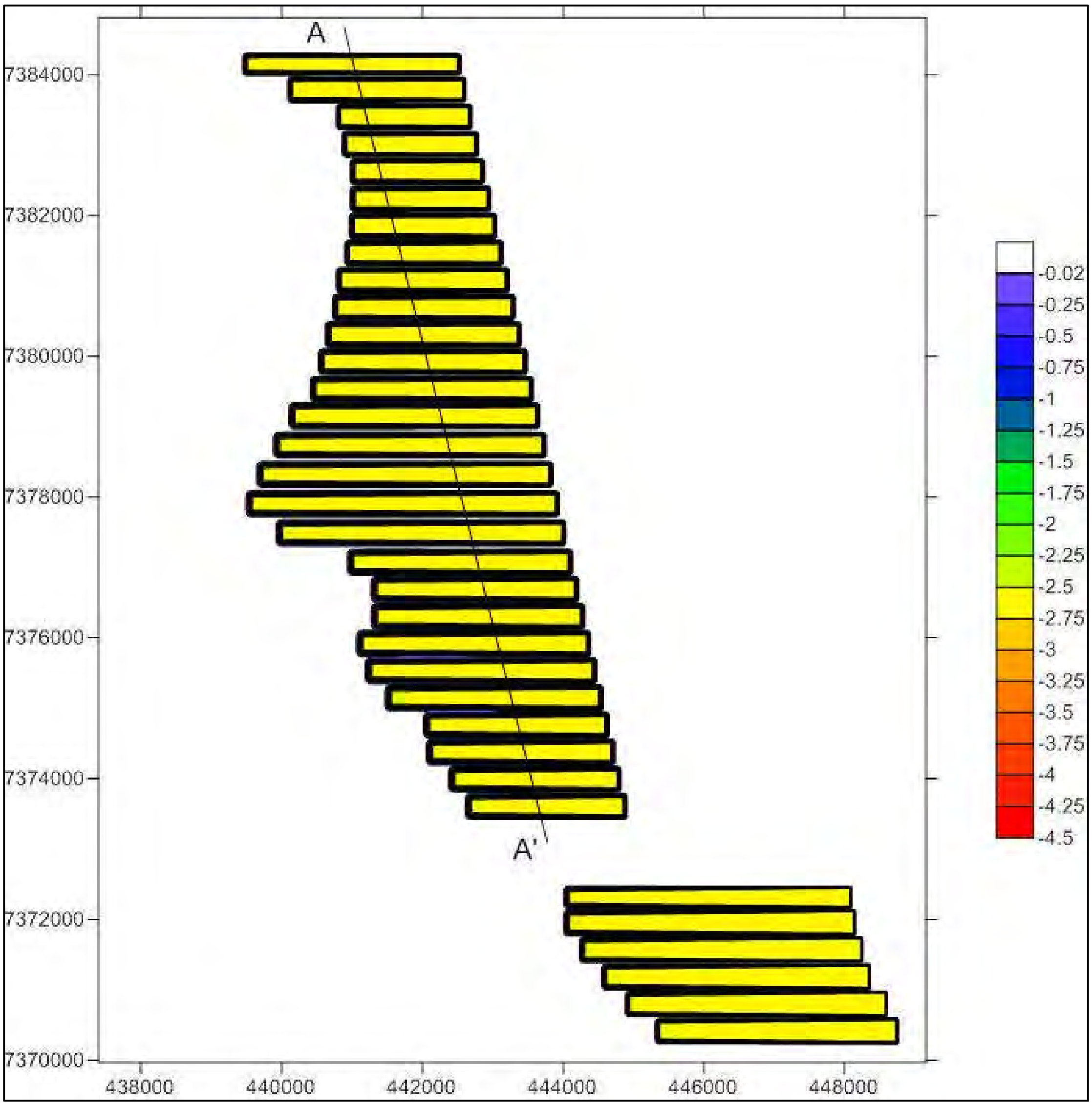


Figure 17 Distribution of vertical subsidence associated with just the D1 seam (in metres)

