Waratah Coal
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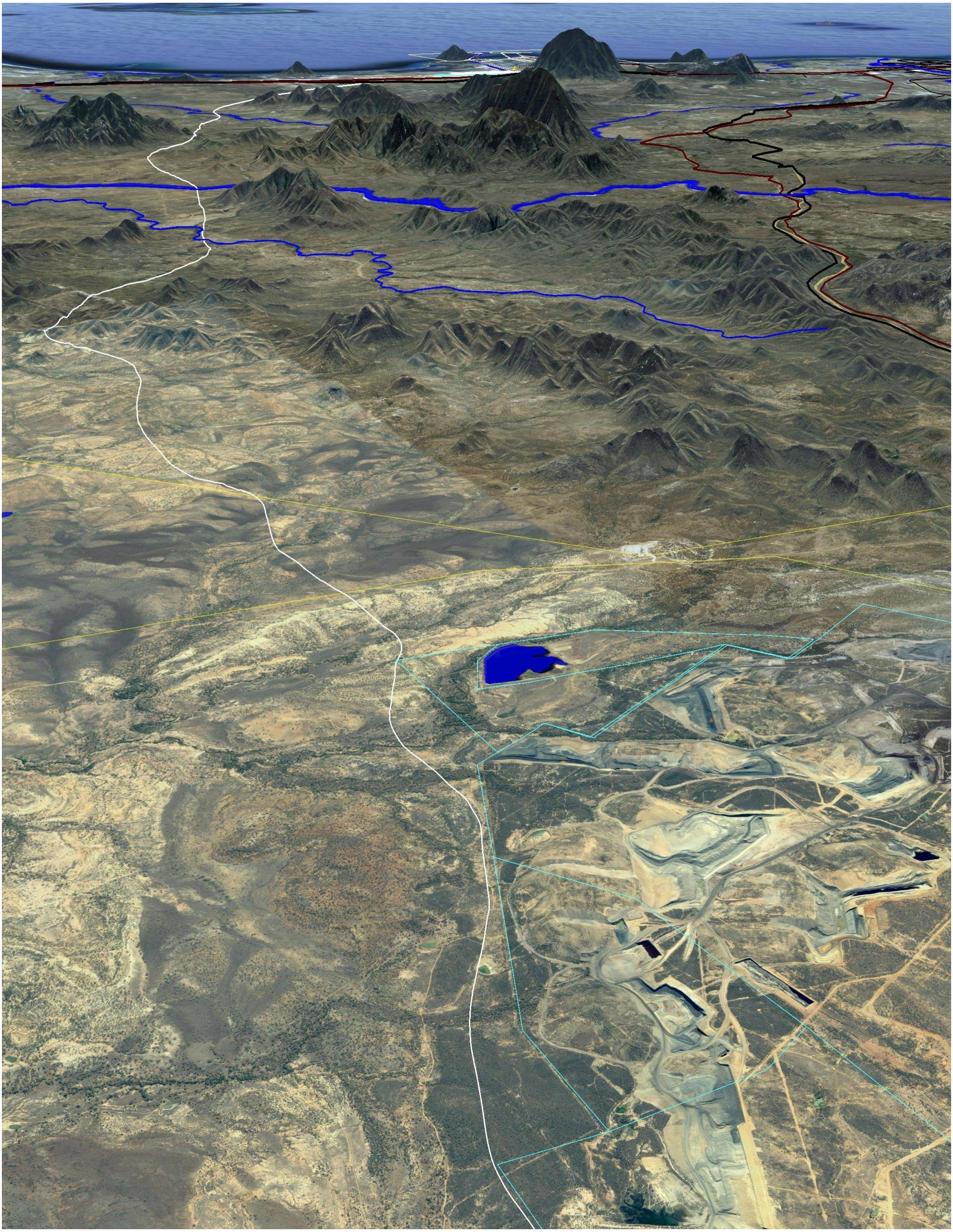
Galilee Basin Railway Strategic Planning Study
50km to 1.5km Quantm Corridor Analysis

CHINA FIRST
Developing the Galilee Basin



Galilee Basin Railway Strategic Planning Study
50km to 1.5km Quantm Corridor Analysis

Final Report

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1 Executive Summary

Waratah Coal has conducted a strategic concept planning study for a totally dedicated heavy haul railway to link their mining operations in the Galilee Basin to a proposed coal export port facility at Abbot Point on the Queensland Coast. The rail study is part of the overall project known as 'China First', which includes the development of the mine site, a new coal export terminal at Abbot Point, as well as the railway to link the two. Metallurgical Corporation of China (MCC) has been engaged as the project's engineering, procurement and civil contractor.

The objective of the study was to identify the most technically feasible corridors between the mine site and port, that achieved the minimum rail engineering and safety requirements for a heavy haul railway, protected the environment where possible, supported local land use plans and policies, and was compatible with the small number of surrounding communities. Consideration was given to accommodating potential third party users, as was the possible integration of the new route into existing infrastructure corridors such as the narrow gauge Newlands Railway System.

The study was undertaken between August 2009 and February 2010 and carried out in a number of distinct phases. Phase I of the study consisted of a regional assessment of heavy haul rail project requirements together with the development of a broad range of alternate corridors to meet those needs. Short listed corridors were then ranked on their suitability based on evaluation criteria such as constructability, civil works, environmental and land-use impacts, socioeconomic value and operational efficiency[1]. The outcome of this was the selection of a preferred 10km wide corridor, which triggered a secondary more detailed corridor refinement phase to investigate location specific alternatives within the isolated corridor. The final result was the recommendation of a 1.5km wide corridor for future assessment.

The investigation utilised the Trimble® Quantm™ Alignment Planning System. This route planning tool provides for a more comprehensive investigation of alternatives than would have been possible if a conventional approach had been adopted. The speed of this sophisticated technology in delivering a range of alternatives that provides improved environmental outcomes, while simultaneously meeting engineering, community and heritage constraints and reducing project construction costs, meant that a large number of corridors and scenarios could be evaluated despite the large extent of the initial study area.

A project database was assembled from commercially available site specific data including a digital terrain model, land-use and topography information. Despite the ground survey and constraint mapping being relatively coarse in scale, it was considered as a suitable starting point for a preliminary comparative analysis of corridors across such an extensive study area.

A flood study provided the 1 in 100 year flood extents to ensure the route had suitable flood immunity, while environmental mapping of key constraints such as national parks and reserves, protected wetlands, large scale dams and sensitive vegetation habitats were modeled accordingly. Existing infrastructure constraints were also integrated into the analysis and included the latest mining tenements, townships, location of houses, transport infrastructure and utilities. Constraints of high

[1] Based on geometric properties of alignments only (grade, curvature, etc). No train performance modelling was carried out in this study.

impact such as operating mines, houses, national parks, were modeled with avoidance weightings that penalized the route from crossing them.
Unit construction costs for earthworks and structures were defined (e.g. costs for cut, fill, mass haul, ballast, tracks, etc), as was the minimum engineering design standards for a heavy haul standard gauge railway line (e.g. maximum grade, minimum radii, curve compensation, etc). Based on this complete set of inputs, namely terrain, constraint mapping, geometrics and costing, a number of scenarios were optimised to generate low cost and constraint complying alignments between the mine site and port.

Quantm's free-to-roam optimisation was utilised to provide an unbiased output of route options that spread the entire study area. Obvious patterns and trends in the results were identified, such as where alignments clumped together to indicate a region of low cost and where alignments fanned out providing greater flexibility in selecting between different routes. Progressively the overall study area was reduced about the potential corridors as the less technically feasible areas could be ruled out, such as steep topography, high impact constraints, etc.

Corridors between the mine site and Leichardt Ranges generally exhibited easy rolling grades across the flat to undulating topography, with the extensive Q100 floodplains of the Belyando River, Mistake Creek and Suttor River, being the key drivers in influencing corridors. Routes traversing lengthy sections across floodplains were generally discouraged due to both the expected high infrastructure costs required for building flood protected embankments and structures and the likely environmental impacts that will result to aquatic supporting ecosystems and habitats.

Route options between the Leichardt Ranges and port were predominantly influenced by the moderate to steep topography that exists throughout the Leichardt and Clark Ranges, together with the restriction to comply with the stringent heavy haul rail geometry requirements. Consideration was given to selecting corridors that provided a balance between reduced civil works and linear length. Tunnels were generally discouraged due to the known difficulties associated with operating a tunnel to support heavy haul railways. A common trend observed from the onset were alignments favoring a crossing of the Clark Ranges to the west of Collinsville through Peter Gordon Pass. This corridor was considered to have more accommodating topography and less existing infrastructure constraints than the Newlands Corridor that currently supports the western Bowen Basin Mines east of Collinsville.

From the first round of assessment five distinguishable concept corridors were short-listed based on an array of costs, impacts and benefits. In summary;

- **Corridor Option C1** (441.4km at $667M[2]): a 1 in 200 western alternative that crosses the Leichardt Ranges near Mount Coolon and passes to the west of Collinsville on route through the Clark Ranges. This option is considered to have comparatively lower impacts to existing infrastructure than the other corridors, particularly those that utilise the existing Collinsville Newlands Corridor. It also exhibits minimal environmental impacts, avoiding all national parks, reserves, nature refuges, protected wetlands and large dams.

- **Corridor Option C2** (441.8km at $678M): presents a similar costing and length to option C1; however, takes a distinctively different path through the eastern part of the study area, climbing through the Leichardt Ranges near Eaglefield. It's expected that this route will have higher

[2] Raw construction cost in Quantm dollars – does not include contingencies, overheads and profits.

environmental impacts and infrastructure costs for crossing floodplains than the more western alternatives. Its path through the Leichardt Ranges across more accommodating topography may yield some benefits with reduced earthworks. A key benefit of this far eastern alternative is that it passes within a close proximity to the Western Bowen Basin and thus could provide future third party access to the established coal mines throughout this area. On the downside; however, it only encompasses a fraction of the Galilee Basin which may be less favorable to local government and other Galilee Basin stakeholders.

- **Corridor Option C3** (438.7km at $855M.): the most competitive option of the 1 in 300 loaded grade corridors considered. Due to the restrictions with allowable grades, this route exhibits higher overall civil works and environmental impact due to a larger footprint than the 1 in 200 grade corridors. Despite the higher capital cost for this corridor, it's expected that the flatter and shorter route will provide long term operational and maintenance benefits to the project.

- **Corridor Option C4** (460.5km at $708M): a slightly longer alternative with it traversing over 150km of the Galilee Basin before heading north-east towards the Queensland coast. This has the benefit of opening up the northern end of the Galilee Basin resource, providing future growth opportunities to new mines which may not be economically viable without supporting rail infrastructure.

- **Corridor Option C5** (450.4km at $769M.): this follows the existing Collinsville Newlands Corridor through the Clark Ranges. Despite the extra capital investment needed for this route, it has the distinct advantage of passing across the Western Bowen Basin with potential for accommodating future third party access. The corridor is also expected to require less property severance and overall impact to landowners where the corridor can utilise parts of the existing railway easement. The environmental impact along this route; however, is expected to be higher than other corridors with it crossing a state forest, two nature refuges and exhibiting a larger footprint encroachment across river floodplains south of the Leichardt Ranges.

Short-listed corridors were screened against an evaluation framework to more easily establish the most superior and promising corridors, as well as highlight key characteristics of alternatives showing the greatest differences. This included consideration of capital costs, civil works, operating efficiency, environmental impacts, compliance to land use requirements, third party usability and overall constructability. This resulted in Corridor C1 having the highest overall ranking and considered to provide the greatest overall benefit to the project.

A subsequent refinement development stage was carried out on Corridor C1, concentrating on areas of the route that traversed challenging topography, particular the steep slopes of the Leichardt and Clark Ranges, which are likely to result in some heavy earthworks. By focusing the optimisation over more defined paths it allowed the corridor to more closely conform to natural contours and provide better compliance to crossings of existing constraints.

In refining the selected corridor the project's impact to the natural environmental and land-owners was reduced. Footprint encroachment through protected vegetation was minimised through the inclusion of regional ecosystems (endangered and of-concern). The route was also refined to ensure perpendicular crossings of major rivers and short crossing of their large floodplains wherever practical. Table E.1 provides a general overview of the main features for the preferred corridor.

The final corridor is considered to be at a level sufficiently detailed to allow the corridor to be quickly taken through the statutory planning and approval process and into detailed planning, should a decision be taken to proceed with this option. The refinement of the recommended corridor will likely require specific constructability issues to be resolved and mitigation of social and environmental impacts that may arise from future detailed field investigations, statutory approvals processes and continued stakeholder engagement. If required the other short-listed corridors developed in this study should be considered as feasible secondary options, should the recommended corridor be ruled out.

Table 1-1 - China First Heavy Haul Railway – 1.5km Corridor (Key Characteristics)

Key Features	• 443.6km in length[3] • Single standard gauge track with at least nine passing loops • Continuously welded rail • Rail corridor 60-80m wide with widening in some areas to accommodate significant areas of earthworks
Trains	• Diesel powered trains supplied from either China or North America • Payload of train – 20,000 tonnes • Train Consist approximately 3.2km long • Distributive power with electronically controlled pneumatic air brakes • Annual Tonnage – 25MTA initially ramping up to 50 MTA over 5 years
Geometrics	• Maximum Design Speed – 100 km/hr (empty) & 80km/hr (laden) • Max Design Grade: 1 in 200 (laden) and 1 in 80 (unloaded) • Maximum Horizontal Radius of Curvature of 1000m • Maximum Vertical Radius of Curvature of 7200m
Civil Works	• Total Construction Cost – $1 Billion AUD • Estimated bulk earthworks - 22 Million m^3 • Estimated Deepest Cutting of 20m and Highest Embankment of 19m (both occurring over the steep crossing of the Clark Ranges through Peter Gordon Pass) • Estimated Quantity of Ballast - 1 Million m^3 BCM • Estimated Number of Sleepers – 981,000 sleepers spaced 600mm apart
Operation[4]	• Mode of Discharge – cylindrical rotary • Estimated time to load a full train – 3.5 hours • Estimated time to empty a train – 4.2 hours
Structures	• Eleven bridge crossings of major rivers • Four road-over-rail bridge crossings of existing road arterials • One flyover crossing of North Coast Railway • Significant structures – Bogie River (435m+ bridge), Pelican Creek (365m bridge) and Bowen River (345m bridge)
Flood Immunity	• 100 year Average Recurrence Interval
Constraints	• Avoids all mining leases, mining development leases and townships • Grade separated crossings of major rivers and North Coast Railway • Road-over rail crossings for existing roads • One crossing over major gas line and no crossing of major water pipelines • Three crossings under high voltage power lines • Crosses three registered native title applications • No impact to non indigenous heritage

[3] Following the refinement of Corridor C1 (10km wide x 441.5km in length) with new constraints.
[4] Planned train performance modelling to establish annual operational & maintenance costs, as well as train cycle times.

- Avoids all National Parks, State Forest and Resource Reserves
- No impact to protected wetlands or nature refuges

2 Project Description

2.1 Introduction

Waratah Coal plans to build a standard gauge heavy haul railway between their mining leases located within the Galilee Basin in Central Queensland, to a 40 million tonne per annum (Mtpa), two berth coal export terminal at Abbot Point near Bowen.

It is proposed that the 50-year design life railway will operate up to 21,000 net tonne diesel train sets catering for maximum design speeds of 80km/hr and 100km/hr for laden and empty trains respectively.

A 490km concept route developed by WorleyParsons from a previous Infrastructure Options Study[5] (known as Route Option 1), formed the starting point for the corridor selection study (refer to Figure 2-1).

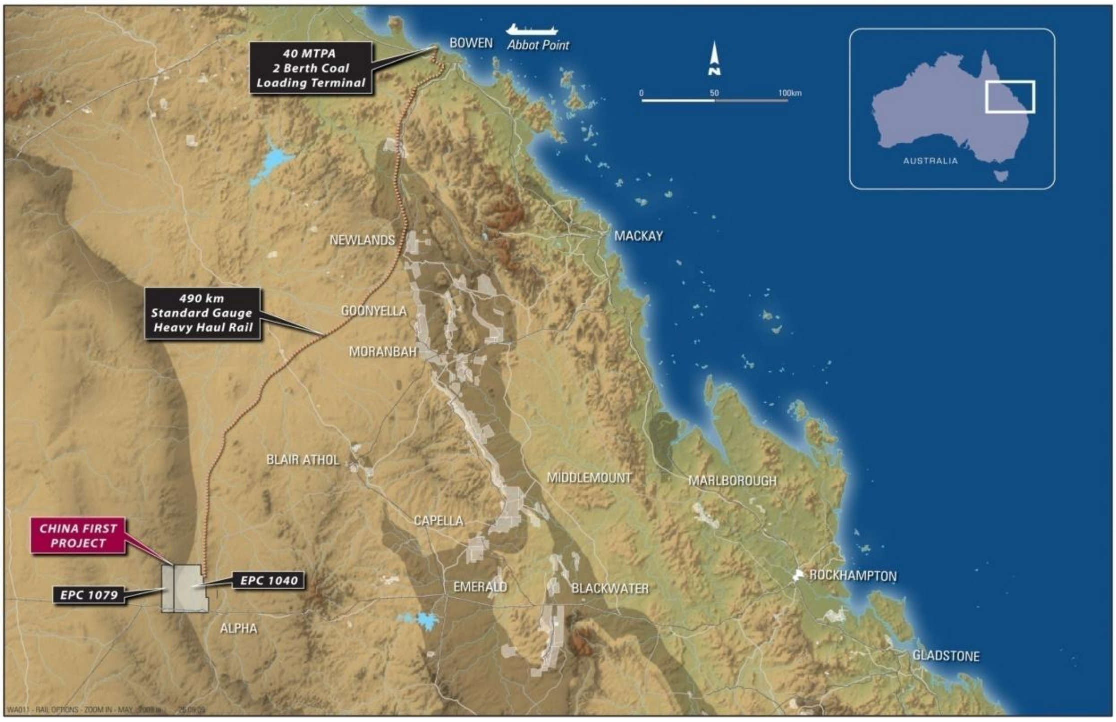


Figure 2-1 - Project Schematic

[5] WorleyParsons Pty Ltd, *Infrastructure Options Study*, Galilee Coal Project, Central Queensland, 2008.

Quantm's innovative and unique route selection software was engaged for the corridor selection to develop feasible lowest costs routes that achieved the engineering, environmental and land-use requirements for the project.

This report describes the methodology and outcomes of the 50km Quantm study (Q50) and will form the basis for undertaking subsequent more detailed feasibility work.

2.2 Study Goal and Objectives

The primary goal for this study is to demonstrate a comprehensive investigation of the entire study area for the most cost effective, technically feasible corridors, which are compatible with the land-use and environmental constraints, whilst achieving the operational and engineering requirements for a standard gauge heavy haul railway. To achieve this goal, the following key objectives were defined:

- Generate the lowest cost route between the mine site and port;
- Meet the minimum rail engineering requirements for a standard gauge heavy haul railway;
- Provide the most optimal grade route that balances capital costs with operating efficiency;
- Minimise impacts to the natural, built up, and aesthetic environments;
- Minimise impacts to cultural, historical and indigenous resources; and
- Consideration of route options to accommodate third party users.

The study was carried out in two distinct phases; an initial phase consisting of the development and assessment of a number of broad corridor options; followed by a more detailed assessment of the preferred 10km corridor to location specific alternatives. An alternatives evaluation matrix based on the following categories was established that allowed a clear comparison between varying options:

- Capital Costs;
- Civil Works (e.g. volume of earthworks, number of bridges, culverts, etc);
- Operating Efficiency (grades, curvature, etc);
- Environmental Impacts;
- Compliance to Land Use Requirements;
- Third Party Usability; and
- Constructability.

The final outcome of the study was the recommendation of a preferred 1.5km corridor that provided the best fit to the requirements above and would form the basis for a more detailed route selection study prior to detailed design.

2.3 Background

2.3.1 Project Extents

The study area extends from the mine site near Alpha, approximately 170km west of Emerald in Central Queensland, to the proposed port facilities at Abbot Point near Bowen. This covered an area of over 39,000 km^2.

The study boundary as illustrated in Figure 2-2 (red zone) was developed from Infrastructure Options Study Route Option 1, by allocating between 25km to 50km either side to provide the necessary scope needed for a wide range of corridor options to be investigated.

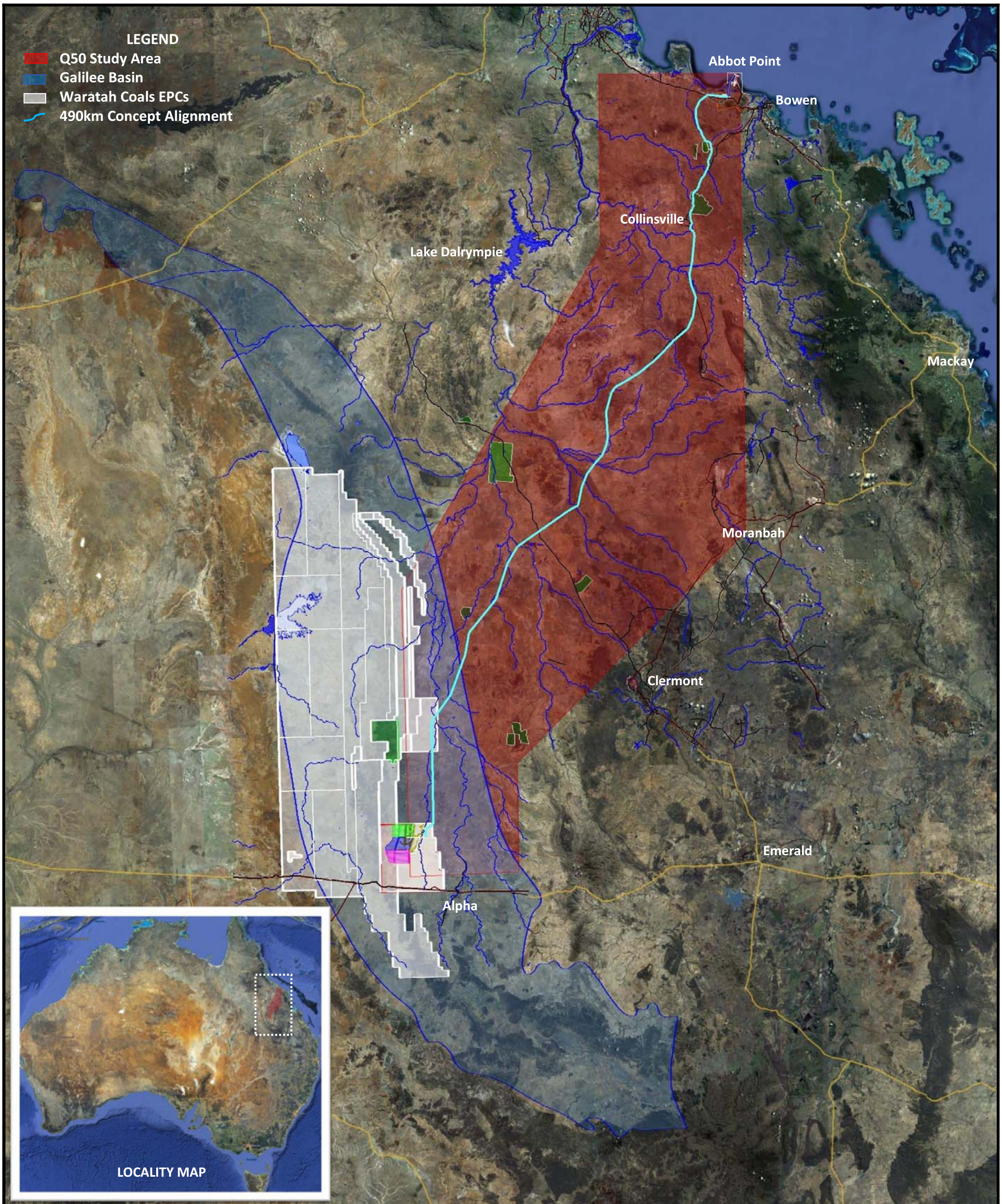
Starting at the mine the study area traverses north, generally in the direction of the extensive Belyando floodplain, where it then crosses the Great Divide and Gregory Developmental Road, into the Suttor River catchment area.

Crossing the Suttor River Floodplain, alignments negotiate a number of channels of the lower Suttor River before passing through grassland to open forested country in easy rolling grades through the Leichardt Ranges trending downhill to Collinsville. Alignments require a number of bridges through this section, the most significant being a 350-400m span across the Bowen River.

The study area allows for options east and west of Collinsville to be investigated. The existing Queensland Rail operated Newlands Railway located to the east of Collinsville, which has a current grade of 1:80 (1.25%), presents an obvious corridor; however, the terrain to the west provides more accommodating grades for flatter grade alignments.

From Collinsville the terrain is relatively steep through the Clarke Range where the route is required to deviate around the foothills of Mount Aberdeen, Mount Mackenzie and Mount Abbot. There will be at a couple of significant bridge crossings through this area.

The alignment will finish with a level grade crossing over the Bruce Highway (with provisions made for the highway to pass over the top of new railway) and then a grade separated crossing over the North Coast Railway, finally ending with two unloading rail loops within the Abbot Point State Development Area (APSDA). The location of a marshalling and maintenance yard at the port had not been established prior to the commencement of this study.



0 100 200 Km

Geographic Coordinate System (WGS84)

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A	18/2/10	Concept Design	BH	NH
Rev	Date	Description	ORIG	CHK

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Galilee Basin Coal Railway
Pre Feasibility Study
Quantm Route Analysis
Figure 2-2 – Study Area Extents
GALILEE BASIN, QUEENSLAND
Australia

DRG NO: 10.60.002-010-1

2.3.2 Study Areas

Due to the large extent of the study area there was a requirement to break the model into more manageable sections for the Quantm corridor analysis. This allowed for a more focused and detailed search, ultimately improving the quality of the alignments generated. It also had the advantage of improving software loading times and Quantm optimisation processing times.

It was decided that the study area would be broken into 2 x 250km sections denoted simply ‘South’ and ‘North.’ Each section overlaps the other by approximately 50km to provide the necessary area needed to identify corridor trends that were consistent between both sections. Where the cheapest corridors from both the north and south sections converged / overlapped, these were generally used as tie in points for splicing together a composite corridor during the concluding stages of the analysis.

The southern study area begins at the mine and finishes approximately 25km north-east of Mt Coolum, whereas the northern study area commences approximately 25km north-west of Mazeppa National Park and finishes at Abbot Point, as illustrated in Figure 2-3.

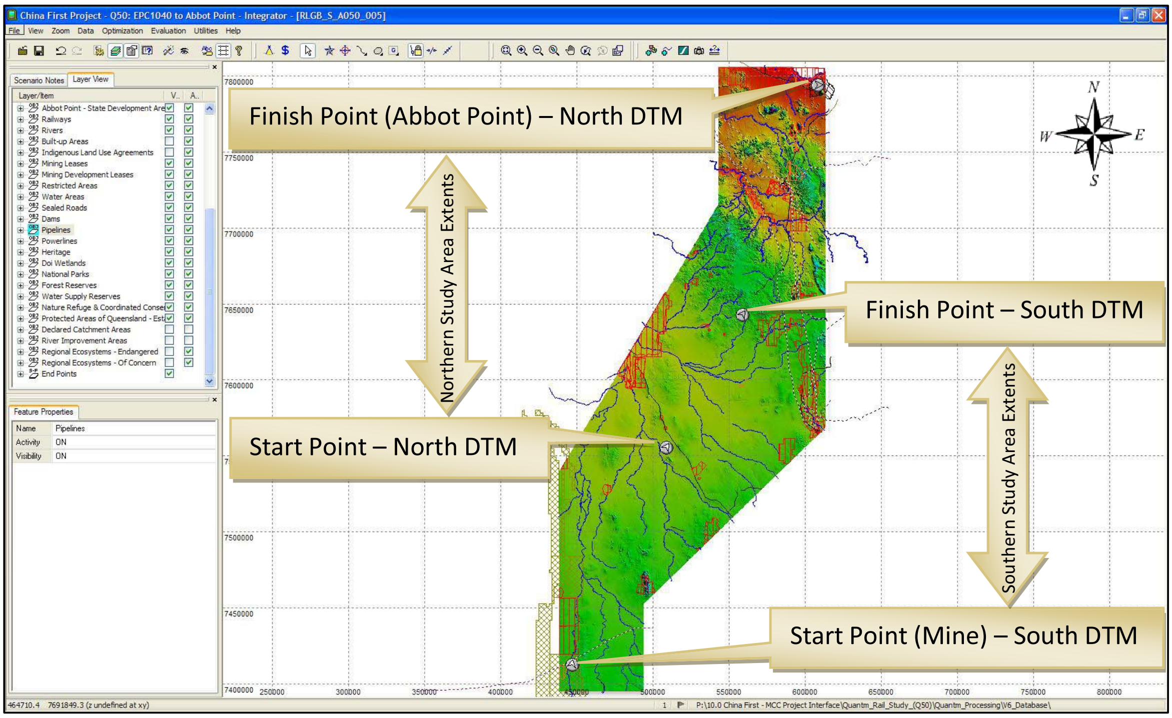


Figure 2-3 - Definition of South and North Study Areas

2.3.3 Terminal Points

The heavy haul railway will commence in advance of the balloon loop within EPC 1040 (mine) and end prior to the balloon loop located within the APSDA (port).

A floating start point for the north section was defined, as was a floating finishing point for the south section (refer to Section 2.3.2). This approach reduced the need to define a single midpoint location, which hadn't been determined during the early stages of the study.

The terminal point coordinates for the Q50 study are provided in Table 2-1.

Table 2-1 - Start and Finish Point Coordinates.

	Geodetic Coordinates		MGA94 Zone 55 Coordinates	
	Latitude	Longitude	Easting	Northing
Southern Study Area				
Start Point (mine)	23°24' 0"S	146°28'48"E	447243	7412442
Finish Point (floating)	21°19'12"S	147°34'12"E	559032	7642340
Northern Study Area				
Start Point (floating)	22° 6' 0"S	147° 5'24"E	509544	7555671
Finish Point (port)	19°57'36"S	148° 2'24"E	608419	7792712

2.3.4 Coordinate System

The Quantm system operates using Cartesian Coordinates (X, Y, Z) and therefore all project data used for the study was converted from geographic coordinates (latitude, longitude) into Quantm compatible Cartesian Coordinates.

For the Q50 study a Map Grid of Australia projection (MGA94) on the Geocentric Datum of Australia 1994 (GDA94) was adopted. This conforms to the internationally accepted Universal Transverse Mercator (UTM) Grid System. Due to the north-south orientation of the proposed rail route, the entire study area fell within UTM Zone 55.

2.3.5 Initial Concept Routes

In April 2008 Waratah Coal commissioned WorleyParsons to provide a preliminary assessment of competitive routes for coal transportation between the mine site and a number of port locations along the Queensland coast[6]. This included two key routes to the existing coal export terminal located at Abbot Point, as illustrated in Figure 2-4.

In assessing possible heavy haul rail routes a number of key logistic issues were addressed including the capital expenditure of a new railway, capital expenditure on upgrading existing rail infrastructure facilities and rail operating and maintenance costs.

A range of train configurations, axel loads and train lengths for both narrow and standard gauge track configurations was considered at production levels of 25 Mtpa and 75 Mtpa. Consideration was also given to current and forecast traffic on the existing Queensland Rail operated Newlands Railway.

This resulted in a total of 20 x options to Abbot Point being developed, which were then evaluated and ranked based on capital and operating costs discounting over a 50 year period. The overall outcome showed that a newly built heavy haul standard gauge railway was most competitive at higher tonnages. Route Option 1 was subsequently selected as the starting point for the Q50 corridor study.

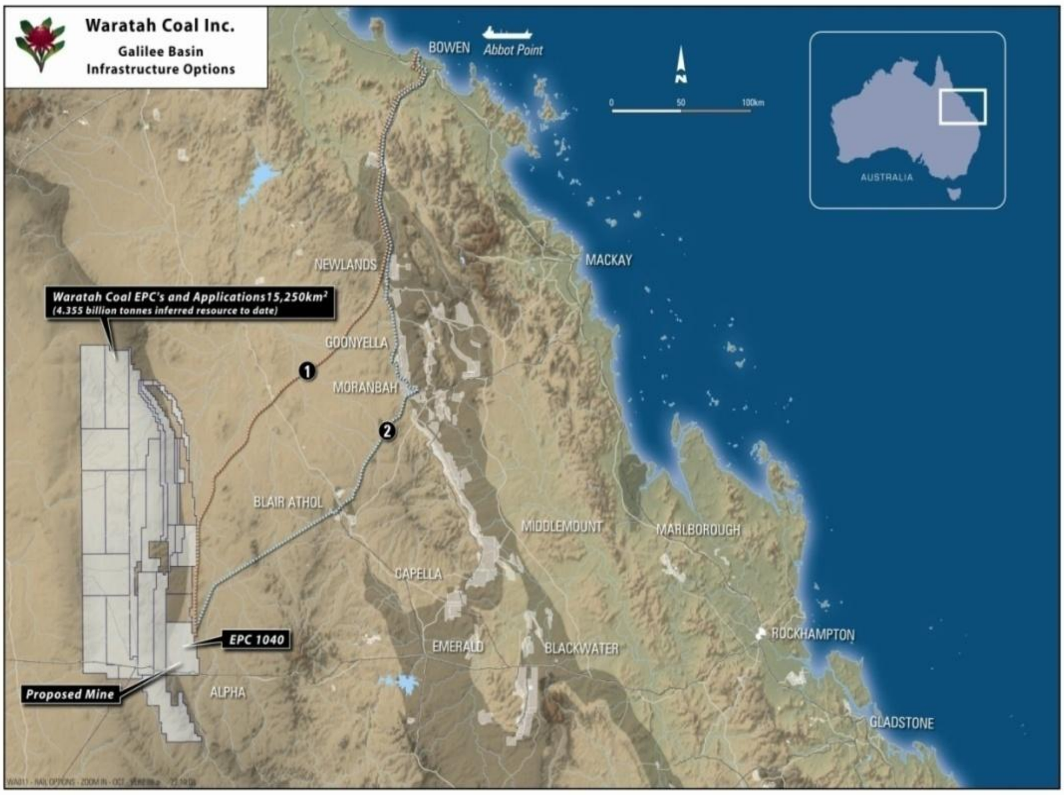


Figure 2-4 - Galilee Basin Infrastructure Rail Options

[6] WorleyParsons Pty Ltd, Infrastructure *Options Study*, 2008.

2.4 Quantm Software

The Q50 study was carried out using the Trimble® Quantm™ route selection software for corridor identification and alignment optimisation. This innovative technology allows planners to address the shortcomings of the conventional approach to transportation route planning being essentially a manual process; the rail planner uses professional judgment and experience in selecting alternatives that appears to the trained eye to provide the best fit. This process is labor-intensive and for this reason usually only a limited number of alternatives will be considered.

The Quantm system; however, is a computer-based optimisation tool that simultaneously optimises the horizontal and vertical alignment to deliver a range of alternatives that meet the engineering, social and environmental constraints defined for the project. Based on the user defined criteria, the system investigates millions of alignment options per scenario, before delivering a range of alternatives in just a relatively short period of time (24-48 hours). This enables the planner who has local knowledge and experience to determine the most optimal outcome based on a wide range of criteria and not exclusively based on cost.

The planner inputs all relevant data into the front-end system, known as Quantm Integrator. This includes a digital terrain model, geology (location of various rock types, costs for cuttings, embankments, haul, etc), rail design criteria (rail formation, minimum curvatures, maximum grades, etc.), and site specific geographic constraints (locations of protected habitats, wetlands, regional ecosystems, streams, existing infrastructure and utilities). This information is then sent to the optimisation search engine, Quantm Pathfinder, in Melbourne Australia, which uses a cluster of servers to simultaneously consider all these factors to generate multiple alternatives (Figure 2-5).

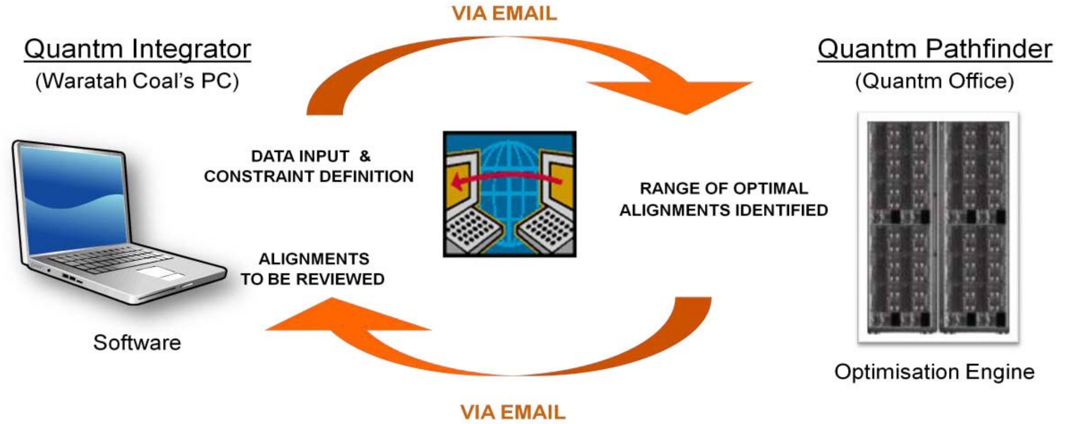


Figure 2-5 - Quantm System Architecture.

Alignments can be viewed in plan, profile and dynamically in cross-section, either individually or collectively to reveal clumping of alignments indicating favorable corridors. Each option has an associated summary table providing a breakdown of construction quantities and costs for earthworks and structures, allowing strategic cost comparisons between varying corridors to be easily established.

Alignment strings can be manually edited and customized to change the lengths and locations of structures, degree of curves and grades, etc. Full 3D geometric alignments can be easily exported from Quantm into CAD design packages, or rail operating software for train performance modeling.

3 Constraint Definition

All available topography applicable to the Q50 Study was acquired from a number of commercially available sources. These were generally obtained as digital GIS or CAD datasets in geo-referenced formats for input into Quantm and then constrained with crossing rules to ensure both impacts on protected areas was minimised and minimum clearances over existing infrastructure were adhered to. A summary of the major constraints modeled within the Quantm study is provided in the following sections.

3.1 Topography

3.1.1 Terrain

A digital terrain model (DTM) is a detailed representation of the topographical relief in the Earth's ground surface. For the Q50 Study a 25m raster based model was acquired from Queensland's Department of Environment and Resource Management (DERM). This was originally compiled from 1:100,000 scale topography containing contours in 20m and 40m intervals. The purported vertical accuracy of the 25m DTM is within +/- 10m.

Initially the ESRI based DTM was provided to Quantm for encryption into their proprietary terrain format. The resulting DTM is based on a square mesh, where the easting and northing of a point directly gives its row and column in the array respectively. The terrain model is presented as an image that is color-coded with respect to altitude, and shaded to provide increased detail on local variations, as illustrated in Figure 3-1.

