12 Groundwater

Section 12 Groundwater

12.1 Introduction

In order to assess the baseline hydrogeological conditions of the Alpha Coal Project (Rail) (herein referred to as the Project) study area, a desktop review of existing data was undertaken. The objective of the data review was to describe the existing environment for groundwater resources that may be affected by the Project, during construction and operation stages. An assessment of the potential environmental impacts on local groundwater resources has also been identified so as to enable identification of mitigation measures.

The following data resources have been used in the preparation of the desktop review:

- published digital geological maps, 1:250 000 scale, Geological Survey of Queensland (GSQ);
- Department of Environment and Resource Management (DERM) Groundwater Bore Database (April, 2009);
- the Water Entitlements Registration Database (WERD) from DERM was unavailable at the time of writing this report;
- Australian Natural Resources Atlas (ANRA) interactive website, the Department of Sustainability, Environment, Water, Population and Communities (DSEWPC, 2010); and
- Bureau of Meteorology (BoM) rainfall data from stations at Bowen Airport and Bowen Post Office.

12.2 Description of Environmental Values

12.2.1 DERM Groundwater Bore Database

A search of the Queensland DERM Groundwater Database (2009) identified 263 registered bores within a five km buffer of the Project (refer to Figure 12-1). Information outlining bore construction, driller's log descriptions, water levels, water quality data and authorised purpose that were available from the database are summarised in Volume 6, Appendix D. Information obtained from the database has been used to provide information on baseline hydrogeological conditions in the vicinity of the Project.

Given the vast amount of information extracted from the groundwater bore database, for ease of assessment the Project has been divided into four sections according to geographical location. The sections are summarised in Table 12-1 and can be viewed on Figure 12-1.

Table 12-1: Project sections

Section	Location Names	Chainages in kilometers	Number of Bores
1	Windaree to Clonmell	0 – 110	25
2	Clonmell to Newlands	110 – 300	48
3	Newlands to Bogie River	300 – 430	59
4	Bogie River to Willmington Station	430 – 495	131

For each section of the alignment data for all registered groundwater bores within five km of the Project were extracted from the DERM database and reviewed in conjunction with the underlying dominant geological units. Figure 12-2 details the location of the registered bores and the mapped geology. Volume 6, Appendix D summarises extracted data (by sections) from the DERM groundwater bores database.

12.2.2 Groundwater Management in Queensland

12.2.2.1 Overview

In Queensland, licensing systems of groundwater management operate in Declared Groundwater Areas (DGA). The Government declares these areas and, will continue to, where there is competition for the available resource. Groundwater resource areas are split into Groundwater Management Units (GMU), which incorporate areas that rely extensively on groundwater resources and have extensive data available for monitoring the resource; and Unincorporated Areas (UA), which are areas where there is little to no data on groundwater resources and exploitation of the resource is not well developed (DEWHA 2007).

The majority of the Project traverses a groundwater UA for Yarraman and Bowen. It is not until the Project reaches the coastline where it enters a designated Groundwater Management Unit (GMU) for the Don River. Each of the management areas are shown in Figure 12-1 and described below based on information provided in the ANRA (DEWHA 2007). Table 12-2 provides statistics on groundwater characteristics within the GMU and UA, which were reported in the National Land and Water Resources Audit (NLWRA, 2001).

Table 12-2: General groundwater statistics for the groundwater management units and unincorporated areas (NLWRA, 2001)

Section	Bowen	Yarraman UA	Don River GMU
Area	153,800 km^2	118,700 km^2	543 km^2
Total water allocated	no data	no data	no data
Total water consumed	14,900 ML/yr	100,000 ML/yr	12,792 ML/yr
Average salinity	755 mg/l	994 mg/l	1,524 mg/l
Depth to top of aquifer	45 m	20 m	6 m

12.2.2.2 Bowen Unincorporated Area

The Bowen Unincorporated Area (UA) includes the Bowen Basin, Drummond Basin, Galilee Basin and the Anakie Inlier. The UA is bound to the west by the Great Artesian Basin (DEWHA 2007).

The North-South trending Denham Range, Peak Range and the Drummond Range control the structure of the river systems that include the Suttor, Nogoa, Isaac-Mackenzie, Dawson, Belyando, Burdekin and Bowen Rivers. The rivers flow for only a few months of the year although the larger channels do contain permanent waterholes (DEWHA 2007).

Aquifers within the Bowen UA generally provide groundwater for pastoral, irrigation, mining, stock and domestic, and town water requirements. Increased irrigation, developments in the local coal industry and increased mining activity in the gemfields has resulted in escalating groundwater demands (DEWHA 2007).

The major aquifers within the UA are the Quaternary alluvium, the sand and gravel horizons of the Tertiary sediments and the Tertiary basalts. Bore yields are generally below 5 l/sec and defined as marginal, however supplies of good quality groundwater are common from the alluvial and basalt aquifers. Poorer quality groundwater is typical of the coal bearing strata particularly in the Bowen Basin Stratigraphy (DEWHA 2007).

12.2.2.3 Don River Groundwater Management Unit

The Don River GMU is situated in the Don River basin along the coastline. The Don River alluvial aquifers supply water to the town of Bowen as well as to the agricultural industry for irrigation purposes. Horticulture is the major agricultural industry. Bore yields range between 4 l/s and 32 l/sec. Extended drought periods have resulted in reduced yields and declining water levels in recent years (DEWHA 2007).

Water quality is generally fresh to marginal and is suitable for most purposes. This is a reflection of the streamflow recharge mechanisms within these localised areas. Water quality elsewhere in the GMU predominantly falls into the brackish category (DEWHA 2007).

12.2.2.4 Yarraman Unincorporated Area

The majority of groundwater in the Yarraman UA occurs in igneous and sedimentary rock aquifers. Supplies and supply rates in the UA are unsuitable or marginal for irrigation and urban supplies. Supply rates of groundwater in the fractured igneous aquifers are highly variable ranging from 0.5 to 10 l/sec and in sedimentary aquifers are usually less than 10 l/sec. No assessment of sustainable yield has been conducted for the UA (DEWHA 2007).

Groundwater use in the northern region of the UA is influenced largely by the sugar industry which is the dominant primary industry. The majority of bores in the UA are suitable for stock and domestic and some irrigation facilities. Assessment of the total annual groundwater abstraction in the Yarraman UA has not been conducted (DEWHA 2007).

12.2.3 Groundwater Use

Of the 263 registered bores identified within the search area, 69 are reported as abandoned of which 52 are no longer useable (reported as abandoned and destroyed) and 194 bores are reported as existing (assumed to still be in use). The major facility role for all the bores identified are detailed in Table 12-3.

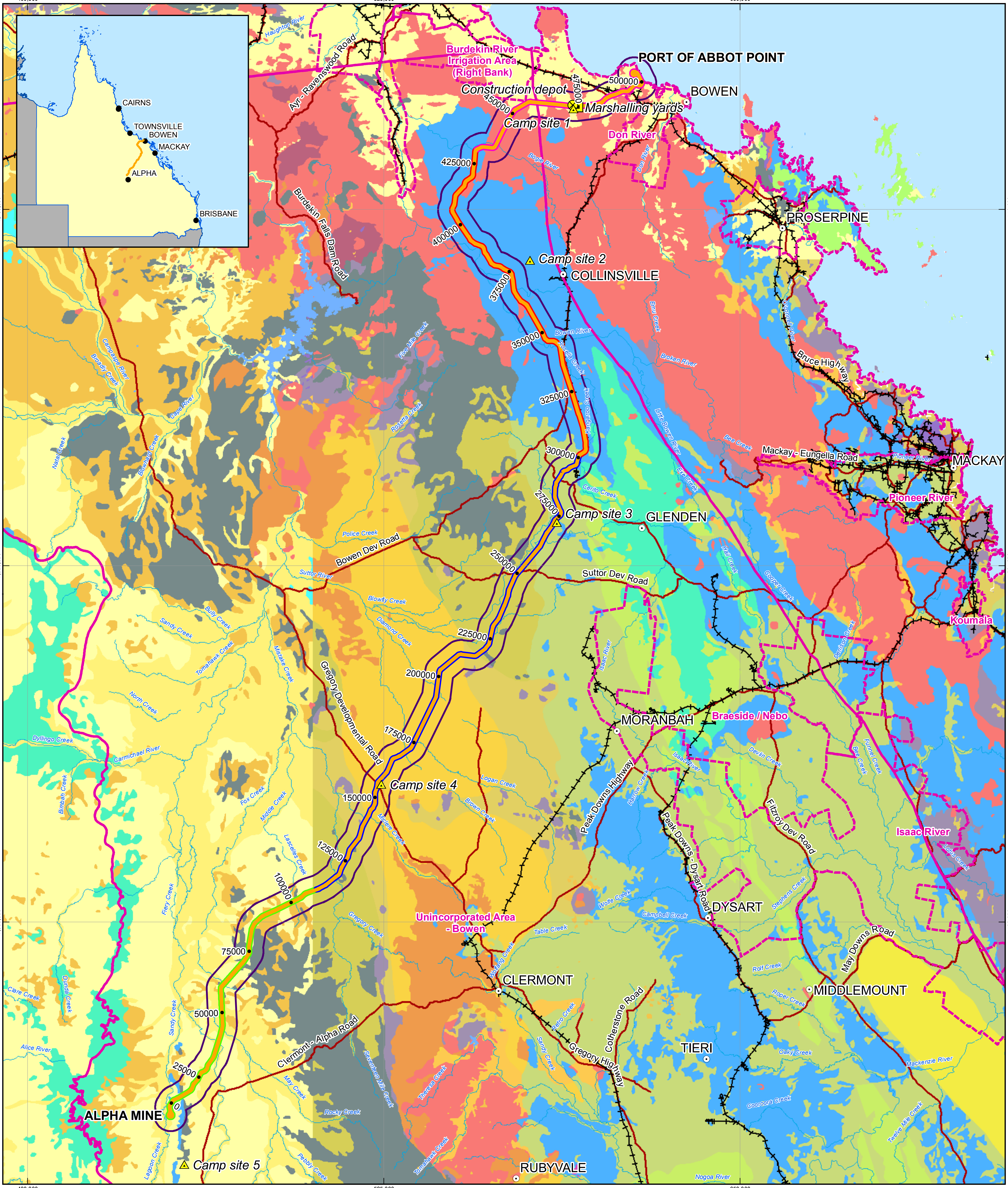
Table 12-3: Type and status of groundwater bores from the Department of Environment and Resource Management database (2009)