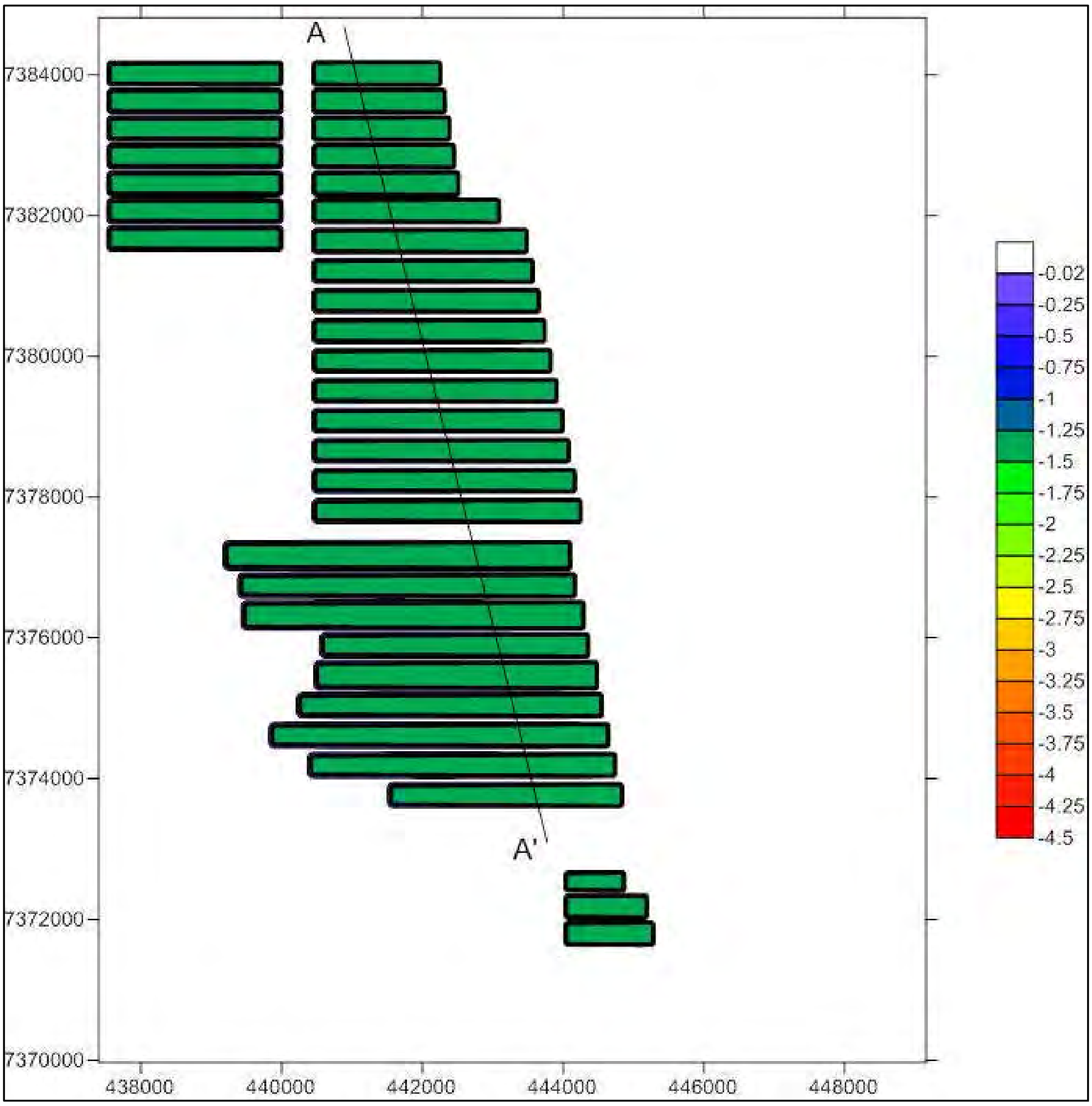


Figure 18 Distribution of vertical subsidence associated with just the D2 seam (in metres)

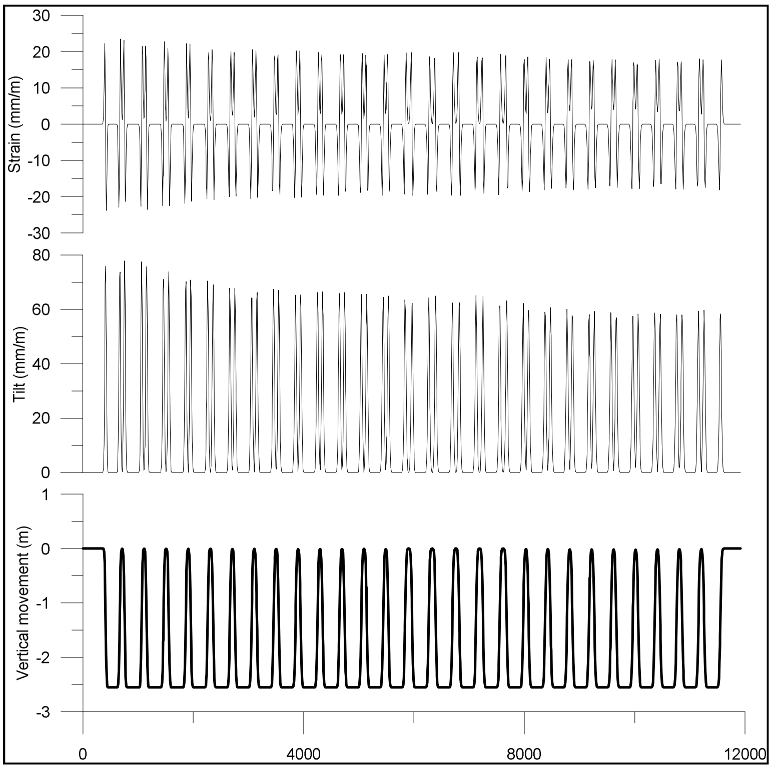


Figure 19 Distribution of vertical subsidence, tilts and strains along the AA' crossline for the D1 seam