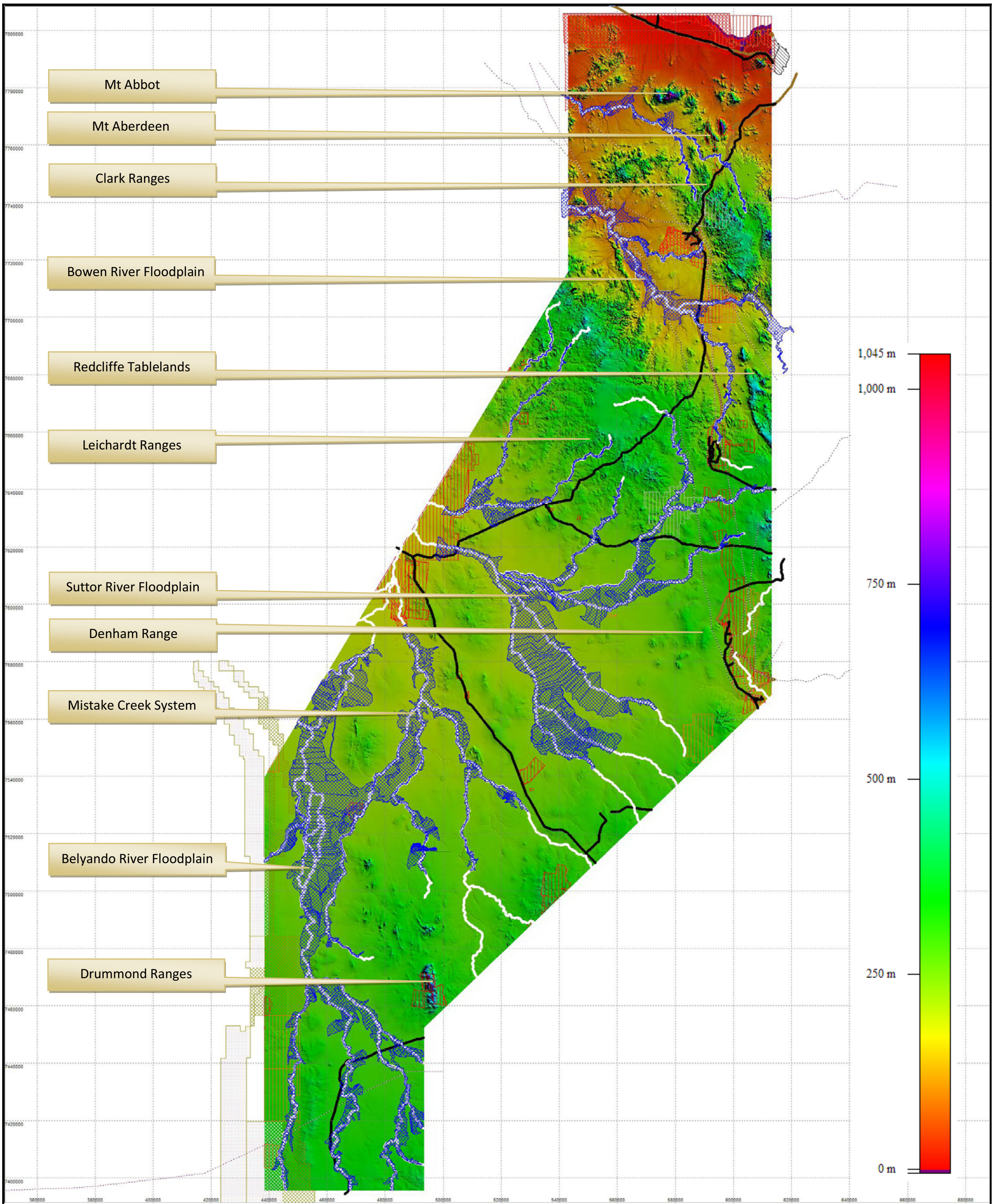
Due to the large extent of the study area there is a significant variation in the terrain, ranging from flat to undulating slopes across the Belyando and Suttor River floodplains, moderately undulating slopes across the Leichardt Ranges, to steep terrain across the Clark Range near the Queensland Coast.

The Quantm DTM is predominantly used for optimising quantities of earthworks (Cut, Fill, Mass Haul), to suitably fit the horizontal and vertical geometry of the route, and as a datum reference for vertical clearances over required crossings. It was also used to generate the flood extents and cross-sections for the 1 in 100 year floodplain modeling.

3.1.2 Geology

A three-dimensional geological model representing the spatial distribution of sediments (clays, sands, etc) and rocks in the subsurface across the study area was developed. This was used in conjunction with a developed cut template (defining cut depths, slopes and batters) to accurately calculate earthworks throughout the route. Geological mapping and soil classifications was sourced from both the Bureau of Rural Sciences (Digital Atlas of Australian Soils) and Geosciences Australia (regional geology mapping). The raw surface geology encompassing the project area is illustrated in Figure 3-2. This information was supplemented with a helicopter soil survey of the regional geology between the mine site and Abbot Point, completed by Australian Mining Engineering Consultants (AMEC), on the 9th September, 2009[7].

[7] Australian Mining Engineering Consultants, *Soil Survey Report for Alpha to Abbot Point Railway*, 2009.



0 50 100 Km

Map Grid of Australia – Zone 55
Geocentric Datum of Australia 1994

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A	22/02/10	Concept Design	BH	NH
Rev	Date	Description	ORIG	CHK

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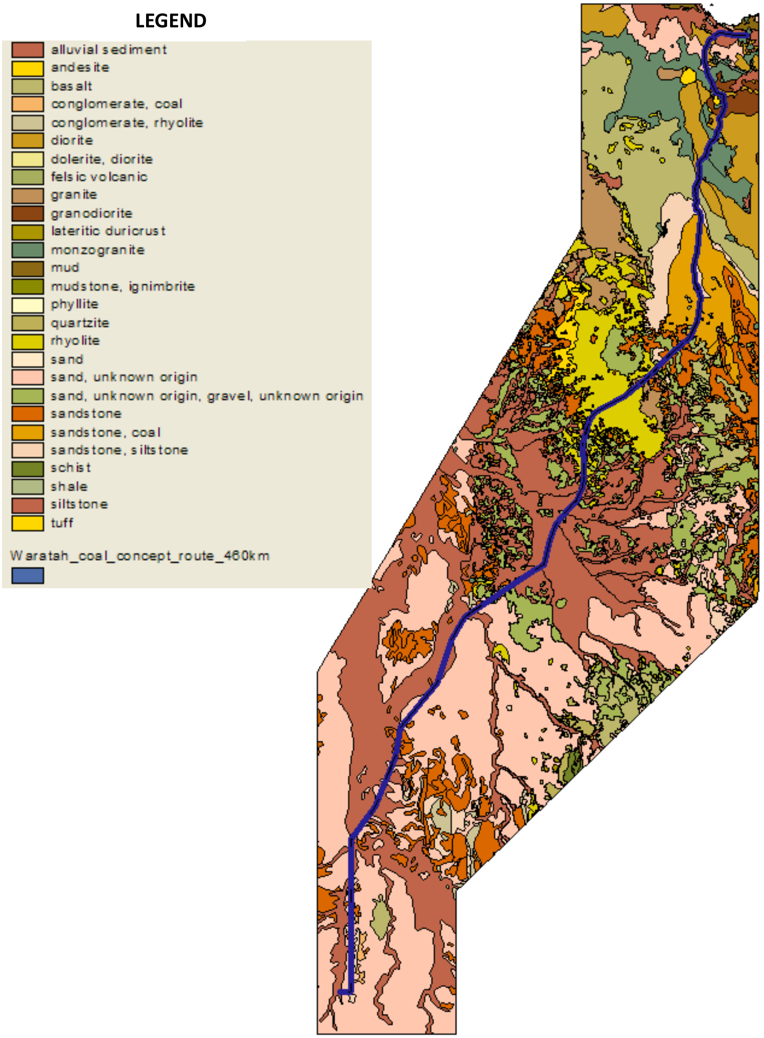
Galilee Basin Coal Railway
Pre Feasibility Study
Quantm Route Analysis
Figure 3-1 - Digital Terrain Model
GALILEE BASIN, QUEENSLAND
Australia

DRG NO:10.60.002-001B-1



Geology Type	Description
alluvial sediment	Channel and flood plain alluvium; gravel, sand, silt, clay
andesite	Intermediate and acid lavas and volcaniclastics; rare conglomerate, sandstone, shale, siltstone, coal
basalt	Basaltic to andesitic lava and volcaniclastic rocks (including breccia and arenite), rhyolitic to dacitic lava and volcaniclastic rocks (including ignimbrite); local siltstone, shale and polymictic conglomerate
conglomerate, coal	Tillitic conglomerate, lithic sandstone, siltstone, minor mudstone and coal
conglomerate, rhyolite	Lithic conglomerate, feldspatholithic sandstone, rhyolitic to dacitic ignimbrite and flows, tuffaceous siltstone and rare sinter
diorite	Diorite, quartz diorite, hornblende-augite diorite, tonalite, gabbro, granodiorite
dolerite, diorite	Dolerite, microdiorite, gabbro, diorite; minor monzonite and meladiorite - Georgetown Hodgkinson region
felsic volcanic	Rhyolitic, rhyodacitic, dacitic and minor andesitic welded tuffs, lavas and air-fall volcaniclastics, intrusive rhyolite and porphyry
granite	Alkali granite, quartz syenite
granodiorite	Biotite-hornblende granodiorite, biotite monzogranite, aplitic microgranite, diorite
lateritic duricrust	Ferruginous duricrust, laterite; may include massive to pisolitic ferruginous subsoil, mottled clays
monzogranite	Monzogranite, granodiorite, granite; minor microgranite, porphyry, quartz diorite, granophyre, microtrondhjemite
mud	Estuarine, tidal delta deposits; coastal mud flats; may contain older vegetated black soils
mudstone, ignimbrite	Volcaniclastic mudstone and sandstone; andesitic rudite and lava; dacitic to rhyolitic ignimbrite and lava; intrusive rhyolite
phyllite	Chlorite-quartz phyllite, muscovite-plagioclase-quartz schist, marble, hornfels, amphibolite, gneiss, serpentinite
quartzite	Low-medium grade meta clastic sediments. Quartzite, phyllite, feldspathic quartzite, psammitic schist, amphibolite
rhyolite	Intrusive rhyolite and dacite
sand	Tailings and waste rock from coal mining
sand, unknown origin	Sand plain, may include some residual alluvium; sand dominant, gravel, clay
sand, unknown origin, gravel, unknown origin	Colluvium and/or residual deposits, talus, scree, sheet wash; boulder, gravel, sand; may include minor alluvial or sand plain deposits
sandstone	Lithic sandstone, pebbly lithic sandstone, green to reddish brown mudstone and minor volcanilithic pebble conglomerate (at base)
sandstone, coal	Sandstone, siltstone, shale, mudstone, coal, tuff, conglomerate
sandstone, siltstone	Flaggy quartzose sandstone, siltstone and minor limestone
sandstone, siltstone	Quartzose to lithic sandstone, siltstone, carbonaceous shale, minor coal and sandy coquinite
schist	Grey, fine to medium-grained, mica schist, quartz-mica schist grading to phyllite, quartzite, fine grained greenstone and calc-silicate schist, laminated amphibolite, metadolerite and metagabbro
shale	Shale, siltstone, medium to coarse feldspathic sandstone, polymictic granule conglomerate, oligomictic
siltstone	White and grey siltstone and fine sandstone, minor medium to very coarse-grained sandstone, chert, granule to pebble conglomerate, rare tuff, ignimbrite and dacite/andesite
tuff	Tuff, rhyolitic to dacite ignimbrite, trachyte, epiclastic sediments, sinter deposits, minor sandstone and siltstone

0 50 100 Km

Map Grid of Australia – Zone 55
Geocentric Datum of Australia 1994

N W E S

Waratah Coal
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Waratah Coal Pty Ltd

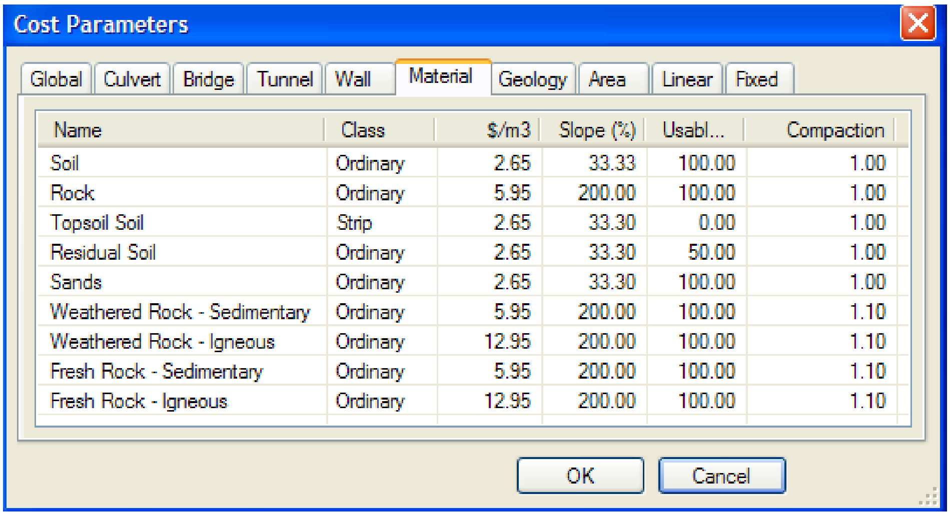
Rev	Date	Description	ORIG	CHK
A	18/09/2009	Concept Design	BH	NH

Galilee Basin Coal Railway
Pre Feasibility Study
Quantm Route Analysis
Figure 3-2 - Raw Surface Geology
GALILEE BASIN, QUEENSLAND
Australia

DRG NO: 10.60.002-004A-1

Dominant geological formations across the study area were identified and simplified into a number of distinguishable regions. Generally these comprised of regions of grey reactive clays characterized by melon-hole country, brown non-cracking clays, pale brown and reddish sandy soils and small areas of black reactive soils near the Queensland coast.

Vertical soil profiles compromised of several distinguishable layers of strata and corresponding benching requirements were then established for each geological area. These consisted of a layer of top soil (to be stripped), followed by residual soil, weathered rock and finally a bottom layer of fresh rock. The depth to the sedimentary or igneous rock was estimated to occur between 5-20m below the natural surface. For each material type, varying cut extraction rates, batter slopes, percentage usable (as Fill) and compaction / bulking factors were also defined, as illustrated in Figure 3-3.



Name	Class	$/m3	Slope (%)	Usabl...	Compaction
Soil	Ordinary	2.65	33.33	100.00	1.00
Rock	Ordinary	5.95	200.00	100.00	1.00
Topsoil Soil	Strip	2.65	33.30	0.00	1.00
Residual Soil	Ordinary	2.65	33.30	50.00	1.00
Sands	Ordinary	2.65	33.30	100.00	1.00
Weathered Rock - Sedimentary	Ordinary	5.95	200.00	100.00	1.10
Weathered Rock - Igneous	Ordinary	12.95	200.00	100.00	1.10
Fresh Rock - Sedimentary	Ordinary	5.95	200.00	100.00	1.10
Fresh Rock - Igneous	Ordinary	12.95	200.00	100.00	1.10

Figure 3-3 - Geological Material Properties

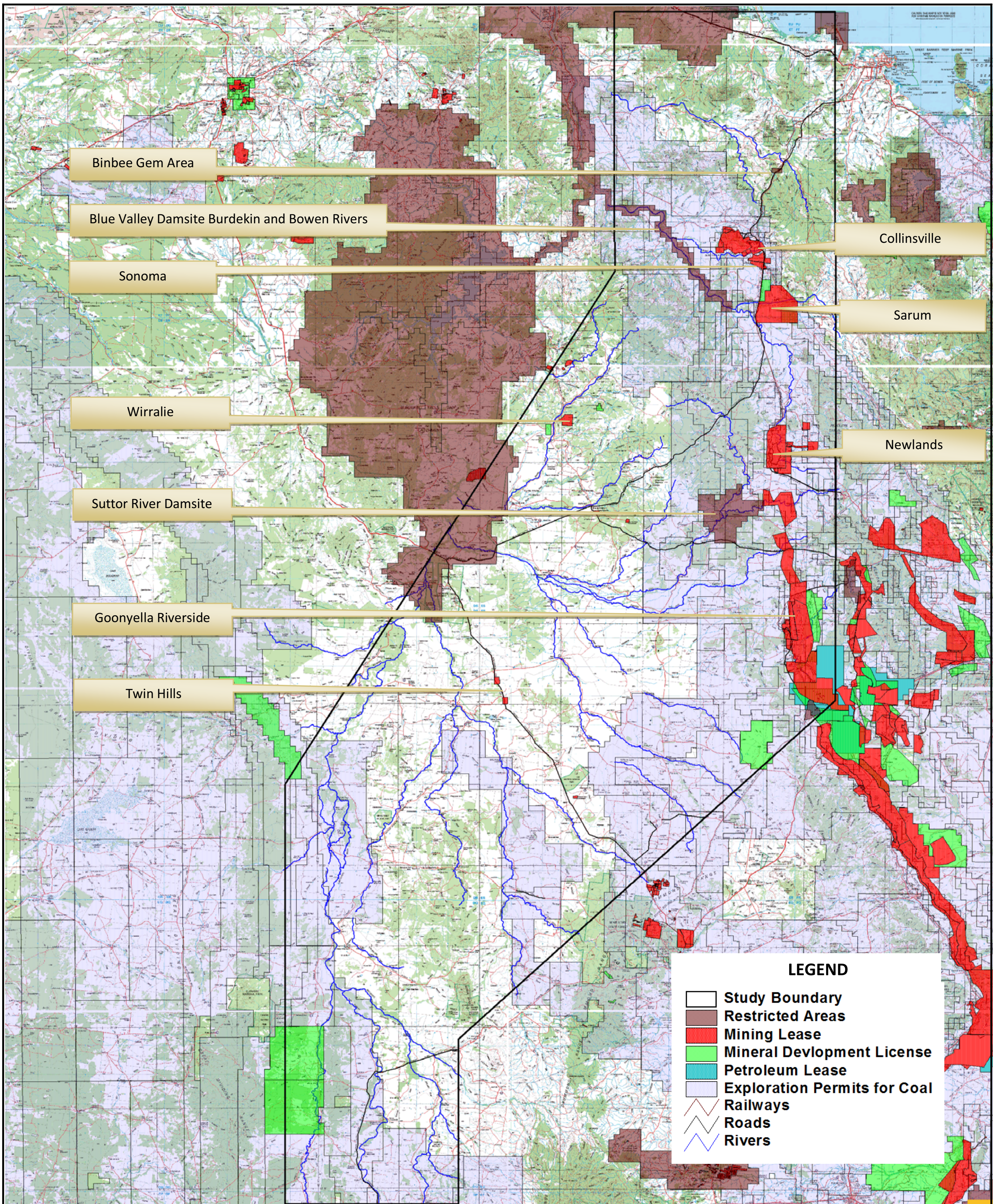
The overall conceptual geological model although relatively coarse was deemed sufficient for this preliminary assessment; however, a detailed ground geotechnical survey will be required along the final 1.5km corridor prior to detailed design to allow more accurate estimates of civil works to be established.

3.1.3 Mining

The latest mining tenements applicable to the study were acquired from the mines section within the Queensland Department of Employment, Economic and Innovation (DEEDI). This included datasets for the existing Mining Leases (ML) and Mineral Development Licenses (MDL), as shown in Figure 3-4.

Petroleum Leases were also checked; however, only one small tenement located on the edge of the study area near Moranbah was found. Abandoned mines (possible areas of unstable land) were not included for the preliminary corridor assessment; however, will be considered at the next stage of assessment.

Quantm's avoidance criteria were used to constrain the mining datasets. These fall into three categories of differing priorities; high, medium and low. High Priority avoidance does not allow alignments into these regions under any circumstances and were reserved for the MLs. Medium and Low priority allow alignments to enter these regions providing there are reduced costs or improvements to the geometry. MDLs were constrained using medium priority avoidance.



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Map Grid of Australia – Zone 55
Geocentric Datum of Australia 1994

N E S W

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Rev	Date	Description	ORIG	CHK

Waratah Coal Pty Ltd

Galilee Basin Coal Railway
Pre Feasibility Study
Quantm Route Analysis
Figure 3-4 - Q50 Mining Constraints
GALILEE BASIN, QUEENSLAND
Australia

DRG NO:10.60.002-006A-1

The restricted areas dataset was also sourced from DEEDI. These define regions where exploration activity may occur but with increased restrictions and conditions, as specified by Schedule 3 of the Mineral Resources Regulations 2003. These areas are commonly dam catchments or areas needing special consideration and include the Suttor River Damsite, Binbee Gem Area and Blue Valley Damsite Burdekin and Bowen Rivers which all fall across the Q50 study area. Within the Quantm analysis these were treated with low priority avoidance; however, it's recommended that a register search be conducted prior to detailed design to identify the particular restrictions applicable to any of the areas that the final corridor may impact.

3.1.4 Environmental

Environmentally responsible planning and ecologically sustainable development for the construction and operation of a new rail corridor was a key focus of this study. Consideration was given to minimising environmental impacts to areas of significant environmental value or concern wherever feasible.

The primary environmental issues associated with the study included avoiding national parks and protected reserves, limiting impacts to regional farming lands, ensuring appropriate clearances over streams, minimising encroachment into floodplains, wetlands and riparian ecosystems and limiting disturbances to regional vegetation habitats.

Environmental datasets were acquired from a number of commercially available sources and generally defined with either high, medium, or low priority avoidance criteria (refer to section 3.1.3 for an explanation of these criteria). The level of priority (sensitivity) was dependant on their degree of significance, with protected areas such as national parks designated as high priority (absolute no-go), whereas less sensitive areas such as regional ecosystems attributed with medium or low priority avoidance that still attempted to minimise encroachment into these areas where possible.

Table 3-1 provides a summary of all key environmental datasets included for the Q50 study, with their locations illustrated in Figure 3.5a and Figure 3.5b.

3.1.4.1 *National Parks, Resource Resources, State Forest*

The *Nature Conservation Act 1992* establishes thirteen categories of wildlife and habitat controlled areas that protect Queensland's biological diversity and outstanding natural and cultural features. The Protected Areas of Queensland Estate GIS dataset was obtained from the Environmental Protection Agency (EPA) to identify protected areas applicable to the Q50 study. These fell into the following categories:

- **National Parks** – primary conservation category used to define areas for permanent preservation of their natural condition to the greatest extent. Under this category protection is given to the area's cultural resources and values to ensure that their only use is nature-based and ecologically sustainable. National Parks that fall across the study area include Mazeppa National Park, Narrien Range National Park, Nairana National Park and Cape Upstart National Park.

- **National Parks (Scientific)** – regions that are highly protected due to their exceptional scientific value. These areas ensure processes of nature continue unaffected, control threatening processes to protect endangered species, protect the area's biological diversity to the greatest possible extent, and allow controlled scientific study and monitoring of the area's natural

resources. Epping Forest National Park, the site of the last remaining colonies of the critically endangered northern hairy-nosed wombat, is classified as a National Park (scientific).

- **National Parks (Recovery)** - this categorisation applies to locations that have been declared protected areas but whose cultural and natural resources and values are considered not to be up to full national park standard. They are usually areas that have been subjected to a previous use such as forestry or some form of agriculture. They are generally managed to restore the parks natural condition and conservation values so that they can be eventually dedicated as a national park. A section of the Nairana National Park, which contains the endangered regional ecosystems of the Brigalow habitat, falls into this category.

- **Resources Reserves** –declared areas which have a high conservation value but cannot be reserved as a national or conservation park (e.g. mining or intensive tourism areas). These provide for the controlled use of the area's cultural and natural resources and maintain the area in a predominantly natural condition. There were two resources reserves found within the study area, namely Cudmore Resources Reserve and Abbot Bay Resources Reserve.

- **State Forest Reserves** - preserved habitat areas for flora and fauna, timber and other forestry vegetation. Two state forest reserves were identified within the study area, Blair Athol and Sonoma State Forests (as shown in Figure 3-5).

- **Nature Refuge** - protected areas under private ownership, normally from a voluntary conservation agreement between a landholder and the government (EPA) that acknowledges a commitment to preserve land with significant conservation values. A number of these areas were identified within the study area including the 813ha Mount Pleasant Nature Refuge that protects rare and threatened upland mossy forest species of Mount Aberdeen and Highlanders Bonnet National Park, as well as the riparian communities of the Bogie River.

It was decided that for the Quantm analysis National Parks, National Parks (scientific), National Park (recovery) and Resources Reserves would be constrained using the high priority avoidance criteria to prohibit alignment encroachment into these protected areas.

State Forest Reserves and Nature Refuge, deemed to be of less significance, were designated as medium priority avoidance to permit intrusion only if it provided a significant reduction in alignment cost.

3.1.4.2 *Regional Ecosystems*

Regional Ecosystems (REs) are defined as vegetation communities in a bioregion that are consistently associated with a particular combination of geology, landform and soil type. Under the *Vegetation Management Act 1999*, the status of each RE is defined as either:

- **Endangered** – less than 10% of the pre-clearing extent remains, or 10–30% of the pre-clearing extent remains and the area of remnant RE remaining is less than 10,000 ha.

- **Of Concern** - 10–30% of the pre-clearing extent remains, or more than 30% of the pre-clearing extent remains and the area of remnant RE remaining is less than 10,000 ha.

- **Not of Concern** - more than 30% of the pre-clearing extent remains, and the area of remnant RE remaining is more than 10,000 ha.

The regional ecosystem dataset as illustrated in Figure 3-6 and Figure 3-7 was sourced from the EPA, with polygons for Endangered and Of-concern extracted and constrained using medium and low priority avoidance criteria respectively.

3.1.4.3 *Koala Habitats*

The Koala Plan 2006-2016, is a koala conservation plan to promote the continued existence of viable koala populations in the wild, prevent the decline of koala habitats, including providing for the rehabilitation of cleared or disturbed koala habitats, and promote future land use and development that is compatible with the survival of koala populations in the wild. This dataset was sourced from the EPA, Queensland; however, not found to contain any areas that fell across the study area.

3.1.4.4 *World Heritage Areas*

World Heritage Areas are regions that have outstanding cultural and heritage value. These were sourced from the Australian Government's Department of Environment, Water, Heritage and Arts. The Great Barrier Reef Area, the world's most extensive coral reef system and richest area in terms of biological diversity, was found to fall across the northern edge of the study area. However, as its outer boundary lies beyond the finishing point for the railway, it wasn't necessary to include this as a constraint within the Quantm analysis.

3.1.4.5 *Wetlands*

Wetlands in Queensland are generally defined under the Ramsar international wetland conservation treaty, being areas of marsh, fen, peatland or water, whether permanent or temporary, with water that is static or flowing, fresh, brackish or slat, including areas of marine water the depth of which at low tide does not exceed six meters.

The Directory of Important Wetlands in Australia (DIWA), an inventory for important wetland sites across Australia, was acquired from the EPA. A small number of sites were identified within the study boundary, including a 540 hectare region along a 15km stretch of the Bowen River between Birralee to Pelican Creek. DIWA wetlands were constrained within Quantm as medium priority avoids zones. There were no wetlands listed in the DIWA that fell within the Q50 study area that has RAMSAR status.

3.1.4.6 *Fish Habitat & Dugong Protection Areas*

A declared fish habitat area (FHA) is an inshore and estuarine fish habitat (e.g. vegetation, sand bars and rocky headlands) that is protected against physical disturbance from coastal development.

Dugongs are large marine mammals that live in the shallow coastal waters of north-eastern Australia and are protected under the *Environment Protection and Biodiversity Conservation Act 1999*.

FHAs and Dugong protected habitats were acquired from Queensland Department of Primary Industries and Fisheries and although found within the very northern part of the study area, would not be effected by the rail corridor terminating further inland.

3.1.4.7 *River Improvement Trust Areas*

A river improvement trust area is constituted under the *River Improvement Trust Act 1940* to protect and improve rivers, repair and prevent damage to rivers and prevent or mitigate flooding of land by riverine floods. These were sourced from DERM and found to have two areas that fell across parts of the study area (Don and Burdekin River Improvement Trust Areas). It was decided that they would not significantly affect the rail corridor and would be included at a later stage in the project.

3.1.4.8 *Dams and Water Storage*

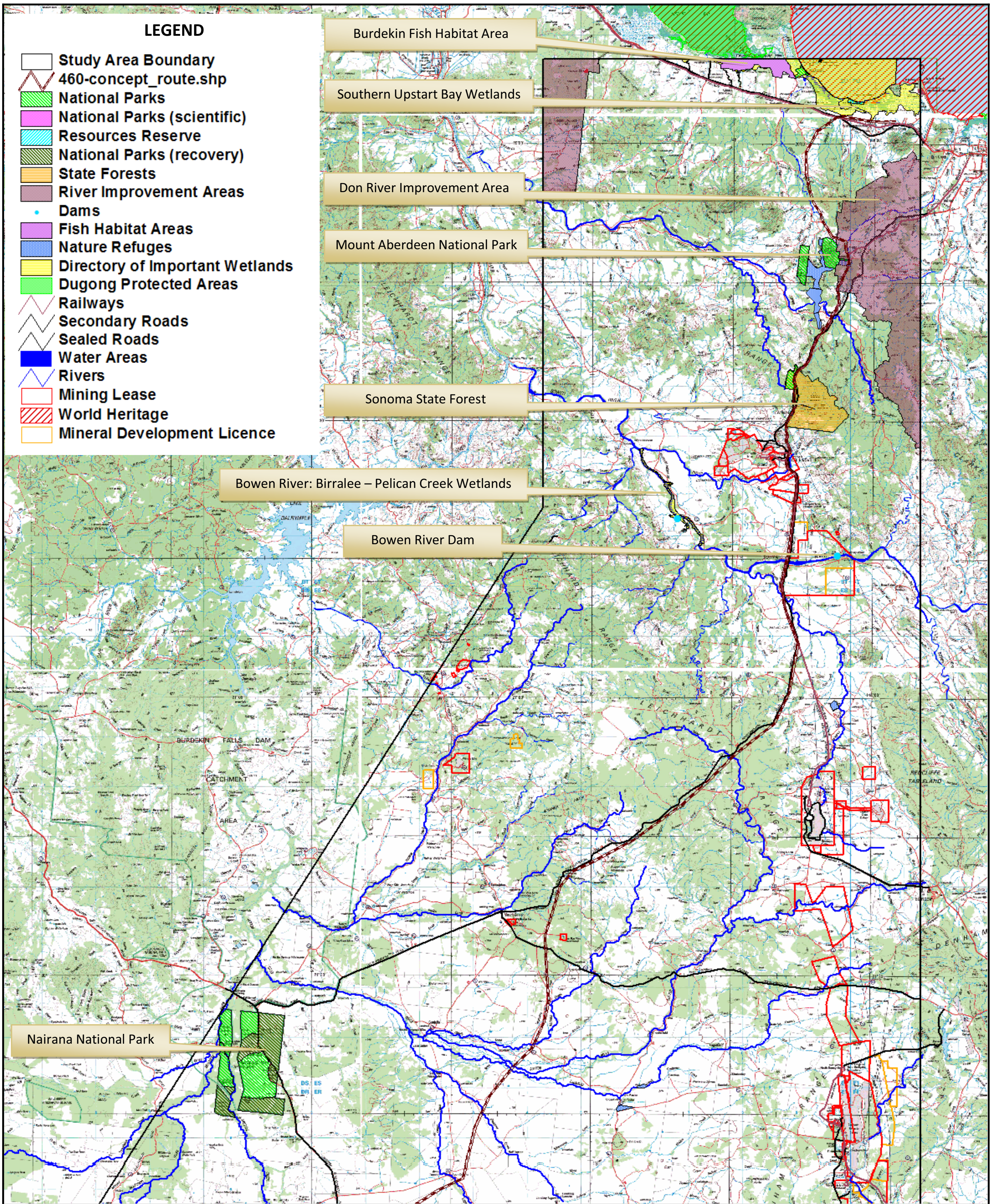
Dam and Water Storage areas define boundaries of large publically owned reservoirs in Queensland. This dataset was obtained from Geoscience Australia and found to include two dams within the study area including a 2,360 ML capacity concrete dam on the Bowen River used for Irrigation and Urban water supply. Dams sites were suitably buffered and constrained as high priority avoidance within Quantm.

3.1.4.9 *Declared Catchments Areas*

Declared catchment areas are established by regulation under the *Water Act 2000* by declaring an area to be a catchment area for the purpose of preserving the quality of water in the area. Within these areas DERM and local government have jurisdiction to consider the impacts from certain developments, that won't risk degradation on water quality entering the adjacent storages. The Burdekin Falls Catchment Area falls across the western boundary of the study area and was constrained using the high priority avoidance criteria.

Table 3-1 - Q50 Environmental Datasets

Constraint Type	Dataset	Source	Within Q50 Study Area	Quantm Criteria
National Parks	Protected Areas of QLD Estate	Environmental Protection Agency, QLD	Yes	High priority avoidance
National Parks (Scientific)	Protected Areas of QLD Estate	Environmental Protection Agency, QLD	Yes	High priority avoidance
National Parks (Recovery)	Protected Areas of QLD Estate	Environmental Protection Agency, QLD	Yes	High priority avoidance
Resource Reserves	Protected Areas of QLD Estate	Environmental Protection Agency, QLD	Yes	High priority avoidance
State Forests Reserves	Protected Areas of QLD Estate	Environmental Protection Agency, QLD	Yes	Medium priority avoidance
Nature Refuge	Protected Areas of QLD Estate	Environmental Protection Agency, QLD	Yes	Medium priority avoidance
Regional Ecosystems (Endangered)	Regional Ecosystems	Environmental Protection Agency, QLD	Yes	Medium priority avoidance
Regional Ecosystems (Of-Concern)	Regional Ecosystems	Environmental Protection Agency, QLD	Yes	Low priority avoidance
Regional Ecosystems (Not-of-Concern)	Regional Ecosystems	Environmental Protection Agency, QLD	Yes	Not included in Q50 Study
World Heritage Areas	World Heritage	Department of Environment, Water, Heritage and Arts, Aus Gov.	Yes	n/a
Koala Habitats	Koala Plan 2006 -2016	Environmental Protection Agency, QLD	No	n/a
Wetlands (DIWA)	Directory of Important Wetlands, Australia	Environmental Protection Agency, QLD	Yes	Medium priority avoidance
Wetlands (Ramsar)	Ramsar Sites, QLD	Environmental Protection Agency, QLD	No	Falls outside rail corridor
Fish Habitat Areas	Queensland Fish Habitat Areas	Department of Primary Industries & Fisheries, QLD	Yes	Falls outside rail corridor
Dugong Habitat Areas	Dugong Protection Areas	Department of Primary Industries & Fisheries, QLD	Yes	Falls outside rail corridor
River Improvement Areas	Queensland River Improvement Trust Areas	Department of Environment and Resource Management, QLD	Yes	Not included in Q50 Study
Dams	Dams & Water Storage Areas	Geoscience Australia	Yes	High priority avoidance
Declared Catchments	Declared Catchments of Queensland	Department of Environment and Resource Management, QLD	Yes	High priority avoidance



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Map Grid of Australia – Zone 55
Geocentric Datum of Australia 1994

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Rev	Date	Description	ORIG	CHK
A	22/02/10	Concept Design	BH	NH

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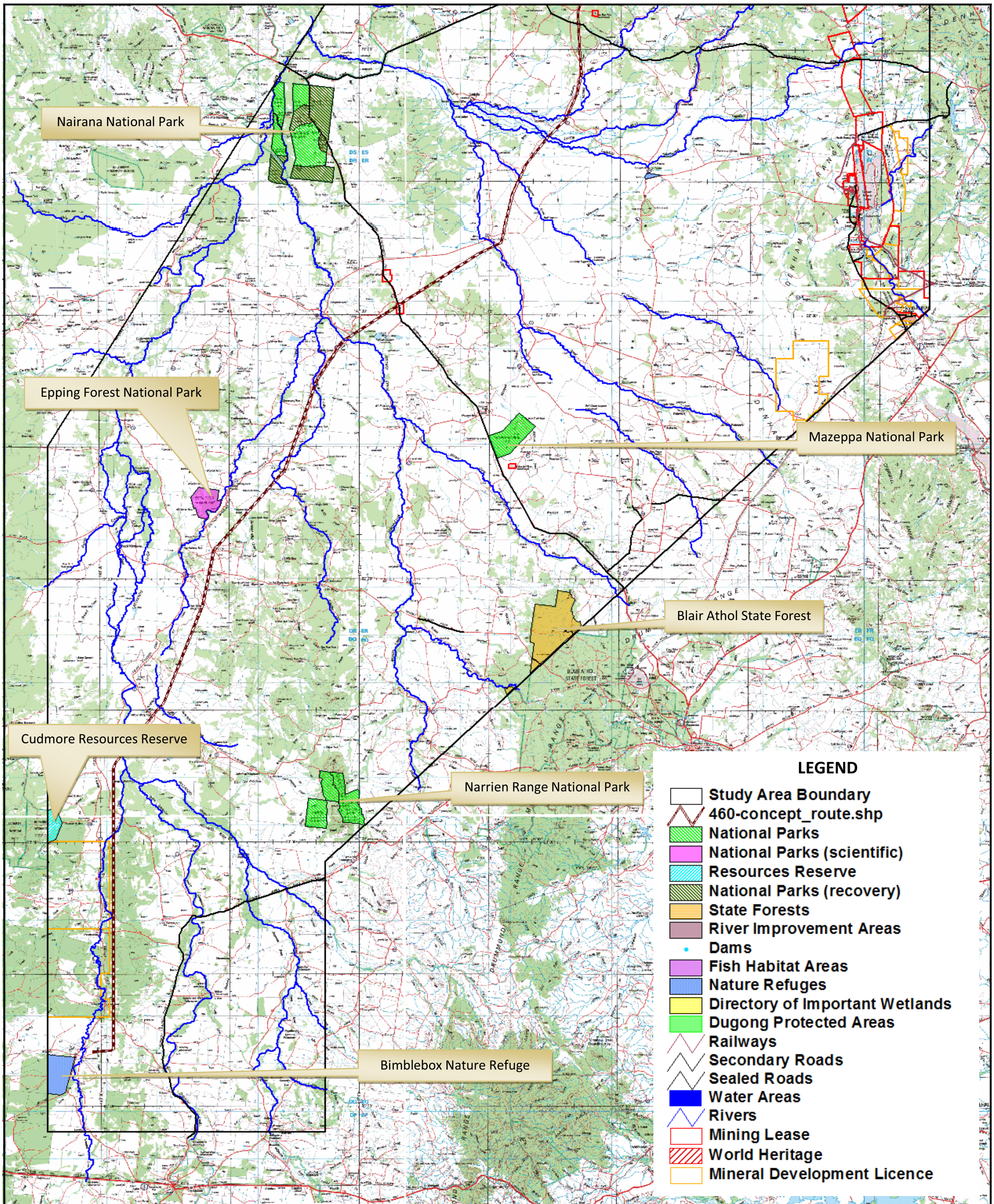
Galilee Basin Coal Railway
Pre Feasibility Study
Quantm Route Analysis
Figure 3-5a - Q50 Environmental Constraints
(northern study area)
GALILEE BASIN, QUEENSLAND, Australia

DRG NO: 10.60.002-003-1



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Geocentric Datum of Australia 1994

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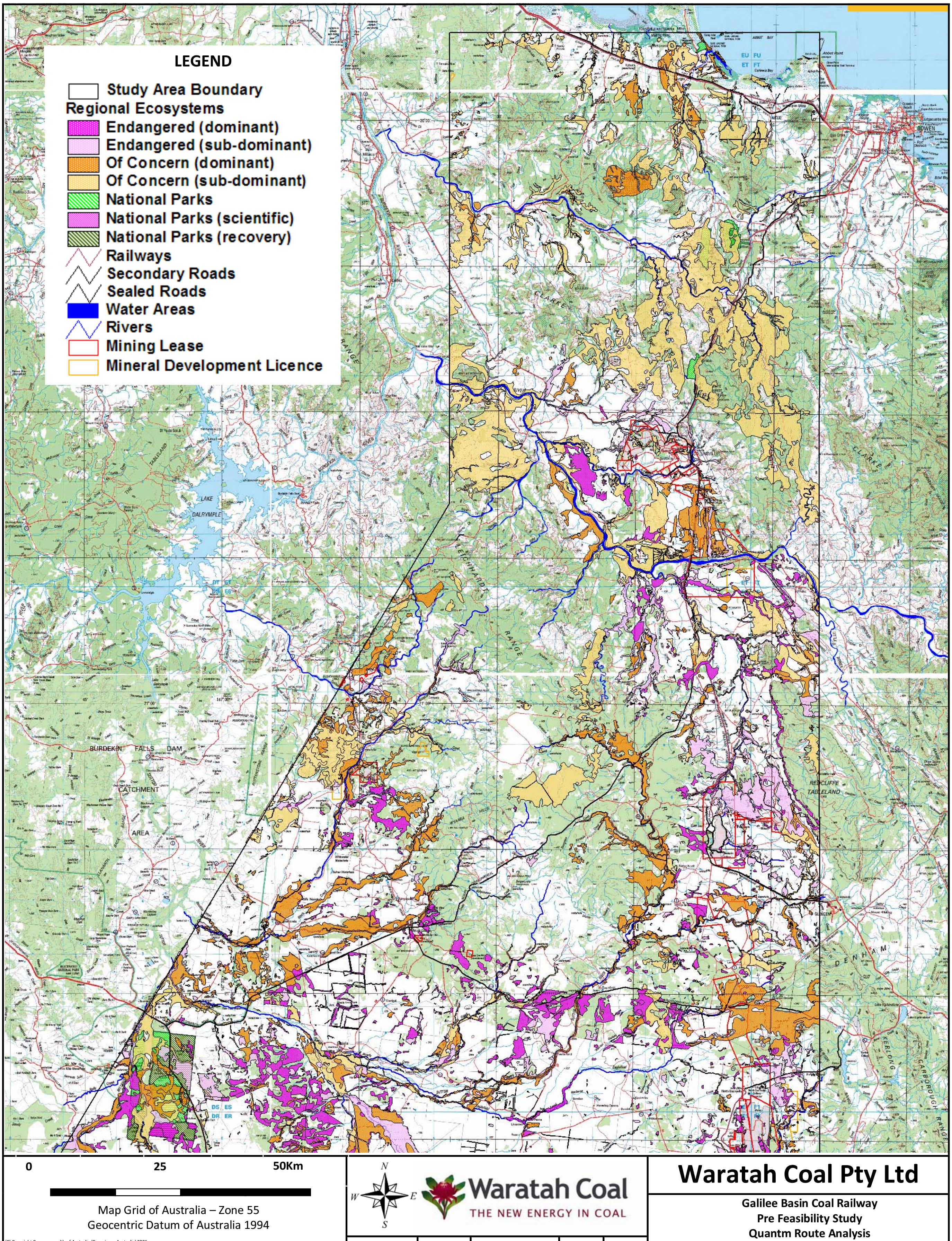
Galilee Basin Coal Railway
Pre Feasibility Study
Quantm Route Analysis
Figure 3.5b - Q50 Environmental Constraints
(southern study area)
GALILEE BASIN, QUEENSLAND, Australia

DRG NO: 10.60.002-003-2



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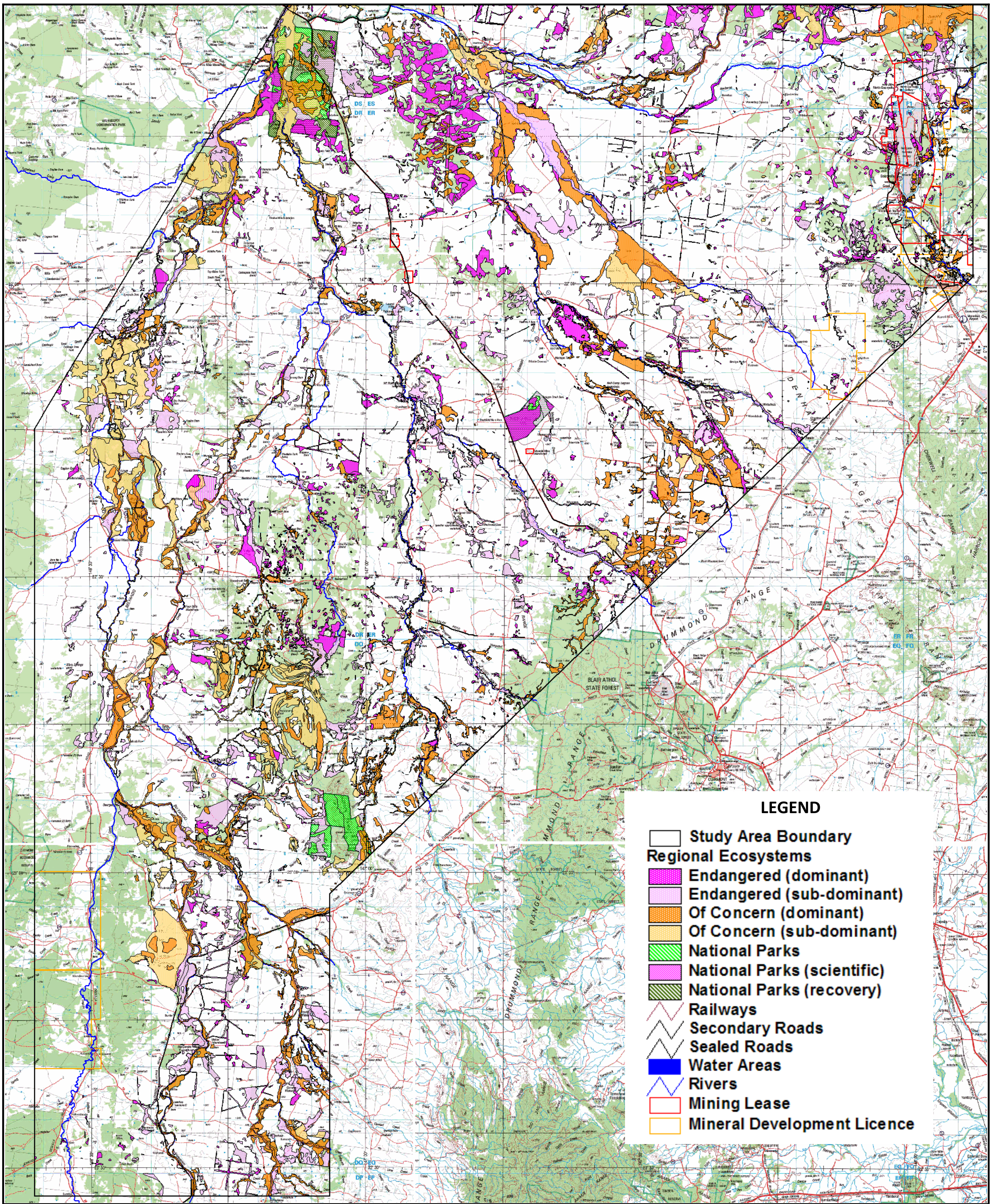
Pre Feasibility Study
Quantm Route Analysis
Figure 3-6 - Regional Ecosystems
(Northern Study Area)
GALILEE BASIN, QUEENSLAND, Australia

DRG NO: 10.60.002-003H-1



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Rev	Date	Description	ORIG	CHK
A	22/02/10	Concept Design	BH	NH

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Galilee Basin Coal Railway
Pre Feasibility Study
Quantm Route Analysis
Figure 3-7 - Regional Ecosystems
(Southern Study Area)
GALILEE BASIN, QUEENSLAND, Australia

DRG NO: 10.60.002-003H-2

3.1.5 European Heritage

Non indigenous heritage is based on physical artifacts and intangible attributes that reflect significant events and meanings in history, which are inherited from past generations, maintained in the present and bestowed for the benefit of future generations. These places are permanently protected under the provisions of the Queensland *Heritage Act 1992*.