Facility Role	Existing	Abandoned (useable)	Abandoned Destroyed
Unknown	117	7	28
Water Supply	51	4	17
Groundwater Investigation	15	6	3
Other exploration / investigation	4	-	2
Sub-Artesian Monitoring	1	-	1
Stratigraphic Investigation	6	-	-

Facility Role	Existing	Abandoned (useable)	Abandoned Destroyed
Mineral or Coal Exploration	-	-	1
Unknown	117	7	28

A total of 51 existing water supply bores have been identified within the five km assessment buffer of the Project; however it is possible that a proportion of the bores with a facility role described as 'unknown' may also abstract groundwater. The existing water supply bores are summarised in Volume 6, Appendix D.

The majority of existing water supply bores are located both up-gradient and down-gradient of the Project within Section 4, and based on their location and the information provided in the database (where recorded) some are indicated to penetrate the alluvium and some the igneous bedrock. Where available, information in the database indicates that existing water supply bores located in Section 2 typically penetrate igneous bedrock with a small proportion of bores penetrating sedimentary bedrock. There are limited data to indicate the tapped aquifer for the water supply bores identified in Section 1 and Section 3, however are likely to include abstraction from both alluvium and bedrock sources.



LEGEND

- Town
- Camp
- Marshalling Yards
- Depot
- Proposed Alignment
- State Road
- Existing Railway
- Watercourse

Proposed Alignment Section
- Section 1
- Section 2
- Section 3
- Section 4

- Waterbody
- Groundwater Management Unit
- 5km Alignment Buffer

Source: See Copyright Details below and for full disclosure please refer to the EIS ***Volume 4 - References***

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0 5 10 20 30 40 50

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 55

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Environmental Impact Statement

REGIONAL GEOLOGY AND HYDROGEOLOGY

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Date	21-09-2010

Figure: 12-1

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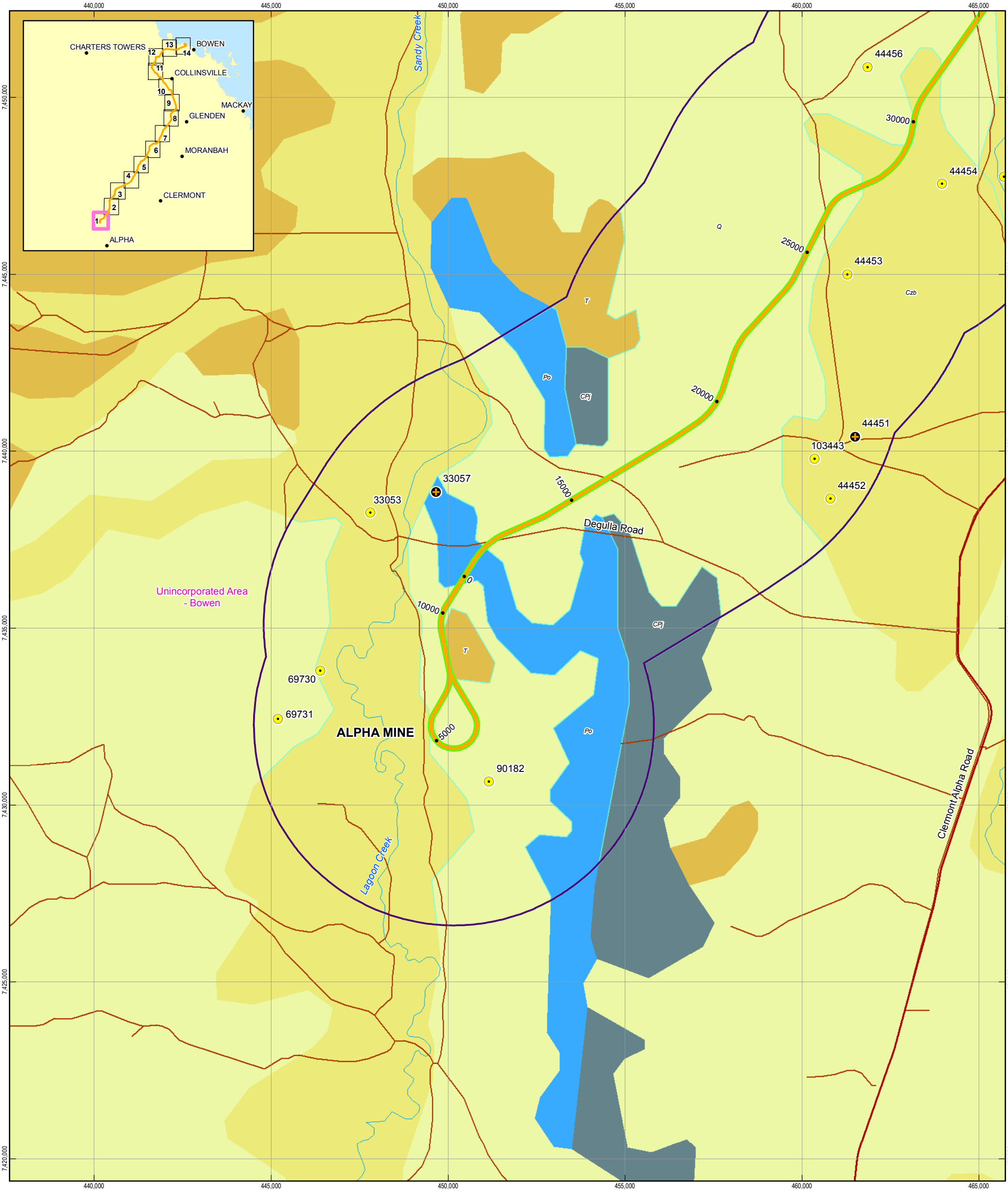

LEGEND

- Town
- Camp
- Marshalling Yards
- Depot

Status Of Groundwater Bores

- Abandoned and Destroyed
- Abandoned but Still Useable
- Existing
- Unknown

- Proposed Alignment
- Existing Railway
- State Road
- Local Road
- Watercourse

Proposed Alignment Section

- Section 1
- Section 2
- Section 3
- Section 4

- Waterbody
- 5km Alignment Buffer
- Groundwater Management Unit

Source: See Copyright Details below and for full disclosure please refer to the EIS ***Volume 4 - References***

1:100,000 (at A3)

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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 55

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DERM GROUNDWATER BORES

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Figure: 12-2
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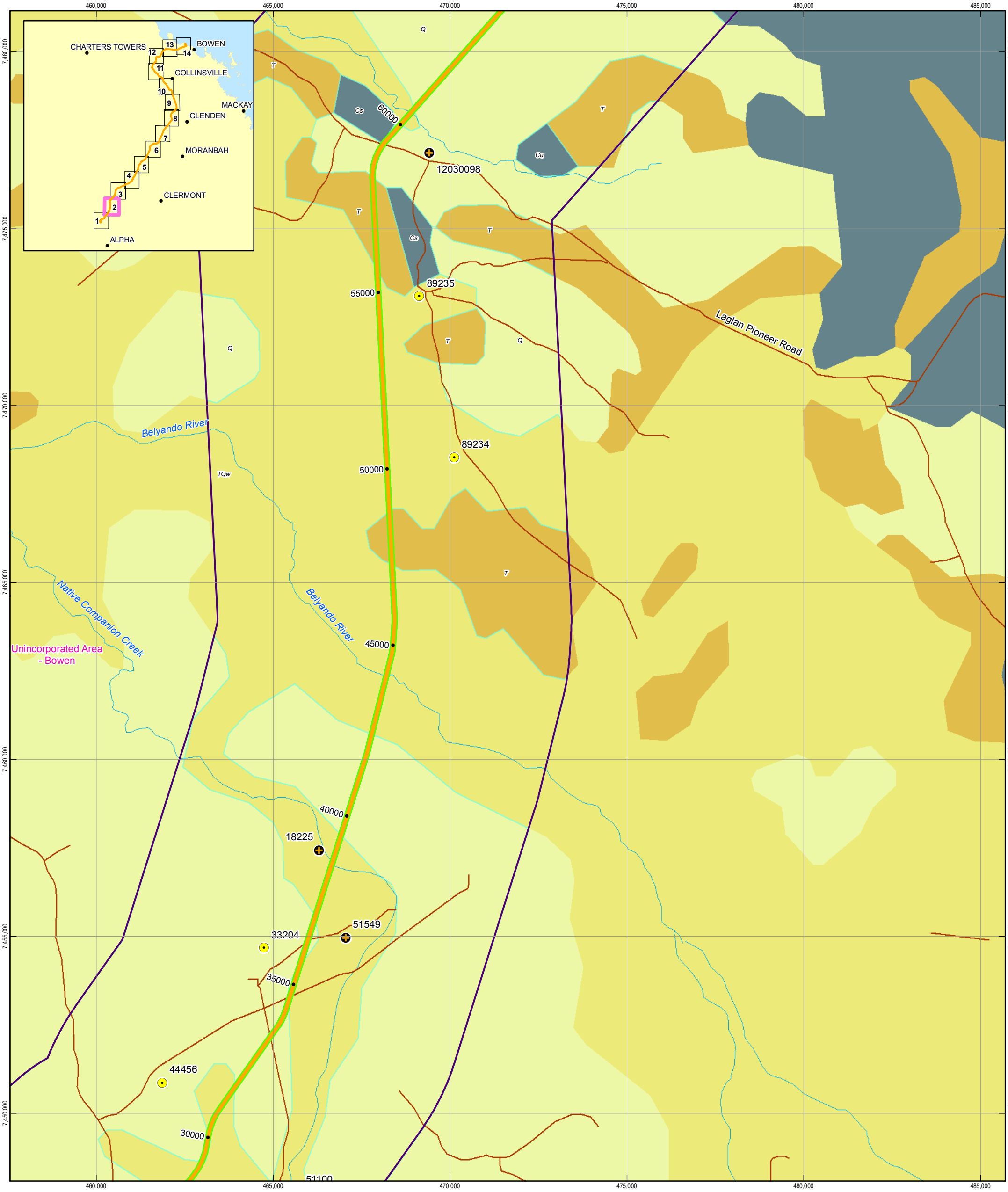