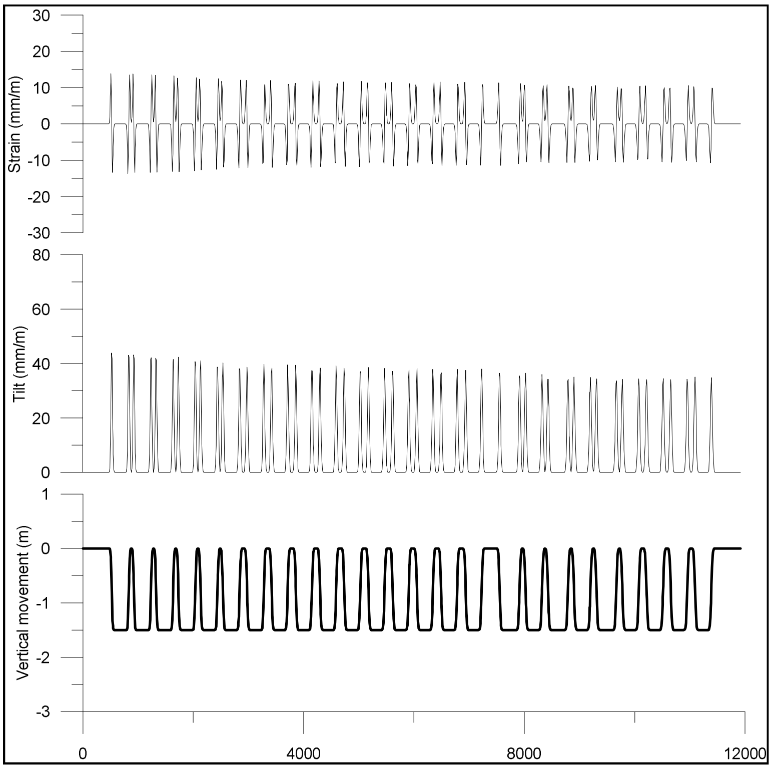


Figure 20 Distribution of vertical subsidence, tilts and strains along the AA' crossline for the D2 seam

5.4.2 Combined seams

The subsidence deformations for both seams (Figures 21-23) include a maximum vertical subsidence of 4.2m, a maximum tilt of 112 mm/m, and a maximum strain of 35mm/m. The distribution of parameters along the crossline is shown in Figure 24.