The Queensland Heritage Registered Places dataset was obtained from the EPA and found to contain two areas of non indigenous heritage: The Bowen River Hotel, which is representative of a transitional type of timber construction which led to the development of a distinctive style of architecture in Queensland and Mount Coolon Gold Mines Battery, which reflects the evolution of gold mining in Queensland. Both these areas were attributed with high priority (absolute) avoidance criteria to ensure the railway would have no impact on these protected areas.

3.1.6 Indigenous Heritage

Indigenous heritage provides for the recognition and protection of land that is of spiritual, social, historical, cultural and economic importance to Aboriginal people and Torres Strait Islanders. Native Title provides indigenous people with rights and interests to their land that come from their traditional laws and customs. These titles are protected by Australian law with boundaries and core attributes about applications listed within the Register of Native Title Claims. This dataset was acquired from Geoscience Australia and can generally be classified into the following categories:

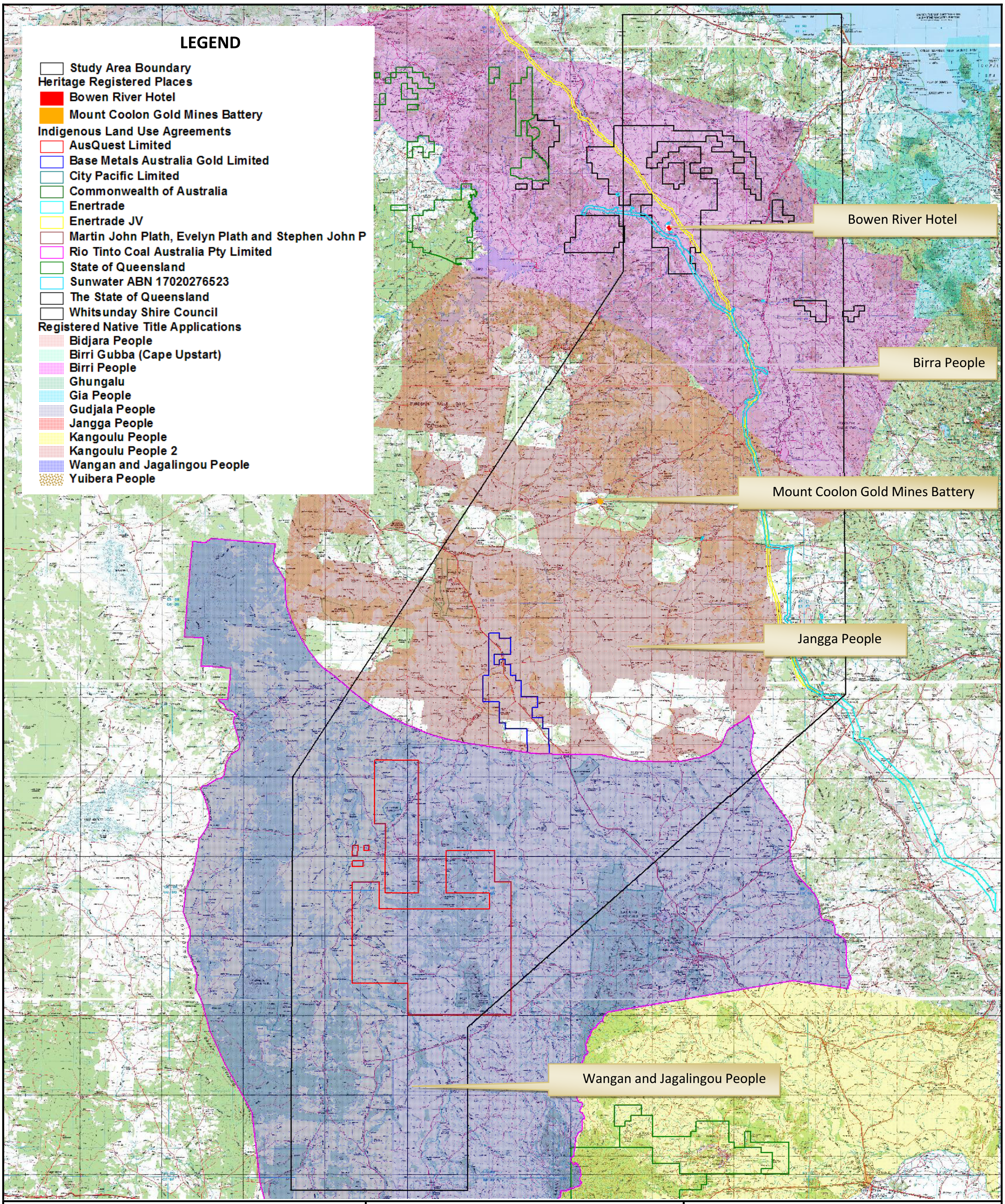
- **Registered Native Title Applications** - applications that have been filed by a native claim group to the Federal Court of Australia seeking determination that recognise them as native title holders;

- **Determinations of Native Title** - reflects the areas which have been determined by the Federal Court of Australia to have, or not have, native title exist over a particular area of land; and

- **Indigenous Land Use Agreements** – an agreement between a native title group and others to the use and management of land and / or waters. These allow developments on land to happen independently of any application for a determination of native title.

A large proportion of the study area is covered by native title applications (see Figure 3-8).

Native Title Applications were not included as a constraint due to them being relative unavoidable within the study area.



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Waratah Coal
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Rev	Date	Description	ORIG	CHK
A	22/02/10	Concept Design	BH	NH

Waratah Coal Pty Ltd

Galilee Basin Coal Railway
Pre Feasibility Study
Quantm Route Analysis
Figure 3-8 - Cultural and Indigenous Heritage Areas
GALILEE BASIN, QUEENSLAND
Australia

DRG NO: 10.60.002-003-3

3.1.7 Socioeconomic

The impacts of the China First Railway on the social and economic environment will include both the negative impacts to affected landowners (e.g. property severance, coal dust, train noise, waste, traffic disruptions, etc) and the positive effects that the project will bring to nearby communities including new infrastructure and facilities, employment, skills and training. For this study only the macro level impacts were assessed included minimising the number of properties impacted, as well as consideration for benefits in locating the route close to townships that would provide workforce and other resource benefits to the project.

The proposed railway is likely to cross up to three regional council areas; namely Barcaldine, Isaac and Whitsunday Regional Councils. The regional townships within these administrative regions that may be directly or indirectly impacted by the proposed railway includes:

- **Bowen** – located on the Queensland coast servicing both the Bruce Highway and North Coast Railway. Bowen lies approximately 20km south east of the coal export terminal situated at Abbot Point where the future port infrastructure facilities for the China First Project will be located. As of the 2006 census, Bowen has a population of 7,484.

- **Guthalungra** – small rural township located on the Queensland Coast that services both the Bruce Highway and North Coast Railway. As of the 2006 census, Guthalungra has a population of 109.

- **Collinsville** – is a mining town in the coal rich Bowen Basin region of central Queensland. It lies on the Bowen Developmental Road and Collinsville Newlands Railway line. The China First Railway will pass within a close proximity of Collinsville, likely to draw on its workforce and associated resources during the construction and operational phases of the project. As of the 2006 census, Collinsville has a population of 2,063.

- **Moranbah** – mining town located on the Peak Downs Highway between Mackay and Clermont. A significant proportion of the local residents work in some capacity to support the BHP Australia Coal owned mine Goonyella Riverside. It is likely that Moranbah will provide resources and workforce for the construction of the China First Railway. As of the 2008 census, Moranbah has a population of 8,000.

- **Mount Coolon** – located on the Bowen Developmental Road and Police Creek, the surrounding areas have provided gold mining exploration in the past. Mount Coolon is earmarked as a suitable point mid-route to house maintenance and construction teams for constructing and operating the China First Railway.

- **Alpha** – lies on the Capricorn Highway and Alpha Creek, within 10km of the China First mine. Initially Alpha was established as a temporary terminus during construction of the Great Northern Railway; however, it now provides a service centre for the surrounding pastoral properties and travelers. As of the 2006 census, Alpha has a population of 402.

- **Emerald** – lies on the junction of the Capricorn and Gregory Highways and is a service town for the extensive mining operations and agriculture industries (cotton, grain, citrus, etc) in the area. It is likely that Emerald will provide resources and workforce for the construction of the China First Project. As of the 2006 census, Emerald has a population of 10,999.

Boundary limits for townships were acquired from Geoscience Australia and included as high priority avoidance areas within the study. This ensured that railway routes would not directly impact these communities; however, those generated within 2-10km were deemed favorable should the towns be suitable to draw on construction resources, or house future maintenance teams.

The majority of the properties affected along the rail corridor will be beef cattle stations and agriculture pastures. Cadastral property boundaries and their related property descriptions (lot number and plan number) were extracted from Queensland's Digital Cadastral Database (DCDB). Due to the large number of parcels falling across the entire study area (over 6,400), the treatment of minimising property severance was considered to detailed for the initial overall assessment. These were included; however, at the corridor refinement stage when evaluating the short listed corridors.

Satellite imagery extracted from Google Earth was utilised in conjunction with land parcel boundaries to identify house locations within individual properties to ensure the route did not encroach within a close proximity to these. Stock routes and existing infrastructure easements were considered as favorable locations to funnel the route along.

3.1.8 Drainage

Ensuring flood immunity for the 1 in 100 year flood event was an important design requirement for this project, particularly in light of the major floods in February 2008 that inundated large parts of the study area. To accurately model this, Waratah Coal commissioned WorleyParsons to undertake a large scale flood investigation study to determine the 100 year Average Recurrence Interval (ARI) floodplain extents of the major watercourses falling within the study area[8]. Outputs from the investigation included mapping of the 100 year ARI floodplains of the major catchments, as well as digitised stream line centerlines with associated widths developed from geo-referenced Google imagery, as illustrated in Figure 3-9.

3.1.8.1 *Major Catchments*

The major catchments falling across the study area includes:

- **Belyando River** – dominant river system located in the south west portion of the study area, draining an area of around 23,000km^2. It flows in a northern direction through the study area, joining the Suttor River downstream before flowing into the Burdekin River and then out into the Coral Sea. Its major tributaries include Sandy Creek, May Creek, Native Companion Creek, Dunda Creek and the Carmichael River. During times of flood, waters from the Belyando River are able to break out onto the Fox Creek floodplain to the east.

- **Mistake Creek** – a tributary of the Belyando River flowing in a northern direction and draining an area of around 9,000km^2. Its major tributaries within the study area include Fox Creek, Middle Creek, Gregory Creek and Miclere Creek.

- **Suttor River** – a tributary of the Belyando River flowing in an westerly direction across the study area and draining an area of around 11,000km^2. The major tributaries of this river include Logan

[8] WorleyParsons Pty Ltd, *Waratah Coal Abbot Point Railway Corridor - Preliminary Flooding Investigation*, November 2009.

Creek, Brown Creek, Diamond Creek, Eaglefield Creek, Suttor Creek, Rosetta Creek, Police Creek and Verbena Creek.

- **Bowen River** – a tributary of the Burdekin River draining in a north-west direction over an area of around 9,000km^2. Its major tributaries include Pelican Creek, Rosella Creek, Little Bowen River, Broken River and Emu Creek.

- **Bogie River** – a tributary of the Burdekin River draining in a north-west direction over an area of around 1,600km^2. The major tributary of this river within the study area is Sandy Creek.

- **Caley Valley Wetlands** – a low lying poorly drained area subject to tidal inundation, situated to the south west of Abbot Point. The wetland is fed by a series of relatively small coastal creeks including Armstrong Creek and Sandy Creek, with the total catchment draining to the wetland estimated to be 400km^2. Although noted as a possible source of flooding of the railway near the port, it was not modelled in this preliminary investigation but will form part of future design works.

The catchments along with general flow directions are shown in Appendix A.

3.1.8.2 *Hydrologic Assessment*

Initially a hydrologic study was conducted using the WBNM software to assess the major design flows along the major rivers over a range of standard AR&R storm burst durations ranging from 60 minutes up to 72 hours. Flood runoff from rainfall hydrographs were developed for a number of sub-catchment areas of the Belyando, Suttor and Burdekin River systems. These were calibrated using flood frequency analysis (FFA) based on two historic rainfall gauges selected within each region. Intensity-Frequency-Duration data at each of these locations was acquired from the Bureau of Meteorology. The FFA was undertaken utilising a pearsons III frequency distribution which was generally found to be the best fit for each gauge. Peak flows from the sub-catchments of each of the WBNM models was then input into the HECRAS hydraulic models.

3.1.8.3 *Hydraulic Assessment*

Hydraulic modelling was carried out using the HEC-RAS software package, which is a one-dimensional program with no direct modeling of the hydraulic effect where cross sections change shape, bends, and other two- and three-dimensional aspects of flow. This approach was deemed sufficient for this preliminary assessment; however, it is suggested more detailed modelling be carried out to reflect the true two-dimensional nature of flooding in areas, particularly where catchments break out and converge with other systems.

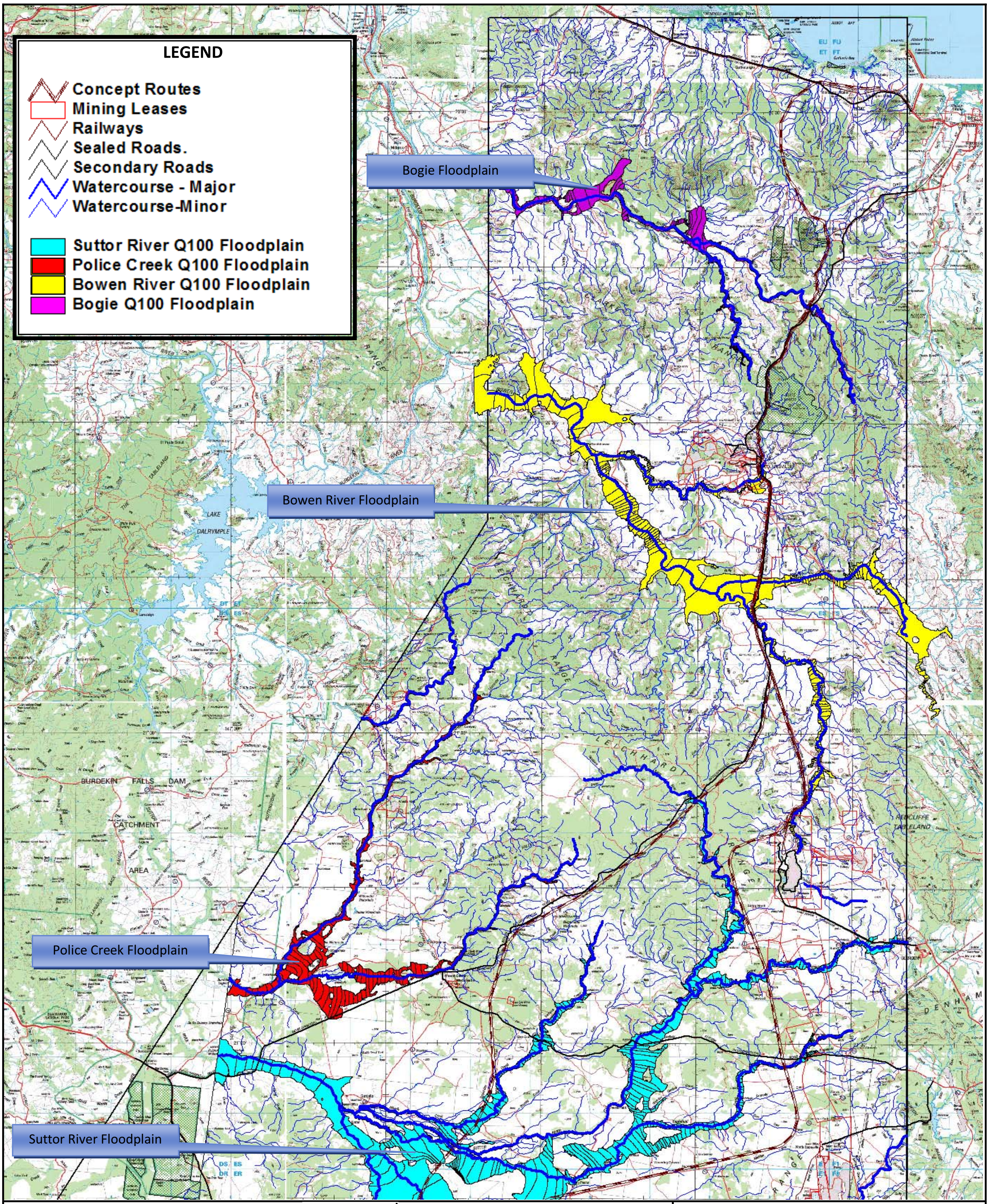
The analysis was run in steady state using the peak 100 year ARI flow rates generated from the hydrologic assessment. This hydraulic investigation was carried out on only the major rivers and creeks which included the Belyando River, Mistake Creek, Suttor River, Police Creek, Bowen River and Bogie River. A conservative global Manning’s roughness value of 0.08 was used to account for the significant amount of vegetation within the floodplains and creek beds.

The output of key hydraulic parameters included 1 in 100 year ARI peak flood levels, flow rates and velocities at each cross section of the models. Peak flood inundation extents were then generated in 1m intervals for input into the Quantm model.

3.1.8.4 *Quantm Integration of Flood Outputs*

A requirement for the project was to ensure that the railway would remain operational during the 1 in 100 year flood event. Therefore the surface level of the alignment was designed to be a minimum of 1m above the 100 year ARI flood line, as per Queensland Rail standards. To achieve this, flood extents as 1m contours with associated heights were imported into Quantm and constrained with a minimum clearance of 1m above the floodplain. In addition to this a culvert every 250m was used to allow flood waters to flow underneath the route.

Major rivers and creeks were also input into Quantm as centerline strings. These were specified with associated widths, with rivers constrained to be crossed using concrete deck bridges with associated freeboard and structural clearances, while creeks would be crossed using suitably sized culverts.



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Map Grid of Australia – Zone 55
Geocentric Datum of Australia 1994

N W E S

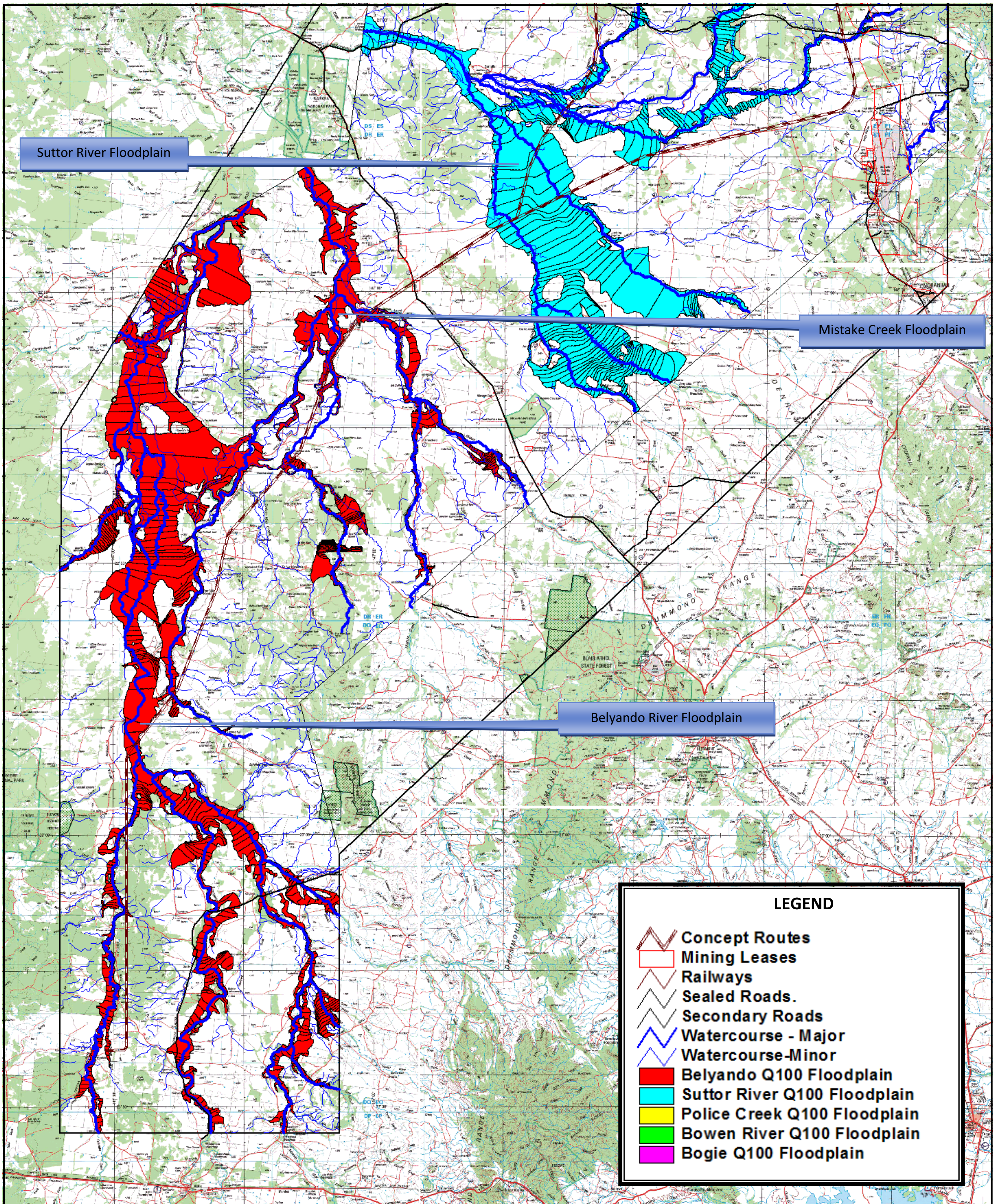
Waratah Coal
THE NEW ENERGY IN COAL

A	22/02/10	Concept Design	BH	NH
Rev	Date	Description	ORIG	CHK

Waratah Coal Pty Ltd

Galilee Basin Coal Railway
Feasibility Study
Quantm Route Analysis
Figure 3-9a - 1 in 100 ARI Floodplains
(Northern Study Area)
GALILEE BASIN, QUEENSLAND, Australia

DRG NO: 10.60.002-002A-1



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Geocentric Datum of Australia 1994

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Waratah Coal
THE NEW ENERGY IN COAL

A	22/02/10	Concept Design	BH	NH
Rev	Date	Description	ORIG	CHK

Waratah Coal Pty Ltd

Galilee Basin Coal Railway
Feasibility Study
Quantm Route Analysis
Figure 3.9b - 1 in 100 ARI Floodplains
(Southern Study Area)
GALILEE BASIN, QUEENSLAND, Australia

DRG NO: 10.60.002-002A-2

3.1.9 Transport Infrastructure & Utilities

Existing infrastructure potentially impacted by the proposed railway includes roads, railways, electricity transmission lines and water and gas pipelines. These are summarised in Table 3-2 with their locations within the study area illustrated in Figure 3-11. Datasets containing transport infrastructure and utilities was sourced from Geosciences Australia. Other less significant infrastructure to be crossed such as communication lines (telephone, fibre optic, etc), irrigation and wastewater channels and pipelines will be identified through services searches during the detailed design phase of the project.

It was a design requirement that level crossings of existing road and rail infrastructure be avoided along the proposed route to ensure minimal interruption to the rail traffic, although some reduction in speed may be required in accordance with rail authority procedures.

The roads dataset fell into several categories including principal, secondary, minor roads and tracks. Principle and secondary roads would be crossed at grade and pass over the new railway (overpass). Minor roads and tracks were not included in the preliminary assessment; however, it's proposed that during concept design these will be deviated to cross the railway at nominated grade separated crossings along the route.

Preference was given for grade separated 10m crossings for existing railways to minimise distributions to existing services (Figure 3-10). A 10m minimal clearance allowed for traffic clearance, a nominal bridge superstructure depth and railway track structure depth.

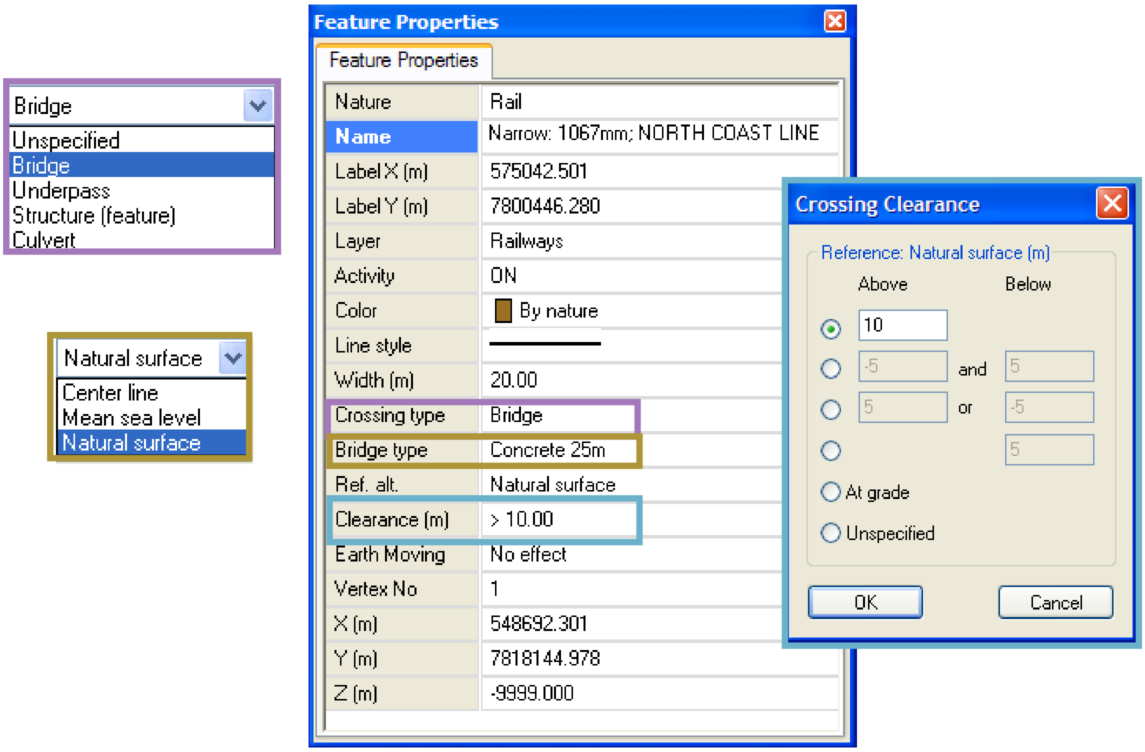


Figure 3-10 – Quantm Crossing Requirements for the North Coast Railway.

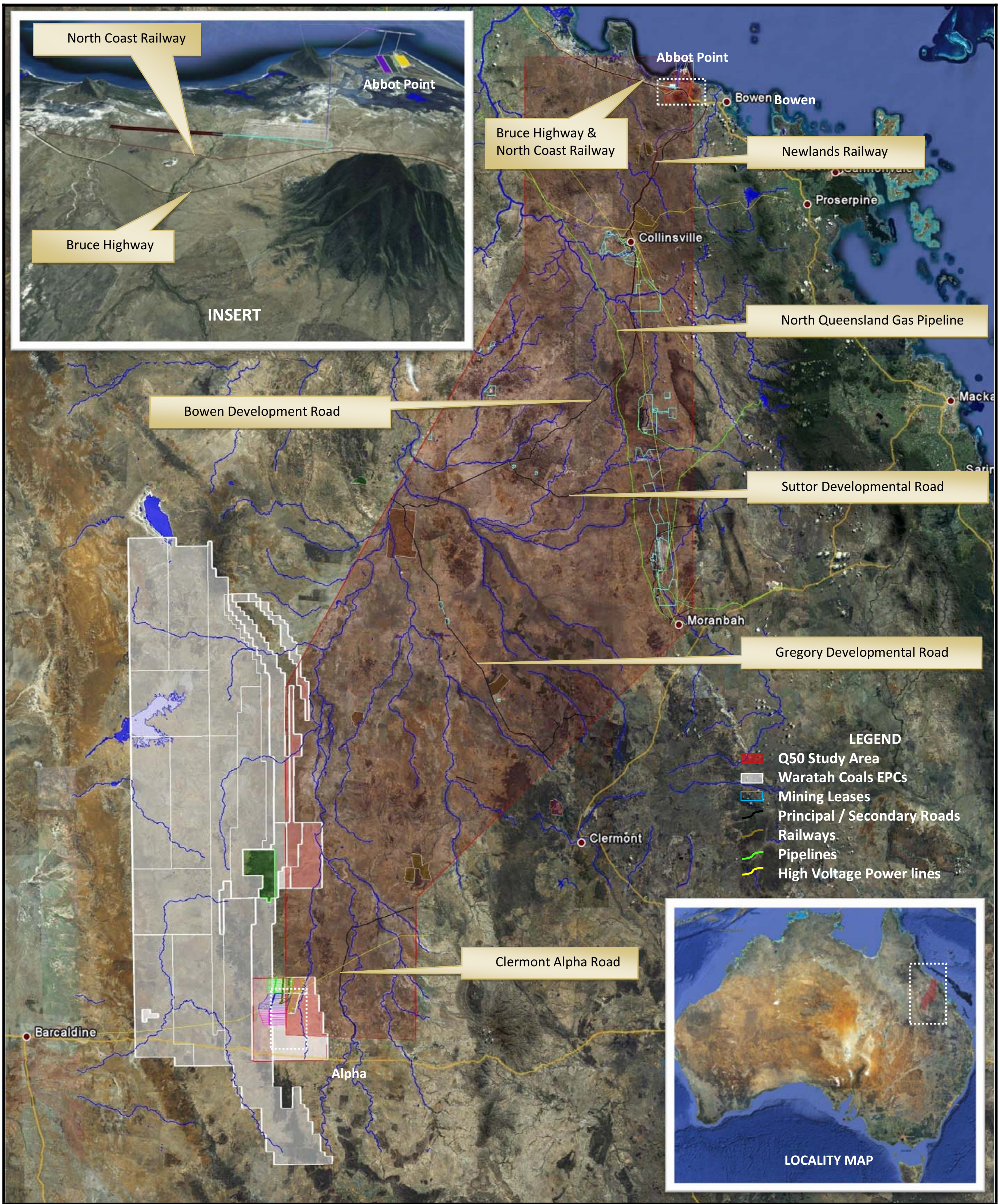
Underground and over-ground pipeline crossings will be constructed on shallow embankments to ensure train loads will not require the pipelines to be relocated deeper, whilst a minimum clearance underneath overhead high voltage power lines was enforced during the vertical optimisation of alignments. Crossing of pipelines may require concrete casing. All crossings of existing pipelines and transmission lines would be as perpendicular as possible, while the location of towers and the proximity of footprint earthworks affecting their foundations will be considered at the concept design phase.

Two dimensional centerline strings representing the major utilities were imported into Quantm and constrained with both the desired vertical clearance (e.g. greater than 8m, or at grade, etc) and type of construction required (e.g. bridge, or culvert, etc). Clearances were specified relative to the natural surface.

The costing of the railway bridge assumes a fixed cost per unit area of deck, with the area of the deck spanning between both abutment limits. As Quantm does not optimise the vertical location of existing roads to be raised over the railway alignment, allowances has been made for road-over-rail bridges in the design and costing.

Table 3-2 - Existing Infrastructure crossing Q50 Study Area.

Infrastructure Name	Type	Asset Owner	Description	Width	Crossing Clearance
North Coast Railway Line	Narrow Gauge Railway	Queensland Rail	Non electrified from Rockhampton to Cairns, caters for freight (incl. coal) and passenger.	20m	>10m (5m wide concrete deck girder bridge)
Collinsville Newland Branch Railway	Narrow Gauge Railway	Queensland Rail	Non electrified line connecting coal mines in the northern Bowen Basin to the export terminal at Abbot Point.	20m	>10m (5m wide concrete deck girder bridge)
Bruce Highway	Principal Road	Queensland Main Roads	Major coastal National Highway from Brisbane to Cairns and is entirely sealed with Bitumen throughout.	30m	At Grade (with the road to cross over the railway)
Bowen Developmental Road	Principal / Secondary Road	Queensland Main Roads	Mostly sealed principal road from Bowen to Mt Coolon (does contain some unsealed parts).	30m	At Grade (with the road to cross over the railway)
Gregory Developmental Road	Principal Road	Queensland Main Roads	Sealed highway from Charters Tower to Clermont.	30m	At Grade (with the road to cross over the railway)
Suttor Developmental Road	Secondary Road	Queensland Main Roads	Unsealed gravel road from Nebo to Mount Coolon	30m	At Grade (with the road to cross over the railway)
Clermont Alpha Road	Secondary Road	Queensland Main Roads	Unsealed road from Clermont to Alpha.	30m	At Grade (with the road to cross over the railway)
Minor Roads (multiple)	Minor Roads	Queensland Main Roads	Unsealed Gravel Roads	n/a	To be assessed at detailed design
Tracks (multiple)	Tracks	Queensland Main Roads	Unsealed gravel or sand tracks, can also sometimes represent stock routes.	n/a	To be assessed at detailed design
North Queensland Gas Pipeline	Underground Pipeline	Enertrade JV	A 400km high pressure gas transmission pipeline that transports coal seam methane gas from Moranbah to the Yabulu Power Station in Townsville.	n/a	>1m (relative to the natural surface)
Burdekin Moranbah Pipeline	Underground Water pipeline	Sunwater	The 218 km pipeline transports about 17,000 ML of water per annum from the Burdekin River to the Moranbah area. The pipeline begins at Gorge Weir and joins the Enertrade Gas Pipeline route before running east to join the route of the existing Eungella Water Pipeline to Moranbah.	n/a	>1m (relative to the natural surface)
Collinsville Pipeline	above-ground Pipeline	SunWater	The Collinsville Pipeline takes water from the Bowen River Weir and distributes the water to several mines and the Collinsville Power Station, as well as the township of Collinsville.	n/a	>4m (relative to the natural surface)
Newlands Pipeline	Underground Pipeline	SunWater	Underground water pipeline from the Bowen River Weir to Newlands mine.	n/a	>1m (relative to the natural surface)
High Voltage Power Lines (multiple)	Transmission Lines	Ergon	A number of overhead power lines that branch off from Collinsville power station. Includes a line that cuts through EPC1040.	n/a	>-1m and <4m (relative to the natural surface)



0 50 100Km

Geographic Coordinate System (WGS84)

Waratah Coal
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Rev	Date	Description	ORIG	CHK
A	22/02/10	Concept Design	BH	NH

Waratah Coal Pty Ltd

Galilee Basin Coal Railway
Pre Feasibility Study
Quantm Route Analysis
Figure 3-11 - Existing Transport Infrastructure & Utilities
GALILEE BASIN, QUEENSLAND, Australia

DRG NO: 10.60.002-011B-1

3.2 Geometric Design

This section outlines the engineering requirements for the railway including the alignment and track structure, design criteria and any assumptions that were made. To adequately define the railway design criteria, Waratah Coal previously engaged WorleyParsons to provide a Basis of Design (BoD) for a heavy haul standard gauge railway based on industry best practices, as applicable to the requirements of the China First Project. The standards and specifications as recommended adhere to one or more of the Australian Standards, the American Railroad Engineering and Maintenance-of-way Association standards and the Australian National Code of Practice standards, and formed the basis for the geometric inputs used within this Quantm study.

3.2.1 Track Alignment Parameters

Waratah Coal's 50 year design life railway will operate up to 36 tonne axle load trains[9] catering for maximum design speeds of 80km/hr and 100km/hr for loaded and unloaded trains respectively. The BoD recommends a 1,000m minimum horizontal radius of curvature and 7,200m minimum vertical radius of curvature. Curve compensation through curves was specified at 0.034%.