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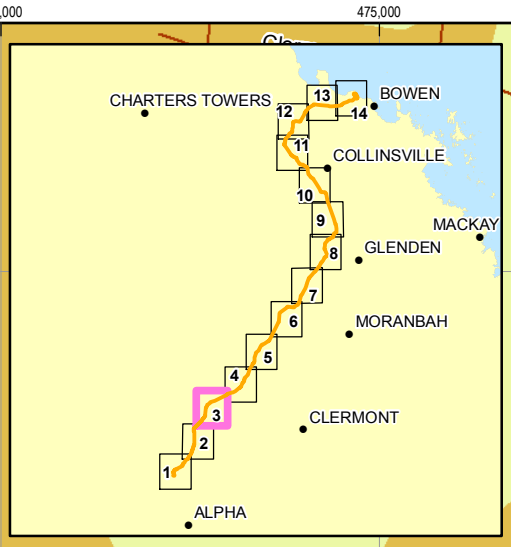

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7,510,000 7,505,000 7,500,000 7,495,000 7,490,000 7,485,000

89426
62647
89386
12030158
62646
62792
89364
105000
100000
95000
90000
85000
80000
75000
70000
65000
Unincorporated Area - Bowen
Lascelles Creek
Q T Cu Cs Ch Cr TQw

LEGEND

- Town
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Kilometres

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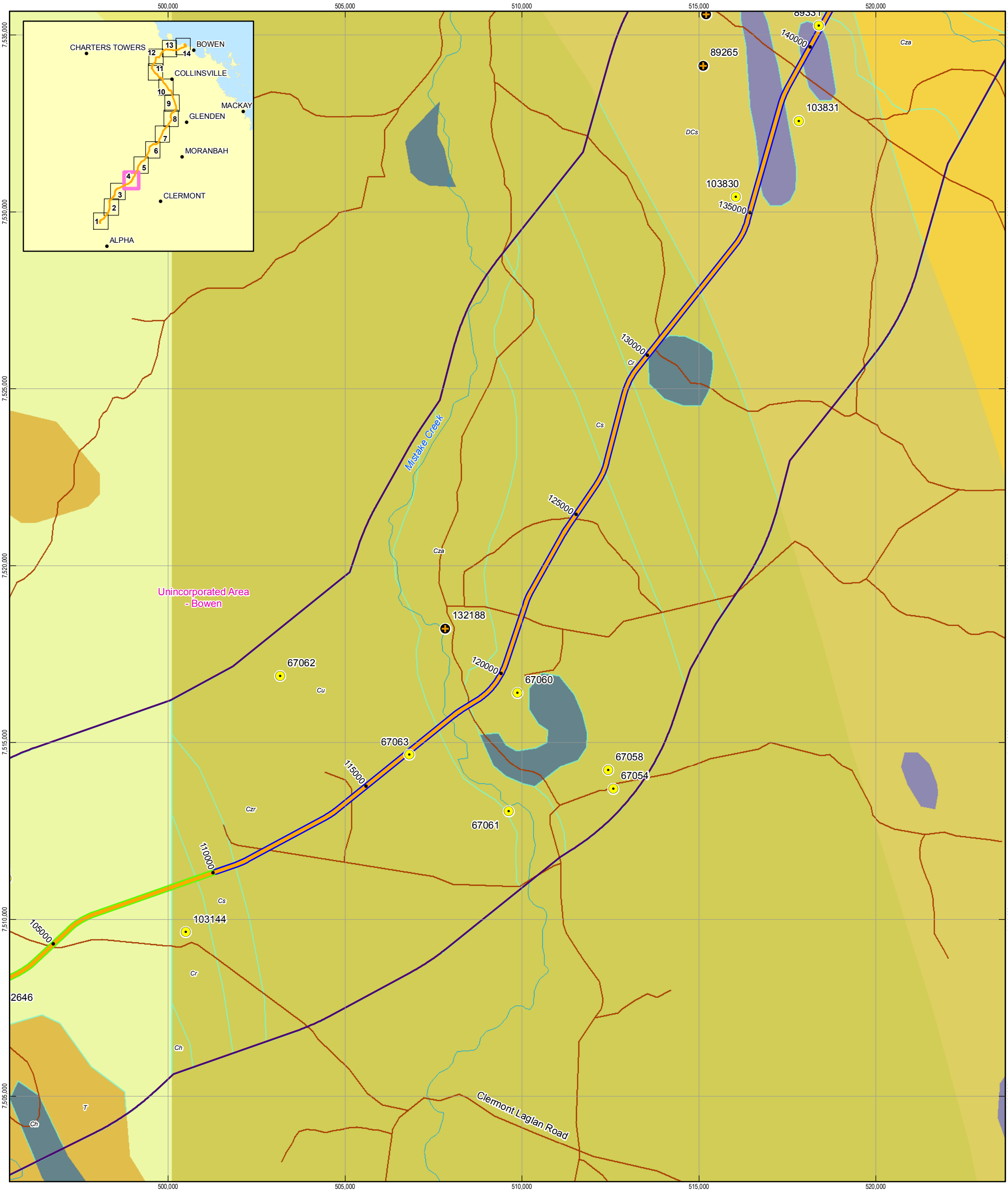

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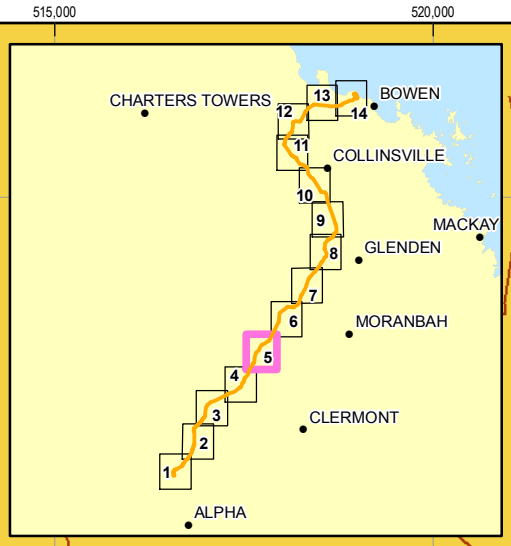

515,000 520,000 525,000 530,000 535,000 540,000

7,565,000 7,560,000 7,555,000 7,550,000 7,545,000 7,540,000 7,535,000

Golden Downs Road
Logan Creek
Dooruna Road
Brown Creek
Gregory Developmental Road
Miclere Creek
Unincorporated Area - Bowen
Camp site 4

Czd
PLEa
Cza
Czr

12030173
175000
170000
165000
160000
155000
150000
145000
140000

103501
103472
103642
89333
103505
84042
67319
89283
89417
89334
89332
89331
89265

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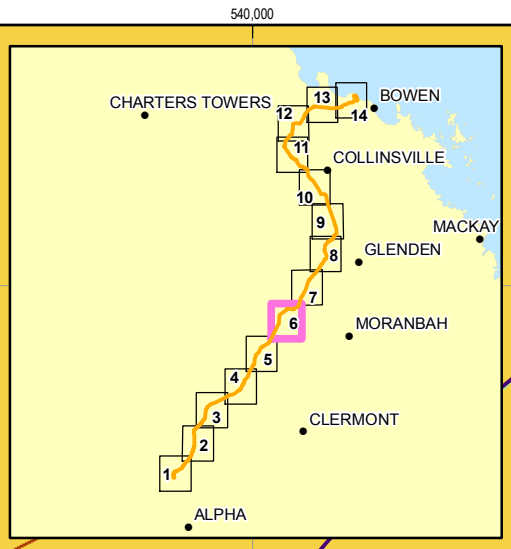