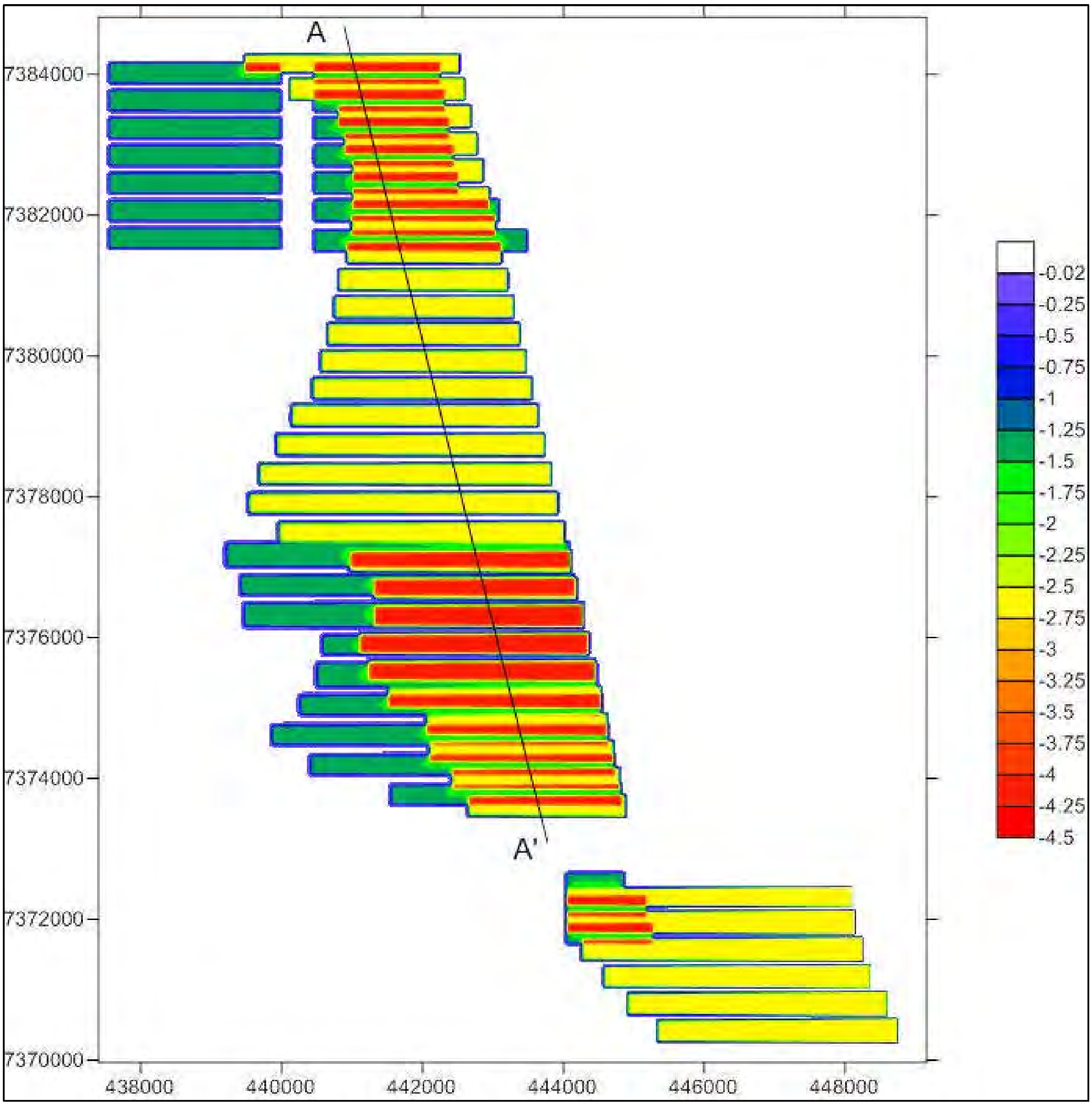


Figure 21 Vertical subsidence (m) – both seams

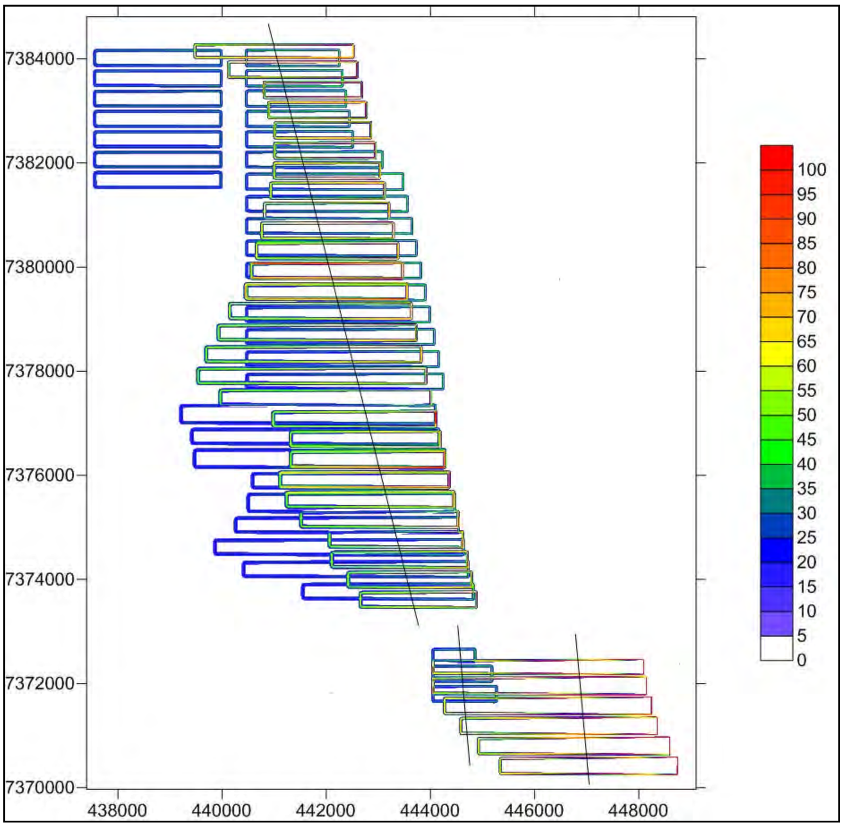


Figure 22 Tilt (mm/m) – both seams

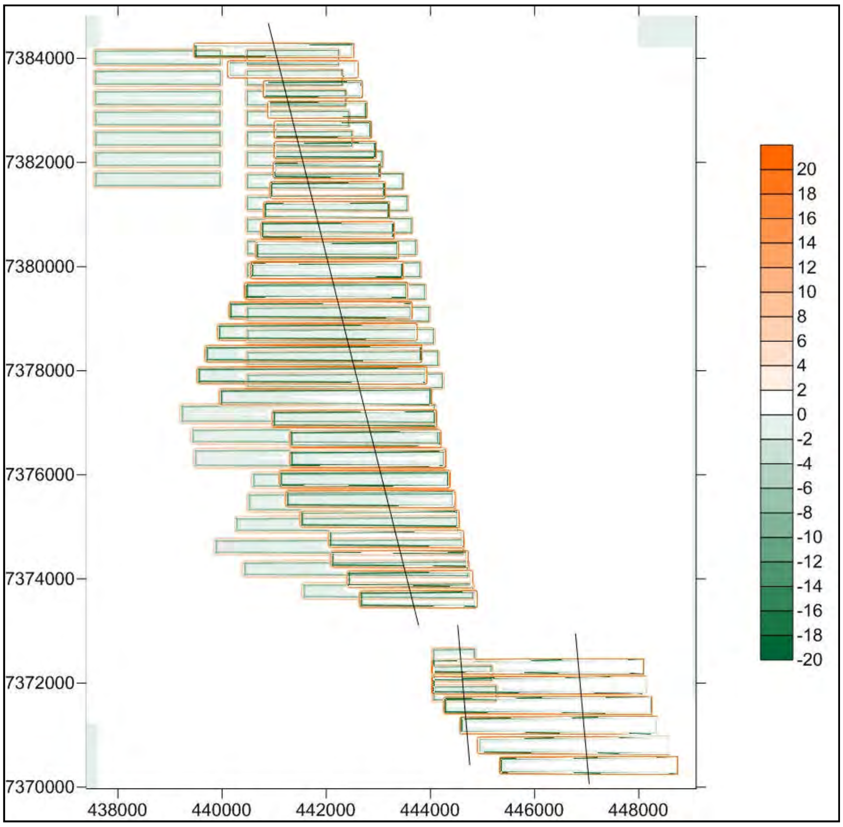


Figure 23 Strain (mm/m) – both seams

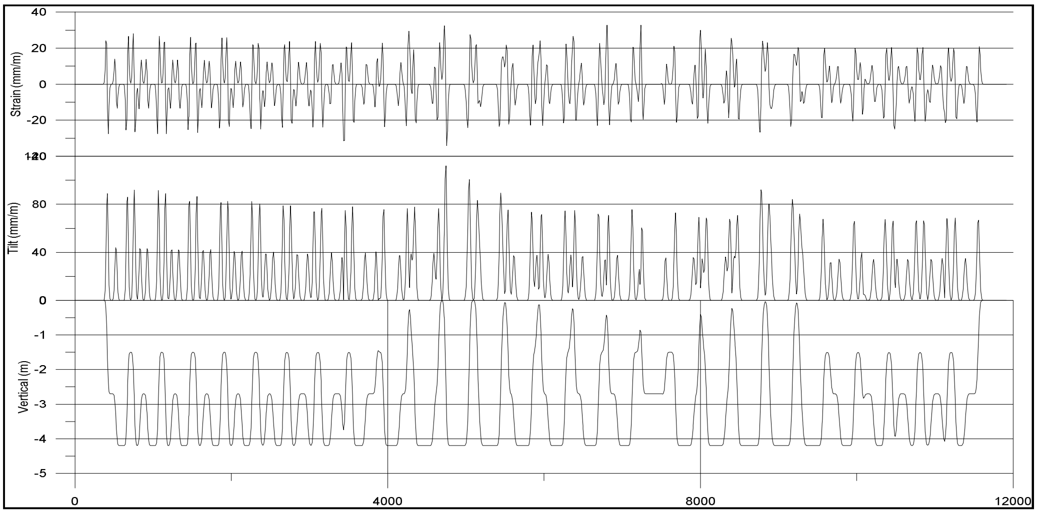


Figure 24 Subsidence parameters along crossline AA'

5.5 POST MINING TOPOGRAPHY

The post mining topography (i.e. topography of the ground surface following mining-induced subsidence) is shown in Figure 25. Figure 25 has 5m contour intervals to enable the impact of the longwall subsidence to be more readily discerned. The supplied dxf provides contours at 1m intervals.

6 POSSIBLE IMPACTS

6.1 SURFACE DRAINAGE

The predicted maximum vertical subsidence is 4.2m. Should the groundwater table lie closer than this to the surface, inundations will develop. A detailed groundwater assessment will be prepared separately by specialist groundwater consultants and will be appended to the SGCP EIS.

Following subsidence, short-term partial loss of surface water may be observed in waterways compared to the baseline conditions, particularly if the groundwater table is depressed after a long dry period. This loss is due to the greater volume of voids filled by surface water recharge. This is usually observed by a greater "lag" time for groundwater levels to recover after subsidence has occurred.