The maximum ruling grades on unloaded and loaded trains was defined at 1 in 80 (1.25%) and 1 in 100 (1%) respectively; however, more accommodating grades were desired to minimise long term operating and maintenance costs. At various stages throughout the study sensitivity testing of various combinations of ruling gradients (Table 3-3) was carried out to determine what additional capital expenditure would occur with a flatter gradient route.

Table 3-3 -Grade Scenarios Modeled within Quantm.

	Loaded Grade (%)	Unloaded Grade (%)
1:100	1.0%	1.25%
1:200	0.5%	1.25%
1:300	0.33%	1.0%
1:350	0.29%	1.0%
1:400	0.25%	1.0%
1:500	0.2%	1.0%

3.2.2 Track Structure Criteria

The heavy haul railway will be of standard gauge structure, 1,435mm for tangent track measured 16mm below the head of the rail. The track will be of 68kg/m[10] AS plain carbon continually welded rail mounted on monoblock pre-stressed concrete sleepers, spaced 600mm apart and fully emerged within a layer of 53mm size deep clean ballast. This is consistent with track configurations currently employed by heavy haul railways in the Pilbara, Western Australia. Based on these requirements, the following track structure criteria were specified within Quantm:

- Depth of Ballast (measured from the top of sleepers) – 510mm;
- Width of Ballast at formation level – 4.9m;
- Ballast shoulders – 300mm; and
- Rail Height (measured from top of sleepers) – 190mm.

[9] Based on North American supplied enlarged AutoFlood III Aluminium Hopper Car, however Chinese supplied C80 wagons will cater for 25t axel loads.
[10] Chinese supplied rail may have a 75kg/m design loading.

3.2.3 Level Formation

The level formation for embankments and cuttings was defined as 8.5m and 10.5m respectively. A slightly wider formation is required through cuttings to allow for drainage either side. The formation provides for a single lane earth formed access road for emergency and maintenance access that will be located parallel and as close as practical to the alignment[11]. The typical cross sections in Cut and Fill are illustrated in Figure 3-12.

Batter slopes on embankments was set at 3H:1V (33%), while within cuttings 3H:1V (33%) through soils and 1H:2V (200%) through rock to reflect the extra stability. Benches 3m in width will be introduced where earthworks exceed 7m in height.

A typical corridor width of 60m-80m has been adopted to include access for fencing, drainage and signaling; however, this is dependent upon the embankment heights and cutting depths. Retaining walls may be required where cuttings exceed a maximum depth. Where the available corridor space is at a premium such as near Collinsville, a constrained corridor with limited earthworks will need to be employed.

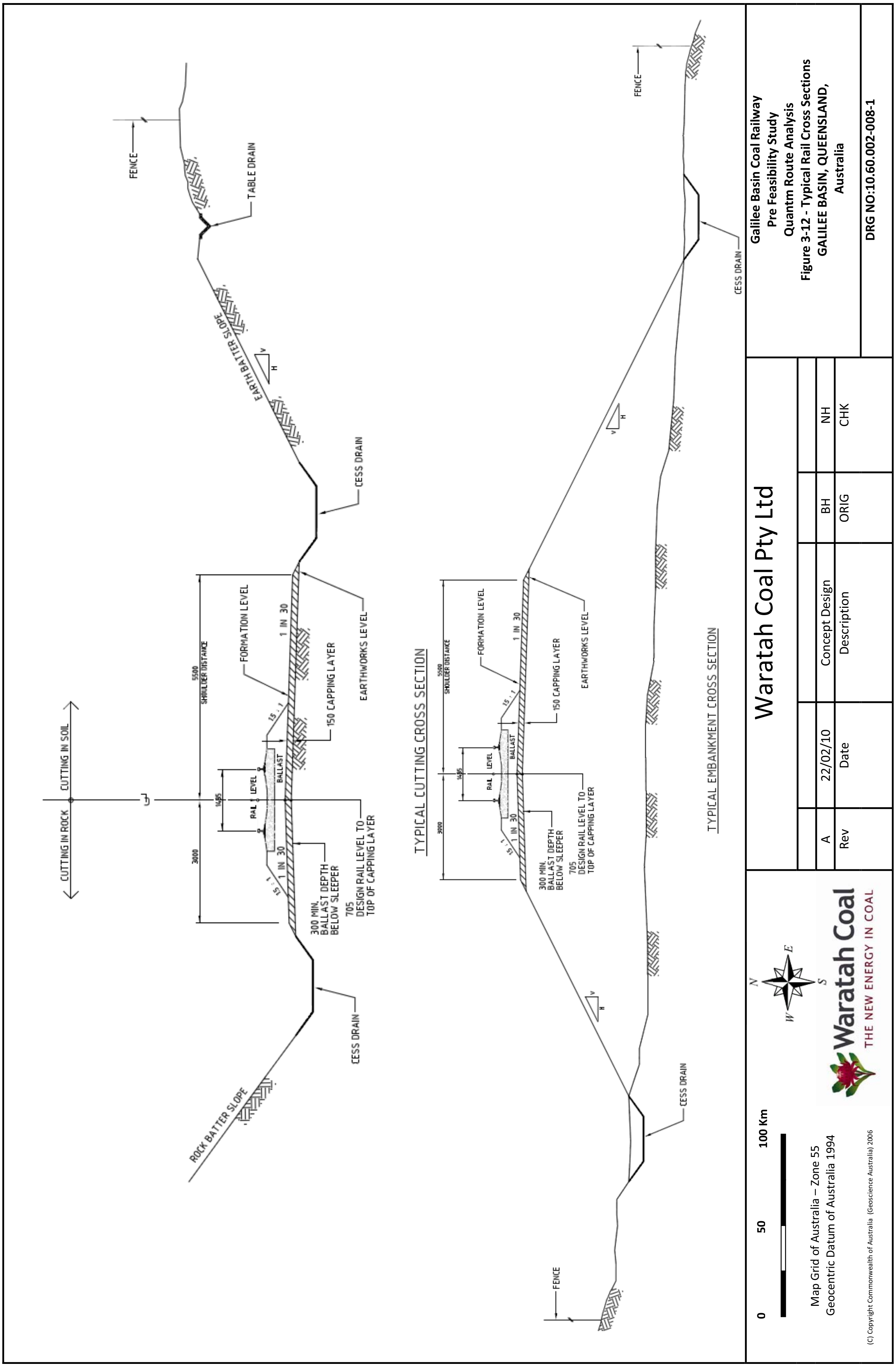
3.2.4 Train Operating Parameters

Quantm does not model train operating performance; however, future train performance modelling using Rail//Train for the short-listed routes is planned. This is to establish long-term operational and maintenance costs for operating the railway to allow a whole of life assessment (CAPX and OPX) for each of the short-listed corridors to be established. Train simulations will also provide travel times, suitable locations for passing loops, and appropriate wagon and locomotive configuration of train consists.

Table 3-4 and Table 3-5 provide a breakdown of the train operating parameters for the heavy haul railway for each of the Chinese and North American rolling stock options.

Figure 3-13 and Figure 3-14 show the proposed rolling stock to be supplied from China (DF8DJ locomotive and C80 wagon) and North American (ES44DCi locomotive and AutoFlood III Hopper Car).

[11] New configurations may dictate the access road to be located along the level formation and not necessarily next to railway.


TYPICAL CUTTING CROSS SECTION
TYPICAL EMBANKMENT CROSS SECTION
CUTTING IN ROCK
CUTTING IN SOIL
FENCE
TABLE DRAIN
EARTH BATTER SLOPE
ROCK BATTER SLOPE
CESS DRAIN
FORMATION LEVEL
150 CAPPING LAYER
EARTHWORKS LEVEL
1 IN 30
5500
SHOULDER DISTANCE
3000
1435
RAIL LEVEL
BALLAST
300 MIN.
BALLAST DEPTH
BELOW SLEEPER
705
DESIGN RAIL LEVEL TO
TOP OF CAPPING LAYER
Galilee Basin Coal Railway
Pre Feasibility Study
Quantm Route Analysis
Figure 3-12 - Typical Rail Cross Sections
GALILEE BASIN, QUEENSLAND,
Australia
DRG NO:10.60.002-008-1
Waratah Coal Pty Ltd
A
22/02/10
Concept Design
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Map Grid of Australia – Zone 55
Geocentric Datum of Australia 1994
(C) Copyright Commonwealth of Australia (Geoscience Australia) 2006
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Table 3-4 - Train Operating Parameters – Chinese Supplied

Wagon Design	
Type	C80 (Chinese built) Open Top Gondola Car
Structure	Aluminum Alloy
Length / Width / Height (m)	12.0 / 3.28 / 3.76
Tare Mass	20.0 Tonnes
Payload	80 Tonnes
Gross Volume (m^3)	148
Maximum Speed - Laden	100
Maximum Speed - Empty	100
Braking System (e.g. ECP)	Air Brake - electronically controlled pneumatic
Axle Configuration	4 Axles
Mode of Discharge	Cylindrical Rotary
Total Number of Wagons (including spares)	2379
Number of Wagons per Train Set	250 wagons per train
Time to Empty a Full Wagon	3 minutes per wagon, triple wagon rotary unloading, 4.2 hr. per train (250 wagons)
Time to Load a Full Wagon	3.5 hr. for 250 wagons
Load per meter on track	8.33t/m
Bogie Type	3-piece, 8200mm between pivot centers
Locomotive Design	
Type	DF8DJ (Chinese built)
Diesel Engine type	CAT3616 from Catpillar
Weight in working order (including fuel, sand, water)	150 tonnes
Capacity of Fuel Tank / Water Supply / Sand / Oil	9000L / 2450kg / 800 kg / 1080L
Length / Width / Height (m)	22.3 / 3.304 / 4.736
Alternator Type	CDJF205 Made in China
Traction Motor	JD124 Made in China
Maximum Speed - Laden	Depends on Tractive Effort
Maximum Speed - Empty	120km/hr
Continuous Tractive Effort	480KN
Maximum Power and Power for Traction	Diesel engine service output power: 4800 kW Locomotive nominal power: 3900 kW
Fuel Consumption	0.198 Kg/kwhr
Axle Configuration	C0-C0
Total Number of Locomotives (including spares)	40
Number of Locomotives per Train Set	5
General Specifications	
Net Tonnage of Trains	20,000 tonnes
Gross Tonnage of Trains	25,750 tonnes
Tonnage rate per annum	25MTA initially, ramping up to 50 MTA over five years
Number of train sets for 40Mta	6-7
Train Configuration	Each locomotive set up within a sub-train with 50 wagons (the locomotive at front), the whole train comprised of 5 sub-trains (i.e. 250 wagons)
Passing loops	At least nine at 3.2km in length
Rail Design Loading	75 Kg

Table 3-5 - Train Operating Parameters – North American Supplied

Wagon Design	
Type	AutoFlood III Hopper Car
Structure	Aluminium Alloy
Length / Width / Height (m)	16 / 3.25 / 4.06
Tare Mass	25.0 Tonnes
Payload	118 Tonnes
Gross Volume (m^3)	120
Maximum Speed - Laden	80
Maximum Speed - Empty	100
Braking System (e.g. ECP)	Air Brake - electronically controlled pneumatic
Axle Configuration	4 Axles
Mode of Discharge	Cylindrical Rotary
Total Number of Wagons (including spares)	1350
Number of Wagons per Train Set	180
Time to Empty a Full Wagon	2h 11min (180 wagons) – based on WP Figures
Time to Load a Full Wagon	3h 49min (180 wagons) – based on WP Figures
Load per meter on track	8.93t/m
Bogie Type	3-piece
Locomotive Design	
Type	General Electric ES44DCi (Evolution Series) locomotive
Diesel Engine type	GEVO-12 capable of producing 4,400 horsepower.
Weight in working order (including fuel, sand, water)	196 Tonnes
Capacity of Fuel Tank / Water Supply / Oil	19,306 L / 1,703L / 1,703L
Length / Height (m)	22.3 / 4.7
Alternator Type	
Traction Motor	
Maximum Speed - Laden	Depends on Tractive Effort
Maximum Speed - Empty	70 mph
Continuous Tractive Effort	537kN @ 18 km/h
Maximum Power and Power for Traction	3357kW (4500hp)
Fuel Consumption	42,718 l per train cycle
Axle Configuration	C0-C0
Total Number of Locomotives (including spares)	30 (includes 4x banking and 2x spares)
Number of Locomotives per Train Set	4x ES44DCi plus 2x ES44DCi for banking
General Specifications	
Net Tonnage of Trains	21,240 tonnes
Gross Tonnage of Trains	26,916 tonnes
Tonnage rate per annum	25MTA initially, ramping up to 50 MTA over five years
Number of train sets for 40Mta	6 -7
Train Configuration	Distribute Power
Passing loops	At least nine at 3.2km in length
Rail Design Loading	75 Kg

C80 Coal Wagon

DF8DJ Locomotive

Figure 3-13 – Chinese Supplied Rolling stock to be operated along China First Railway.

AutoFlood III Hopper Car

General Electric ES44DCi locomotive

Figure 3-14 - North American Supplied Rolling stock to be operated along China First Railway.

3.3 Construction Costs

For the purposes of this study and for comparative purposes in selecting corridors, it was assumed that unit construction costs were independent of any significant variability in material transport logistics, such as availability of suitable ballast material, crushed stone, water for construction and pre-cast materials. These factors will need to be considered during the detailed design stage.

Generally most rates were extracted from a previous 2008 WorleyParsons corridor study[12] investigating route options between the mine site and an alternate port location at Shoalwater Bay. Due to the close similarities between the two study areas, it was assumed costs rates would be consistent enough to use for this secondary study. In some instances revised rates were added to reflect new information that had become available. All rates are in 2008 dollars and based on recent historical data only.

3.3.1 Earthwork Rates

Unit costs for earthworks relates to the costs of material extraction (Cut), construction of embankments (Fill), the movement of materials along the rail corridor (Mass Haul), the cost to borrow material from a quarry or dry creek bed (Borrow), and the cost to dump unwanted excess Cut or spoil such as topsoil (Dump). Quantm uses these rates and their associated parameters to optimise locations where it may be cheaper to source Cut, to locally balance Cut and Fill, reduce overall Mass Haul tasks, etc. The earthwork rates used within the study are summarised in Table 3-6 - Earthwork Rates..

Table 3-6 - Earthwork Rates.

CATEGORY	DESCRIPTION	UNIT RATE
Fill	Cost to lay and compact Fill embankments	$\$2.97/m^3$ with 33.3% batters
Borrow	Cost to acquire Fill material from external borrow pit	$\$4.3/m^3$
Dump	Cost to dump excess cut material or spoil	$\$0.79/m^3$
Cut	Cost to extract material from the earth surface	Varies depending on regional geology (refer to Section 3.1.2)
Mass Haul	Cost to move material along the route	$\$0.79/m^3/km$

3.3.2 Structure Rates

Structure rates are used by Quantm to determine if using a structure provides more of a saving than earthworks (such as introducing a tunnel at a depth where it becomes too expensive or difficult to Cut). These rates, as illustrated in Table 3-7, are also used to calculate the costs for crossing certain features that require mandatory structure crossings, such as a bridged river, culvert over a minor waterway, or an overpass over an existing railway or road.

The cost of crossing a feature that requires a culvert depends on the type and length of channel required and on the cost of the portals at either end. A minimum cover of earth was specified consistent with design standards to ensure train loads would be appropriately dissipated.

[12] WorleyParsons Pty Ltd, *Galilee Basin Railway Pre-Feasibility Study - Quantm Route Analysis: Q40 Study Corridor Report*, October 2008.

Tunnels costs consist of a cost per unit distance plus a cost for each portal to cover setup costs.
The costing of bridges assumes a fixed cost per unit area of deck. The span of the bridge over the feature being crossed is the area of deck over the feature increased by the slope of the abutments at either end.

Table 3-7 - Structure Rates.

STRUCTURE TYPE	DESCRIPTION	UNIT RATE	OTHER
Culvert	1200x1200 RCB	\$1800/m	\$2,400 portals and 0.7m cover for floodplains
	3600 CSP	\$1100/m	\$5000 portals and 2m cover
	1500 CSP	\$500/m	\$1300 portals and 1.2m cover for crossing minor waterways
Bridge	Concrete Deck	\$11,500/m^2	67% abutments
Retaining Walls	3m-6m Concrete faced	\$1800/m^2	1000% vertical sloped
Tunnel	Single track	\$20,000/m	\$2,000,000 portals

3.3.3 Track Structure and Other Costs

The cost for the track structure (ballast, sleepers, tracks, etc) and required installation work was included in Quantm as a single cumulative linear cost. Linear costs increase the cost of construction proportionally to its length. A global land clearing cost for clearing and removing vegetation based on the area occupied by the earthwork footprint was also included, as provided in Table 3-8.

A fixed cost was included to account for road overpasses over the new railway and where minor roads may need to be strategically deviated to level crossings along the route. It also accounts for the culvert underpasses that will be required to allow, stock, vehicles and machinery to cross under the railway for each of the impacted properties. It is recommended that a more detailed assessment of these rates be conducted during the detailed design phase.

Table 3-8 - Other Rates.

CATEGORY	DESCRIPTION	UNIT RATE
Track Structure	Ballast, sleepers, rail and installation works	\$886/m
Clear and Grub	Clearing vegetation and scrub prior to construction	\$0.36/m^2
Crossings of existing roads over the new railway + minor road deviations	Fixed lump sum cost for up to five road over rail crossings	\$30,000,000

3.4 Other Criteria

3.4.1 Earthwork Limits

An earthwork limit constraint was included to limit scarring on the landscape in Cut and Fill to 30m and 20m respectively. This would ensure that if the centerline of alignments exceeded these limits, the system would automatically insert a dry bridge in Fill, or tunnel in Cut. Bridge abutments limits and tunnel entry depths were specified at 10m and 7m respectively to control the height or depth at which bridges or tunnels would commence.

3.4.2 Borrow & Dump Locations

Quantm typically balances earthworks between the terminal points of the route, where excess cut or spoil material is dumped and borrow material can be borrowed. However, in optimising over such large distances this can result in unrealistic high haulage costs to dump or borrow material. Therefore to provide a more realistic model, borrow pits (areas where extra construction material can be acquired) and dump locations (areas where unusable excess cut or spoil can be dumped) were introduced every 5km along the route. This reflects the assumption that suitably available construction material could easily be accessed within at least 5km of the route. Similarly with the dumping of unwanted material assumed to occur no more than 5km from any point along the route.

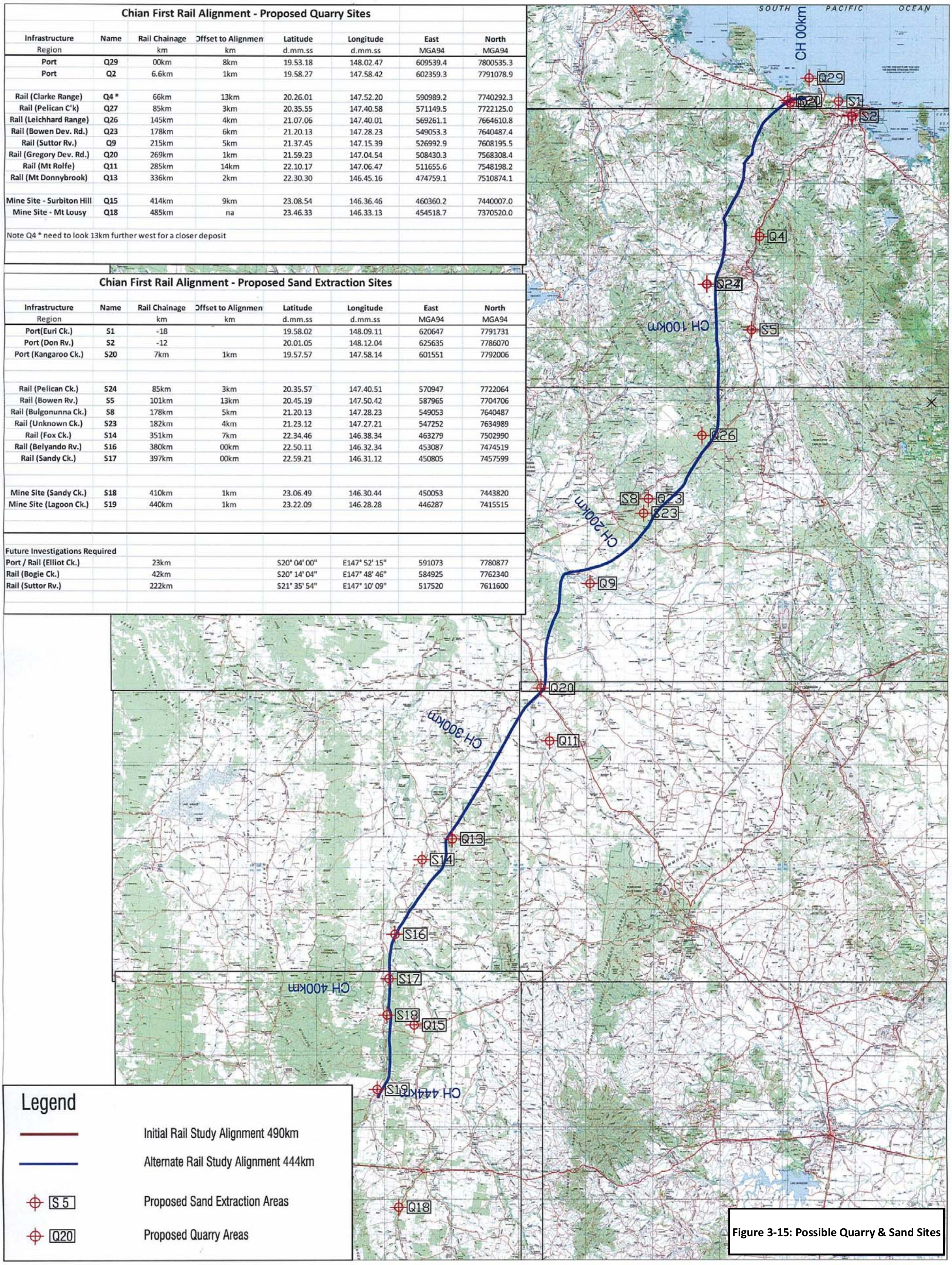
3.4.3 Construction Resources & Logistics

Due to the large extent of the study area some consideration was given to the effects of construction resources and logistics on potential corridors. This included assessment of possible sources of ballast and aggregate, suitable locations to house maintenance teams, communication and water access points, possible options for passing loops, etc. With this; however, being a preliminary assessment, only limited information has been considered and thus it's recommended that a more comprehensive study of these factors be conducted for the selected corridor.

3.4.3.1 *Ballast and Aggregate*

It is proposed that the supply of permanent way ballast for the construction of the railway will be sourced from a number of commercially available quarries located throughout the study area. Where these are not available within a suitable distance of the corridor, access will be sought from natural sources such as dry creek beds or alternatively hauled in from external sites.

A helicopter soil survey between the mine site and Abbot Point was completed by AMEC on the 9th September, 2009. This included identifying sites of both established and future sources of suitable ballast, as illustrated in **Error! Reference source not found.**Figure 3-15. A more detailed study will be conducted during the next phase of work to confirm ballast storage and handling works, together with transport logistics for the material both during construction and operation for the final alignment.



Chian First Rail Alignment - Proposed Quarry Sites

Infrastructure Region	Name	Rail Chainage km	Offset to Alignmen km	Latitude d.mm.ss	Longitude d.mm.ss	East MGA94	North MGA94
Port	Q29	00km	8km	19.53.18	148.02.47	609539.4	7800535.3
Port	Q2	6.6km	1km	19.58.27	147.58.42	602359.3	7791078.9
Rail (Clarke Range)	Q4 *	66km	13km	20.26.01	147.52.20	590989.2	7740292.3
Rail (Pelican C'k)	Q27	85km	3km	20.35.55	147.40.58	571149.5	7722125.0
Rail (Leichhard Range)	Q26	145km	4km	21.07.06	147.40.01	569261.1	7664610.8
Rail (Bowen Dev. Rd.)	Q23	178km	6km	21.20.13	147.28.23	549053.3	7640487.4
Rail (Suttor Rv.)	Q9	215km	5km	21.37.45	147.15.39	526992.9	7608195.5
Rail (Gregory Dev. Rd.)	Q20	269km	1km	21.59.23	147.04.54	508430.3	7568308.4
Rail (Mt Rolfe)	Q11	285km	14km	22.10.17	147.06.47	511655.6	7548198.2
Rail (Mt Donnybrook)	Q13	336km	2km	22.30.30	146.45.16	474759.1	7510874.1
Mine Site - Surbiton Hill	Q15	414km	9km	23.08.54	146.36.46	460360.2	7440007.0
Mine Site - Mt Lousy	Q18	485km	na	23.46.33	146.33.13	454518.7	7370520.0

Note Q4 * need to look 13km further west for a closer deposit

Chian First Rail Alignment - Proposed Sand Extraction Sites

Infrastructure Region	Name	Rail Chainage km	Offset to Alignmen km	Latitude d.mm.ss	Longitude d.mm.ss	East MGA94	North MGA94
Port(Euri Ck.)	S1	-18		19.58.02	148.09.11	620647	7791731
Port (Don Rv.)	S2	-12		20.01.05	148.12.04	625635	7786070
Port (Kangaroo Ck.)	S20	7km	1km	19.57.57	147.58.14	601551	7792006
Rail (Pelican Ck.)	S24	85km	3km	20.35.57	147.40.51	570947	7722064
Rail (Bowen Rv.)	S5	101km	13km	20.45.19	147.50.42	587965	7704706
Rail (Bulgonunna Ck.)	S8	178km	5km	21.20.13	147.28.23	549053	7640487
Rail (Unknown Ck.)	S23	182km	4km	21.23.12	147.27.21	547252	7634989
Rail (Fox Ck.)	S14	351km	7km	22.34.46	146.38.34	463279	7502990
Rail (Belyando Rv.)	S16	380km	00km	22.50.11	146.32.34	453087	7474519
Rail (Sandy Ck.)	S17	397km	00km	22.59.21	146.31.12	450805	7457599
Mine Site (Sandy Ck.)	S18	410km	1km	23.06.49	146.30.44	450053	7443820
Mine Site (Lagoon Ck.)	S19	440km	1km	23.22.09	146.28.28	446287	7415515
Future Investigations Required							
Port / Rail (Elliot Ck.)		23km		S20° 04' 00"	E147° 52' 15"	591073	7780877
Rail (Bogie Ck.)		42km		S20° 14' 04"	E147° 48' 46"	584925	7762340
Rail (Suttor Rv.)		222km		S21° 35' 54"	E147° 10' 09"	517520	7611600

Figure 3-15: Possible Quarry & Sand Sites

3.4.3.2 *Water Supply*

The construction and operating stages of the railway will demand the supply of both potable drinking water to support its workforce (at construction camps, maintenance yards, loading and unloading stations, etc), as well as raw water for construction activities such as embankment compaction and dust control.

At the port, water will be provided from the existing Bowen water supply grid which is currently sourced from groundwater aquifers. A future water source from the Clair Weir on the Burdekin River is proposed by SunWater via a 150km pipeline that will supply the APSDA with 60,000 mega liters of water per annum (ML/a). The Environmental Impact Statement for this project was released in November 2009 and if approved, construction is expected to commence in 2011.

At the mine, water will be provided from one of the following options:

1. A major dam at the mine holding groundwater pumped from the underground and open cut dewatering operations.

2. A new 225km pipeline from Moranbah to the mine, tapping into SunWater's proposed 49,500 ML/a water supply pipeline[13] from the Connors River Dam to Moranbah (133km in length).

3. Harvesting water from the Belyando River utlising a turkey nest dam built along the bank of the Belyando River. Water will then be transported to the mine site and holding facility via a 45km pipeline, following the route and existing 132KV power line easement.

4. Pumping water from two dams identified by Bridge Oil Limited[14] approximately 70-75 Km south of the mine site near Alpha, each with 25,000 ML capacities.

5. Pumping of water from a new 935,000 ML dam to be built 70km north of the mine, on the confluence of the Belyando River, Native Companion Creek and Sandy Creek (near Degulla Lagoon).

6. A 315km pipeline from the Burdekin Falls Dam to the mine. This is considered the most expensive and least favorable of all the water supply options.

Along the railway corridor, water will be sourced from existing domestic supplies where practical, including those from established townships such as Collinsville and Mount Coolon. Due to the rural and isolated nature of the railway corridor, water will also be sourced from existing surface storages such as farmer's dams and harvesting of existing turkey nest dams. Further to this, any shortfall to water requirements will be made up by tapping into potential groundwater from alluvial basins flowing beneath the Belyando and Suttor Rivers.

A general water supply schematic for the railway corridor is provided Figure 3-16: Railway Water Supply Options. The next level of assessment will require water demands and quality to be established, as well as the identification of reliable sources, their suitability for drinking and construction purposes, storage & holding areas,

[13] SunWater Ltd, *Connors River Dam and Pipeline Environmental Impact Statement*, February 2010
[14] Bridge Oil Limited, *Queensland Final Report on Exploration 1978-1993*, 1994.

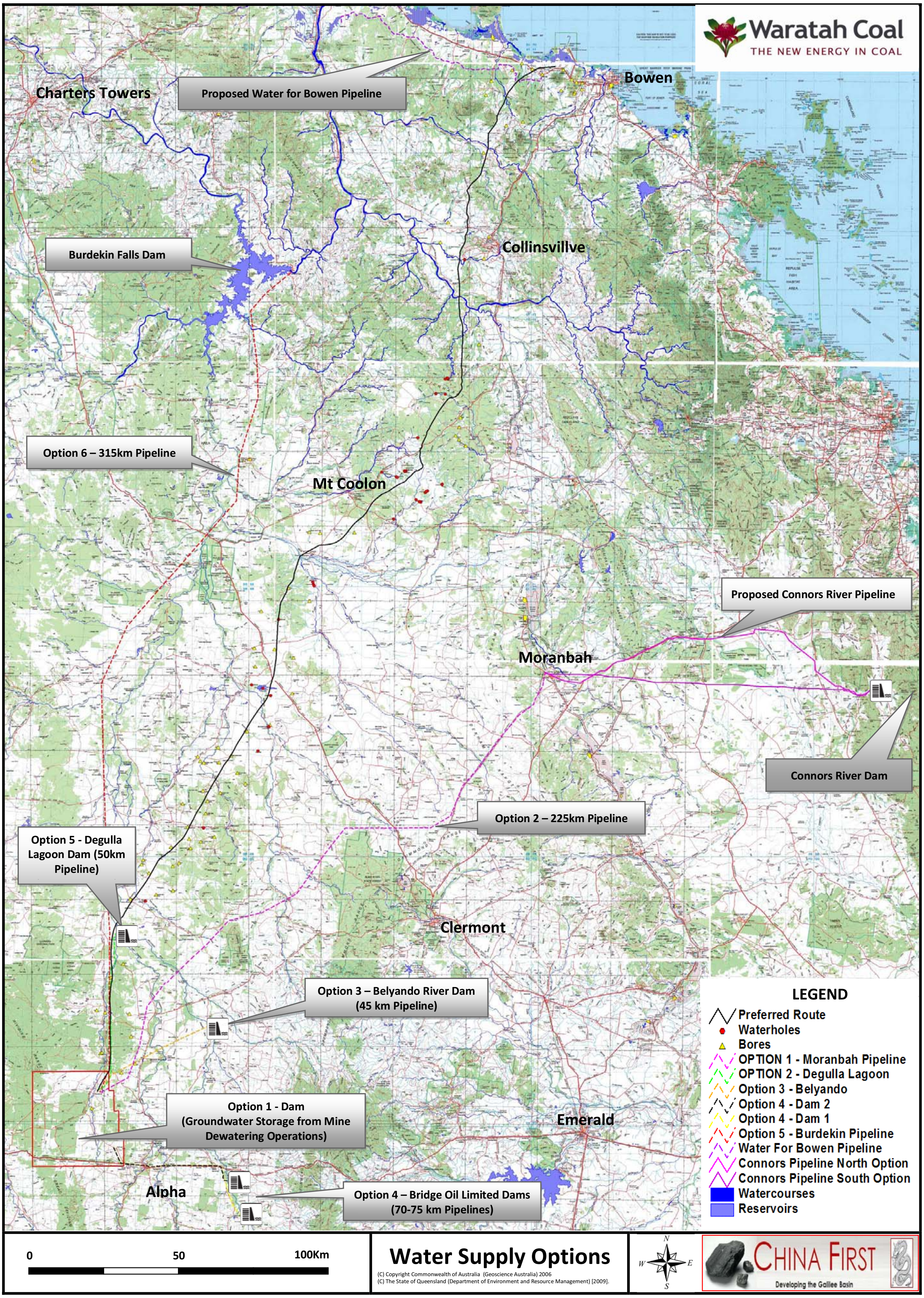


Figure 3-16: Railway Water Supply Options

conveyance (either through permanent pipelines, tanker trucks, etc) and associated environmental impacts and required approvals.

3.4.3.3 *Water Drainage*

Construction activities and operating trains have the potential to impact surface and ground water quality within the project area including increasing sediment loads from runoff, contamination from fuel / oil / chemical spills and transfer of weed seeds from construction machinery and vehicles. With this being a preliminary assessment, no consideration for surface water control has been carried out; however, a detailed management plan for preventative measures of contamination or degradation of water quality will be carried out at detailed design.

3.4.3.4 *Communication, Signaling & Turnouts*

The railway will draw on the latest signaling and communication technology to ensure the safe and efficient delivery of coal from the mine site to Abbot Point.

A fiber optic cable will be installed along the length of the railway and linked to a centralized traffic control (CTC) centre likely to be established within the APSDA. This will enable train dispatchers to control train movements and monitor train condition and occupancy in real time.

On-board computers will be installed on each train to provide a global positioning satellite interface with the CTC, which allows remote monitoring of the locomotives performance, data transmission to the control centre and automatic identification of locomotives and wagons. It is also proposed that all mainline and yard operational signaling will be in-cab type signaling.

A hot box temperature detection system will also be installed along the main line to detect when axel bearings may overheat and cause derailment. In addition, barriers will be added at all crossings, while derailment detectors will be installed ahead of passing loops and main bridges to automatically stop trains operating in both directions in the event of a derailment.

All external signaling and communication infrastructure along the railway corridor will be installed with systems that protect equipment from lightning and other natural phenomena (flood, fire, etc).

Turnouts of the mainline, yards and sidings will be tangential 1 in 18 turnouts designed for 80km/hr operation.

3.4.3.5 *Power*

Power demands for the railway (non electric traction) will be required to support the communication, signaling and lighting equipment at passing sidings and over infrastructure crossings. Loading and unloading facilities at the mine and port respectively will also require power, as will the refueling and maintenance workshops and construction camps.

Power requirements for rail facilities at the mine is likely to be supplied by means of a dedicated 275kV overhead line from the distributor at Lillyvale using the existing power corridor, feeding into a HV substation on the mine lease.

Power demands for rail facilities at the port are likely to be provided from a dedicated supply to the APSDA according to an application made by the Abbot Point Coal Facility requesting the power supply be increased to 10MVA and provide a dedicated 66kV feeder from the Merinda Sub-Station.

In remote locations along the railway, power will be obtained from the local electricity distribution grid where practical (such as the 188 megawatt coal fired Collinsville Power Station), or alternatively provided through diesel generators and solar paneling. A detailed assessment of power requirements and supporting infrastructure for the construction and operation of the railway will be conducted at detailed design.

3.4.3.6 *Maintenance & Construction Camps*

A construction workforce of 900 people is considered necessary for the railway development. This workforce will be accommodated in temporary camps to be built and operated by the construction contractors. The permanent personnel needed for the daily maintenance and refueling operations of the railway is estimated to be up to 200 workers and likely to be housed in one of the towns en-route depending on the selected corridor:

- Alpha;
- Epping;
- Twin Hills;
- Mount Coolon;
- Collinsville;
- Bowen;
- Moranbah; and
- Clermont.

Within the Quantm study, those corridors passing within a close proximity to remote communities with already established infrastructure and utilities were treated more favorably than those likely to require the temporary construction of new camp facilities.

A more detailed assessment of camp design, construction and operation along the railway corridor will be established through future planning studies.

3.4.3.7 *Transport and Access Arrangements*

The following transport routes are proposed for the delivery of equipment, materials and workforce transportation for the railway corridor:

From Mackay, Rockhampton or Brisbane to mid-route:

- Bruce Highway;
- Peaks Downs Highway; and
- Suttor Developmental Road.

From Mackay, Rockhampton or Brisbane to Alpha:

- Bruce Highway; and
- Capricorn Highway.

From Bowen or Collinsville to end-route:

- Bruce Highway; and
- Bowen Developmental Road.

From Townsville or Charters Towers:

- Gregory Developmental Road; and
- Bruce Highway.

Assessment of transport and access arrangements is outside the scope of this study. A detailed Traffic Management Plan will be prepared during the next phase to include more detail on traffic volumes related to the construction of the rail link, preferred haulage routes for construction materials and equipment to and from the construction site, workforce population, sourcing of material and construction programming and timing.

4 Quantm Methodology & Approach

This section outlines the process and steps adopted during this study in developing corridor alternatives, including the modeling of major constraints, sensitivity testing of key geometric constraints, corridor evaluation criteria, and the route selection methodology employed.

4.1 Constraint Integration

Given the location and sensitivity of the project, one of the challenges faced was to integrate the multiple and complex environmental and land use constraints into the planning process. The basic planning principle was to avoid significant constraints where possible (such as protected areas) and to only transgress those where unavoidable. Where such transgression had occurred, mitigation strategies and actions will be required at the more detailed corridor refinement stage.

Constraints were iteratively integrated into the Quantm software to ensure local impacts and cost implications of each layer of mapping could be easily established. The most significant constraints and parameters were modeled first, and then as the planning became more focused, further detail and accurate information was incorporated. Datasets were initially prioritized based on their level of significance:

- **High Adverse Impact** – those likely to be an important consideration at the federal or state level and present potential concerns to the project. Mitigation measures and detailed design work are unlikely to remove all of the impacts upon the affected communities or interests. Examples include National Parks, Townships, Cultural Heritage Protected Areas, Mining Leases, etc. These were generally avoided at all costs within the Quantm study.

- **Moderate Adverse Impact –** important at a state, regional or local level, and represent issues where impacts will be experienced but mitigation measures and detailed design work may ameliorate some of the consequences upon the affected communities or interests. Examples include property severance, indigenous heritage areas, sensitive wetland crossings, etc. Alignment encroachment into these areas was minimised by using penalty weightings to increase the cost of alignments going through these zones thereby discouraging impact, but not going to the extreme position of making them absolute avoidance.

- **Low Adverse Impact** – impacts that are recognisable but acceptable. These issues are unlikely to be of importance to the decision making process; however, are of relevance in enhancing the subsequent design of the project and in the consideration of mitigation or compensation measures. Examples include regional ecosystems, state forests, minor creeks and existing infrastructure crossings, etc. These were included within the Quantm study to ensure engineering compliance to crossing these features.

- **Negligible Adverse Impact** – impacts which are within normal bounds of variation and have no effect on the decision making process. These may require some negotiations or approvals from relevant parties. An example of this would be negotiating access to cross existing Indigenous controlled lands, crossing of existing utility services, access to quarry sites, etc.

- **Beneficial Impact** – those impacts that add environmental, social or political value to the project. An example of this would be to strategically locate the heavy haul railway to provide future third party access to open up the Galilee Basin resources to other mining developers.

At selected stages of the study constraints and their effect on alignment results were ascertained with adjustments made accordingly. The speed and operation of the Quantm system allowed changes to constraints to be quickly included and reevaluated within days. Since the system generates a range of alternatives, rather than a single least-cost solution, it provided the freedom to balance environmental and social impacts against costs for routes using different parts of the corridor and various scenarios of cost, structures and constraints. Ultimately new corridors were developed that delivered improved environmental and community outcomes at a reduced project cost.