540,000 545,000 550,000 555,000 560,000

7,595,000 7,590,000 7,585,000 7,580,000 7,575,000 7,570,000

89422

Mabbin Road

220000

215000

210000

205000

200000

195000

190000

185000

180000

10853

10854

Unincorporated Area - Bowen

Diamond Creek

Kilcummin - Diamond Downs Road

Czr

DCs

Czs

LEGEND

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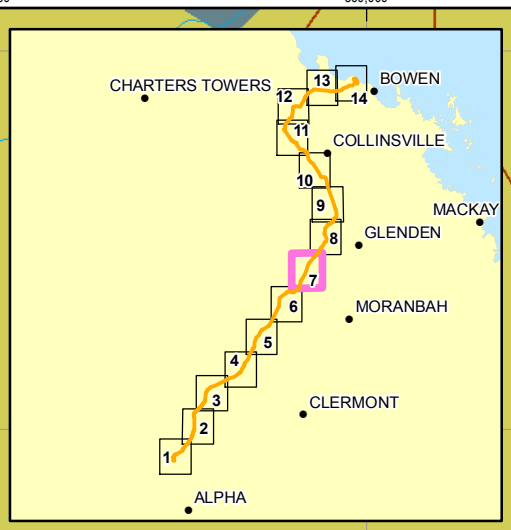

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7,630,000 7,625,000 7,620,000 7,615,000 7,610,000 7,605,000 7,600,000

260000 255000 250000 245000 240000 235000 230000 225000

Suttor River
Suttor Dev Road
Mabbin Road
Eaglefield Creek

125850
12030095
125851
89422

Czr
Cvb

Unincorporated Area
- Bowen

LEGEND

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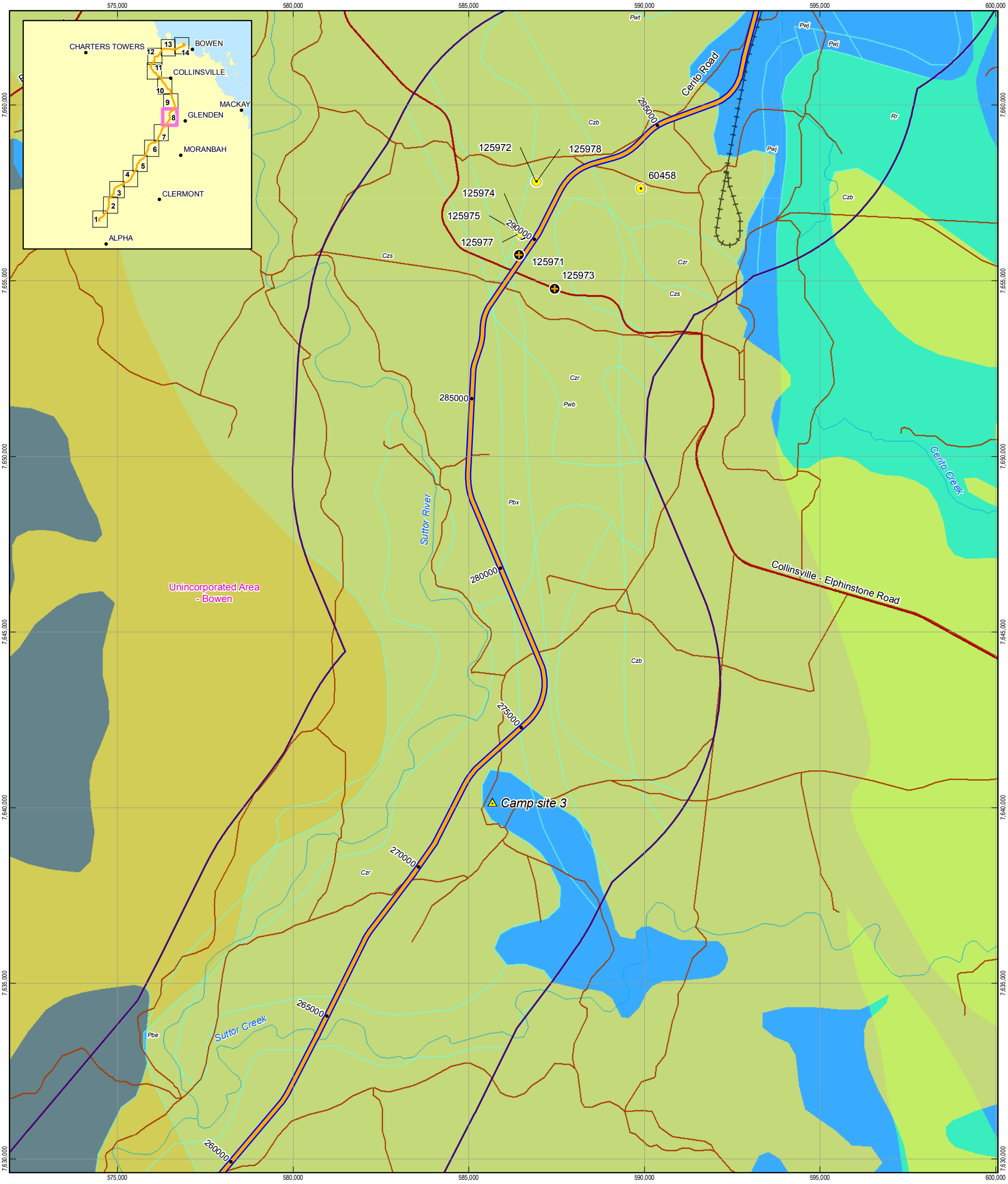

LEGEND

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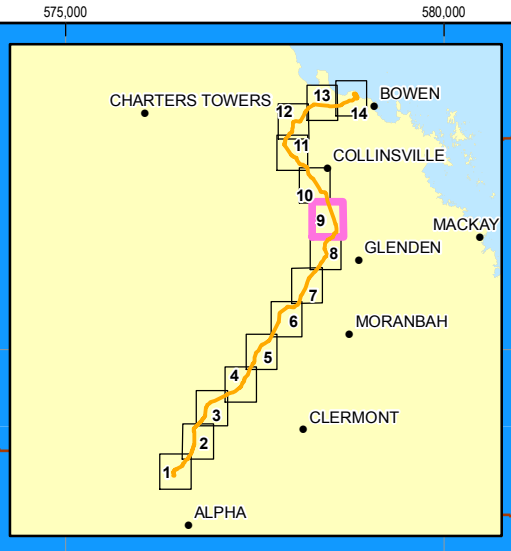

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7,690,000 7,685,000 7,680,000 7,675,000 7,670,000 7,665,000

25670 22742 25667 25666 330000 25673 325000 25671 70019 320000 25668 315000 33215 54108 310000 25636 25638 25635 25633 305000 300000

Rosella Creek
Kangaroo Creek
Unincorporated Area - Bowen
Collinsville - Elphinstone Road
Suttor River
Bowen Dev Road
Cerito Road

Pb Pbx Pwb Tb Pbe Ki Kl Pw Tb Czb Pwb Tb Ki Ki Pbx Tb Tb Pwt Tb Czb Tb Czb Tb Pwb Tb Pwb Pwj Pwj Rr Rr Pwj Rr Pwj Rr Pwt Pwj Pwj Pwt Pwj Rr Pwj Pwt Pwj Czb Pwt Pwj Pwj

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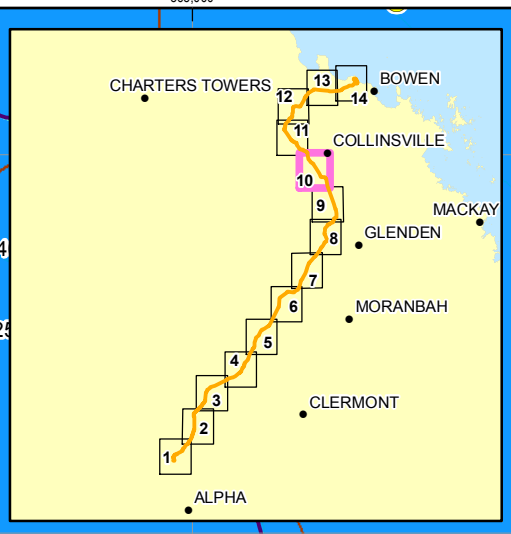