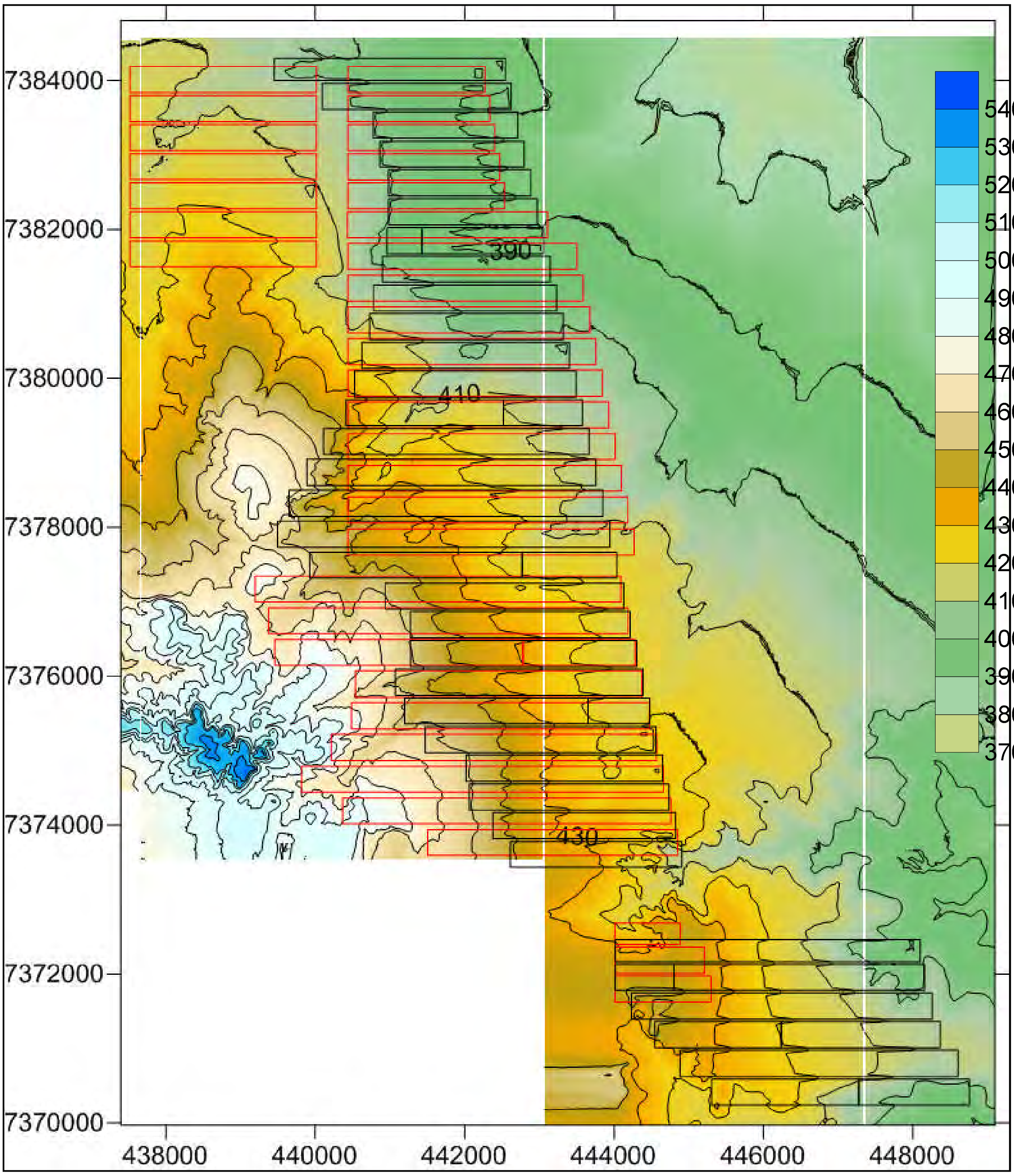


Figure 25 Post mining topography (compare with Figure 2)

6.2 SURFACE CRACKS

The development of cracking at the surface will depend on the nature of the soils and weathered rocks. There may be a large amount of shallow vertical cracks. Deeper and wider cracking (e.g. in excess of 50mm wide and 1m deep) could be associated with tensile strains in excess of 5mm/m. For the maximum tensile strains being predicted, the widest of the cracks is predicted to be in the order of 100mm - 200mm wide and extend to about 10 – 15m below ground level. Cracks of this nature can be readily remediated by reforming the surface with small excavators and dozers.

6.3 CONNECTION TO UNDERGROUND WORKINGS

The height of the fracturing or caving zone above longwalls and interaction with groundwater in this zone has been studied extensively. Data collected from Bowen Basin mines suggests the presence of a fractured zone extending 90m to 115m above a single seam longwall.

We are not aware of previous empirical studies examining the height of fracturing above multiple seam longwalls. The nomogram reproduced in Figure 14 would suggest significant water inflows to the mine workings for the combined seams. However, such an application to multiple seams may not be valid. Water inflows relate to the formation of zones of fractured rock and the dimensions of these cannot be directly related to the vertical subsidence developed on the surface. Recognising that fracture zones develop upwards from the longwall extraction, Figure 26 shows that the height of the fractured zones associated with a lower seam extraction are not higher than those associated with the upper seam. The vertical subsidence will be higher, and this can be considered as simply the overall lowering of the upper seam and its subsidence bowls.