4.2 Corridor Development

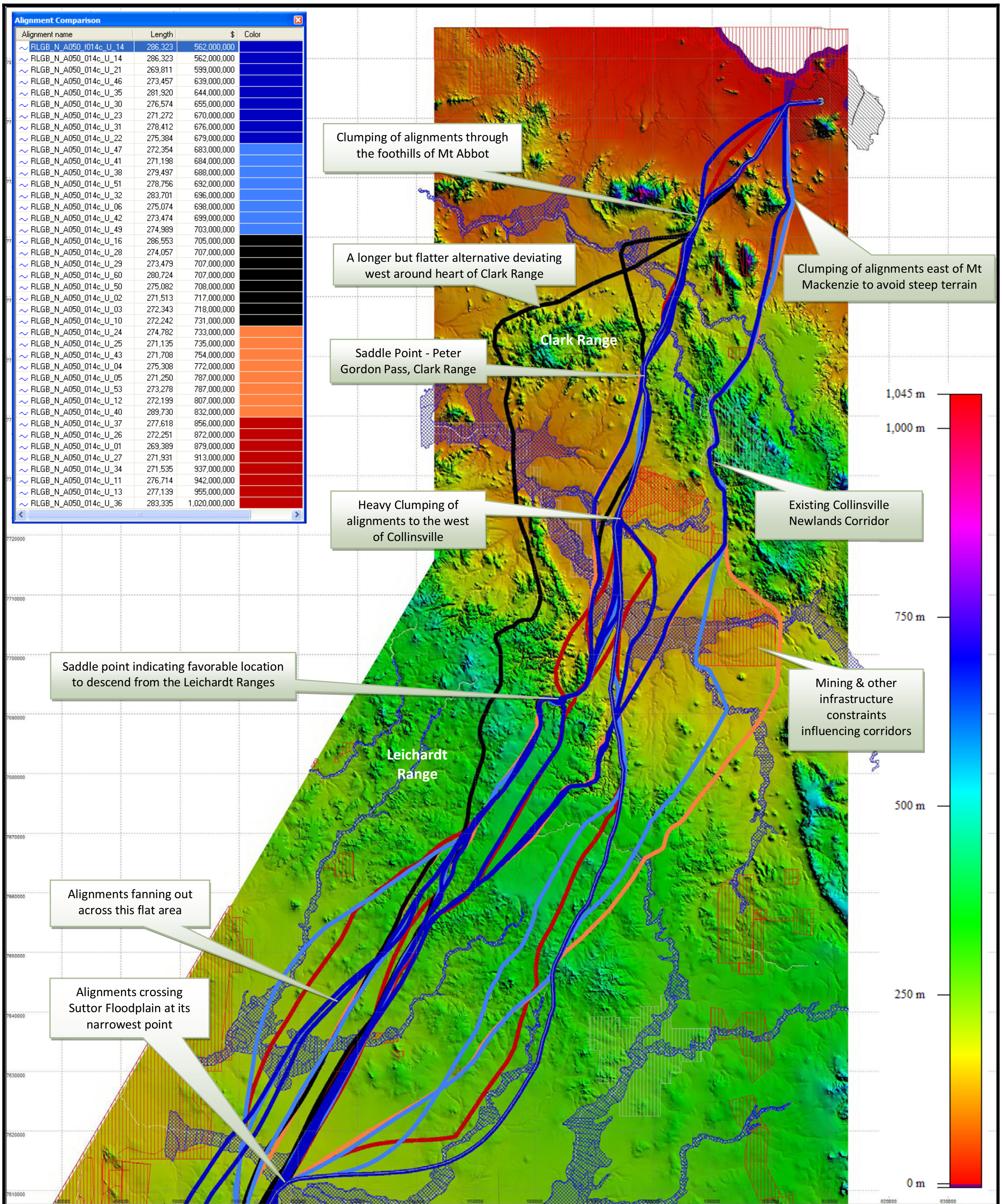
Quantm's free-to-roam optimisation algorithm was used to develop the corridor options. With this type of optimisation the software generates a spread of fifty alignments covering the entire study area from which the planner can identify the most promising corridors. The pattern of alignments can reveal much about potential corridors, the need to stick to certain locations, and the freedom to deviate. In general where routes converge to pass through a narrow corridor indicates its importance in containing costs, whereas where routes fan out indicates costs is not an important driver and provides more flexibility to satisfy other criteria with minimal impacts to costs.

As an example, Figure 4-1 illustrates a typical set of corridor results generated from a free-to-roam optimisation of the northern study area. It can be seen that initially alignments fan out across the Leichardt Ranges where the terrain is flat to undulating, whereas through the steep topography through parts of the Clark Range there are a number of distinct corridor options where alignments have clumped together. This suggests that there are only a couple of clear options to negotiate the mountainous regions, but more scope exists to deviate elsewhere.

On close inspection the corridors through the Clark Range clearly transgress narrow paths, indicating that there is little room to move without significantly increasing overall costs. By reviewing alignment costs it can be seen that the west most corridor (black in colour) is approximately $100 million dollars more expensive than the cheapest corridor options closer to Collinsville (dark blue in colour), likely ruling this out as a feasible option for the heavy haul railway. There is; however, a much smaller variation in costs between the two corridors closest to Collinsville, indicating a more selective corridor comparison would be required to properly analyse these.

As layer of constraints were progressively added throughout the study, trends and groupings in lowest costs alignments varied significantly. The nature of the terrain and required geometric limits seemed to be the driving factors in the northern part of the study area, whereas deviation around the extensive floodplains seemed to be more of an influence in the southern part of the study area.

Extensive sensitivity analysis of both varying geometric limits and environmental compliance was conducted throughout the study. By running scenarios with and without environmental constraints it was possible to establish the relative corridor cost to avoid particular environmental constraints. Similarly with the assessment of varying loading grades (1:200, 1:100, etc), corridors were developed for each option allowing for relative cost comparisons to be established between each.



Alignment Comparison

Alignment name	Length	$	Color
RLGB_N_A050_f014c_U_14	286,323	562,000,000	
RLGB_N_A050_014c_U_14	286,323	562,000,000	
RLGB_N_A050_014c_U_21	269,811	599,000,000	
RLGB_N_A050_014c_U_46	273,457	639,000,000	
RLGB_N_A050_014c_U_35	281,920	644,000,000	
RLGB_N_A050_014c_U_30	276,574	655,000,000	
RLGB_N_A050_014c_U_23	271,272	670,000,000	
RLGB_N_A050_014c_U_31	278,412	676,000,000	
RLGB_N_A050_014c_U_22	275,384	679,000,000	
RLGB_N_A050_014c_U_47	272,354	683,000,000	
RLGB_N_A050_014c_U_41	271,198	684,000,000	
RLGB_N_A050_014c_U_38	279,497	688,000,000	
RLGB_N_A050_014c_U_51	278,756	692,000,000	
RLGB_N_A050_014c_U_32	283,701	696,000,000	
RLGB_N_A050_014c_U_06	275,074	698,000,000	
RLGB_N_A050_014c_U_42	273,474	699,000,000	
RLGB_N_A050_014c_U_49	274,989	703,000,000	
RLGB_N_A050_014c_U_16	286,553	705,000,000	
RLGB_N_A050_014c_U_28	274,057	707,000,000	
RLGB_N_A050_014c_U_29	273,479	707,000,000	
RLGB_N_A050_014c_U_60	280,724	707,000,000	
RLGB_N_A050_014c_U_50	275,082	708,000,000	
RLGB_N_A050_014c_U_02	271,513	717,000,000	
RLGB_N_A050_014c_U_03	272,343	718,000,000	
RLGB_N_A050_014c_U_10	272,242	731,000,000	
RLGB_N_A050_014c_U_24	274,782	733,000,000	
RLGB_N_A050_014c_U_25	271,135	735,000,000	
RLGB_N_A050_014c_U_43	271,708	754,000,000	
RLGB_N_A050_014c_U_04	275,308	772,000,000	
RLGB_N_A050_014c_U_05	271,250	787,000,000	
RLGB_N_A050_014c_U_53	273,278	787,000,000	
RLGB_N_A050_014c_U_12	272,199	807,000,000	
RLGB_N_A050_014c_U_40	289,730	832,000,000	
RLGB_N_A050_014c_U_37	277,618	856,000,000	
RLGB_N_A050_014c_U_26	272,251	872,000,000	
RLGB_N_A050_014c_U_01	269,389	879,000,000	
RLGB_N_A050_014c_U_27	271,931	913,000,000	
RLGB_N_A050_014c_U_34	271,535	937,000,000	
RLGB_N_A050_014c_U_11	276,714	942,000,000	
RLGB_N_A050_014c_U_13	277,139	955,000,000	
RLGB_N_A050_014c_U_36	283,335	1,020,000,000	

0 25 50Km

Map Grid of Australia – Zone 55
Geocentric Datum of Australia 1994

N W E S

Waratah Coal
THE NEW ENERGY IN COAL

Rev	Date	Description	ORIG	CHK
A	22/02/10	Concept Design	BH	NH

Waratah Coal Pty Ltd

Galilee Basin Coal Railway
Pre Feasibility Study
Quantm Route Analysis
Figure 4-1 - Free-to-Roam Results
Quantm Route Analysis
Galilee Basin, Queensland, Australia

DRG NO: 10.60.002-009-1

4.3 Corridor Screening & Evaluation

An important step in screening the large number of corridor options generated throughout the study was to assess them against a set of key criteria to compare the effectiveness of each alternative in achieving the study goal. Therefore, the following evaluation categories were established to best reflect the most critical aspects for this preliminary corridor assessment:

- **Engineering Feasibility –** this relates to the technical feasibility of corridor alternatives in regards to their construction costs, compliance to geometric limits, permits and approvals required, compliance to local policies and plans, proximity to rail communication and utilities, site access, etc.

- **Constructability –** criteria established to evaluate the relative complexity of constructing the rail corridor and associated track structure with consideration to the extents of earthworks (depths of cuttings, height of embankments), number and lengths of new structures (bridges, tunnels, culverts, etc), access to construction resources (ballast and aggregate from quarries), required crossings of existing infrastructure, etc.

- **Environmental Impact -** the evaluation of the natural environment considers the comparative impacts of each alternative on national parks and reserves, biological resources, wetlands, floodplains, rivers, and ecosystems under threat or endangered.

- **Social Impact –** this relates to the social feasibility of alternatives to negatively affect communities they traverse through, including noise, aesthetics and dust impacts to townships, encroachment through indigenous and cultural heritage areas, etc.

- **Built environmental Impact –** considers potential impacts to existing transport infrastructure and utilities, property severance, communities, mining leases under ownership, townships, etc.

- **Rail Performance –** relates to the operating efficiency of the railway (maximum grades, linear length, curvature, etc) and possible third party usability benefits.

At selected stages of the study, corridors were populated into an evaluation framework matrix that allowed clear ranking of options according to the criteria specified above. A scoring system of 1 to 10 was used when assessing the relative merits of corridors to each of the evaluation criteria above. Those with the highest overall tally were determined the most feasible.

Excellent	9-10
Good	7-8
Average	5-6
Poor	3-5
Unacceptable	1-3

5 Corridor Outcomes

Progressive desktop reviews were undertaken at selected stages of the study to assess the Quantm results. Those that best achieved the engineering standards and were of lowest cost, whilst minimised potential impacts to the built and natural environmental, were short listed and refined in subsequent investigations. This resulted in the selection of five broad corridors showing the greatest potential to meet the overall project objectives, as illustrated in Figure 5-1. Each of these was then individually assessed against the established evaluation criteria to enable a detailed comparison and comparative ranking of each alternative, as shown in Table 5-1. The outcome of this was the selection of a preferred western corridor, known as C1, which was further refined with more detailed information down to a location specific corridor recommended for future assessment.

5.1 Shortlisted Corridors

The selection and assessment process to determine the preferred corridors involved a comprehensive search of the entire study area subject to the latest constraints, costing and geometrics. Quantm's free-to-roam optimisation was utilised to provide an unbiased output of route options that spread the entire study area.

Obvious patterns and trends in the alignments results were identified, such as where alignments clumped together indicating favorable regions of low cost, and where alignments fanned out providing greater flexibility in selecting between different routes. Progressively the overall study area was reduced about the potential corridors as the less technically feasible areas could be ruled out, which included regions of difficult terrain, high impact constraints, etc.

Corridors through the southern part of the study area generally exhibited easy rolling grades due to the flat terrain, with the extensive Q100 floodplains of the Belyando, Mistake and Suttor River systems being the key drivers in defining the corridor paths. Penalty weightings were used to discourage the route from traversing floodplains in an attempt to reduce costly lengths of flood protected embankments and structures, as well as limit the likely environmental impact to their aquatic supporting habitats.

Routes through the northern part of the study area were predominately influenced by the hilly topography found throughout the Leichardt and Clark Ranges, together with the restriction to comply with the stringent heavy haul rail geometry requirements. Careful consideration was given to selecting paths that provided a balance between reduced earthworks and linear length. Tunnels were generally discouraged due to the difficulties associated with operating a tunnel to support heavy haul railways, while select river crossings were optimised to reduce the length of bridges and embankments over the environmentally sensitive floodplains.

5.1.1 Corridor Option 1 (C1)

Option C1 is the highest ranked route being the cheapest ($667M.) and second shortest of all the short-listed corridors (441.4km). Commencing at the mine it covers over 50km of the Galilee Basin before heading in a north-easterly direction past the Twin Hills Mines, avoiding the large Belyando River and Mistake Creek Q100 floodplains lying to the west. Upon crossing the Suttor River the route climbs steeply through the Leichardt Ranges, passing within 10km of Mount Coolon, a possible location mid-route to house maintenance and construction teams for the project.

From here the route continues to climb at maximum grade for over 20km, crossing the top of the range including the Bowen Developmental Road, before descending steeply downhill towards Collinsville. The corridor travels along the western boundary of Xstrata's mining lease at Collinsville where it commences a steady climb into the Clark Ranges. It crosses the range through Peter Gordon Pass introducing a deep cut, before descending steeply downhill towards the port crossing the foothills between Mt Aberdeen and Mt Abbot, as well as both Sandy and Bogie Creeks with large bridge structures. It is expected that a crossing of the Clark Ranges to the west of Collinsville will provide less civil works from the more favorable topography than using the existing Newlands Corridor to the east of Collinsville.

Corridor C1 is considered to have comparatively lower impacts to existing infrastructure than the other corridors, particularly those that utilise the existing Collinsville Newlands Corridor which currently supports road, rail, mine and various utility infrastructure. The route will have at least twelve major river bridge crossings, the largest being a 400m+ span across the Bogie River. It will also exhibit four additional road-over-rail bridges for crossing of existing arterials.

It avoids all major land-use constraints including mining leases, mining development leases, and townships, while maintains at least a 2km distance from any house (as determined from Google Earth satellite imagery[15]). The route also avoids all major water pipelines; however, passes under three major transmissions lines, and over the North Queensland Gas Pipeline near Collinsville.

The corridor has minimal environmental impact avoiding all national parks, reserves, nature refuges, protected wetlands and large dams. It does; however, cross through an area of endangered regional ecosystems mid-route, where it deviates north to cross a narrow stretch of the Suttor River. It's expected that a crossing of the Suttor River at this point; however, will reduce the overall environmental impact by limiting the number of structures & embankments that would otherwise be required by crossing the large floodplain falling to the east.

5.1.2 Corridor Option 2 (C2)

Corridor Option C2 presents a similar cost ($678M.) and length (441.8m) to option C1; however, takes a distinctively different path through the eastern part of the study area. From the mine it heads in an easterly direction passing around the edge of Narrien Range National Park, and across the upper reaches of the Mistake and Suttor River Floodplains traversing predominately easy rolling grade country. It's expected that the route through this section will exhibit higher environmental impacts and infrastructure costs for the crossing of floodplains than the more western alternatives.

At Eaglefield the route begins its climb through the Leichardt Ranges, following a path that minimises impacts to topological features. The terrain is mostly undulating with gentle sloping hills and rocky basalt outcrops, before descending steeply downhill towards Collinsville where some moderate earthworks are expected. From here the route follows a similar path to that of C1, passing to the west of Collinsville and crossing the Clarke Ranges through Peter Gordon Pass.

Similar to the other short-listed options, C2 has been optimised to reduce environmental and land-use impacts where possible. It avoids all national parks, protected reserves and wetlands, as well mining leases, townships and other significant land-use constraints. An estimated five road-over-rail bridges will be required for crossings of existing roads, together with three crossings under high

[15] This will need to be confirmed from a ground survey / aerial flight along the selected corridor as imagery may be outdated.

voltage transmissions lines. A shallow embankment crossing over the North Queensland Gas Pipeline immediately prior to crossing the Bowen River will also be required.

A key benefit of this far eastern corridor over the others shortlisted is that it passes within a close proximity to the Western Bowen Basin and thus could provide future third party access to coal mines throughout this area. In contrast though, the corridor only encompasses a fraction of the Galilee Basin which may be less favorable to local government and other Galilee Basin stakeholders.

5.1.3 Corridor Option 3 (C3)

Corridor Option 3 (438.7km at $855M.) was found to be the most competitive of the 1 in 300 loaded grade corridors considered. Geometric compliance to this grade proved difficult and limited the number of feasible corridors to only those through the eastern part of the Leichardt Ranges (similar to C2), and those to the west of Collinsville (similar to C1).

Investigations into the viability of a 1 in 300 railway though the existing Newlands Corridor (which currently supports a 1 in 80 grade railway) demonstrated that significant landscape and ecological impacts would result from the construction of a new railway at this stringent grade. In particular the topography was found to be too steep and would result in significant quantities of earthworks and structures including the need for a tunnel and several lengthy bridges.

A longer far western corridor paralleling the northern edge of the Bowen River (across flat terrain inland) and passing around the outer western edge of the Clark Ranges near Mount Herbert, presented a route with excellent topological relief. This route was ruled out due to the extra capital investment required with constructing a longer route.

Due to the more stringent allowable grades the route exhibits higher overall civil works than the 1 in 200 grade corridors. This includes the requirement for a 57m deep tunnel through Peter Gordon Pass, Clark Ranges. It also has a larger overall footprint and thus environmental impact across the sensitive floodplains and protected vegetation habitats.

Despite the higher capital cost for this corridor, it’s expected that the flatter and shorter route would provide long term operational and maintenance benefits to the railway. It is expected that this will be ascertained through future train performance modelling of this route.

5.1.4 Corridor Option 4 (C4)

Corridor Option 4 is a slightly longer alternative (460.5km at $708M.) with it traversing over 150km of the Galilee Basin before heading north-east towards the Queensland coast. This has the benefit of opening up the northern end of the Galilee Basin resource, providing future growth opportunities to new mines which may not otherwise be economically viable without supporting rail infrastructure.

From the mine, the corridor follows the existing Galilee Basin EPCs north, choosing to cross the upper reaches of the Belyando River Floodplain at a narrow point near Mount Gregory. Deviating around some hilly slopes, the route then heads north-east crossing the Gregory Developmental Road near Nairana National Park before crossing the Suttor River and following a similar route to options C1 and C2 through the Leichardt and Clark Ranges.

By crossing the southern part of the study area further west, it's expected less bridge crossings of upstream river tributaries will be required. The route also avoids crossing through a densely populated area of endangered regional ecosystems south of the Suttor River, as encountered in C1.

5.1.5 Corridor Option 5 (C5)

Corridor Option 5 ($769M. at 450.4km) is the only short listed option that follows the existing Collinsville Newlands Corridor through the Clark Ranges. Initially it traverses a similar path to C1 to where it crosses the Gregory Developmental Road. From here the route cuts through the middle of the Suttor River Floodplain following a similar path into the Leichardt Ranges as C3. It descends close to Newlands Mine, before crossing over the Collinsville Newlands Railway and Kangaroo Creek.

At this point the route deviates along the eastern boundary of Xstrata's Sarum mining lease, rather than following the existing corridor west of this lease into Collinsville. This provides for a shorter bridge crossing over a narrow stretch of the Bowen River to the east. It also has the benefit of allowing the route to commence an earlier climb at maximum grade through the Clark Ranges, thereby gaining altitude quicker, and ultimately reducing civil works.

Due to the steeper topography encountered along this established corridor, the 1 in 200 grade route is required to wind heavily in attempt to stick close to the natural surface to reduce quantities of cuts, fills, and bridging. Across the top of the range the route will need to extend into the Sonoma State Forest area. There are also a number of existing infrastructure constraints and utilities stemming from Collinsville that service the Bowen Basin Mines that will need to be negotiated.

On the decent the route crosses the Bowen Developmental Road, together with the Collinsville Newlands Railway a second time near the Binbee, before passing through the Mount Pleasant Nature Refuge, along the boundary of Mount Aberdeen National Park and finally into the APSDA.

Despite the extra capital investment needed for this route, the corridor has the distinct advantage of passing across the Western Bowen Basin with potential for accommodating future third party access to the mines in this coal rich area. The corridor is also expected to require less property severance and overall impact to landowners where the corridor can utilise parts of the existing railway easement. Also by following parts of the existing Newlands corridor it is expected that there should be abundant information available on the receiving environment from previous surveys.

The potential environmental impact along this route; however, is expected to be higher than other corridors with it crossing a state forest, two nature refuges and exhibiting a larger footprint encroachment across river floodplains.

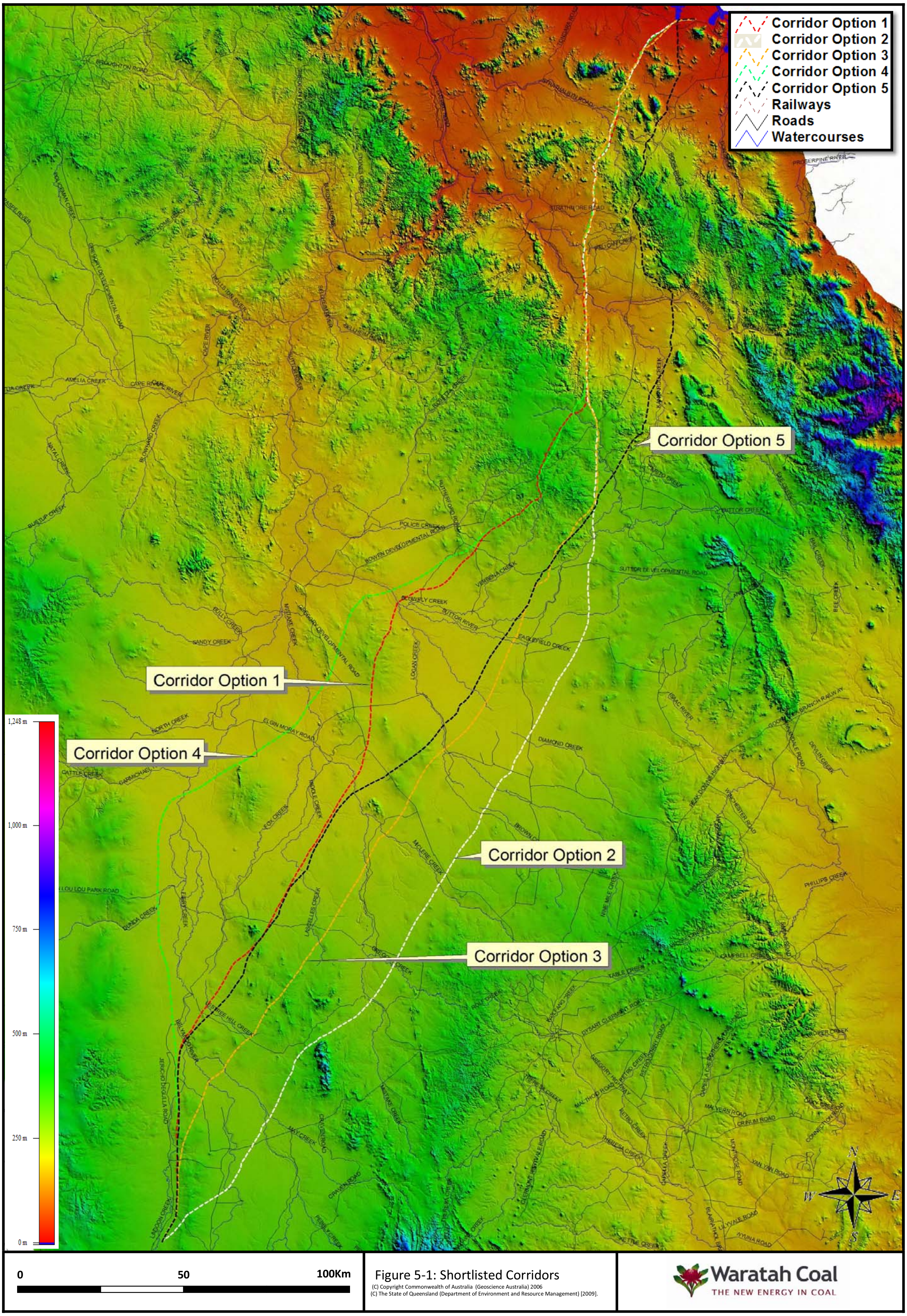


Figure 5-1: Shortlisted Corridors

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	Evaluation Criteria	Corridor Option 1 RLGB_C1_C050_005_U_44	Corridor Option 2 RLGB_C2_C050_004_U_39	*Corridor Option 3 RLGB_C3_C033_001_QBT_07*	*Corridor Option 4 RLGB_C6_C050_001_U_48*	Corridor Option 5 RLGB_C5_C050_001_U_15
Civil Works	Total Construction Cost (Quantm Dollars $)[#]	$667,000,000	$678,000,000	$855,000,000	$708,000,000	$769,000,000
	Alignment Length (km)	441.4	441.8	438.7	460.5	450.4
	Cost for Track Structure ($)	$391,000,000	$391,000,000	$389,000,000	$408,000,000	$399,000,000
	Alignment Footprint Area (m^2)	9,040,000	8,950,000	10,800,000	9,510,000	9,690,000
	Total Land Clearing Cost ($)	$3,260,000	$3,220,000	$3,900,000	$3,430,000	$3,490,000
Earthworks	Total Volume of Cut (m^3)	13,700,000	13,100,000	20,400,000	14,900,000	16,500,000
	Total Cost of Cut ($)	$72,800,000	$62,400,000	$110,000,000	$73,600,000	$88,400,000
	Deepest Cutting (m)	25m (CH 409,180m)	27m (CH 409,700m)	30m (CH 252,860m)	25m (CH 428,520m)	36m (CH 391,260m)
	Total Volume of Fill (m^3)	8,240,000	7,700,000	13,500,000	8,880,000	9,950,000
	Total Cost of Fill ($)	$24,500,000	$22,900,000	$40,200,000	$26,400,000	$29,600,000
	Highest Embankment (m)	19m (CH 380,240m)	20m (CH 380,720m)	19m (CH 263,760m)	18m (CH 400,000m)	18m (CH 382,780m)
	Volume of Borrow Material (m^3)	nil	nil	76,600	nil	nil
	Total Cost for Borrow ($)	n/a	n/a	$329,000	n/a	n/a
	Volume of Dump Material (m^3)	5,840,000	5,800,000	7,760,000	6,550,000	7,090,000
	Total Cost for Dump Material ($)	$4,610,000	$4,590,000	$6,130,000	$5,170,000	$5,600,000
	Volume of Mass Haul (m^3)	64,900,000	63,900,000	148,000,000	80,600,000	109,000,000
	Total Cost for Mass Haul ($)	$51,300,000	$50,500,000	$117,000,000	$63,600,000	$86,400,000
Infrastructure	Bridges - Total Construction Cost ($)	$76,300,000	$90,700,000	$99,200,000	$83,900,000	$111,000,000
	Bridges - Combined Span (m)	1,580	1,877	2,055	1,737	2,288
	Bridges –Total Number	12	18	16	11	17
	Bridges - Number > 100m in length	4	3	4	4	4
	Bridges - Number > 200m in length	3	3	4	4	2
	Bridges - Number > 400m in length	1	1	1	0	1
	Road-over-Rail Bridges Cost ($)	$30,000,000	$30,000,000	$30,000,000	$30,000,000	$30,000,000
	Road-over-Rail Bridges - Number	4	5	5	4	5
	Culverts - Total Construction Cost ($)	$11,700,000	$14,000,000	$16,000,000	$13,500,000	$14,500,000
	Culverts - Combined Length (m)	14,024	14,631	16,765	14,407	15,268
	Culverts - Total Number	359	425	449	398	437
	Retaining Walls - Total Construction Cost ($)	$1,610,000	$8,750,000	$6,990,000	n/a	$2,060,000
	Retaining Walls - Combined Face Area (m^2)	892	4,860	3,880	n/a	1,140
	Retaining Walls- Total Number	3	9	9	n/a	3
	Retaining Walls - Longest Wall	80m (CH 381,180m)	171m (CH 171,180m)	100m (CH 362,940m)	n/a	88m (CH 444,812)
	Tunnel - Total Construction Cost ($)	nil	nil	$36,500,000	nil	nil
	Tunnel - Combined Length (m)	n/a	n/a	813m	n/a	n/a
	Tunnel - Total Number	n/a	n/a	1	n/a	n/a
	Tunnel - Longest & Deepest Tunnel (m)	n/a	n/a	813m long / 57m deep	n/a	n/a
Environmental	National Parks	No Impact	No Impact	No Impact	No Impact	No Impact
	National Parks (Scientific)	No Impact	No Impact	No Impact	No Impact	No Impact
	National Parks (Recovery)	No Impact	No Impact	No Impact	No Impact	No Impact
	Resource Reserves	No Impact	No Impact	No Impact	No Impact	No Impact
	State Forests Reserves	No Impact	No Impact	No Impact	No Impact	1 x (Sonoma State Forest)
	Nature Refuge	No Impact	No Impact	No Impact	No Impact	2 x (Mt Pleasant, Homehaven)

	Regional Ecosystems – Endangered (m^2)	269,000	396,000	611,000	406,000	484,000
	Regional Ecosystems - Of-Concern (m^2)	1,220,000	1,360,000	1,710,000	1,580,000	1,630,000
	Wetlands (DIWA)	No Impact	No Impact	No Impact	No Impact	No Impact
	Large Dams	No Impact	No Impact	No Impact	No Impact	No Impact
	Declared Protected Catchments	No Impact	No Impact	No Impact	No Impact	Suttor River Dam site
Built Environment	Mining Leases	No Impact	No Impact	No Impact	No Impact	No Impact
	Mineral Development Licenses	No Impact	No Impact	No Impact	No Impact	No Impact
	Townships	No Direct Impact	No Direct Impact	No Direct Impact	No Direct Impact	No Direct Impact
	Utilities – Major Gas Lines	1x crossing	1x crossing	1x crossing	1x crossing	1x crossing
	Utilities – Major Water Lines	No Impact	No Impact	No Impact	No Impact	3xcrossings
	Utilities – Major Power Lines	3x crossings	3x crossings	3x crossings	3x crossings	7x crossings
	Road Crossings	4x road over rail crossings	5x road over rail crossings	5x road over rail crossings	4x road over rail crossings	4x road over rail crossings
	Railways Crossings	1x crossing	1x crossing	1x crossing	1x crossing	2x crossing
Socioeconomic	Cultural Heritage	No Impact	No Impact	No Impact	No Impact	No Impact
	Indigenous Heritage	Crosses 3x registered native title applications	Crosses 3x registered native title applications	Crosses 3x registered native title applications	Crosses 3x registered native title applications	Crosses 3x registered native title applications
	Townships within 10km of route (dust, noise impacts)	Collinsville, Alpha, Mt Coolon	Collinsville, Alpha	Collinsville, Alpha	Collinsville, Alpha, Mt Coolon	Collinsville, Alpha
	Townships within 2km of route (dust, noise impacts)	nil	nil	nil	nil	Collinsville
	Cadastral Footprint Encroachment (m^2)	8,900,000	8,700,000	10,800,000	9,370,000	9,290,000
	Connectivity to Existing Rail Systems & Mines	Possible integration with north western Bowen Basin mines via 15-20km spur.	Possible integration with north western Bowen Basin mines via 12-20km spur. Does not service as much of the Galilee Basin as other corridors.	Possible integration with north western Bowen Basin mines via 12-20km spur. Does not service as much of the Galilee Basin as other corridors.	Covers ~150km of Galilee Basin more than any other shortlisted corridor. Possible integration with north western Bowen Basin mines via 15-20km spur.	Easy integration with north-western Bowen Basin Mines.
Geometrics	Design Grade	1:200 (laden) 1:80 (unloaded)	1:200 (laden) 1:80 (unloaded)	1:300 (laden) 1:100 (unloaded)	1:200 (laden) 1:80 (unloaded)	1:200 (laden) 1:80 (unloaded)
	Minimum Horizontal Radius of Curvature (m)	1000	1000	1000	1000	1000
	Minimum Vertical Radius of Curvature (m)	7200	7200	7200	7200	7200
	Curve Compensation (%)	0.034	0.034	0.034	0.034	0.034
SUMMARY	**Engineering Feasibility**	8	8	7	7.5	7
	Constructability	7	6.5	6	6.5	6
	Environment Impact	9	8.5	8	8.5	7.5
	Social Impact	8	8	7.5	8	8
	Built environmental Impact	8	7.5	7.5	8	8
	Rail Performance (not fully assessed)	8	8	9	9	9
OVERALL RANKING		**48**	**46.5**	**45**	**47.5**	**45.5**

Table 5-1 - Evaluation of short-listed corridors.

#**Note on Infrastructure Costs:** Quantm construction costs in 2008 dollars do not include full project costs such as contingencies, overheads or profits. It is recommended that an overall 35% contingency should be applied to the estimates, which is appropriate given the level of pre-feasibility design and investigations for this study.

5.2 Preferred Corridor (C1)

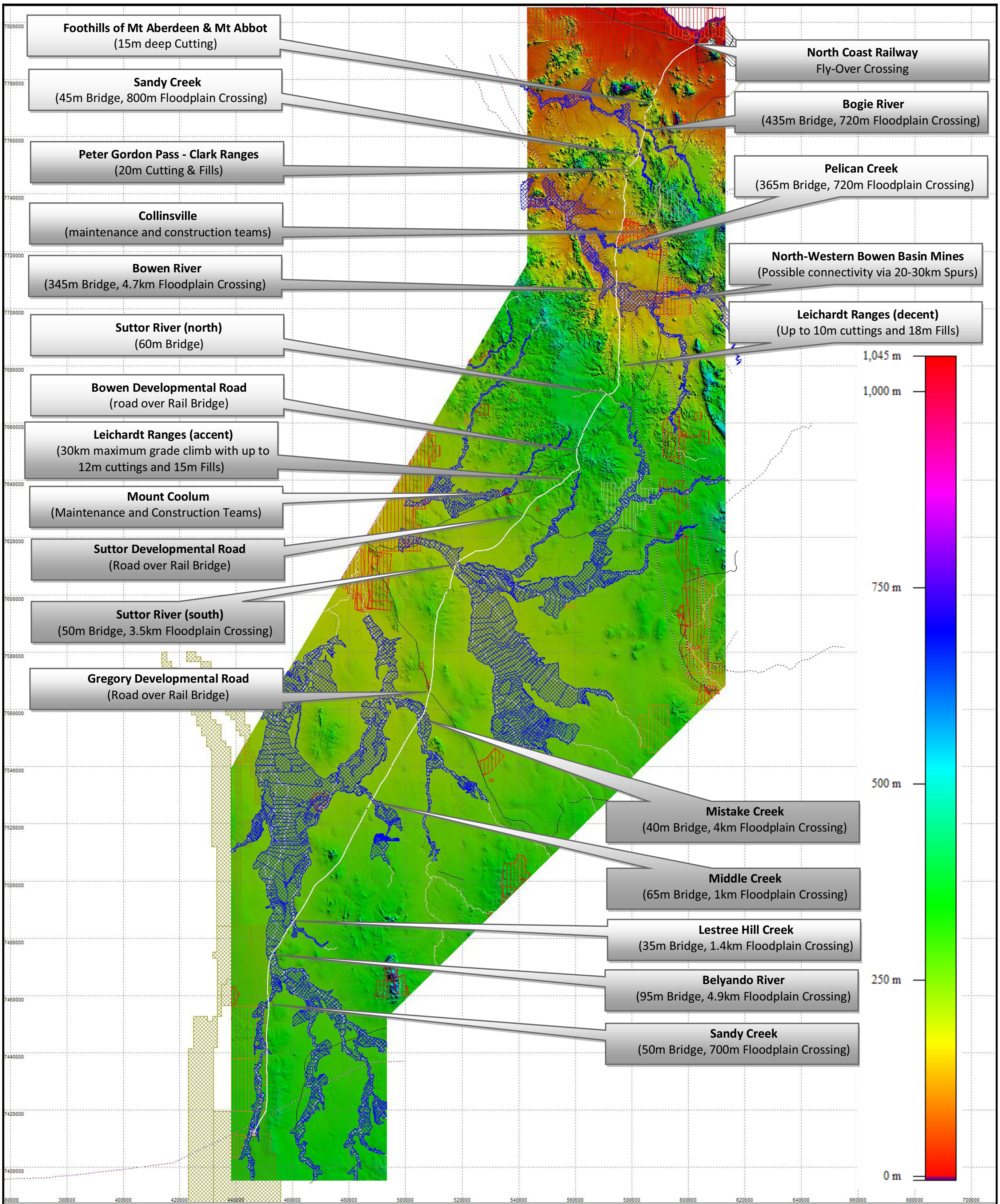
The evaluation process of the short-listed corridors led to the selection of corridor C1 for a more detailed assessment. A subsequent refinement development stage was carried out within the preferred corridor, initially over a 10km band, which was then progressively reduced to 5km wide and finally 1.5km. By focusing the optimisation over a more defined path, the route was fine tuned to more closely conform to the natural contours and to also provide a better compliance to crossings of existing constraints.

In refining the selected corridor the project's impact to the natural environmental and land-owners was reduced. Footprint encroachment through protected vegetation was minimised through the inclusion of regional ecosystems (endangered and of-concern). The route was refined to ensure perpendicular crossings of major rivers and shorter crossing of their large floodplains.

Google Earth satellite imagery was utilised to manually digitize the locations of individual houses, dams and other obvious infrastructure within the corridor. These were included with associated avoidance penalties to ensure the final route passed at least 2km from any of these features.

Another focus of this stage was concentrating on areas of the route that traversed challenging topography, particular the steep slopes of the Leichardt and Clark Ranges, which are likely to result in some heavy earthworks. This resulted in a marginally longer final route (3km longer); however, provided reduced earthworks particularly in known areas of deep cuttings and large fills.

The following sections provide a general overview for the preferred corridor and summary of the issues and potential impacts that will need to be considered during future assessment. The final 1.5km corridor (443.6km long) is illustrated in Figure 5-2, while Appendix B provides engineering plans and profiles for 50km sections along the recommended route.