565,000 570,000 575,000 580,000 585,000 590,000

7,725,000 7,720,000 7,715,000 7,710,000 7,705,000 7,700,000 7,695,000

370000
365000
360000
355000
350000
345000
340000
335000

12020022
25646
12020027
12020026
25669
25670

Unincorporated Area - Yarraman
Unincorporated Area - Bowen

Pelican Creek
Myuna Road (south)
Bowen River
Bowen Dev Road
Rosella Creek

Pbc
Ki
Pbe
Pb
Pbx
Pwb

LEGEND

- Town
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0 0.5 1 2 3 4 5

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N W E S

HANCOCK PROSPECTING PTY LTD

Alpha Coal Project
Environmental Impact Statement

DERM GROUNDWATER BORES

Job Number 41-22090
Revision A
Date 20-09-2010

Figure: 12-2
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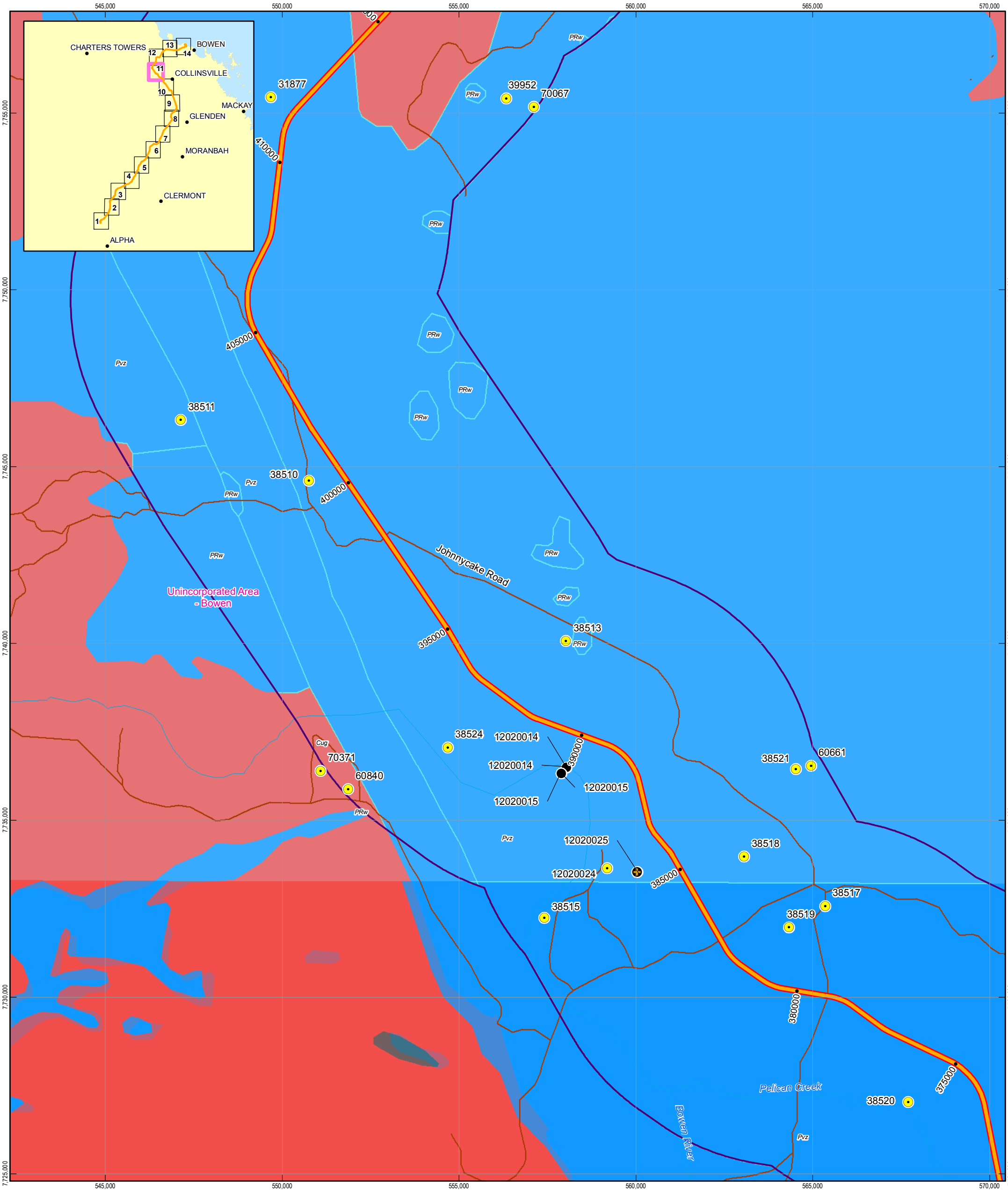

LEGEND

- Town
- Camp
- Marshalling Yards
- Depot

Status Of Groundwater Bores

- Abandoned and Destroyed
- Abandoned but Still Useable
- Existing
- Unknown

- Proposed Alignment
- Existing Railway
- State Road
- Local Road
- Watercourse

Proposed Alignment Section

- Section 1
- Section 2
- Section 3
- Section 4

- Waterbody
- 5km Alignment Buffer
- Groundwater Management Unit

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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 55

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Alpha Coal Project
Environmental Impact Statement

DERM GROUNDWATER BORES

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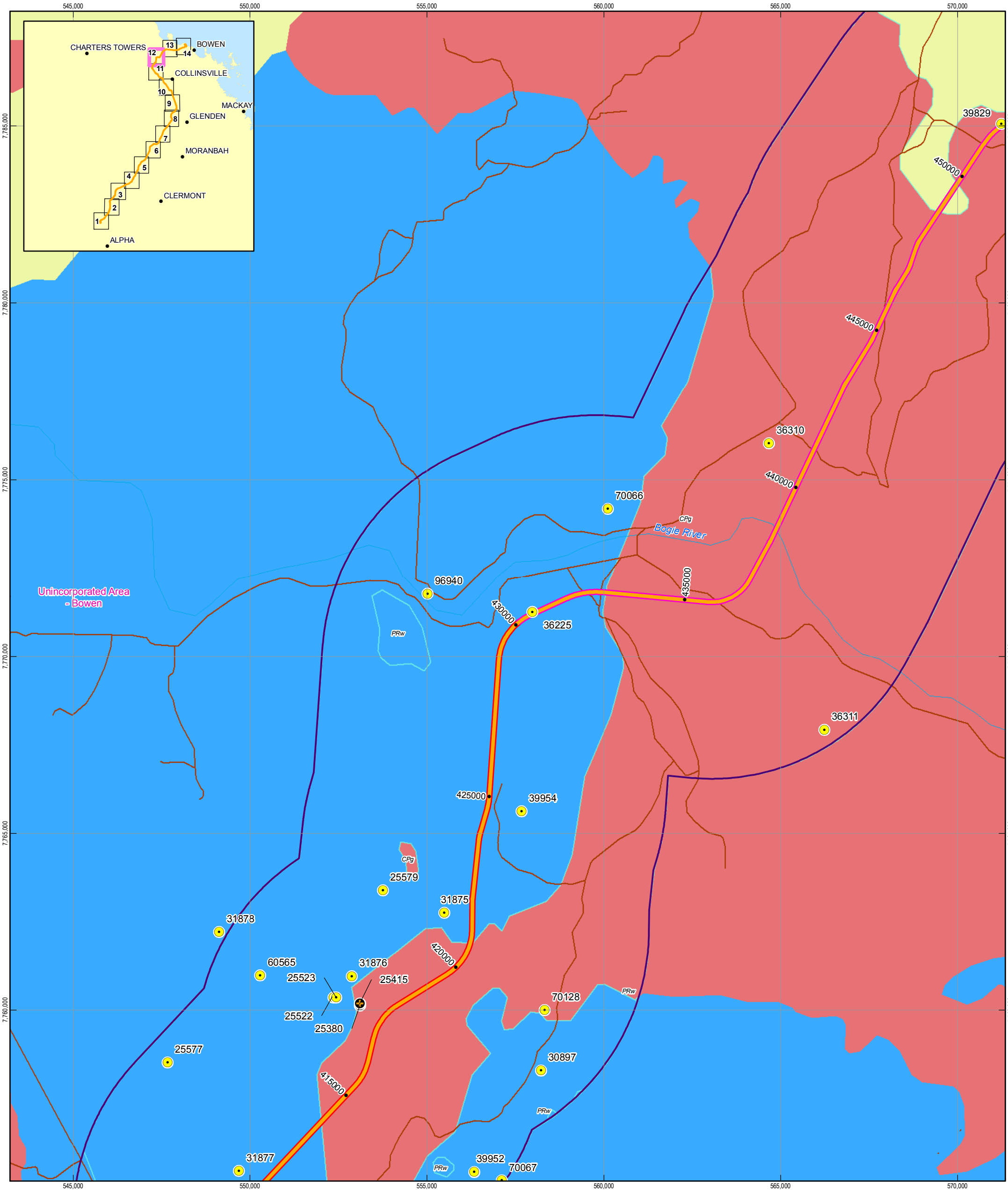