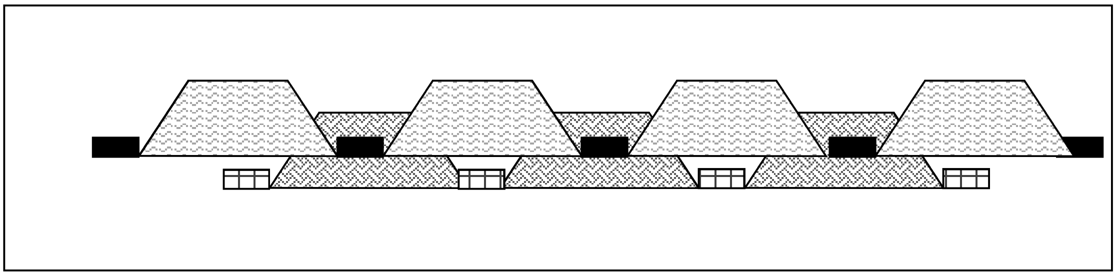


Figure 26 Overlapping fracture zones in multiseam longwalls

The model in Figure 26 has not been validated. In the face of the additional uncertainties with predicting fracturing heights above multiple seam longwalls, it would be good practice to assume a higher overall height of fracturing. For SGCP a value that is 50% higher than for a single seam should be used. For SGCP, this implies a fractured zone extending to 0.5 times the longwall extraction panel width.

6.4 SHALLOW GROUND WATER REGIME

Detailed groundwater assessments will be prepared separately by specialist consultants and will be appended to the SGCP EIS.

There is a potential for short to medium term transfer of surface water to the underlying groundwater system if the surface subsidence cracks connect to an underlying aquifer (Figure 27). The transient tensile strains associated with the subsidence wave may increase the effective pore space in the aquifer and hence there will be a reduction in piezometric head. The increase in bedrock void space may then be filled by surface water flowing into the cracks, temporarily reducing surface overland flow. This loss of surface water can persist for as long as required to fill the new crack voids. Provided that there is no discharge route from the groundwater system, surface flows are generally resurrected when the voids are filled. This filling may be by water, or on a more permanent basis by surface soils.

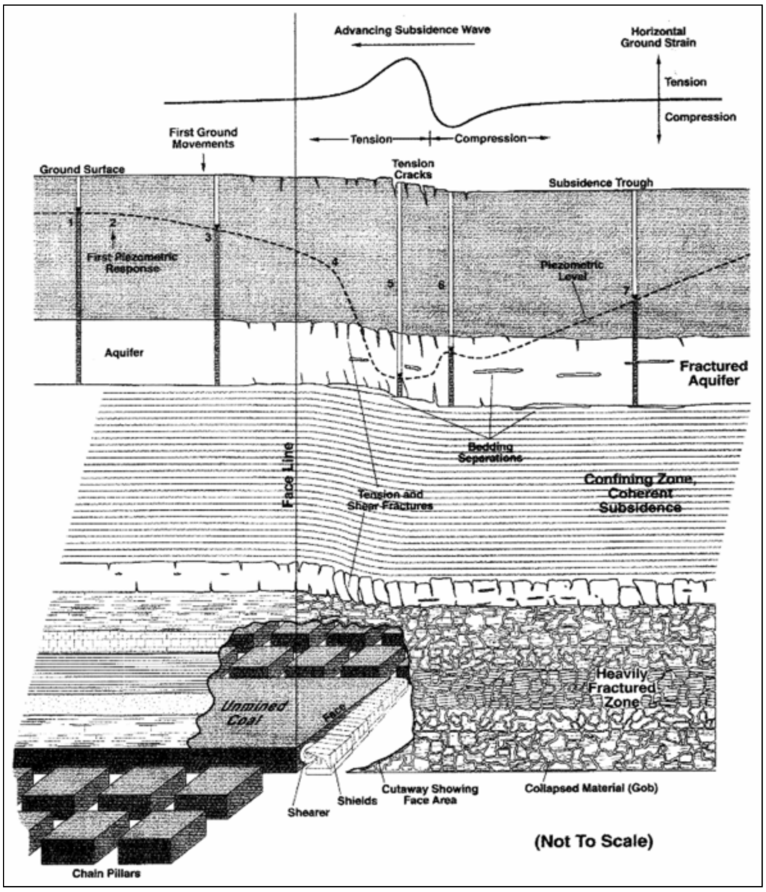


Figure 27 Conceptual model for the transient piezometric response of a near surface fractured rock aquifer above the longwall fractured zone (Booth, 2002)[17]

In deeper mines, localised loss of surface water may occur if there is transfer of water to a shallow groundwater system. This water usually discharges downstream in the catchment as upwelling groundwater without loss to the mine or loss from the overall catchment water budget. For this to happen, the surface flow path needs to be elevated above the groundwater system and this typically requires a steep topography and rocky bars/water falls. This condition is not present at SGCP.

6.5 WATER QUALITY

Water quality (in terms of water chemistry) does not generally change due to subsidence, except for a potential minor increase in salinity through enhanced connection to the underlying bedrock, and / or the increased content of stream bedload and dissolution of salts due to stream bed and bank erosion. Given the recent and Tertiary sediments, the former is unlikely.