0 50 100 Km

Map Grid of Australia – Zone 55

Geocentric Datum of Australia 1994

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Rev	Date	Description	ORIG	CHK
A	22/02/10	Concept Design	BH	NH

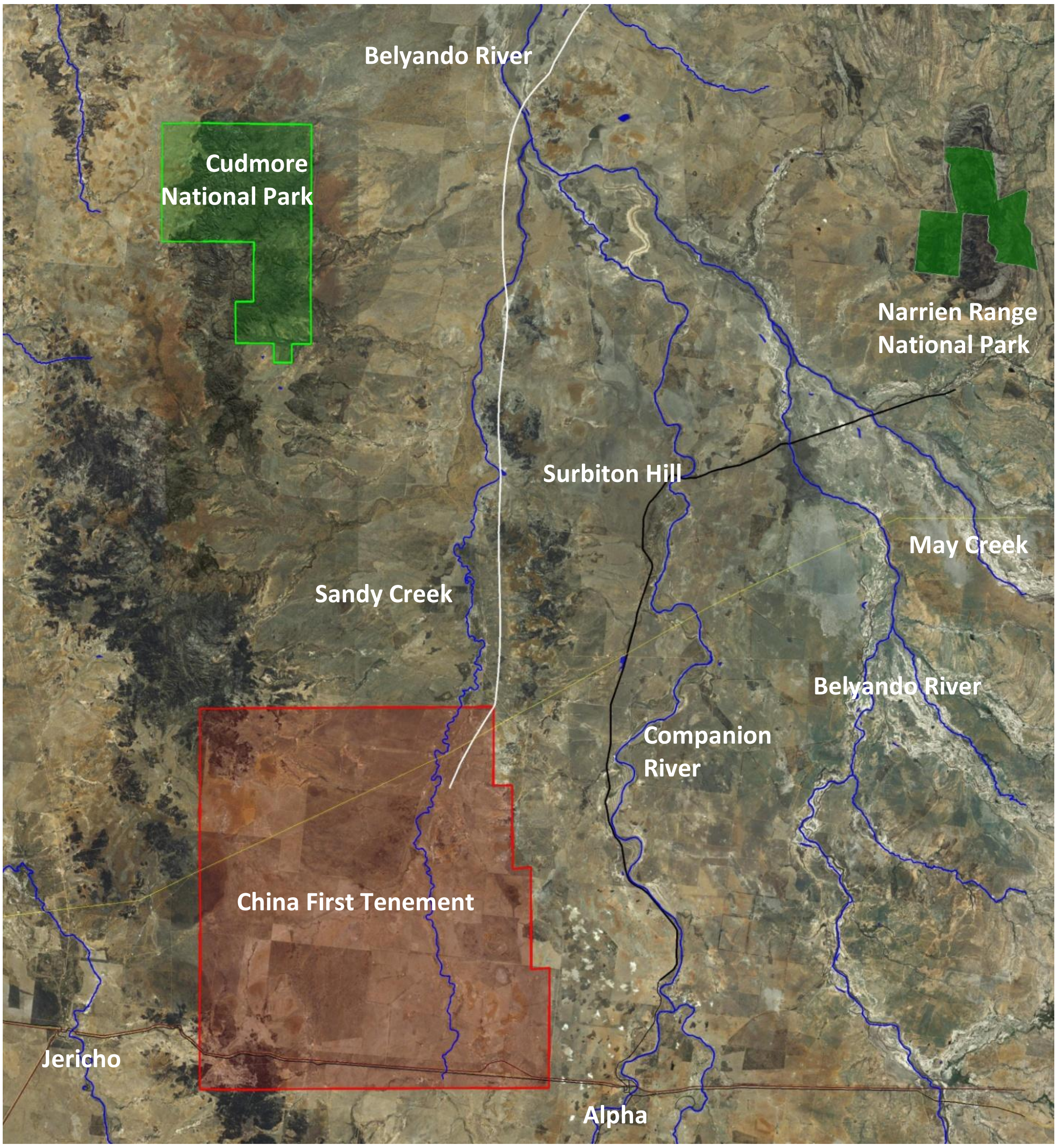
Waratah Coal Pty Ltd

Galilee Basin Coal Railway
Pre Feasibility Study
Quantm Route Analysis
Figure 5-2 – Recommended 1.5km Corridor
GALILEE BASIN, QUEENSLAND
Australia

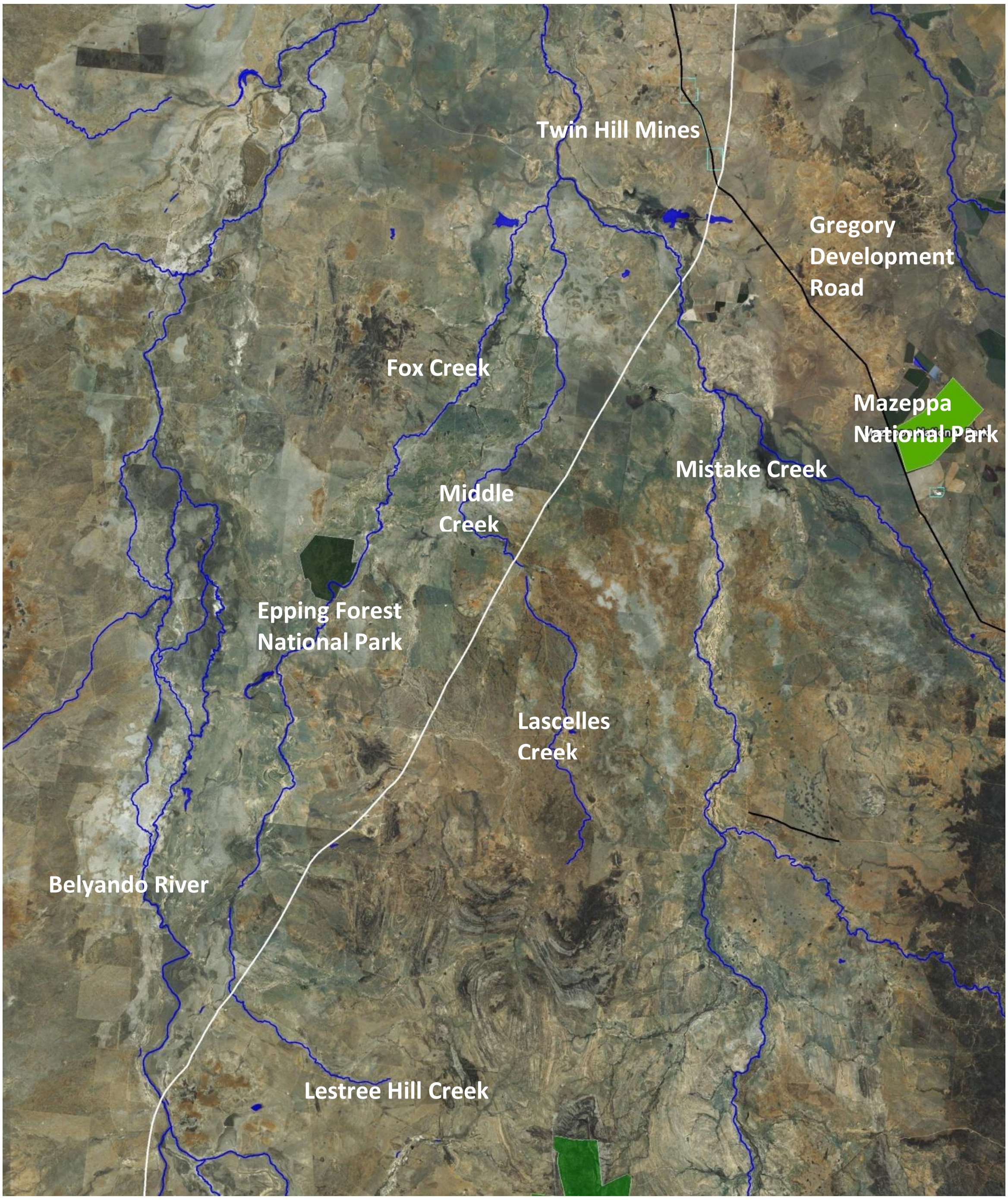
DRG NO: 10.60.002-009-2

5.2.1 General Description

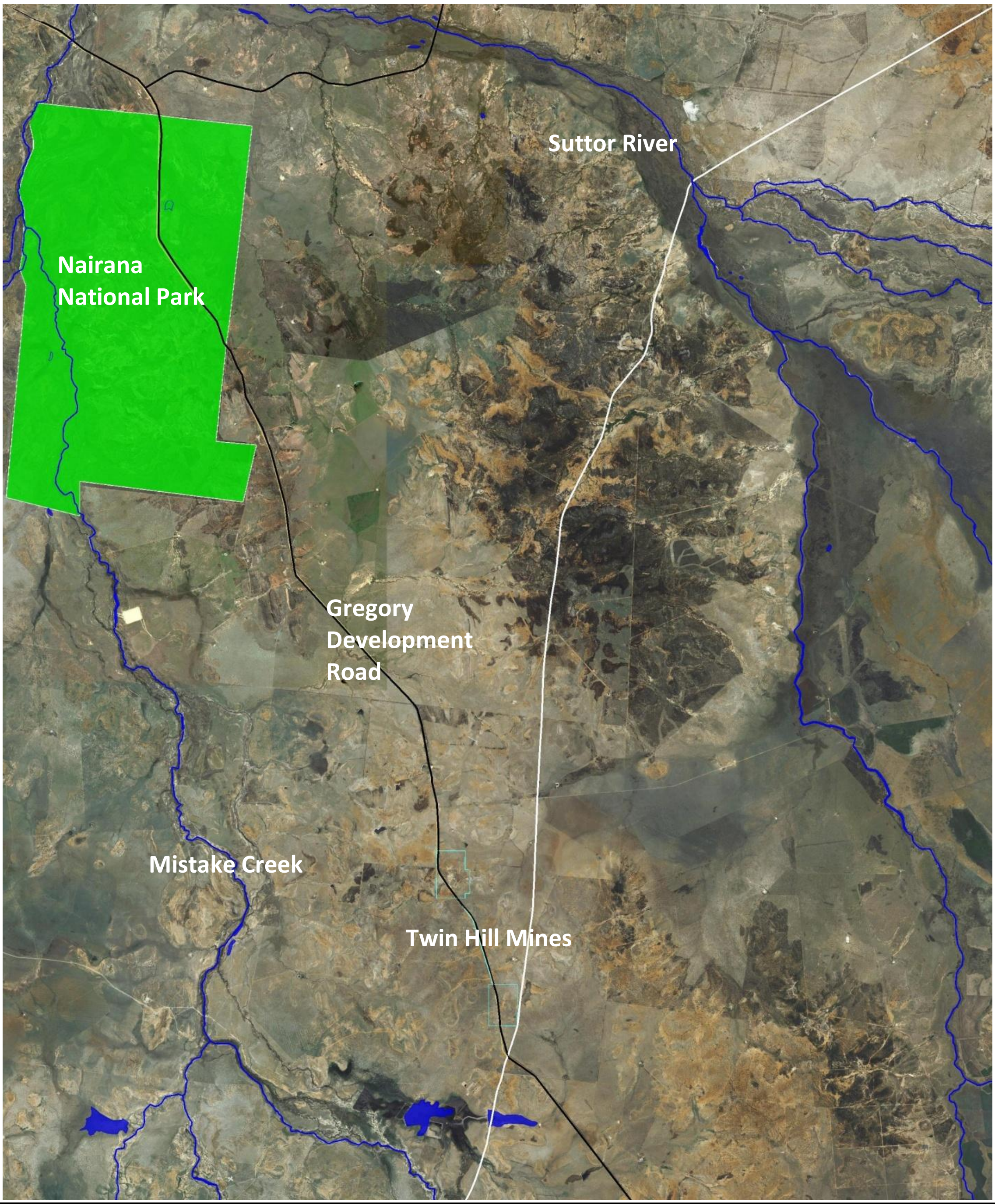
China First Tenement to Belyando River (CH 0km-64km): commencing at the mine the route traverses north, paralleling the existing Galilee Basin EPCs and passing within a close proximity to Surbiton Hill, a possible future source of construction aggregate and ballast for the railway. The route swings north-east where it crosses the confluence of the Belyando River, Sandy Creek and Native Companion Creek. At this point the crossing of the extensive Belyando Floodplain is less than 5km.



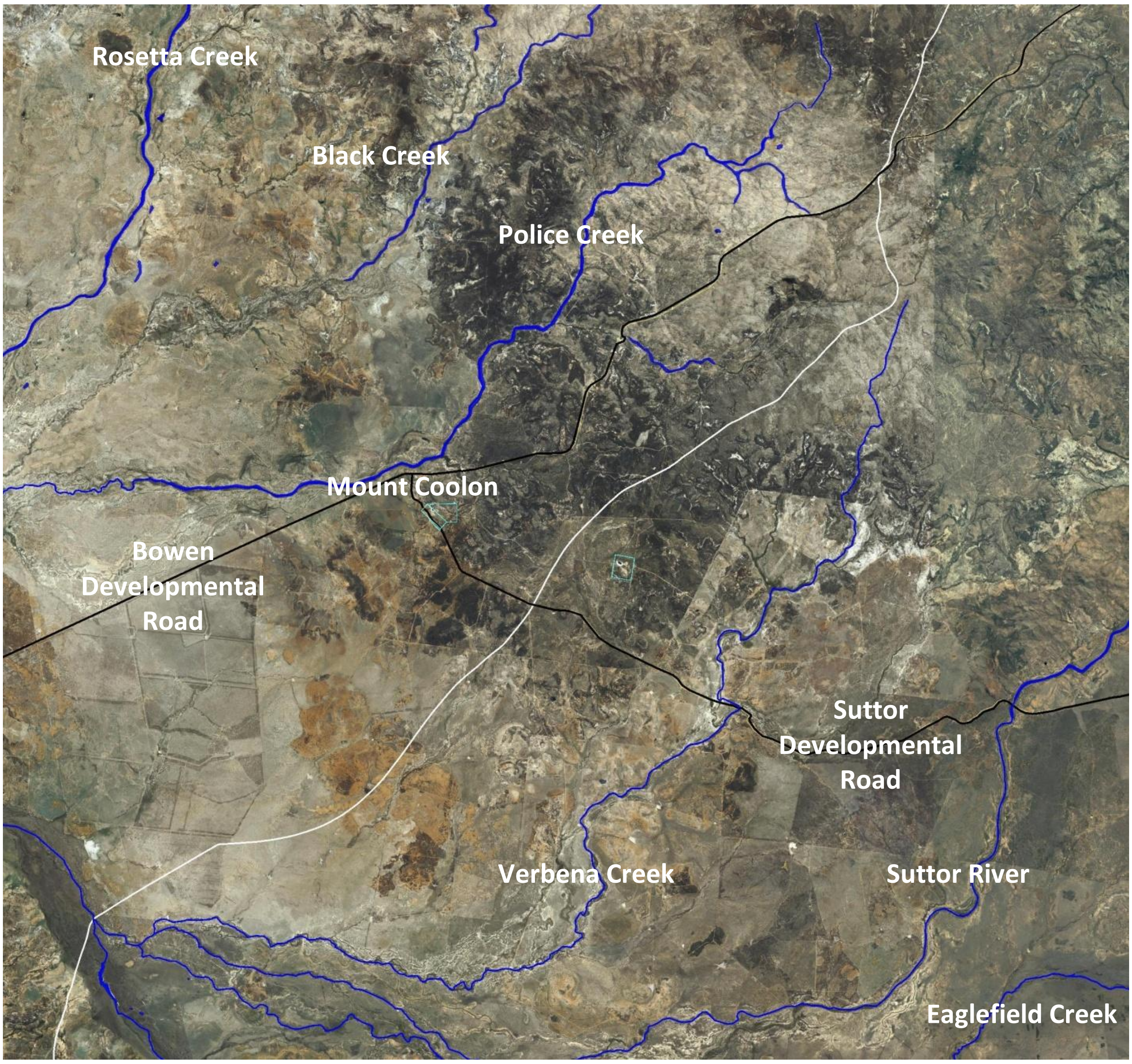
Belyando River to Gregory Developmental Rd (CH 64km-172km): the route continues north-east across relatively flat terrain with easy rolling grades, passing to the south of Epping Forest National Park and avoiding most of the widespread Belyando Floodplain that lies to the north-west. The alignment will cross at least three major watercourses through this area in bridge, including Lestree Hill Creek, Middle Creek, and Mistake Creek.



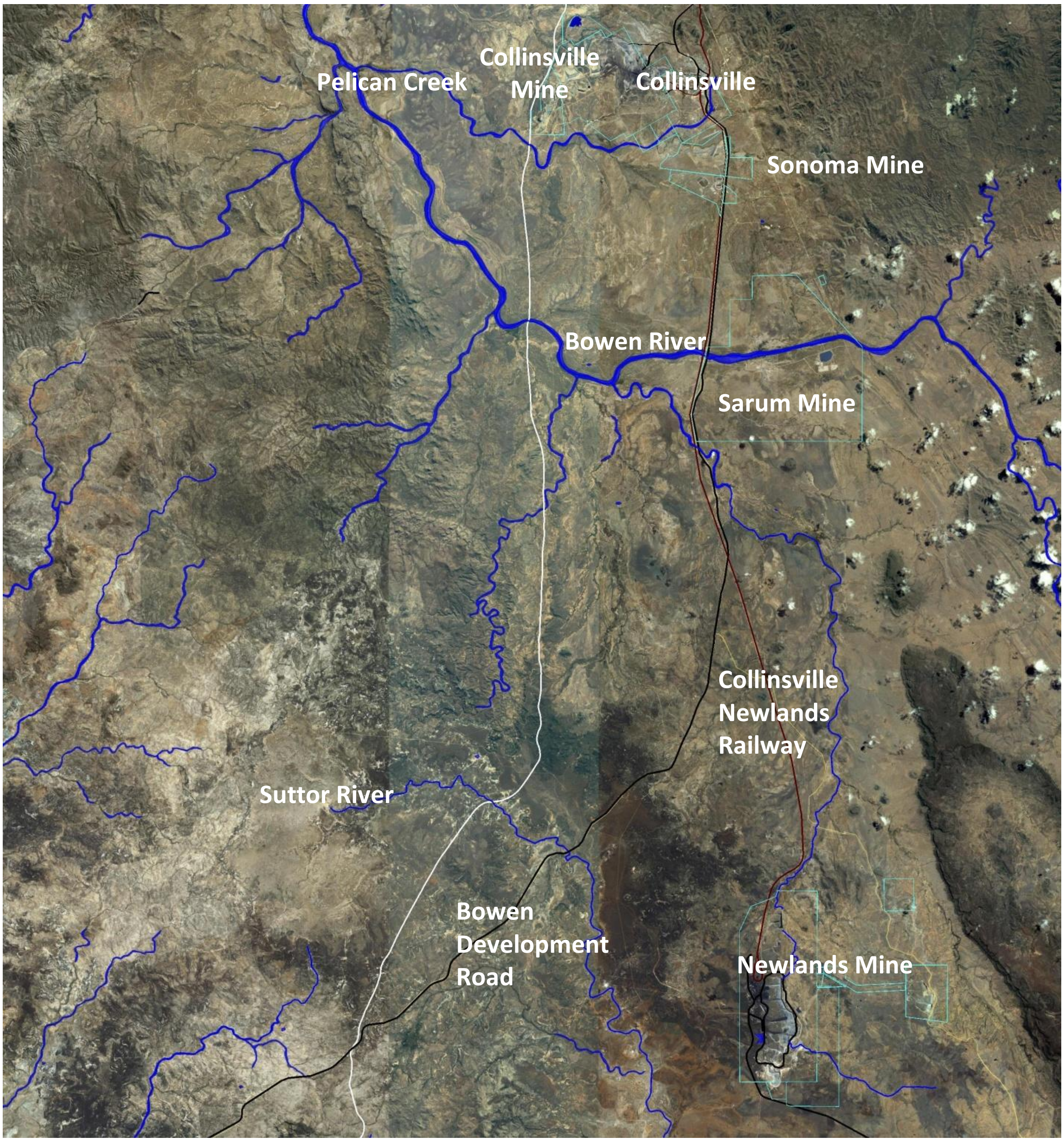
Gregory Developmental Rd to Suttor River (CH 172km-219km): this section sees the route pass close to the abandoned Twin Hill Gold Mine near the Gregory Developmental Road, a possible location for a construction camp and materials storage yard. From here the route deviates north around the confluence of the Suttor River and its upstream tributaries. It is expected that this will provide a significant reduction in the number of major bridge crossings, culverts and flood protected embankments needed to cross this flood prone area.



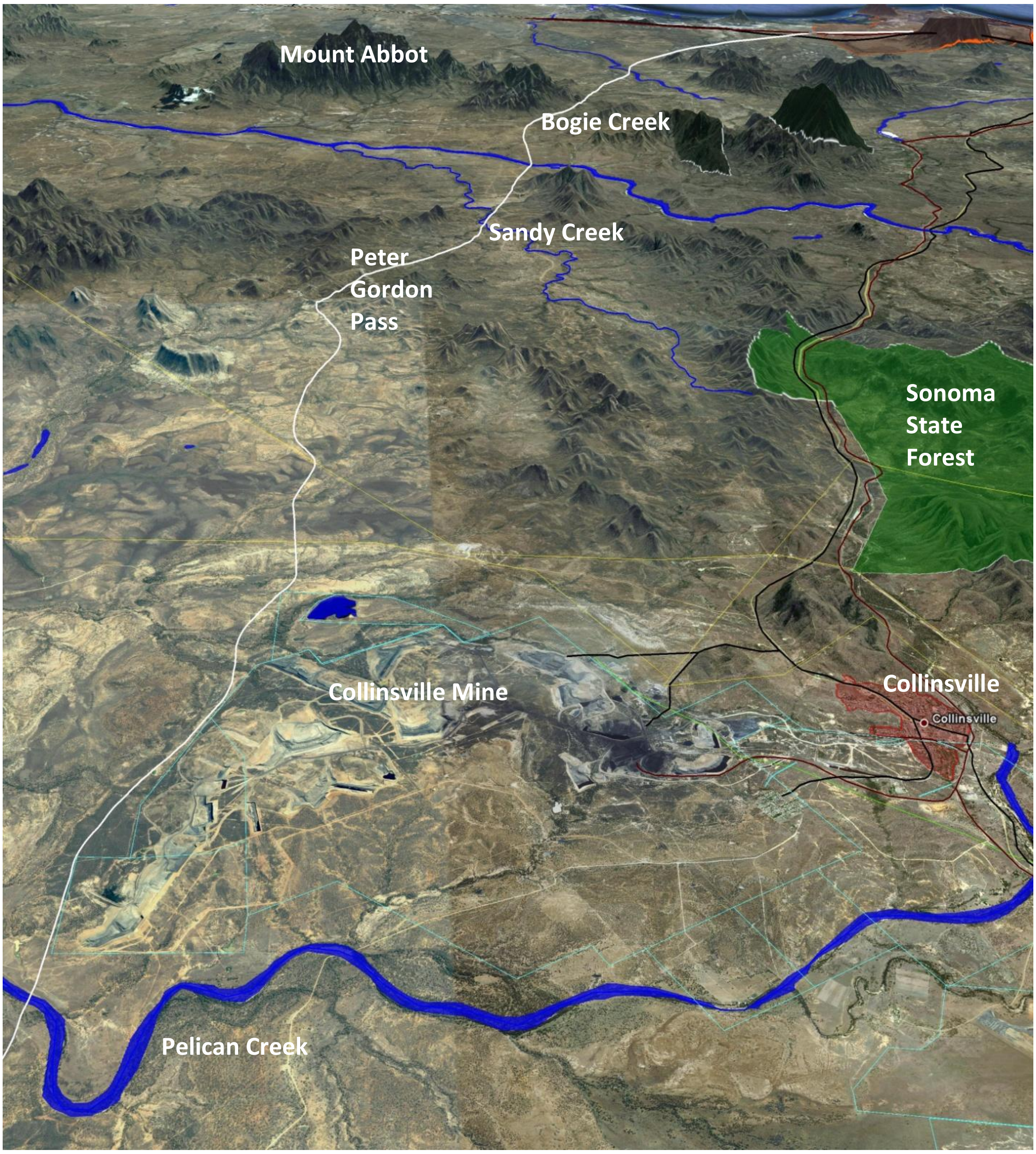
Suttor River to Bowen Developmental Rd (CH 219km-290km): crossing the upper channel of the Suttor River the alignment heads north-east through grassland to open forested country as it climbs steadily through the Leichardt Ranges. This is a particularly long grade climb as the alignment quickly gains altitude (1 in 200 grade for 25km), with some earthworks expected through this climb. In this section the railway will cross the Suttor Developmental Road and Bowen Developmental Road, both requiring road-over-railway bridges. The route will also pass within 10km of the small rural township of Mount Coolon, a possible location to house construction and maintenance teams mid-route for the project.



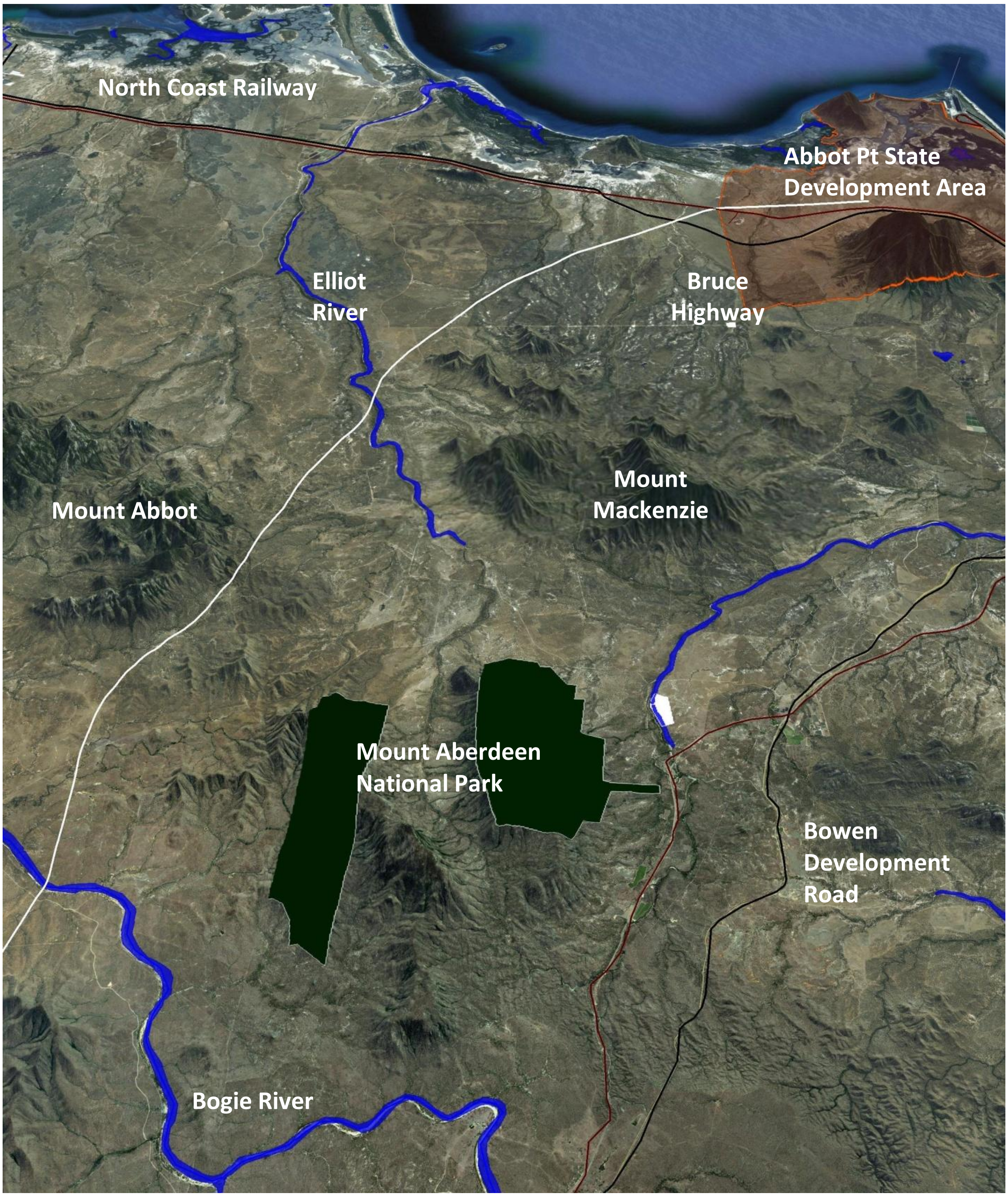
Bowen Developmental Rd to Collinsville (CH 290km-360km): initially the route travels over undulating terrain with moderate Cuts and Fills, crossing the Suttor River (north), before trending downhill towards Collinsville. In this section the alignment crosses the North Queensland Gas Pipeline (near the Bowen River), as well as a 4.5km stretch of the Bowen River Floodplain, and Pelican Creek near Collinsville. On the downhill decent (1 in 80 grade for 9km) some heavy earthworks are expected.



Collinsville to Bogie River (CH 360km-398km): the route passes to the west of Collinsville, running along the boundary of Xstrata Mining Lease before climbing steeply towards Peter Gordon Pass, Clark Ranges. This path is expected to offer more accommodating grades (less than 10km at 1 in 200 grade), with fewer existing infrastructure constraints than following the existing Newlands Corridor immediately to the east. In this section the route will pass underneath two high voltage transmission lines stemming from Collinsville PowerStation, as well as crossing both Sandy Creek and Bogie River on the decent.



Bogie River to Port (CH 398km-443.6km): this section generally offers easy rolling grades except where the route crosses the foothills between Mount Aberdeen and Mount Abbot which exhibits a 2km section of undulating earthworks. The alignment will finish with a road-over-rail bridge crossing of the Bruce Highway, a grade separated crossing over the North Coast Railway, and then ending with two unloading railway balloon loops within the APSDA. The location of the maintenance yard has yet to be confirmed; however, suitable topography exits to the south of the Bruce Highway.



5.2.2 Corridor Features

5.2.2.1 *Project Corridor*

For this preliminary assessment the preferred corridor has been refined down to 1.5km wide. More detailed surveying of existing land use and environmental constraints, together with higher resolution topography mapping is required to take the corridor down to a level of detail suitable for preliminary design. It is estimated that the width of the operating rail corridor will be between 60-80m wide, with widening in some areas required where significant earthworks exist. This will be confirmed during detailed design using airborne laser survey (ALS) terrain, which will allow for more accurate earthwork calculations and footprint extents to be ascertained. During the construction phase of the project a nominal width of 200m may be required to allow sufficient room for construction equipment to maneuver and operate.

5.2.2.2 *Track Layout*

The heavy haul railway will be of single standard gauge track configuration and accommodate up to nine x 3.5km long passing loops. The exact length of the railway (currently estimated at 443.6km) will not be finalised until the specific route within the 1.5km wide corridor and train loadout facilities at the mine and port, have been established. The cost of the route accounts for pre-stressed concrete sleepers spaced 600mm apart and continuously welded 68kg/m rail. These will be supported by a layer of deep clean ballast around 510 mm deep.

The corridor has been selected to accommodate 1 in 200 (0.5%) and 1 in 80 (1.25%) maximum laden and unloaded grades respectively, with no horizontal curves sharper than 1000m (Table 5-2). It's expected that significantly flatter geometry beyond these limits can be achieved between the mine site and Leichardt Ranges where the topography is relatively flat. The alignment has been modelled subject to curve compensation (0.034%) to ease grades around tight horizontal bends. Confirmation of the suitability and operating efficiency of these geometric limits will be established during future train performance modeling studies.

Table 5-2 - Design Criteria for the Preferred Corridor.

Criteria Type	Limits
Railway Gauge	Standard (1435mm)
Maximum Limiting Grade - Laden	0.5% (1 in 200)
Maximum Limiting Grade - Empty	1.25% (1 in 80)
Minimum Horizontal Radius of Curvature	1000m
Minimum Vertical Radius of Curvature (Crest/Sag)	7200m
Curve Compensation	0.034% (per degree of curvature)

5.2.2.3 *Levels*

The railway will be constructed at or near the natural surface where possible, except in locations through steep topography and over constraints requiring grade separated crossings (i.e. rivers, roads, etc). Where the project crosses waterways the route has been vertically optimised to ensure the 100 year flood event does not close the railway, or adversely affect the flow regimes of the waterways.

5.2.2.4 *Earthworks*

A breakdown of quantities and cost of civil works comprising the preferred route is presented in Table 5-3. It should be acknowledged that due to the inaccuracies in the terrain and constraint information used for this preliminary assessment, some variations should be expected.

Table 5-3 - Civil Work Costing for Preferred 1.5km Corridor (mainline only).

Item	Quantity	Estimated Cost
Cut	13,600,000 m3	$69,700,000
Borrow	0 m3	$0
Fill	8,150,000 m3	$24,200,000
Dump[16]	5,870,000 m3	$4,630,000
Mass Haul	75,800,000 m3/km	$59,900,000
Ret. Wall	153 m2	$276,000
Culvert	14,116m	$12,000,000
Bridge	1,681 m	$81,200,000
Tunnel	0 m	$0
Footprint Clearing	8,940,000 m2	$3,220,000
Track – ballast, sleepers, rail	443.6 km	$393,000,000
Fixed Costs	4x road over rail bridges	$30,000,000
Raw Cost	(Quantm Dollars)	$678,000,000
Contingencies	35%	$237,300,000
Total Cost		**$915,300,000**

Quantm construction costs in 2008 dollars do not include full project costs such as contingencies, overheads or profits. It is recommended that an overall 35% contingency be applied to the estimates, which is appropriate given the level of pre-feasibility design and investigations for this study. Note other associated railway costs for signaling, rolling stock, communications, maintenance facilities, passing loops, housing, design fees, etc have been included in the overall construction project costs as provided in Appendix C.

The most significant earthworks are expected to occur through the crossing of the Clark Ranges, as shown in
Figure 5-3. At this point the route climbs steeply at maximum grade and exhibits several deep cuttings, the longest stretching for 3km reaching a maximum depth of 19m (CH 387.km), as illustrated in
Figure 5-4[17]. There will also be a number of other significant cuttings over the Leichardt Ranges requiring excavations greater than 10m where rock may be encountered.

The highest embankment of 19m will be required where the alignment climbs steeply towards Peter Gordon Pass, Clark Ranges. Due to the vertical discrepancies in the current DTM, an ALS survey will confirm the extent of the topography and whether one or more bridge structures will be required rather than using high embankments to navigate the valley crossings. A number of other 10-15m

[16] Accounts for top soil stripping and excess material generated through cuttings along the route.
[17] Actual extents of cuttings may vary significantly due to vertical discrepancies in current DTM.

high embankments will be required where the alignment traverses steep topography through other parts of the Leichardt and Clark Ranges (as shown in
Figure 5-5 and Figure 5-6).

This route requires no tunnel structure; however, a short retaining wall may be required to stabilize a sharp batter where the route cuts through the side of Peter Gordon Pass, Clark Ranges (CH 380.4km). This will need to be confirmed during detailed design with ALS data.

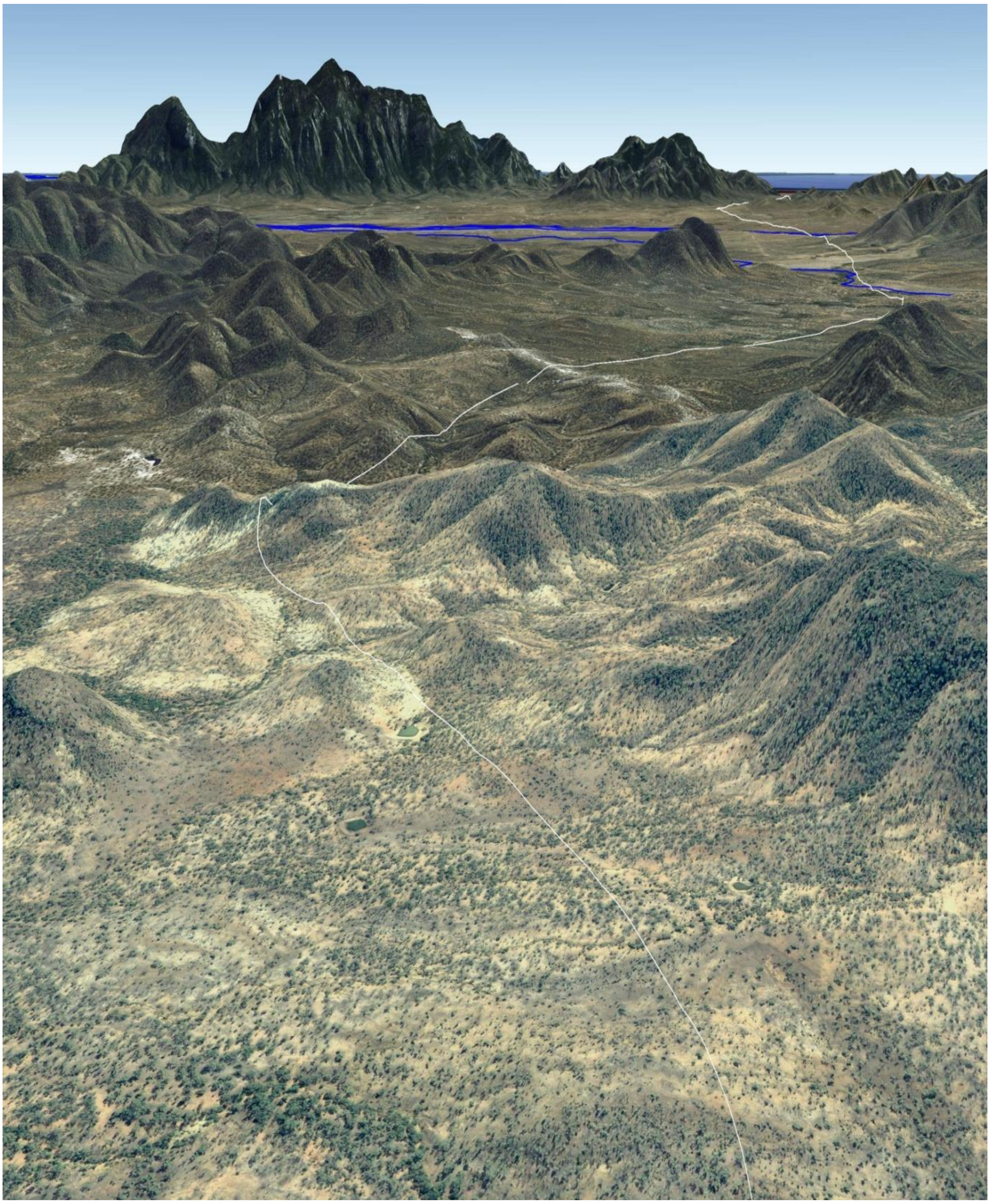


Figure 5-3 – Crossing of Preferred Railway through the Clarke Ranges.

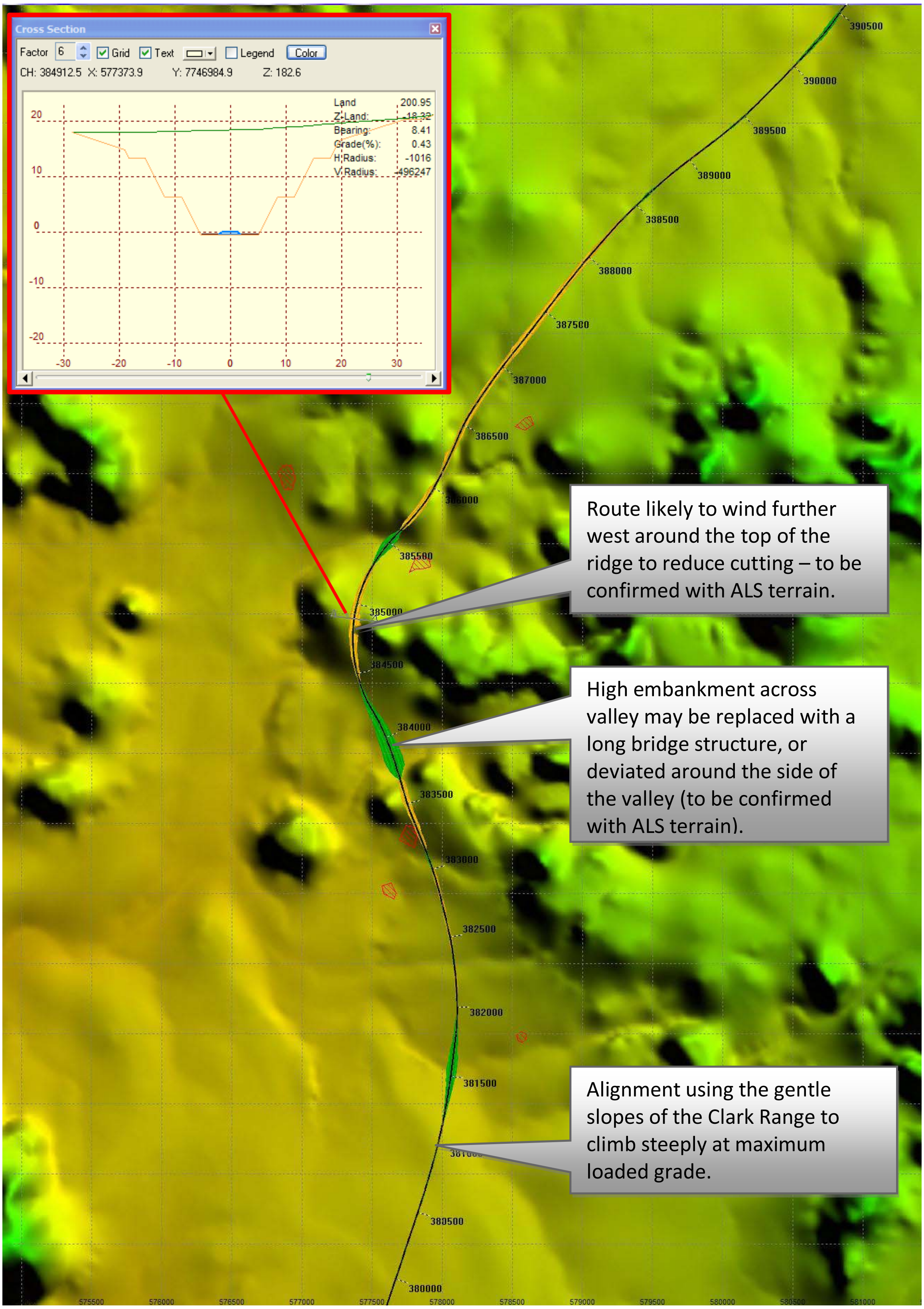


Figure 5-4 – Significant earthworks through Peter Gordon Pass, Clark Ranges.