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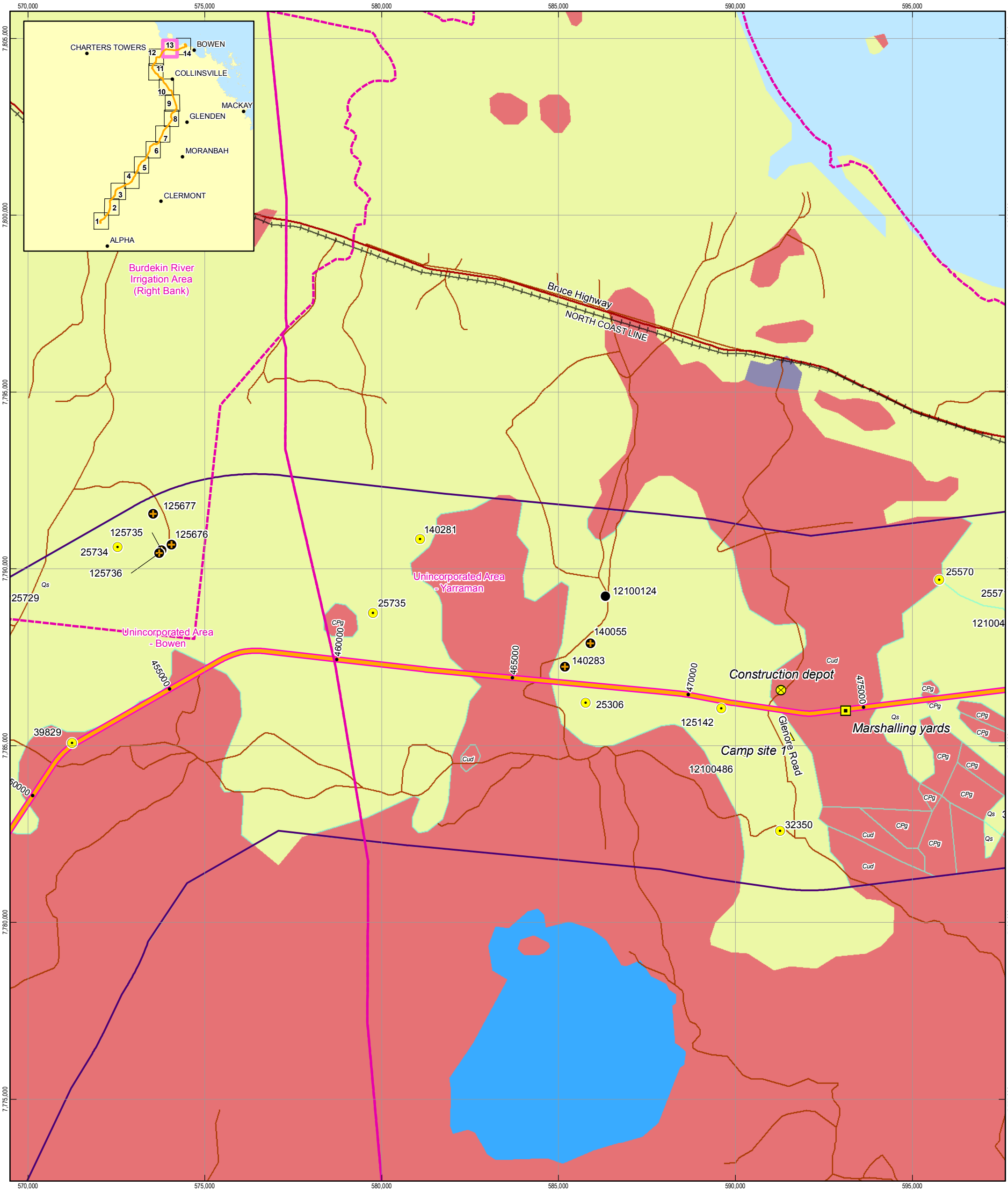

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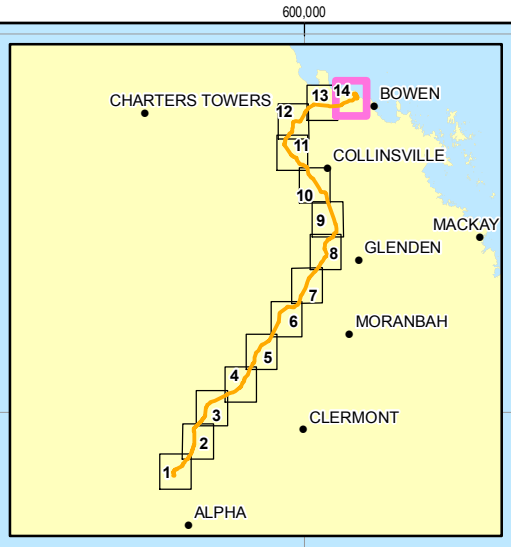

PORT OF ABBOT POINT

Caley Valley Wetlands

NORTH COAST LINE

Bruce Highway

Bowen Dev Road

Unincorporated Area - Yarraman

Don River

MERINDA

600,000 605,000 610,000 615,000 620,000

7,810,000 7,805,000 7,800,000 7,795,000 7,790,000 7,785,000 7,780,000

LEGEND

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Alpha Coal Project
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12.2.4 Hydrogeological Units

12.2.4.1 Overview

Analysis of existing bores and digital geological data indicates four major hydrogeological units beneath and within the vicinity of the Project. The geological units consist of complex compositions of varying sediments and structures and are outlined below:

- Alluvial and colluvial deposits and miscellaneous unconsolidated sediments (Tertiary to Quaternary);
- Sedimentary Bedrock (Carboniferous to Tertiary);
- Igneous Bedrock (Devonian to Cenozoic); and
- Metamorphic (Neoproterozoic to Cambrian).

Detailed geological descriptions of the major geological units are presented in Volume 3, Section 3.2.1 of this EIS. Hydrogeological features of the major geological units are summarised below.

12.2.4.2 Alluvium, Colluvium and Miscellaneous Unconsolidated Deposits

Tertiary to Quaternary aged sediments directly underlie the majority of the Project from the Alpha Coal Mine to chainage 310 km and chainage 450 km to chainage 510 km (Figure 12-1), predominantly within Sections 1, 2 and 4. Most of these sediments have been deposited by adjacent rivers, creeks and associated floodplains and consist of various compositions of sand, silt, gravel and clay.

The majority of the alluvial deposits within Section 1 and Section 2 consist of 'older fluviatile and floodplain sediments with some colluvium also mapped in Section 2. Weathering by-products such as ferricrete and laterite are also present. There is no alluvium mapped within Section 3, however presumably there are localised alluvial deposits associated with the Bowen River and its tributaries. Section 4 is dominated by granite outcrops with overlying residual and colluvial deposits for a large part of the Project before entering the lower lying area of Port of Abbot Point. Port of Abbot Point is typically underlain by alluvium and coastal mudflat deposits.

Colluvium, from weathering of underlying and outcropping bedrock tends to form on slopes and in valleys. Groundwater resources within the colluvium are not expected to be significant, if present. Groundwater bores situated in areas mapped as colluvium in Section 2 and Section 4 are sourcing water from the underlying bedrock.

Borehole logs from the groundwater bore database indicate that the alluvial deposits can range in thickness of between <1 m up to 50 m (Registration number (RN)18,225) in Section 1, <1 m and up to 84 m (RN84,042) in Section 2 and up to 18 m in Section 4. The permeability of the alluvial deposits will vary spatially, and their productivity will be dependent on the presence or absence of coarser-grained sediments such as sand and gravel. The alluvial aquifers are likely to be recharged via direct infiltration of precipitation and from hydraulic connection with surface water bodies.

Many of the local creeks and rivers are dry for most of the year and flow only during the wet season from November to March (DEWHA 2007). Rivers with deeper channel profiles tend to have permanent waterholes all year round. Recharge of alluvial aquifers occurs during the wet season when the rivers and creeks are running. Alluvial aquifers in Section 4 receive a greater potential to recharge due to the higher rainfall along the coastline.

12.2.4.3 Sedimentary Bedrock

Devonian to Cenozoic-aged sedimentary bedrock is mapped at outcrop from 300 km to 350 km (within Section 2 and Section 3 of the assessment area) (refer to Figure 12-1) and mainly consists of Carboniferous to Permian aged coal measures. The outcrop stratigraphy includes Early to Late Permian Back Creek Group (Blenheim Formation and Collinsville Coal Measures), the Permian Blackwater Group (Moranbah Coal Measures, Fair Hill Formation and the Fort Cooper Coal Measures) and the Carboniferous Drummond Group (Star of Hope Formation and Ducabrook Formation). The major rock types within these groups are sandstones and siltstones with coal measures concentrated in the north of Section 2 and south of Section 3 (Bowen Basin). Older Carboniferous aged lithic to feldspathic sandstones, siltstone and conglomerate underly the alluvium dominating the southern part of Section 2 and all of Section 1. Occasional igneous intrusions are common in sedimentary deposits in Sections 2 and 3.

Recharge of these sedimentary rocks is likely to occur directly at outcrop and via infiltration through overlying alluvium. Localised structures trending north-west such as faults and intrusions intersect the alignment and may increase the rate and direction of groundwater flow through these formation units.

Data analysis of the Groundwater Database indicate that sedimentary rocks have a yield ranging between 0.3 L/sec and 12 L/sec with an average yield of 4.8 L/sec.

12.2.4.4 Igneous Bedrock

Carboniferous to Permian aged volcanics outcrop in Sections 3 and 4 between chainages 360 km and 450 km and include unnamed volcanics, the Lizzie Creek Volcanics and Mount Wickham Rhyolites. Tertiary aged olivine basalt outcrops in Section 3 at approximately chainage 330 km however there is no data to suggest that it bears groundwater. Small outcroppings of the Bulgonunna Volcanic Group and Silver Hills Volcanics are mapped in Sections 1 and 2.

The northern most deposits typically range between rhyolitic to dacitic in composition, with some basalt and gabbro present. The southern most deposits are typically rhyolitic to dacitic in composition with minor basalt outcrops.

North west trending structural features within the volcanic rocks such as faulting and fracturing will control the direction and rate of groundwater flow through this unit, and as such the yield and quality of the groundwater is variable.

12.2.4.5 Metamorphic Bedrock

A large unit of the Neoproterozoic to Cambrian aged Anakie Metamorphic Group is located in Section 3 (approximately chainage 140 km to 200 km). The unit consists of siltstone, fine sandstone, phyllite, schist, commonly cleaved and multiply deformed. This unit is typically overlain by a deep weathering profile, durricrust, ferricrete, colluvium and alluvial material, with small outcropping occurring in the vicinity of the Project.

There are a number of water supply bores located within the area mapped as the Anakie Metamorphic Group. Yield is variable and supplied mostly through fractured rock.