Destabilisation of the stream bed and banks can be a significant effect from subsidence in a stream system as the new, post-mining trough and ridge profile along the stream is not geomorphologically stable. The maximum predicted tilts at the SGCP are well in excess of the current topographic slopes, so this impact should be anticipated.

[17] Booth, CJ. 2002. The effects of longwall coal mining on overlying aquifers. In Younger PL and Robins NS (eds) Mine Water Hydrogeology and Geochemistry. Geological Society, London, Special Publications, 198, 17-45

After subsidence, streams attempt to regain their original gradient and energy regime, which is generally achieved by eroding the stream bed and banks over chain pillars along with sedimentation in subsidence troughs. This also has the effect of increased discharge of suspended sediment downstream of the subsidence region.

Each time the creek flows, the new highs are reduced and the lows are filled in within the overall group of subsided panels. The greatest change in water quality is generally observed during flow periods directly after subsidence occurs, with the erosion / sedimentation reducing over time as a new stable state is attained.

Upstream of the overall subsidence region, headward bed erosion and bank destabilisation and / or widening can occur as the stream responds to the change in bed gradient, and attempts to re-establish a new stable state.

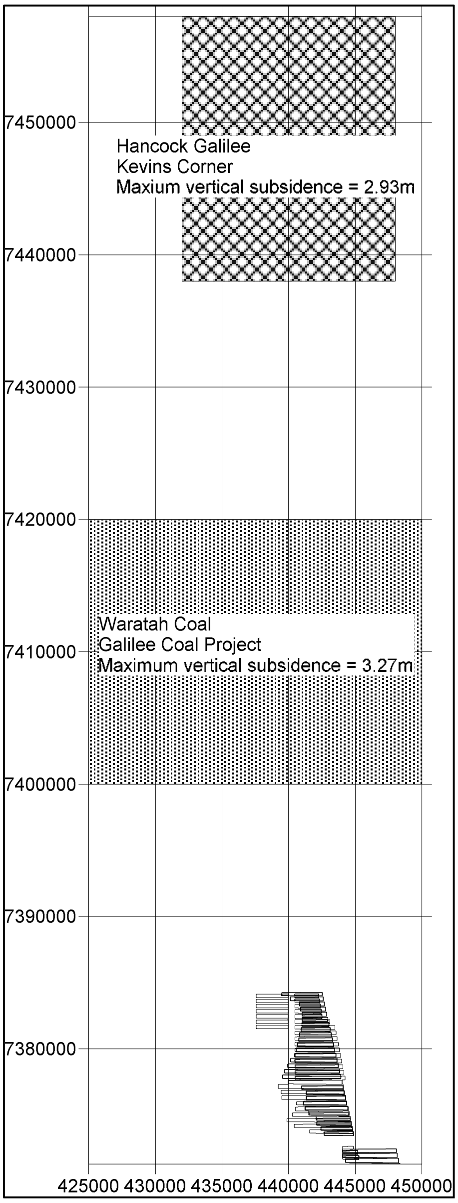


Figure 28 Other Galilee underground proposals

The downstream "edge" of the subsidence region will generally respond by an increase in sedimentation as the low point fills in an attempt to regain its original bed level.

6.6 CUMULATIVE SUBSIDENCE DEFORMATION IMPACTS

The margin figure (Figure 28) shows the location of the SGCP with respect to the other underground projects currently being proposed for the Galilee Basin. There is no underground at Hancock Coal's Alpha Coal Project . The nearest project (Waratah) is some 15 km to the north. In terms of subsidence deformations there will be no interaction between these projects.

7 RECOMMENDATIONS

The subsidence predictions provided in this report should be used as likely indicative maximums, but should not be interpreted as constraints to be applied to the mine design. The state of the art in subsidence modelling and prediction does not allow predictions in new mining districts with very high levels of certainty.

Tilts have been maximised by the selection of a high tanB value, and then somewhat reduced associated strains by a lower strain constant. This is based on previous experience in the Bowen Basin. A consequence is a footprint that is possibly smaller than will be encountered.

In the context of setting deformations for risk assessments, the following is recommended:

- Values 20% higher than in the visualisations.
- At an specific location, deformation values with a 20m radius should be considered.
- An angle of draw of 26.5^o be used for defining the subsidence foot print

Since much of the adverse impact with subsidence comes from the high tilts and strains associated with the edges of the extraction panels, wider panels may reduce the total impact. At this stage, the knowledge of the overburden suggests there is no opportunity to narrow the extraction panels to reduce subsidence impacts by reducing the maximum vertical subsidence to low levels.

The first of the longwall extraction panels should be extensively monitored to provide validated parameters to use in subsequent influence function predictions. The monitoring should include airborne laser surveys to produce detailed contour maps of the subsidence troughs and also some more conventional cross-line surveys to obtain values for tilts and strains. There should be subsurface monitoring to characterise the heights of the fractured zone.

It is likely the multiple seam extraction will begin well into the life of the mine after much more is known of the subsidence behaviour in the Galilee Basin. The monitoring programs used for the single seam can be modified and applied as appropriate to the multiple seam layout.