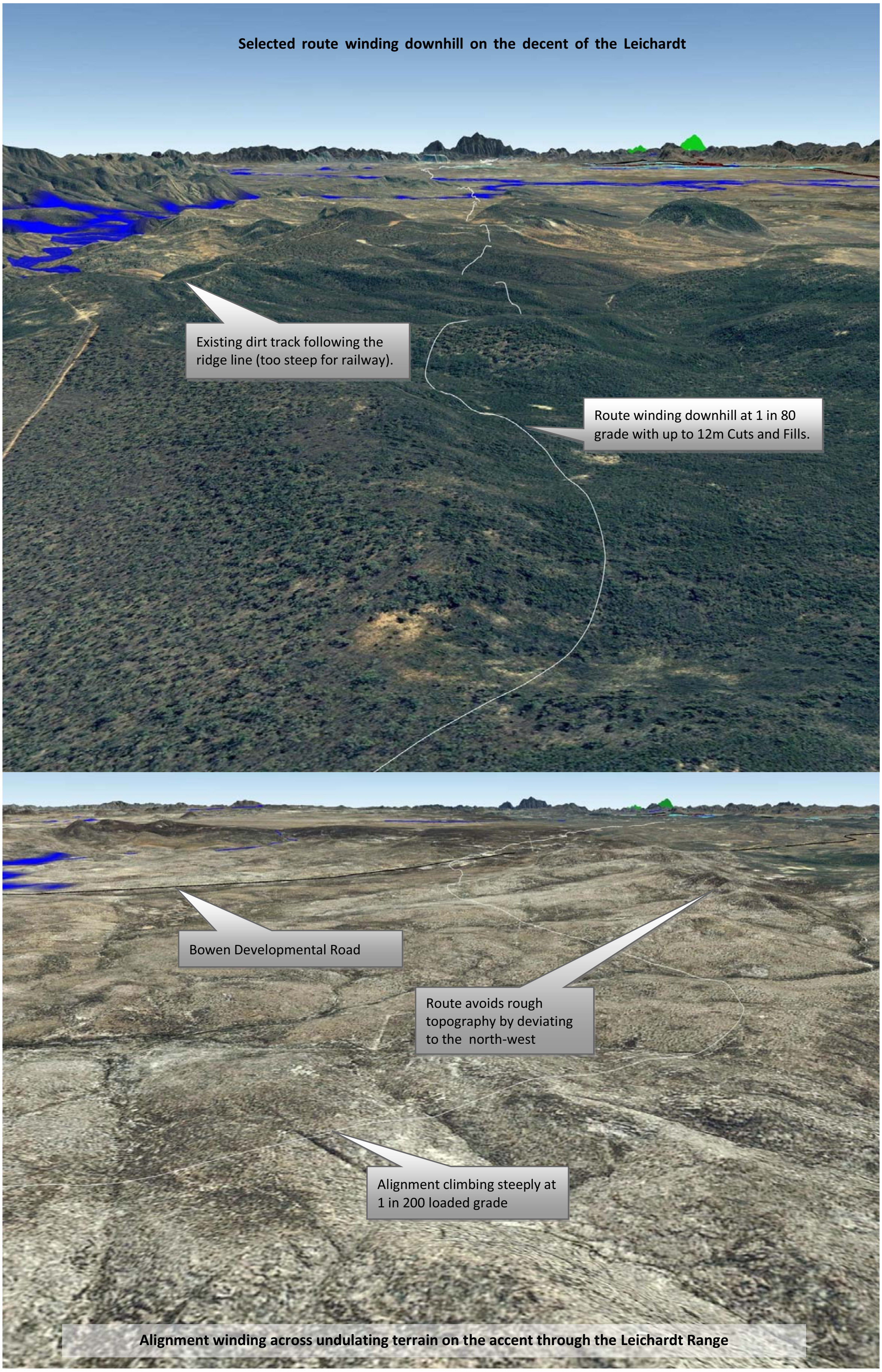


Figure 5-5 – Preferred corridor over the accent and decent sections of Leichardt Ranges.

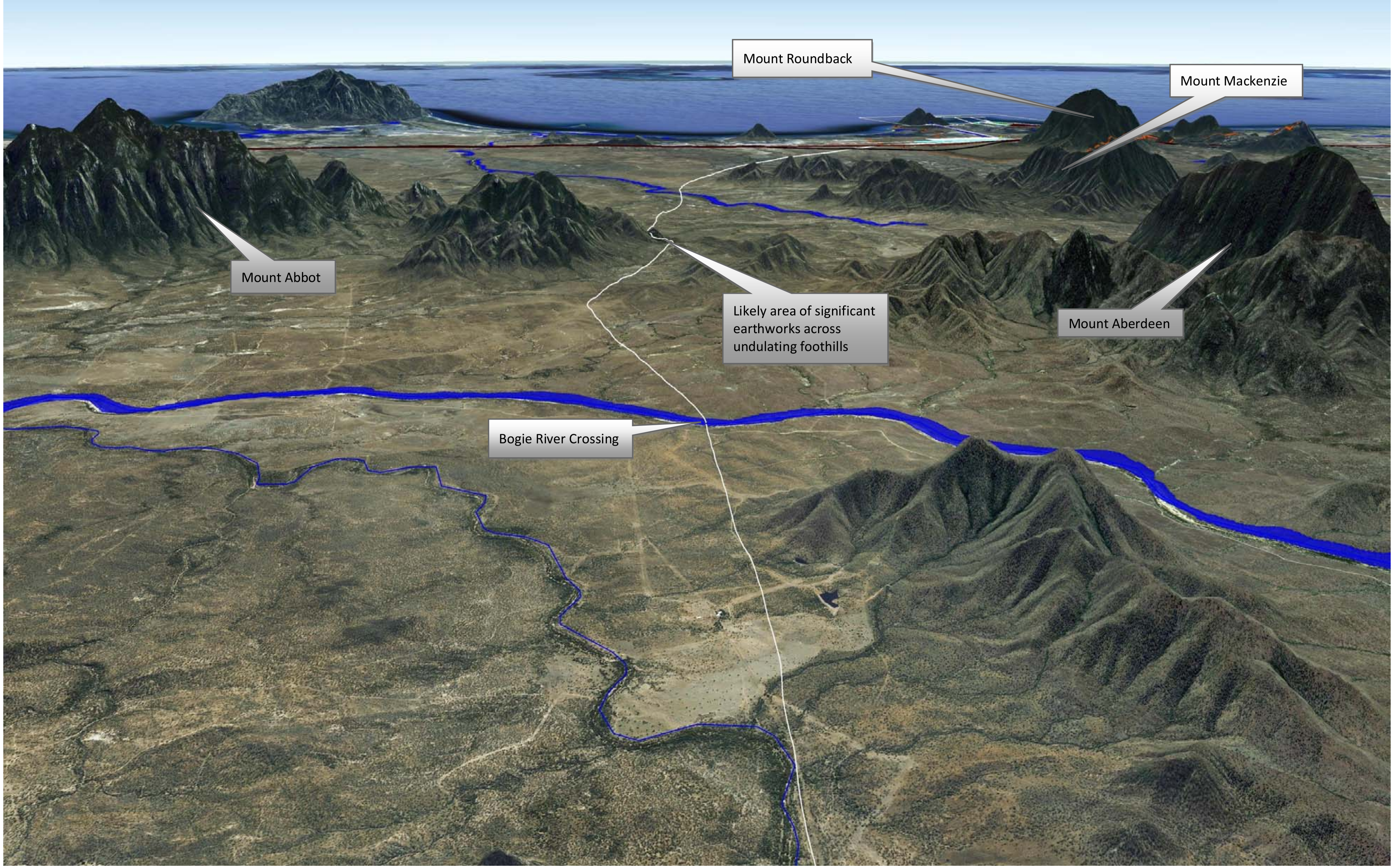


Figure 5-6 – Route traversing the undulating terrain over the foothills between Mt Abbot and Mt Aberdeen.

5.2.2.5 *Surface Geology*

The surface geology along the recommended corridor is illustrated in Figure 5-7, with a detailed breakdown of soil types and composition provided in Appendix D. Generally the corridor ranges from level to gentle sloping volcanic and clay plains in the south, to moderate to steep undulating sandstone ridges with deep gullies through the north.

The southern part of the route (south of the Leichardt Ranges) traverses level to gentle sloping topography and is characterized by its crossing of channel and alluvial clay plains, sandstone low hills and undulating sandy plains. Across floodplains drainage lines are generally broad and shallow. Soil composition is comprised of mostly massive earths, yellow duplex soils and fine textures seasonal cracking clays.

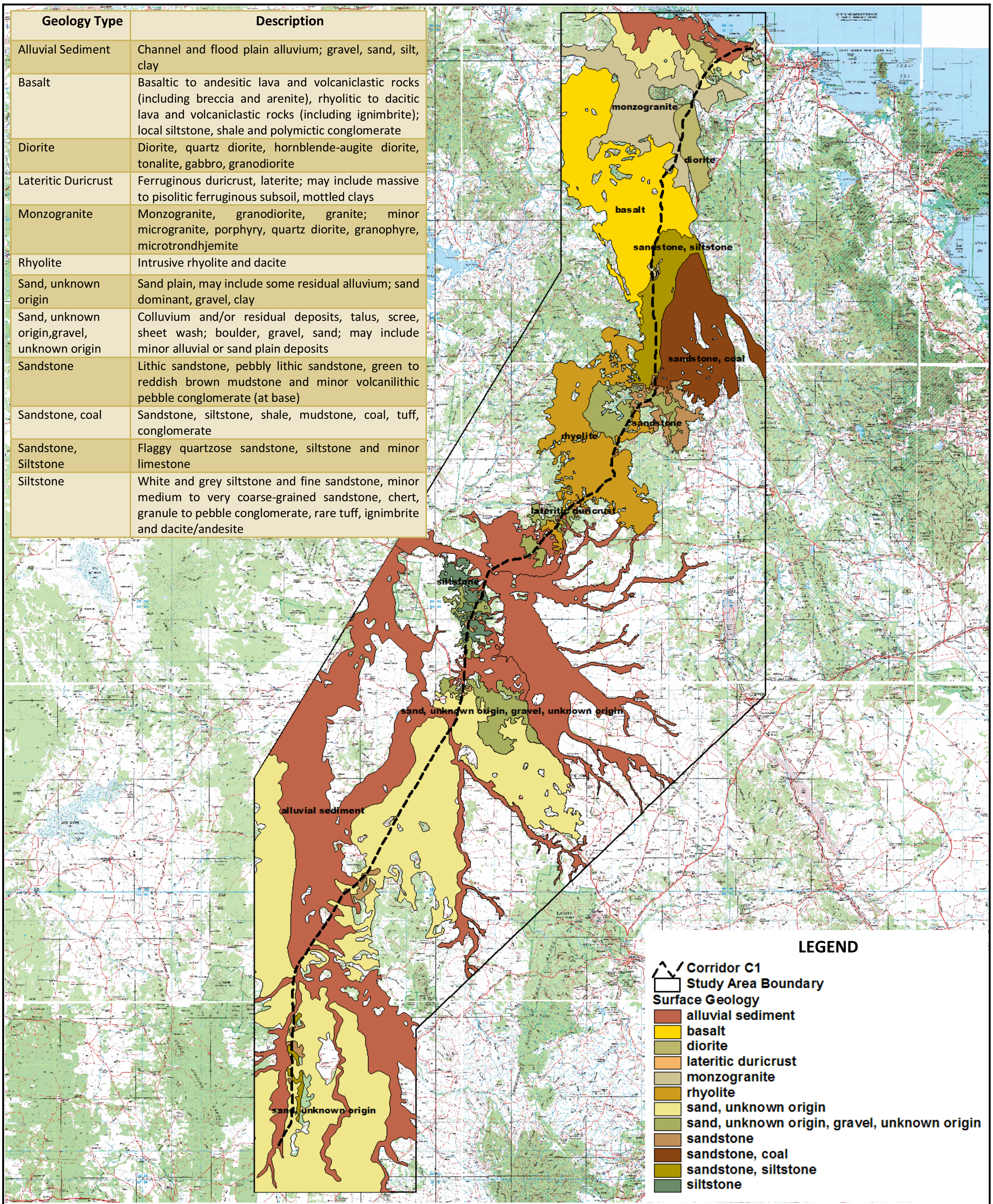
Through the northern part of the study area the route traverses through the moderate to steep undulating slopes of the Leichardt and Clark Ranges. Here the route crosses stony low hills, rocky outcrops, gravelly ridges and exposed cliffs of sandstone, siltstone and basalt. Soil composition is comprised of coarse sandy slopes, yellow-grey duplex soils, red clay soils and cracking clays.

Where possible the route selection has focused on avoiding very steep slopes and erosion prone areas, as well as minimising the disturbances across alluvial floodplains of major drainage lines. The latter presents areas of volatile cracking clays prone to shrinkage and swelling as the soil wets and dries.

The route has allowed for the top 30-50cm soil to be stripped. Dumping stockpiles that are protected from erosion during rain events will need to be established at detailed design. The excavatability of material is expected to reduce significantly with depth, with the upper residual soils being easy to rip, while deeper fresh igneous and sedimentary rock likely to occur between 10-20m below the surface requiring blasting.

At this point in the assessment the disturbance and exposure of soils that are vulnerable to erosion and structural degradation has not been assessed. This is expected to be carried out at detailed design along with other geotechnical investigations to establish depth and quality of useable soils. Of particularly significance will be the assessment of soils on steep slopes that will be exposed through cutting activities.

Geology Type	Description
Alluvial Sediment	Channel and flood plain alluvium; gravel, sand, silt, clay
Basalt	Basaltic to andesitic lava and volcaniclastic rocks (including breccia and arenite), rhyolitic to dacitic lava and volcaniclastic rocks (including ignimbrite); local siltstone, shale and polymictic conglomerate
Diorite	Diorite, quartz diorite, hornblende-augite diorite, tonalite, gabbro, granodiorite
Lateritic Duricrust	Ferruginous duricrust, laterite; may include massive to pisolitic ferruginous subsoil, mottled clays
Monzogranite	Monzogranite, granodiorite, granite; minor microgranite, porphyry, quartz diorite, granophyre, microtrondhjemite
Rhyolite	Intrusive rhyolite and dacite
Sand, unknown origin	Sand plain, may include some residual alluvium; sand dominant, gravel, clay
Sand, unknown origin,gravel, unknown origin	Colluvium and/or residual deposits, talus, scree, sheet wash; boulder, gravel, sand; may include minor alluvial or sand plain deposits
Sandstone	Lithic sandstone, pebbly lithic sandstone, green to reddish brown mudstone and minor volcanilithic pebble conglomerate (at base)
Sandstone, coal	Sandstone, siltstone, shale, mudstone, coal, tuff, conglomerate
Sandstone, Siltstone	Flaggy quartzose sandstone, siltstone and minor limestone
Siltstone	White and grey siltstone and fine sandstone, minor medium to very coarse-grained sandstone, chert, granule to pebble conglomerate, rare tuff, ignimbrite and dacite/andesite



LEGEND

- Corridor C1
- Study Area Boundary

Surface Geology

- alluvial sediment
- basalt
- diorite
- lateritic duricrust
- monzogranite
- rhyolite
- sand, unknown origin
- sand, unknown origin, gravel, unknown origin
- sandstone
- sandstone, coal
- sandstone, siltstone
- siltstone

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Galilee Basin Coal Railway
Pre Feasibility Study
Quantm Route Analysis
Figure 5-7 - Surface Geology
(Southern Study Area)
GALILEE BASIN, QUEENSLAND, Australia

DRG NO: 10.60.002-004A-2

5.2.2.6 *Bridges*

Where major waterways and existing infrastructure need to be crossed, elevated bridges will be constructed to support the rail track above Q100 flood levels. Examples of typical freight rail bridges used in Queensland are illustrated in Figure 5-8.

The preferred route has been vertically optimised to ensure minimum clearances for flood immunity and to reduce overall environmental impact over the river crossings. To reduce disturbance to the surface water flow patterns and directions, the rail corridor has been aligned such that the bridges cross perpendicular to the main drainage channels and floodplains.

A breakdown of the twelve major bridge crossings for the preferred route is provided in Table 5-4. It is expected that more detailed flood studies may identify further bridging requirements. In addition to this, four road-over-rail bridge crossings will be needed for crossings of the Gregory Developmental Road, Suttor Developmental Road, Bowen Developmental Road and Bruce Highway. This is in favor of the rail passing over the road crossings which is expected to result in longer bridge spans and thus cost. An allowance of $30,000,000 AUD in the costing has been made for 4 x additional road-over-rail bridges, with more detailed costing and the design to be determined at detailed design.

Table 5-4 - Bridge Specifications for Major River & Infrastructure Crossings.

No	Watercourse Name	Start (Chainage)	Finish (Chainage)	Bridge Type	Length (m)	Maximum Height of Crossing (m)	Area (m^2)	Cost ($)
1	Sandy Creek	47290	47340	Concrete Deck	50	7.0	209	2410000
2	Belyando River	64023	64114	Concrete Deck	92	6.0	386	4430000
3	Lestree Hill Creek	76752	76787	Concrete Deck	35	6.0	146	1680000
4	Middle Creek	128627	128691	Concrete Deck	64	6.0	268	3080000
5	Mistake Creek	161190	161230	Concrete Deck	40	6.5	168	1930000
6	Suttor River (south)	219020	219066	Concrete Deck	46	7.0	192	2210000
7	Suttor River (north)	303667	303727	Concrete Deck	59	10.0	249	2870000
8	Bowen River	342648	342993	Concrete Deck	345	28.0	1450	16700000
9	Pelican Creek	356492	356855	Concrete Deck	363	17.0	1520	17500000
10	Sandy Creek	392775	392817	Concrete Deck	42	6.5	178	2050000
11	Bogie River	400600	401034	Concrete Deck	434	18.0	1820	21000000
12	North Coast Railway	437839	437950	Concrete Deck	111	10.0	468	5380000

5.2.2.7 *Culverts*

Culverts will support the railway across minor surface drainage features including small creeks, gullies and floodplains. The route will have at least 363 culverts[18]; however, this is likely to increase as more accurate hydrology information is obtained, and to account for locations were stock, farm equipment, and fauna, will need to pass underneath the route. Culverts are likely to be of reinforced box type (RCB), sized suitably to avoid hazardous flooding and failures of railway embankment structures. A typical culvert for a railway stock crossing is shown in Figure 5-9.

[18] Based on crossings of minor creeks using a single cell and across floodplains (4x culverts /km)

Figure 5-8 - Examples of Queensland Rail Bridges at Eumundi & Collinsville over the Bowen River (top left).

Figure 5-9 - Railway Stock Crossing using a Reinforced Box Culvert Cells.

Across the Q100 floodplains culverts will be suitably sized and placed to accommodate flood waters and limit backwater flooding and liquefaction of the rail embankment. Ensuring flood immunity to the 1 in 100 year flood event is essential as the sort of inundation can be seen from Figure 5-10 which shows the flooding of Mistake Creek in February 2008. .

Figure 5-10 - Flooding of Mistake Creek– February Floods, 2008.

5.2.2.8 *Water Supply*

The water supply for the construction and long term operation of the railway and its associated infrastructure will be sourced from either existing urban supplies where practical, or harvested from suitable surface drainage and groundwater sources to be established through more detailed investigations.

It is expected that water for rail unloading facilities and the maintenance and refueling workshop at the port will be provided through the existing Bowen supply water grid, or through the future provision of water to the APSDA by SunWater's proposed 150km pipeline from the Burdekin River.

Water requirements for coal loading infrastructure and associated railway works near the mine will be provided from either groundwater extracted from the dewatering operations at the mine, or a new pipeline serving the mine, drawing on water from either the Burdekin Dam (315km pipeline), Connors River Dam (225km pipeline to Moranbah), or suitably located dam on the Belyando River (50-75km pipelines).

Along the railway corridor water will be sourced from either existing domestic supplies from Collinsville and Mt Coolon, established dams and bores with access to be negotiated with local land owners and as a last resort, through the establishment of new groundwater bores to harvest water from underground alluvial river systems.

Along the proposed corridor a preliminary assessment of existing dams, groundwater bores and reservoirs within a 10km range of the route is provided in Appendix E.

5.2.2.9 *Material Sources*

Construction aggregate for the rail embankments (estimated at 8,150,000 m^3) will be sourced from material recovered from construction of the railway cuttings (estimated at 13,600,000 m^3). The excess cut material is unlikely to be suitable for railway ballast. A proportion of the surplus Cut constitutes topsoil to be stripped and stockpiled for future rehabilitation works. Where suitable construction material cannot be sourced from within the railway cuttings, a series of borrow pits will need to be established, or the material hauled from nearby quarries. The location and spacing of borrow pits have not been established in this study, but will be required to be located away from sensitive environments such as significant vegetation, surface drainage, etc. Ballast material (estimated at 1,000,000 m^3 bulk cubic meters) will be sourced from existing and new quarries sites owned and operated by China First. The locations and availability of suitable grade ballast is currently being investigated through further in house geotechnical studies.

The route has been optimised to minimise and balances earthworks, thereby reducing mass haulage of material of material along the railway corridor or local roads.

Figure 5-11 shows a profile of the preferred route over a section of the Leichardt Ranges which exhibits significant earthworks. The green line, representing the movement of usable material, consistently intersects the axis indicating points were earthworks are regularly balanced thereby reducing the need to haul material over long distances.

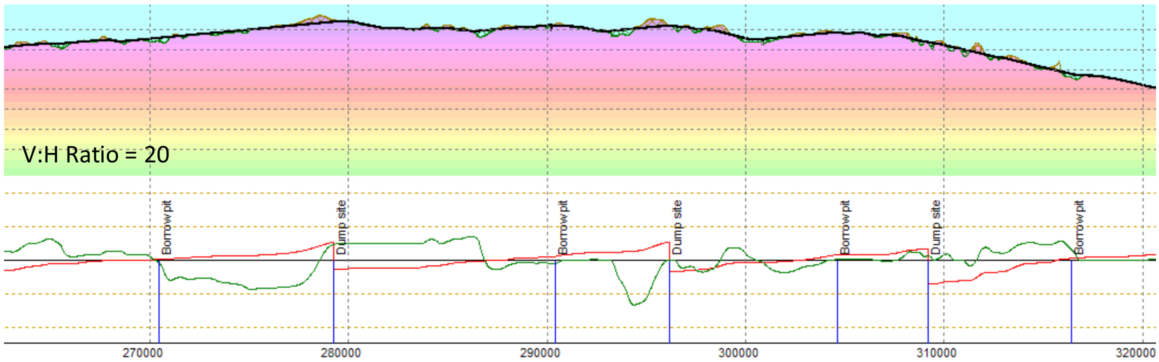


Figure 5-11 - Mass Haul Diagram (CH 260km-320km).

5.2.2.10 *Environmental Impact*

The preferred route has been assessed as having the least environmental impact of all the short-listed corridors. It avoids all identified national parks, protected wetlands, nature refuges, resources areas and state forests. The potential environmental impacts from the railway are the loss of vegetation, impacts to aquatic ecosystems through floodplains, scarring of landscape from cuttings and embankments, impediments to wildlife, noise and dust pollution, and water contamination from runoff. Although measures have been taken in this study to minimise these impacts (such as using penalties weightings to deter encroachment), some will be unavoidable. Suitable mitigation measures for dealing with these impacts will be established at detailed design and incorporated into future Construction and Operational Environmental Managements Plans.

Strategic locations for river and floodplain crossings have been chosen that minimise potential environmental environmental impact caused from structures and flood protected embankments. The alignment has been optimised to been optimised to cross rivers perpendicular, while encroachment through the extensive river systems has been systems has been minimised by deviating the route around the Q100 floodplains. Examples of this are illustrated in are illustrated in

Figure 5-12 and Figure 5-13, showing the route deviating north to cross a narrow part of the Suttor River Confluence. As a result this has reduced the length of the floodplain crossing from over 20km to 5km, and the number of major bridge crossings from 3 down to 1.

The railway corridor will result in the unavoidable loss of vegetation through the clearing, excavating and filling along the railway corridor. The estimated impact of the selected route to endangered and of-concern REs is 201,000 m^2 and 1,390,000 m^2 respectively. The coverage of REs across the preferred railway corridor is illustrated in Figure 5-14, with a more detailed assessment provided in Appendix F.

During the refinement stage of the preferred corridor, REs were included with associated penalty weightings to deter footprint encroachment. As a result the refined route reduced impacts through endangered and of-concern ecosystems by 43%, and 16% respectively, at the expense of a marginally longer route (approximately 2km). Figure 5-15 shows a section of the route before and after it was optimised with consideration to regional ecosystems. It can be clearly seen where the refined route pushes outside or along the boundary of the protected vegetation habitats to reduce impacts.

The primary area of endangered ecosystems impacted falls across a 30km stretch immediately prior to where the route crosses the downstream reaches of the Suttor River (CH 190-220 km). It should be noted that despite the impact to sensitive vegetation through this area, by using this area to deviate around the extensive Suttor River Floodplain the overall environmental impact is expected to be less.

All impacted vegetation is from the Brigalow Belt biogeographic region predominately falling across either flat to gentle alluvial and clay plains, or hills and lowlands on sedimentary or igneous rocks. The more significant vegetation types directly impacted by the preferred route are listed in Table 5-6, with select examples of vegetation types shown in Figure 5-16.

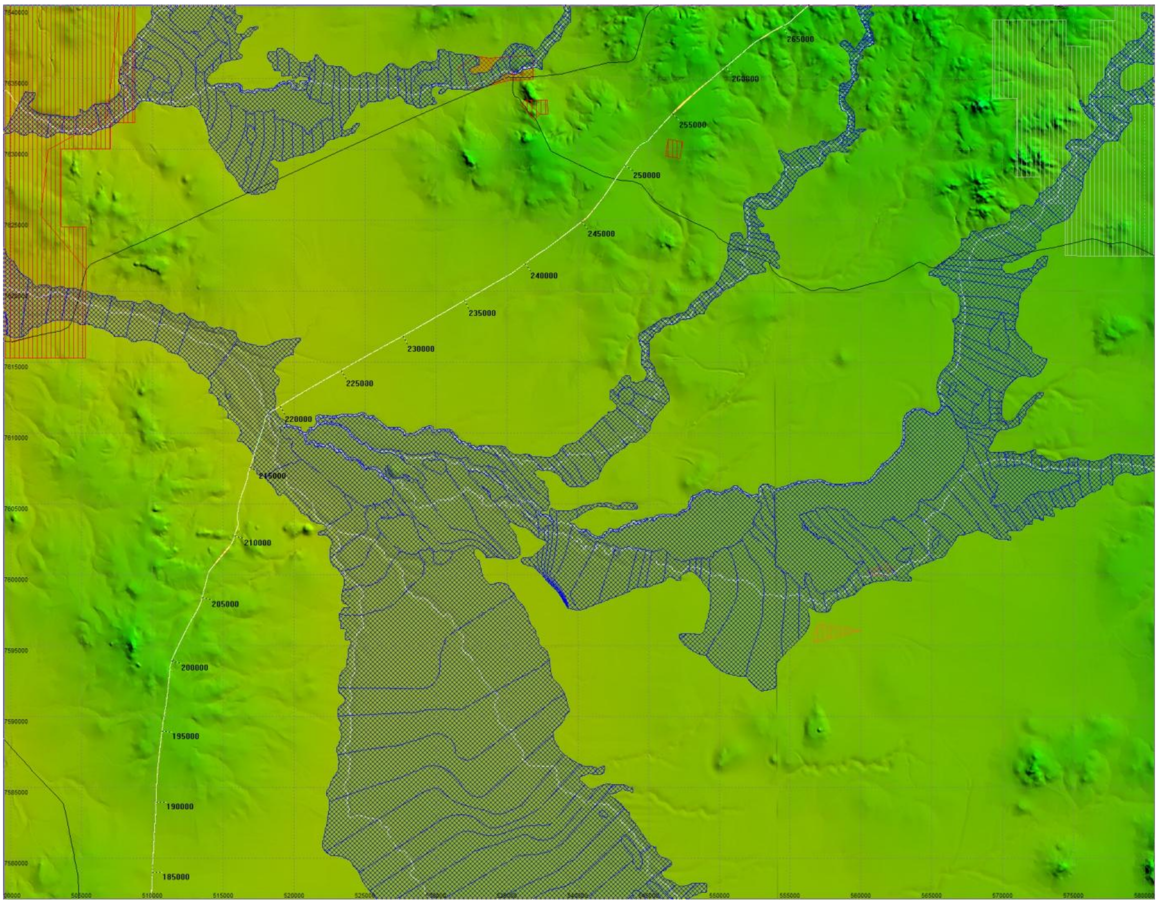


Figure 5-12 - Suttor River Crossing with Q100 Flood Extents (CH 185km -265km).

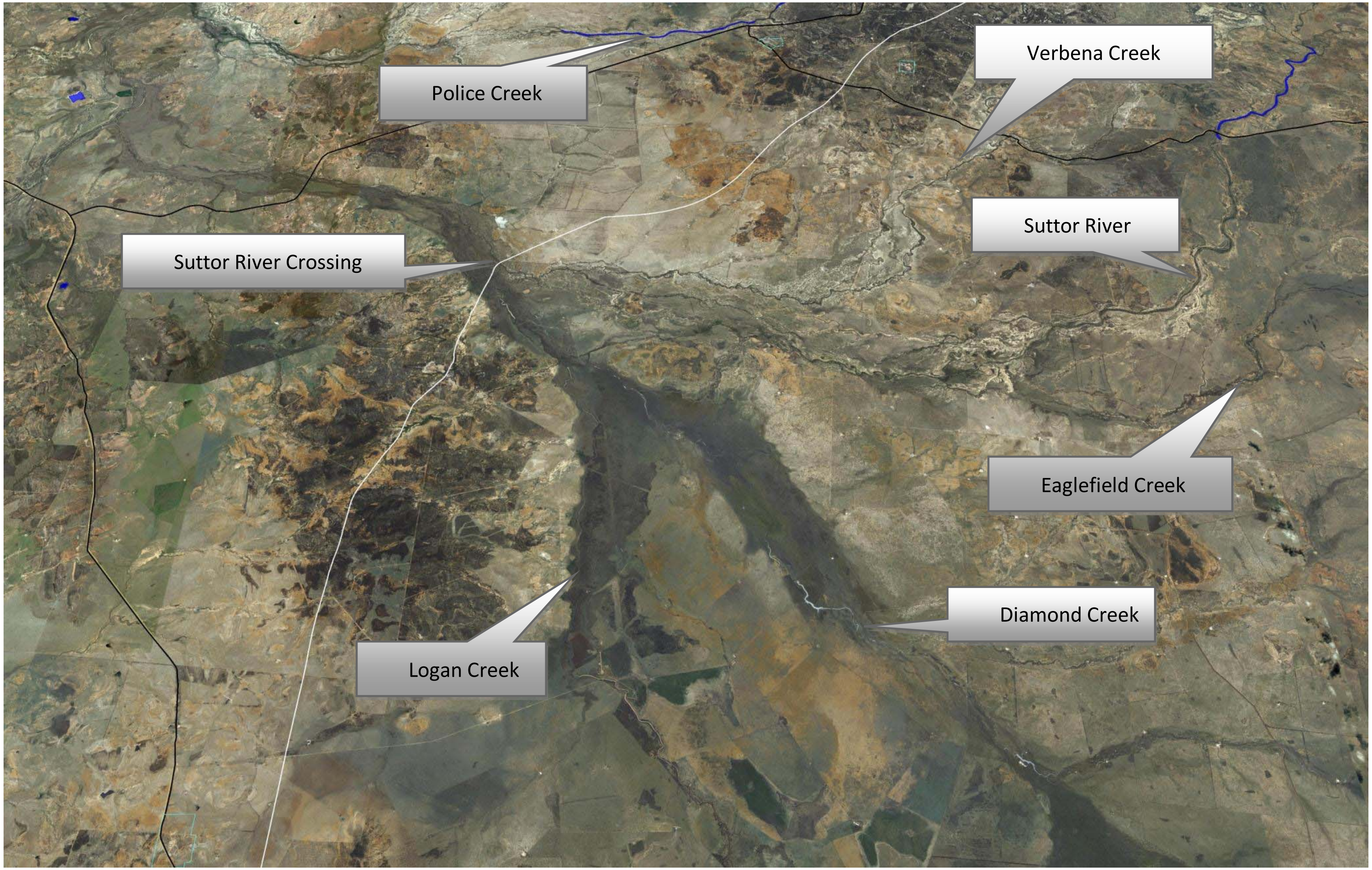
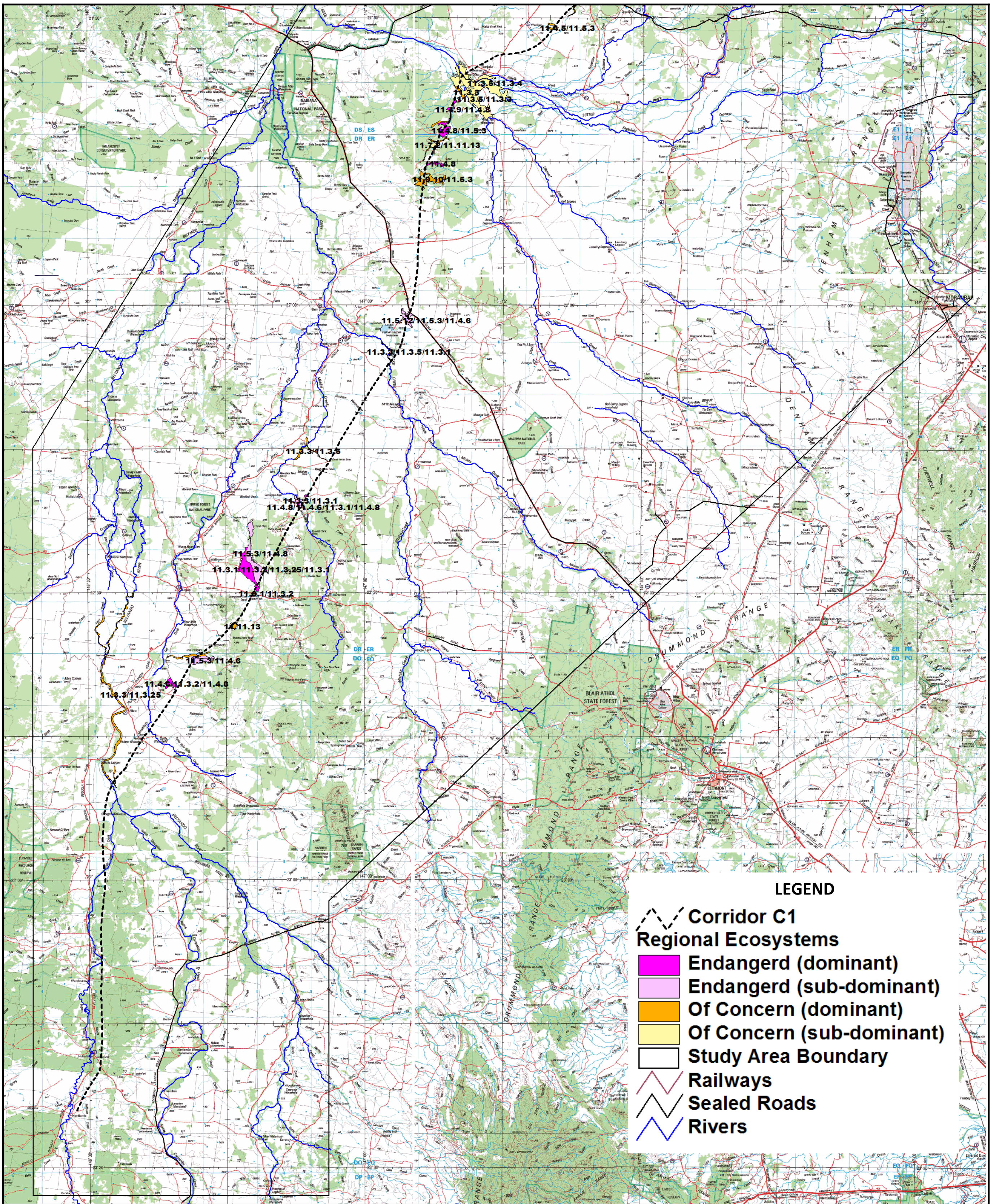


Figure 5-13 – Crossing of the Suttor River System.



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Quantm Route Analysis
Figure 5-14a - Regional Ecosystems
(Southern Study Area)
GALILEE BASIN, QUEENSLAND, Australia

DRG NO: 10.60.002-003H-3

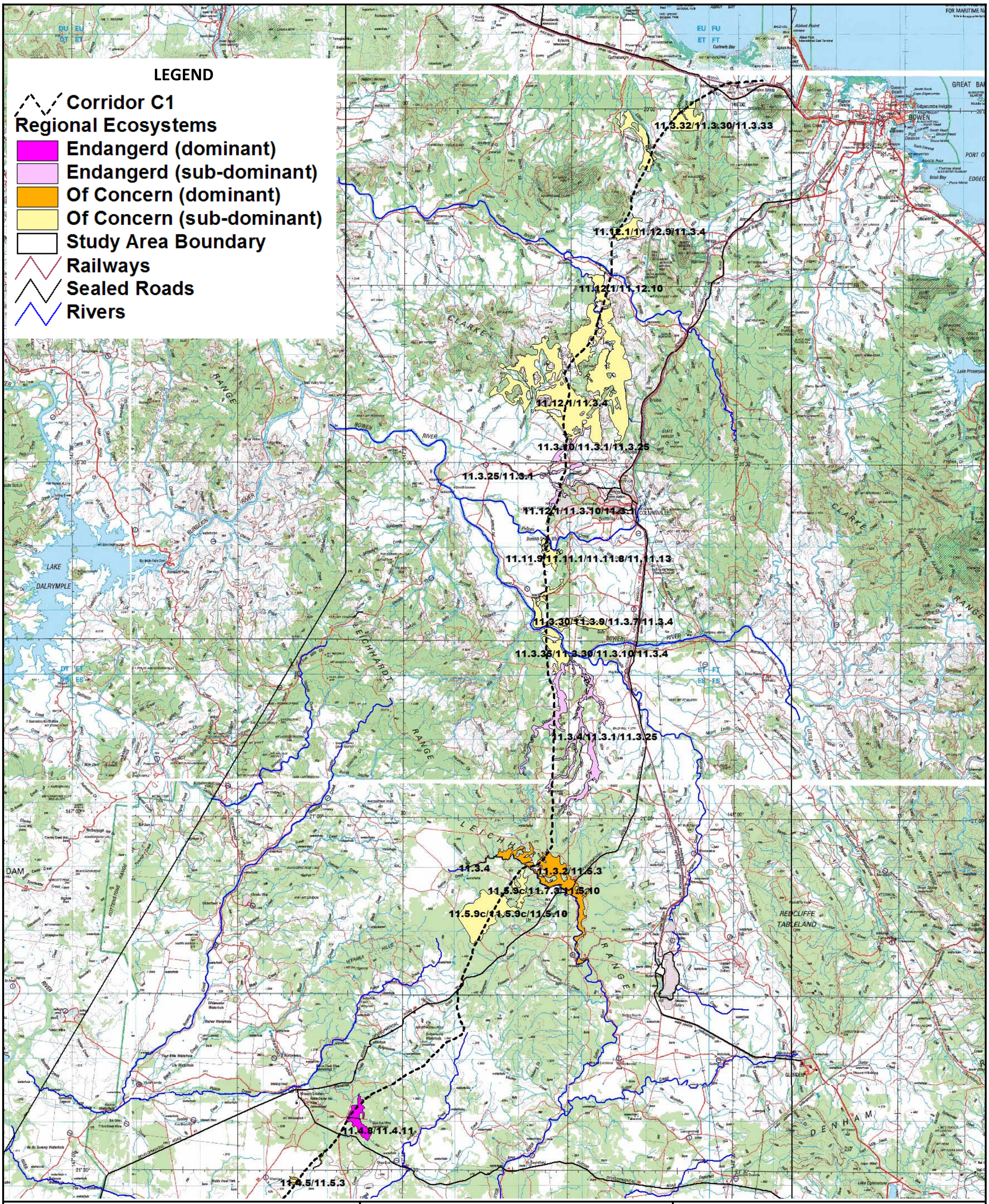

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Figure 5.14b - Regional Ecosystems
(Northern Study Area)
GALILEE BASIN, QUEENSLAND, Australia

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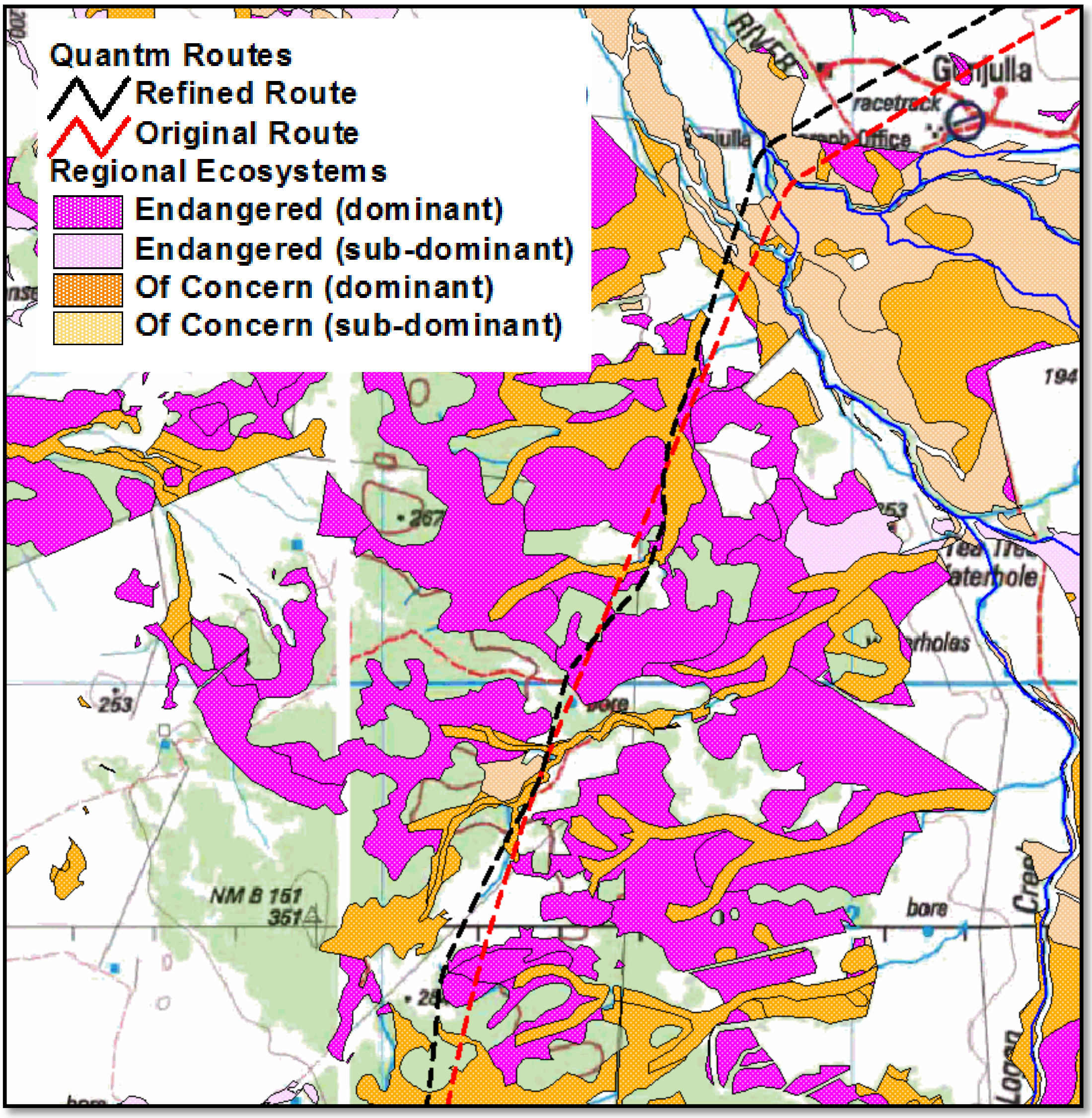
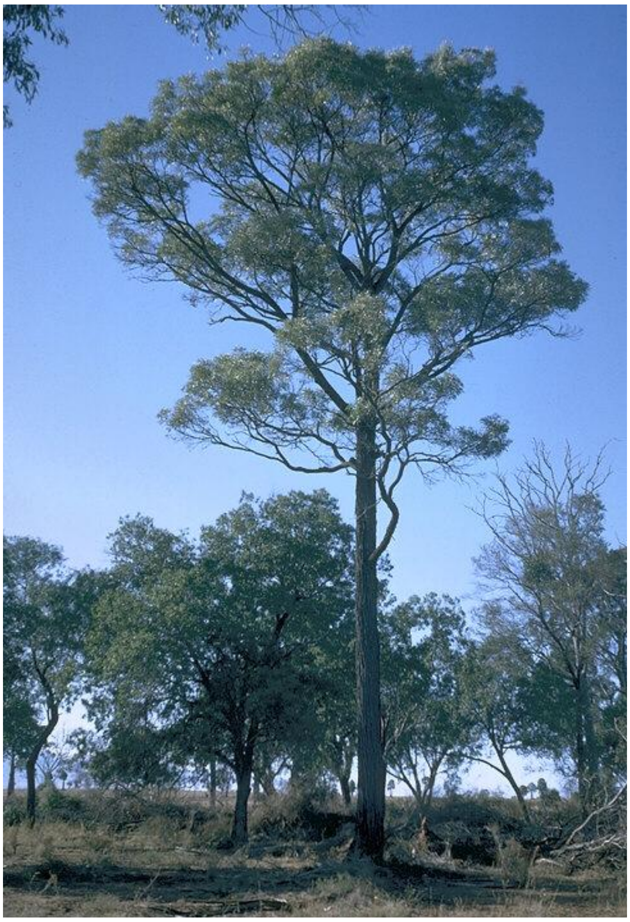


Figure 5-15 - Impact to Regional Ecosystems – South of Suttor River Crossing (CH 195-225km).