12.2.5 River and Creek Crossings

There are a number of river and creek crossings along the Project. The creeks and rivers are typically underlain by alluvial deposits that potentially have a significant groundwater resource. The alluvium in these areas is a potential contamination source and a pathway to interconnected aquifers. Given the proposed construction of bridges at river and creek crossings, there is potential, albeit very low, for the groundwater to be impacted from sources of contamination at the surface such as leaks and spills and from construction activities.

A list of the creek and river crossings is provided in Table 12-4.

Table 12-4: Creek and river crossings within the vicinity of the Project

Section	Approximate Chainage	Water Course Name	Status/Notes
1 Alpha Coal Mine to 110 km	-	Lagoon Creek	Ephemeral, does not cross alignment
	-	Sandy Creek	Ephemeral, does not cross alignment
	38.8	Native Companion Creek	Ephemeral
	43.5	Belyando River	Ephemeral
	60.6	Lestree Hill Creek	Ephemeral
	101.3	Lascelles Creek	Ephemeral
2 Chainage 110 km to 300 km	118.0	Mistake Creek	Ephemeral
	142.0	Miclere Creek	Ephemeral
	170.0	Brown Creek	Ephemeral
	175.3	Logan Creek	Ephemeral
	195.9	Diamond Creek	Ephemeral
	223.7	Eaglefield Creek	Ephemeral
	262.7	Suttor Creek	Ephemeral
	-	Suttor River	Ephemeral, does not cross alignment
3 Chainage 300 km to 430 km	301.7	Kangaroo Creek	Ephemeral, does not cross alignment
	~ 345	Rosella Creek	Ephemeral
	~ 345	Bowen River	Perennial
	375.0	Pelican Creek	Ephemeral
4 Chainage 430 km to 495 km	436.2	Bogie River	Ephemeral

12.2.6 Groundwater Levels and Aquifer Properties

12.2.6.1 Published Levels and Yields

Published groundwater levels, yields and lithological descriptions (from drillers' logs) have been obtained from the DERM groundwater bore database (2009). Interpretation of the data from the database along with geological mapping is provided in the following sections.

Groundwater yield data are summarised in Table 12-5 and described below.

Table 12-5: Summary of the groundwater yield in existing groundwater bores (DERM, 2009)

Section	Minimum and Maximum Bore Yield	Bore ID	Yield Range	Rock/Material Type	Predominant Flow Mechanism
1	Min	RN103443	0.32	Sandstone	Porous
	Max	RN69731	10.1	Sandstone	Porous
2	Min	RN132188	0.03	Sandy clay	Unconsolidated
	Max	RN125974 RN125977	12.0 12.0	Coarse sand Coarse sand	Unconsolidated Unconsolidated
3	Min	-	No Data	-	-
	Max	-	No Data	-	-
4	Min	RN140051 RN140281	0.14 0.14	Granite Granite	Porous Fractured
	Max	RN140634 RN140635	1.5 1.5	Basalt Basalt	Fractured Fractured

On a local scale, groundwater flow is likely to follow the contours of the land surface. Major geological structures such as faults and intrusions may also control the direction of flow. Further investigations would be required to gauge the degree of interaction between groundwater in alluvial deposits and the effect that this has on regional flow.

No hydraulic conductivity data were identified for the search area.

12.2.6.2 Section 1 Groundwater Levels and Flows

Available groundwater level data for Section 1 are shown in Figure 12-3. Limited groundwater level data are available for groundwater bores in Section 1. Time-series groundwater levels are only available for two bores (RN12, 030,158 and RN12, 030,098). Both bores are located close by to creeks and intersect floodplain alluvium to monitor the underlying bedrock. Groundwater levels within the sedimentary bedrock range from 15.2 m below ground level (BGL) (RN12, 030,098) to 65.5 mBGL (RN89, 235).

Yields within the alluvium is not well understood, with only one borehole returning a yield of 0.32 l/sec (RN103,443). This borehole is situated in an area mapped as Raymond Sandstone. This bore is classified as a water supply bore with a yield of 0.32 l/sec (indicating low permeability). Yields within the underlying sandstone units are high, with two boreholes returning values of 8.4 /sec (RN69, 730) and 10.1 l/sec (RN69, 731) indicating relatively high permeability.

12.2.6.3 Section 2 Groundwater Levels

Available groundwater level data for Section 2 are shown in Figure 12-3. Limited published groundwater level data were identified for bores located within Section 2. Spot groundwater level data were identified for seven bores and time series data were identified for two bores (RN 12,030,095 and RN 12,030,173). Lithological data from the database indicates that the majority of bores are screened within sandstone and the water level ranges from 16.15 mBGL (RN 67,061) to 65.6 mBGL (RN12030095). Two bores are screened in weathered volcanics with water levels ranging from 54 mBGL (RN 89,417) to 55 mBGL (RN 89,283). Groundwater yield ranges from 0.3 l/sec in RN 132, 188 to 12 l/sec in RN 125,974 and RN 125,977.

12.2.6.4 Section 3 Groundwater Levels

Available groundwater level data for Section 3 are shown in Figure 12-3. The northern part of Section 3 is underlain by the Lizzie Creek Volcanics. There are 60 groundwater bores in Section 3. Of these, spot groundwater level data were identified for 15 bores and time-series data for four bores. The time series data indicate groundwater levels in the alluvium at RN 12020014 and RN 12020015 were stable during the period of monitoring. Standing water levels (SWL) in Section 3 range from 2.4 mBGL (RN 25,380) to 17.2 mBGL (RN 31,875). The majority of these bores are in close proximity to the Bowen River, which is likely to influence the regional groundwater levels. Figure 12-3 demonstrates all bores that contain groundwater level data.

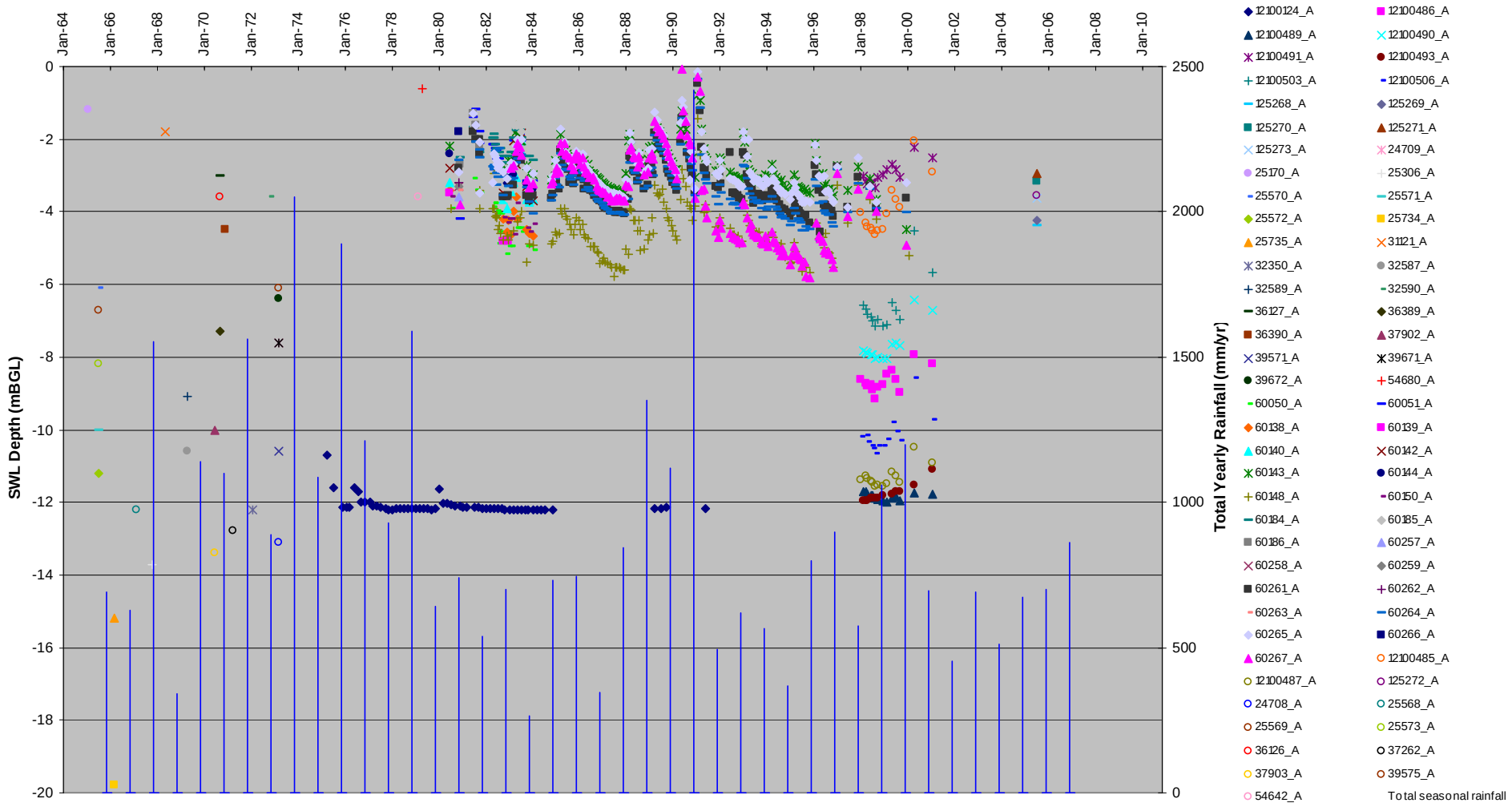
12.2.6.5 Section 4 Groundwater Levels

Available groundwater level data for Section 4 is displayed in Figure 12-3. The majority of bores within the Project area monitor alluvial deposits in the Bowen region. Time series data has been identified for 27 bores, collected over a period of years (refer to Figure 12-3). Two boreholes near Willmington Station (RN60143 and RN60148) have undergone regular groundwater monitoring between July 1980 and February 2000. The groundwater levels in these holes appear to follow a somewhat regular cycle of fluctuations.

Groundwater levels within these bores readily fluctuate in response to rainfall. Periods of high annual rainfall are correlated with increases in groundwater levels. Groundwater levels within the alluvium range from 0.07 mBGL (RN60 267) in June 1990 to 19.8 mBGL (RN25,734) in March 1966.

A number of bores in Section 4 are located in areas mapped as igneous rock formations with water levels ranging from 2.04 mBGL (RN12,100,485) to 13.4 mBGL (RN37,903). The bores within igneous formations show a lag time response to rainfall. The groundwater level fluctuations in the alluvial bores show that recharge of the aquifer is dependant on rainfall and Figure 12-3 demonstrates how responsive the water-bearing strata is to increases in rainfall. Therefore the material is relatively permeable and hydraulically connected to surface water courses and from infiltration sources. There are no yield data available for alluvial materials within Section 4.

Figure 12-3: Reported groundwater levels



12.2.7 Groundwater Quality

Groundwater laboratory water quality data and recorded field data extracted from the DERM database are provided in Volume 6, Appendix D and detailed below. Table 12-6 summarises the ranges of values for the water quality parameters of pH, total dissolved solids (TDS) and electrical conductivity (EC).

Table 12-6: Lab and field results from existing groundwater bores (DERM, 2009)

Parameter	Minimum and Maximum Bore Yield	Section 1	Section 2	Section 3	Section 4
pH	Min	7.4	6.7	7.5	6.8
	Max	8.2	8.8	8.3	8.6
	Average	7.8	7.5	7.9	7.6
	Number of results	11	6	4	69
TDS (ppm)	Min	293	495	742	318
	Max	4,529	37,140	3,303	6,952
	Average	1973	13363	1942	949
	Number of Results	11	6	4	69
Electrical Conductivity (uS/cm)	Min	545	870	1,214	350
	Max	7,700	49,500	6,040	10,700
	Average	3484	19570	3358	1805
	Number of Results	11	6	23	70

12.2.7.1 Section 1 Groundwater Quality

Section 1 is dominated by Quaternary to Tertiary aged alluvium and Devonian aged sedimentary units. Being of older alluvial material groundwater quality is more variable due to the weathering of the underlying bedrock. Groundwater EC values range from 545 µS/cm (RN1,230,158) in sandstone and conglomerate to 7,700 µS/cm (RN89,386) in weathered sandstone.

12.2.7.2 Section 2 Groundwater Quality

Groundwater quality in Section 2 is variable with the varying geological units present in the area. EC values range from 870 µS/cm (RN25,671) in granite to 49,500 µS/cm (RN89,265) in clay and sand at approximately 53 mBGL.

12.2.7.3 Section 3 Groundwater Quality

Section 3 is largely dominated by the Lizzie Creek Volcanics with groundwater EC values ranging from 1,214 µS/cm (RN12,020,021) to 3,750 µS/cm (RN12,020,012). These bores are located in close

proximity to the Bowen River. A single bore within sandstone (RN60,362) to the south of Section 3 reported EC values of 6,040 µS/cm.

12.2.7.4 Section 4 Groundwater Quality

Groundwater quality within Section 4 is highly variable due to the salt water and freshwater interface within coastal deposits (freshwater recharge from rainfall and flow from rivers/creeks and from saline water intrusion). EC values range from 350 µS/cm in creek gravel (RN36,311) to 10,700 µS/cm in sand (RN36,126) but are typically in the range of 350 µS/cm and 4040 µS/cm in weathered granite (RN25573). Water quality will also vary with geological units.

12.3 Potential Impacts and Mitigation Measures

12.3.1 Overview

No significant impacts on groundwater resources and/or groundwater quality are anticipated based on the current understanding of the Project. Construction of new infrastructure such as culverts, cuttings, embankments and bridges has the potential to result in short term, localised impacts on shallow groundwater such as an increase or decrease in groundwater levels, however no significant impacts on groundwater resources are expected given:

- no long term lowering of groundwater levels are anticipated for the Project site given that no major dewatering is proposed; and
- the majority of the Project site and surrounding area is mapped as an Unincorporated GMU (not requiring any special management), therefore groundwater resources and extractions are not considered threatened or vulnerable.

Although no significant impacts are anticipated, the potential impacts on groundwater during construction and post construction of the Project are outlined in the following sections.

12.3.2 Construction

12.3.2.1 Potential Impacts

The following potential impacts in groundwater have been identified for the construction phase:

- potential for localised water logging as a result of groundwater level increases caused by construction of any embankments or as a result of pre-loading, where pre-construction groundwater levels are relatively close to ground surface, particularly in the vicinity of the major rivers and within the low lying coastal flats of Abbot Point;
- potential for localised, temporary reduction in shallow groundwater levels in the vicinity of Suttor River, Bowen River and Bogie River as a result of temporary minor dewatering as part of bridge pile construction works. The dewatering is unlikely to have any significant or long term impact given the short duration, low volume and localised nature of the dewatering; and
- potential for localised degradation of groundwater quality within alluvial deposits or bedrock that intersect the Project, directly beneath or down-gradient of the Project, if any accidental leaks or spills occur during construction. Local water supply bores in Sections 1 and 3 are unlikely to be impacted from construction given the distance to the bores. Bores within Sections 2 and 4 are the most likely to be impacted.

12.3.2.2 Mitigation and Management Measures

The following measures are proposed to monitor and mitigate the potential impacts identified for the construction phase:

- maintenance of regular groundwater monitoring (levels and quality) for a minimum 12 month period prior to the start of construction to establish baseline groundwater conditions at selected locations considered the most susceptible to impact (e.g. alluvium at river crossings). This will allow the confirmation of groundwater quality and level action criteria against which to monitor conditions during construction. This program will be agreed with the regulatory authority prior to Project commencement;
- develop and implement a groundwater monitoring program to monitor groundwater levels and quality of shallow groundwater adjacent to the Project site at selected locations, to confirm any groundwater impacts during the construction phase;
- regular assessment of groundwater monitoring results against baseline groundwater conditions during construction and review of monitoring program if necessary;
- if impacts on groundwater levels or quality are identified an assessment of potential mitigation measures will be conducted;
- storage areas for vehicles, machinery, equipment, chemicals etc. during construction will have appropriate facilities to contain spills, leaks and surface water run off to reduce the potential for contamination of groundwater through infiltration from surface; and
- groundwater monitoring will be conducted by a suitably qualified and experienced professional in accordance with the AS/NZS 5667.11:1998 *Australian/New Zealand Standard for water quality – sampling Part 11, Guidance on Sampling Groundwater.*

12.3.3 Operation

12.3.3.1 Potential Impacts

The following potential impacts on groundwater have been identified for the operational phase of the Project:

- potential for the localised degradation of groundwater quality within the alluvial deposits and bedrock that intersect the Project, from the application of additional herbicide along the Project; and
- there are no potential impacts on groundwater levels identified for the operational phase of the Project, based on the current Project understanding.

12.3.3.2 Mitigation Measures

The following measures are proposed to monitor and mitigate the potential impacts identified for the construction phase:

- develop and implement a groundwater monitoring program to monitor groundwater levels and quality in shallow groundwater adjacent to the Project site.

12.4 Conclusions

Groundwater conditions vary considerably along the Project. Data obtained from the DERM groundwater bore database (DERM, 2009), indicate groundwater is abstracted from both the alluvial deposits and bedrock (including sandstone, fractured volcanics and fractured metamorphic rock). Groundwater yield and quality are variable and dependant on the aquifer rock/material type. Groundwater Standing water level (SWL) in Sections 1 and 2 appear to be at depth (i.e. greater than 15 mBGL and up to 65 mBGL in some bores). Given the complex rock units and structures in Section 3, groundwater levels and quality are highly variable. In general, groundwater resources are likely to be most vulnerable to impact in the vicinity of creeks and river, particularly if there is well developed alluvial material underlying water course as these present a contamination pathway from the surface.

The most well developed groundwater resources are found within the Bowen Shire alluvial aquifers. Many of the bores in this area are for groundwater abstractions, therefore yield and quality are likely to be beneficial for agricultural use. Due to the high yields and connectivity of the aquifers, groundwater resources in Section 4 are vulnerable and source of contamination from surface are easily transported to the underlying alluvial aquifers. Potentially down-gradient groundwater abstractions may be impacted. Very little data is available on groundwater resources within the Bowen Unincorporated groundwater management area.

Based on the current Project understanding, no significant impacts on groundwater resources and/or groundwater quality are anticipated. Construction of new infrastructure such as culverts, cuttings, embankments and bridges has the potential to result in short term, localised impacts on shallow groundwater such as an increase or decrease in groundwater levels, however no significant impacts on groundwater resources are expected given:

- no long term lowering of groundwater levels are anticipated for the Project given that no major dewatering is proposed; and
- the majority of the Project site and surrounding area is mapped as an Unincorporated GMU (not requiring any special management), therefore groundwater resources and extractions are not considered threatened or vulnerable.