Table 5-5 - Vegetation Types Falling Across Preferred Corridor.

RE Index	Description	Biodiversity Status
11.3.1	*Acacia harpophylla* and / or *Casuarina cristata* open forest on alluvial plains	Endangered
11.4.5	*Acacia argyrodendron* woodland on Cainozoic clay plains	Endangered
11.4.6	*Acacia cambagei* woodland on Cainozoic clay plains	Endangered
11.4.8	*Eucalyptus cambageana* woodland to open forest with *Acacia harpophylla* or *A. argyrodendron* on Cainozoic clay plains	Endangered
11.4.9	*Acacia harpophylla* shrubby open forest to woodland with *Terminalia oblongata* on Cainozoic clay plains	Endangered
11.9.10	*Eucalyptus populnea*, *Acacia harpophylla* open forest on fine-grained sedimentary rocks	Endangered
11.3.2	*Eucalyptus populnea* woodland on alluvial plains	Of concern
11.3.3	*Eucalyptus coolabah* woodland on alluvial plains	Of concern
11.3.4	*Eucalyptus tereticornis* and / or *Eucalyptus* spp. tall woodland on alluvial plains	Of concern
11.3.5	*Acacia cambagei* woodland on alluvial plains	Of concern
11.12.10	*Corymbia clarksoniana* woodland on igneous rocks	Of concern
11.11.13	*Acacia harpophylla* or *A. argyrodendron*, *Terminalia oblongata* low open forest on deformed and metamorphosed sediments and interbedded volcanics	Of concern

Eucalyptus Cambageana



Acacia Harpophylla

Eucalyptus Coolabah

Eucalyptus Populnea

Figure 5-16 – Protected Vegetation Habits Impacted by the Selected Route.

It is expected that the overall impact to wildlife will be minimal with known terrestrial environments containing rare flora and fauna avoided. This includes national parks, forests and nature refuges, with the route predominately crossing cleared land used for cattle grazing and agriculture. This includes avoiding Epping Forest National Park which currently provides a habitat for the sole remaining natural habitat of the Northern Hairy Nose Wombat. It is anticipated that a number of culvert underpasses will be located along the railway corridor to provide suitable wildlife crossings, as well as fencing along the boundary of the route to prevent wildlife from entering the railway corridor.

Protected species associated with aquatic resources such as rivers and creeks may be negatively impacted by the construction works of structures over water-crossing. Some of these water bodies are known to contain state-listed species of fish and plants. It's anticipated that consultation with the relevant resource agencies will advise on the most appropriate construction techniques to protect sensitive species and minimize impacts in the specific areas of disturbance. The provision of bridges at waterway crossings will reduce the impact of the project on water flows; however, assessment of abutments and piers on flows will need to be considered at detailed design.

The selected railway route is expected to have the least impact to water quality than the other short listed corridors due to it having the shortest cumulative span over watercourses and floodplains. It is expected that best management practices will be used to suitably alleviate any water quality impacts including the use of silt fencing and use of vegetation swales along the corridor to filter pollutants.

Operational impacts such as noise, dust and vibration emanating from passing trains will be minimal with the railway passing no closer than 2km from the nearest house[19] and 10km from the nearest town.

The areas along the route with extensive earthworks are expected to result in a number of environmental impacts. Cuttings will result in the formation of a scar possibly resulting in loss of visual amenity, while extensive cuttings may affect habitat connectivity and be more sensitive to erosion and flooding.

High embankments can also have visual and aesthetic impacts, reduce stability, restrict habitat movement, provide water flow restriction due to unnatural formations and increase storm water runoff due to varying gradients on the embankments. Where embankments intersect natural drainage lines, it is proposed culvert structures or fauna passages be adopted to reduce the environmental impact at these sensitive locations.

[19] Except for one property near Collinsville (refer to section 5.2.2.11)

5.2.2.11 *Land-Use Impact*

The construction of the railway corridor will result in a number of unavoidable impacts to the various land uses that exist across the study area including coal mining, beef cattle grazing, agriculture and native title regions.

Due to the linear nature of the railway the project will require acquisition of a select number of properties. This is likely to result in fragmentation, temporary disruption to rural activities from land-locking and loss of access, as well as the decline in value of the properties intersecting the corridor. Those that will be directly impacted by the preferred route are illustrated in Figure 5-19, with a more detailed assessment provided in Appendix G.

Direct impacts to houses and other established infrastructure (e.g. large dams, irrigated farmlands, etc) have been minimised by ensuring footprint encroachment is at least 2km away from the boundary of these (often located much further).

One residence exists on the banks of Pelican Creek and west of Xstrata Mine which lies within 600m of the railway of the railway corridor, as shown in

Figure 5-17. This is a critical location for the railway with little freedom to deviate without incurring significant costs. To the east is Xstrata's ML and open cut operations, while deviating to the west is likely to require a significant length of extra track. More importantly though the alignment uses the gently sloping uphill terrain alongside the mining lease, to begin its maximum grade climb into the Clark Ranges. It is expected that if the route was pushed further west it may reduce the overall effectiveness of crossing the Clark Ranges through Peter Gordon Pass.

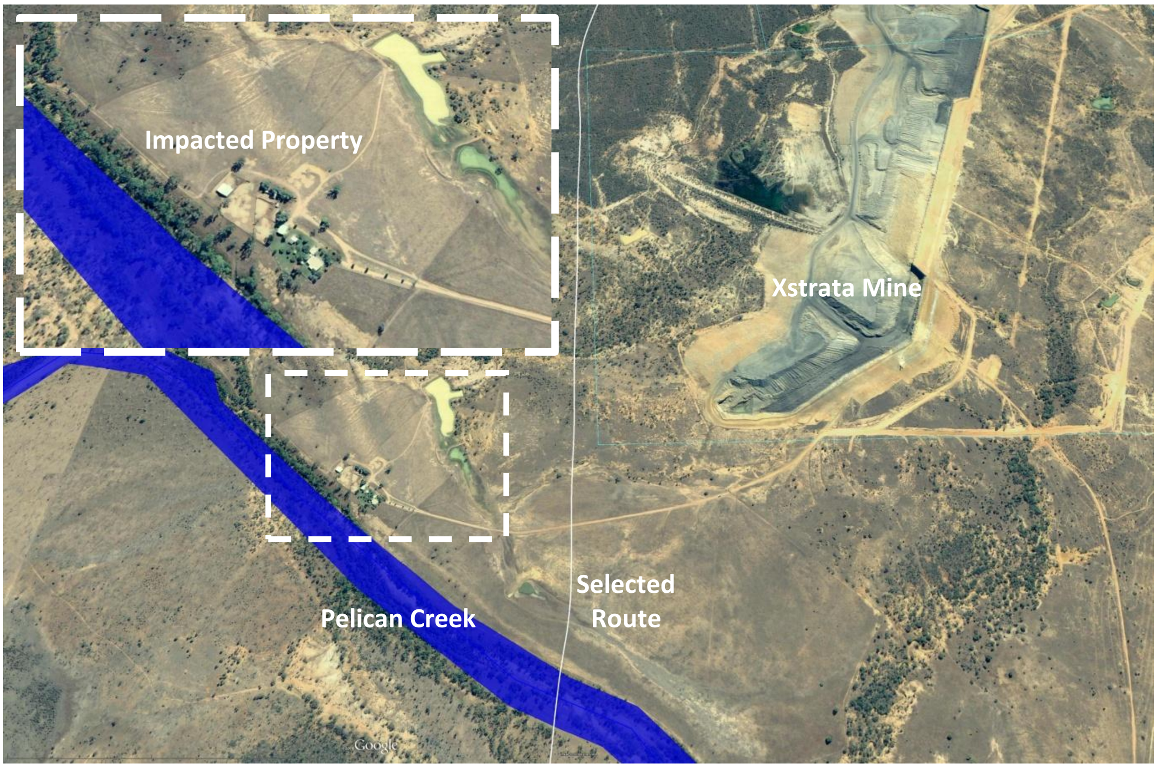


Figure 5-17 - Possible property that may be impacted by the heavy haul railway.

The impact of rail noise and vibration, safety and dust on residential developments and other noise sensitive land uses may vary depending upon a range of factors including the speed of trains, the extent of landform shielding and the location of rail infrastructure such as bridges. It is expected that these effects will be considered in more detail with future planning studies and community consultation.

The preferred route will have limited impacts to the small number of townships situated nearby the railway. These railway. These include Alpha, Mount Coolon and Collinsville, all located more than 10km from the railway corridor. By railway corridor. By passing to the west of Collinsville, as illustrated in

Figure 5-18, the route also has the benefit of avoiding the existing land-use constraints that service the western Bowen Basin mines that lie to the east of Collinsville.

The selected corridor avoids all existing MDLs, MLs, and PLs, while crosses the North Queensland Gas Pipeline in a shallow embankment near the Bowen River and underneath three high voltage power lines (one within the China First Tenement, the others two near Collinsville).

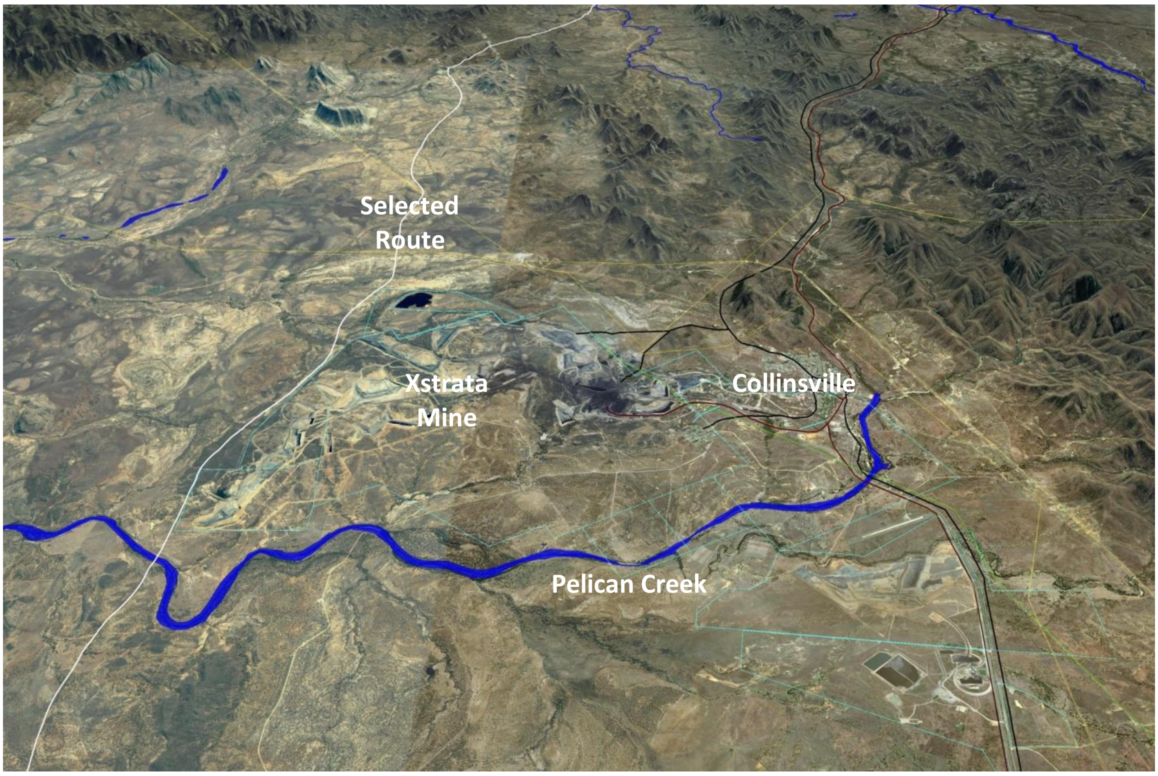


Figure 5-18 - Crossing of Selected Route to the West of Collinsville

The recommended alignment passes through the Blue Valley Damsite Burdekin and Bowen Rivers restricted area, as defined by DEEDI. This region allows exploration activity subject to increased restrictions and conditions, as specified by Schedule 3 of the Mineral Resources Regulations 2003. It’s recommended that a register search be conducted prior to detail design to identify the particular restrictions that may be applicable by crossing this restricted area.

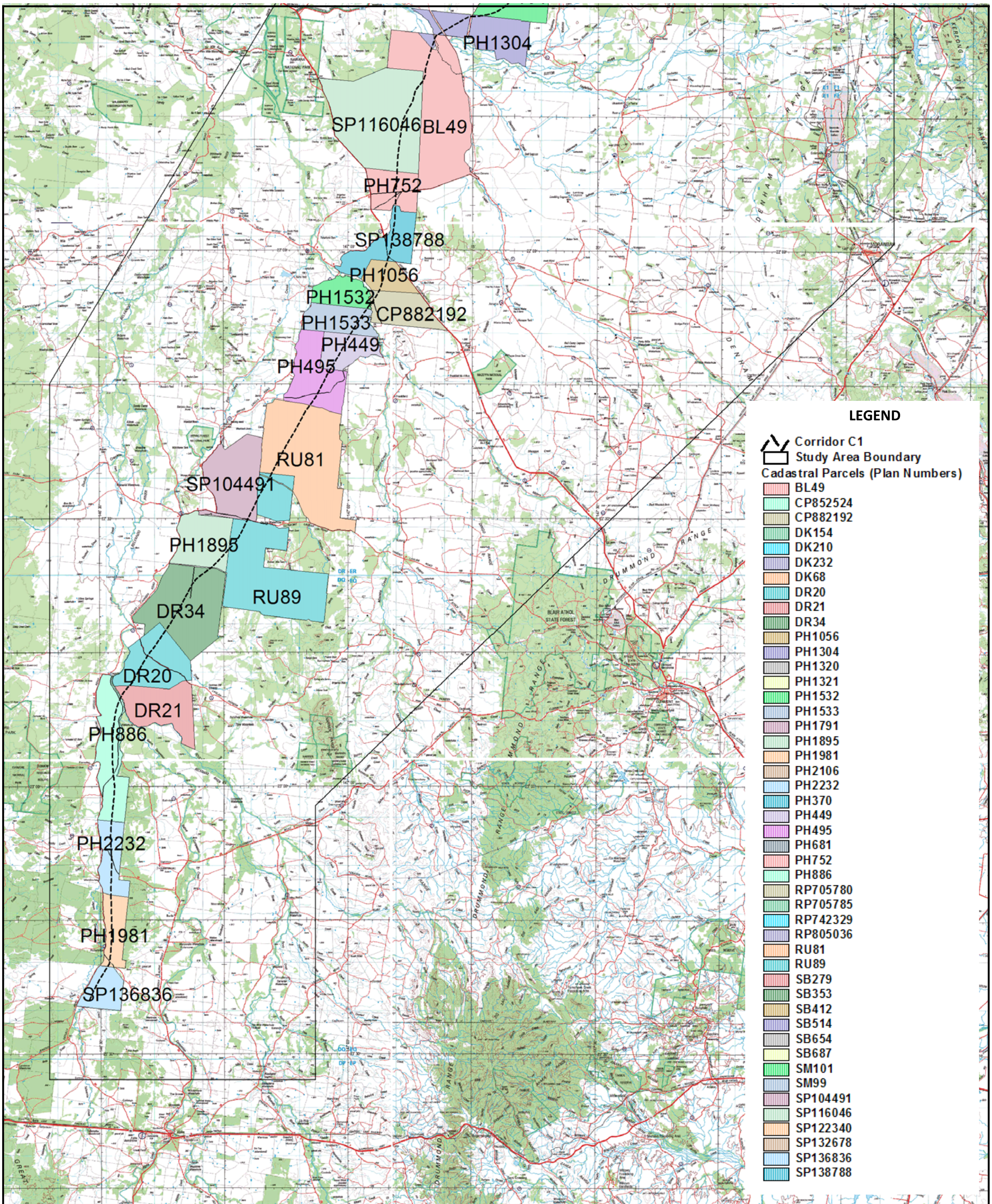


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Figure 5-19a - Cadastral Parcels
(Southern Study Area)
GALILEE BASIN, QUEENSLAND, Australia

DRG NO: 10.60.002-012-1

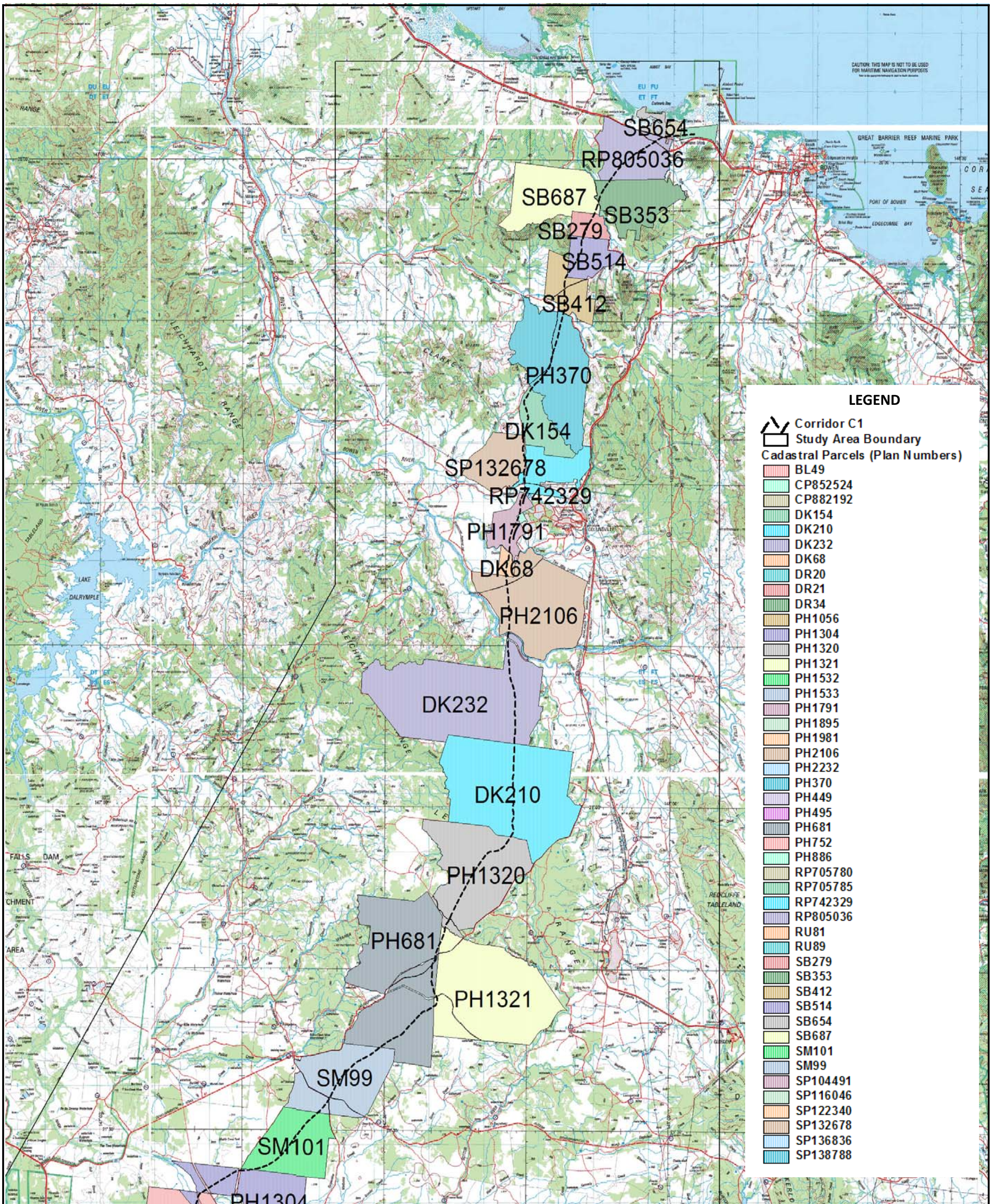

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Figure 5.16b - Cadastral Parcels
(Northern Study Area)
GALILEE BASIN, QUEENSLAND, Australia

DRG NO: 10.60.002-012-2

5.2.2.12 *Passing Sidings and Rail Facilities, Ancillary Services*

The proposed railway has been considered for suitable locations for passing sidings based on the topography and alignment geometrics (no train performance modeling of travel times has been ascertained). Passing loops are required to reduce congestion and delays with passing trains. As a result, nine suitable locations have been identified and are shown in Table 5-6, spaced approximately 40-50km apart and of 3.5km in length to accommodate a full train consist. At these locations the topography has been assessed to be relatively flat, crossing no major watercourses or infrastructure, with the passing lane on a relatively straight horizontal and vertical curve. The location of passing sidings along the selected corridor is shown in Figure 5-20.

Table 5-6 - Possible Locations for Passing Loops, Balloons and Marshalling sidings along the Preferred Route.

Passing Loop	Passing Loop Name	Chainage Start	Chainage Finish	Length
n/a	Mine Loadout Balloons	0km	0km	8.0km x 2
1	Eulimble Siding	39km	42.5km	3.5km
2	Sandy Creek Siding	87km	90.5km	3.5km
3	Lascelles Creek Siding	130km	133.5km	3.5km
4	Twin Hills Siding	176km	179.5km	3.5km
5	Suttor River Siding	222km	225.5km	3.3km
6	Parrot Creek Siding	293.1km	296.6km	3.5km
7	Bowen River Siding	337km	340.5km	3.5km
8	Pelican Creek Siding	357.4km	360.9km	3.5km
9	Bogie River Siding	393.5km	397km	3.5km
n/a	Port Unloading Balloons	443.6km	443.6km	8.0km x 2
n/a	Marshalling Yard (Port)	TBD	TBD	8 x 4km lanes
			Rail for Sidings & Balloons =	95.5km
			Main Line =	443.6km
			Total Rail Required for Project =	539.1km

The cross section of the proposed route allows for an access road adjacent to the railway for maintenance, construction and recovery operations. It's expected that power for the maintenance facilitates will be supplied from the regional power grid, while water is likely to be extracted from existing or new groundwater bores established close to the railway corridor.

Determining the locations for facilities associated with the railway, such as rail unloading / loading loops, train marshalling yards, maintenance facilities, sidings, administration offices, warehouse and service facilities, falls outside the scope of this study and are expected to be considered through more detailed planning studies.

Local roads are expected to be used during construction for the transport of materials (fill, ballast, equipment, personnel, etc) with some impacts to existing traffic expected. The following major roads are considered to be the main routes impacted during construction of the railway:

- Bruce Highway;
- Bowen Developmental Road;
- Gregory Developmental Road;
- Suttor Developmental Road;
- Capricorn Highway; and
- Clermont Alpha Road.

5.2.2.13 *Future Growth Opportunities*

The rail corridor will have a beneficial impact to future Galilee Basin coal mines, as it will allow for improved efficient and viability in the transport of coal to the export port and the ability for these mines to access the rail corridor network through construction of balloon loops.

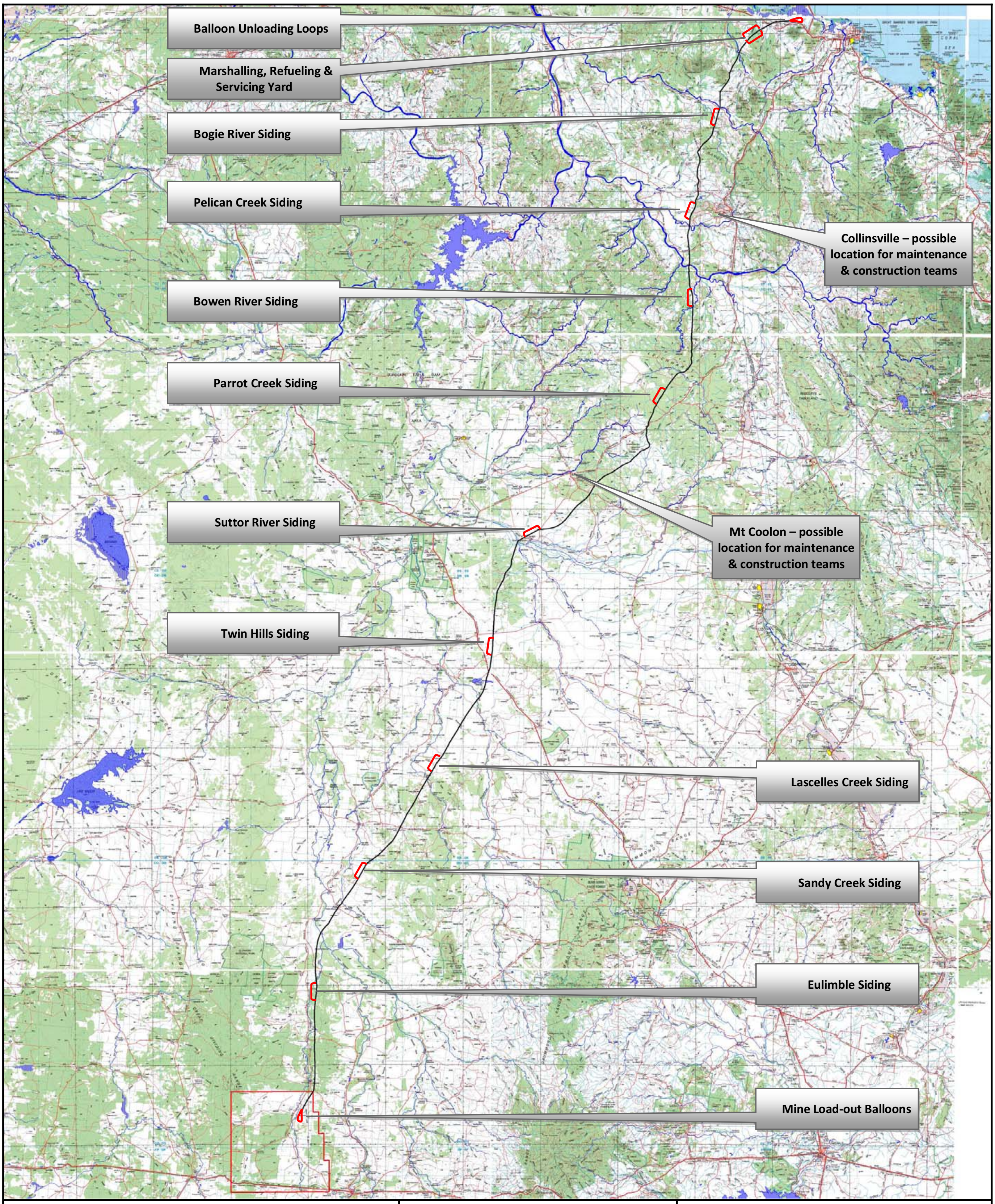

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Figure 5-20 - Location of Passing Sidings
GALILEE BASIN, QUEENSLAND
Australia

DRG NO: 10.60.002-013-1

6 Summary and Recommendations

A strategic railway planning study has been conducted using the Quantm route alignment system to develop the most technically feasible corridor for a state of the art heavy haul railway to link the mine and port. An initial assessment revealed a number of broad corridors which were of low cost, provided compliance to the required engineering standards, and had minimal impacts to the natural and built environments. An evaluation framework formed the basis for comparing and assessing the relative advantages and disadvantages of each alternative. This led to the selection of a preferred corridor (C1), which was subsequently refined to a level sufficiently detailed to allow the corridor to be quickly taken through the statutory planning and approval process and into detailed planning should a decision be taken to proceed with this option. The refined 1.5km corridor is illustrated in Figure 6-1A to Figure 6-1D, with a detailed breakdown of civil works and structures provided in Appendix H.

For the next level of assessment more accurate terrain and constraint data will need to be obtained to generate accurate costing of civil works and to develop the alignment to a suitable accuracy for input into preliminary design. This will need to include the acquisition of high resolution terrain data via an ALS, which will form the basis for a more detailed alignment selection study. It is recommended that a wider capture beyond the current 1.5km width be taken over the less certain sections, such as the steep crossings through the Leichardt and Clark Ranges, across passing loops, at the port to accommodate the marshalling yard and other associated locations where rail infrastructure will be built. It is also recommended that geo-referenced aerial photographs also be captured along the selected corridor as part of the ALS to complement the digital data collected.

More detailed ground investigations and numerical models are recommended to enable cost-effective mitigation measures for the environmental and land-use impacts to be established. This is likely to include in-situ field surveys of geology, ecology and biodiversity, archaeological, flood risk and drainage and cultural and indigenous heritage.

Geotechnical truthing at select locations along the corridor will need to establish soil, rock and groundwater composition and depths. These should concentrate on known locations along the preferred corridor that are likely to present possible areas of deep cuttings (i.e. to establish depth to rock requiring expensive blasting) and known structure crossings over existing infrastructure and rivers. Alignment cuttings through a groundwater table should be identified early, these will need to be mitigated and reduced to neutral level by engineering measures (such as sealed drainage systems). The geology field survey should also include the identification of suitable quarries containing ballast and sub-grade.

Commencement of land negotiations with the affected land owners should begin early to reveal possible barriers and negative impacts associated from operating the heavy haul railway. Although the selected route avoids direct impacts to houses, unavoidable land resumption will result from the intersecting corridor. This includes the landowner residing on Pelican Creek, southwest of Collinsville, where the alignment passes with 600m.

Further work is needed to quantify and mitigate noise, safety and dust impacts to all effected landholders. Consideration for culvert underpasses along each of the affected properties to allow stock, vehicles and machinery to cross under the rail line will need to be established, as will the deviation of minor roads to strategic crossing points along the corridor. The relevant local councils will need to be consulted regarding approval requirements and conditions for crossings of roads under their control.

For the next level of assessment it's suggested that a more thorough socioeconomic appraisal be carried out on each of the individual properties impacted, including determining individual land-use, significance, productivity and value, then estimating appropriate land acquisition and compensation costs, provisions for road access to disjoint or landlocked parcels, mitigation measures from the remnants of dust, noise and weed pollution. Consideration for appropriate compensation and rehabilitation will also need to be given to only those areas temporarily affected during the construction phase of the project.

The preferred corridor demonstrates adequate environmental compliance with it avoiding all national parks, state forest and wetlands, as well as minimising impacts to major rivers systems including providing flood immunity for the 100 ARI event. It's recommended that more detailed in-situ surveying of flora, fauna and cultural heritage be carried out to ensure the final route selection minimises impacts to these. This needs to include the assessment of mitigation measures for crossing through the endangered regional ecosystems identified near the crossing of the Suttor River (such as vegetation rehabilitation). Suitable measures for mitigating contamination of waterways during construction will also need to be considered, as will run-off control, dust suppression and weed management.

A detailed flood assessment is also required to confirm the impact of bridges, culverts and embankments to the obstruction of water flows with consideration to Q10, Q50 and Q100 flood levels. It's also recommended that an assessment of potential backwater flows resulting from blockages of culverts and other simulations for erosion of abutments and scouring of piers be conducted. Suitable erosion control along exposed flood embankment such as the use of rock armo, riprap, and revegetation will also need to be established.

The route has been selected to ensure minimal impacts to current land-use infrastructure including townships, roads, railways and other utilities. Those that cross existing features such as roads, railways, pipelines and transmissions lines, have been designed with suitable clearances. A service search is recommended to ensure all utilities are identified and designed for accordingly. Crossings of existing arterials with road-over-rail bridges have not been considered in this study (beyond the inclusion of a lump sum cost in the overall costing).

It is recommended that detailed design plans and location drawings for each infrastructure crossing within the final 1.5km railway corridor be requested from the relevant owner / authority. Potential construction impacts on existing infrastructure such as interruptions to services would also require further consultation with the relevant third party infrastructure asset owners during the detailed design and delivery phases of the project.

The corridor will not result in the sterilization of known mining leases or negatively impact exiting coal mines; however, the corridor will run alongside Xstrata's western mining lease boundary at Collinsville. The route avoids all MDLs; however, crosses a number of EPCs. It's expected that the operating corridor will foster the development of new mines in the Galilee Basin with the route traversing over 50km before heading north towards the port.

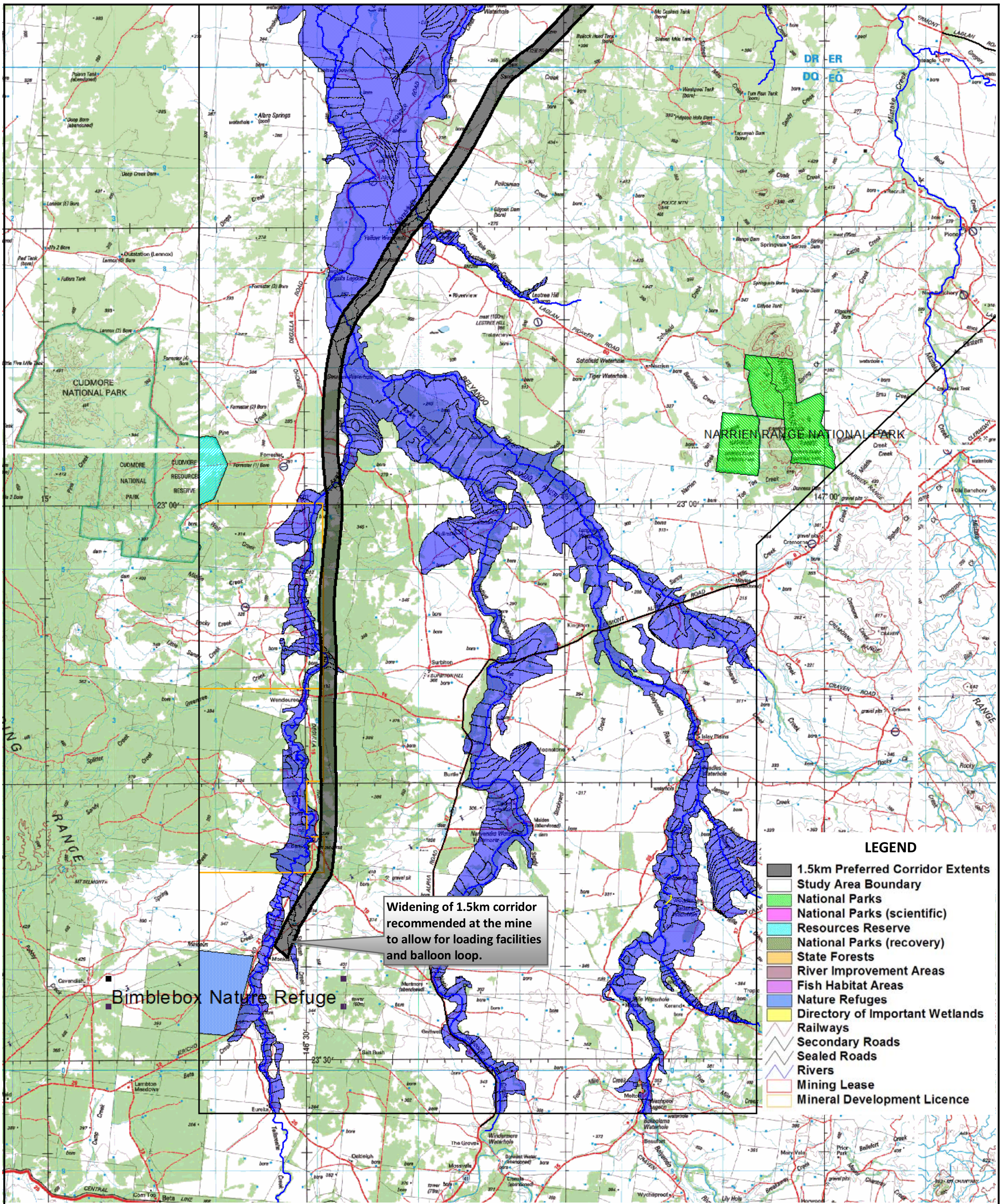
For this study no train performance assessment has been carried out on the selected routes. It's recommended that operational simulations of fuel and running costs, travel times and possible configurations of train consists, be assessed on both the preferred route, as well as the other short listed corridors. This will allow a more complete 'whole-of-life' assessment (i.e. CAPX and OPX) and allow a Net Present Value (NPV) for each corridor to be established. It will also provide the necessary locations for passing loops based on travel times to be established (and the topography generated

from ALS). It is also recommended that further assessment of allowable grades be assessed to ensure the most cost effective design is chosen for the project.

With the definition of the corridor to 1.5km wide other associated rail task can now be considered including suitable locations for the marshalling and refueling yard at the port, and construction and maintenance camps at Collinsville and Mount Coolon. Construction logistics including the supply of material, access roads, etc will also need to be assessed.

As this study has been based on 2008 figures, more up to date costing for civil works from local suppliers and other associated rail infrastructure rates for construction activities should be established.

The refinement of the corridor will likely require specific constructability issues to be resolved and mitigation of social and environmental impacts that may arise from future detailed field investigations, statutory approvals processes and continued stakeholder engagement. If required, the other short-listed corridors developed in this study should be considered as feasible secondary options, should the recommended corridor be ruled out.



0 25 Km

Map Grid of Australia – Zone 55

Geocentric Datum of Australia 1994

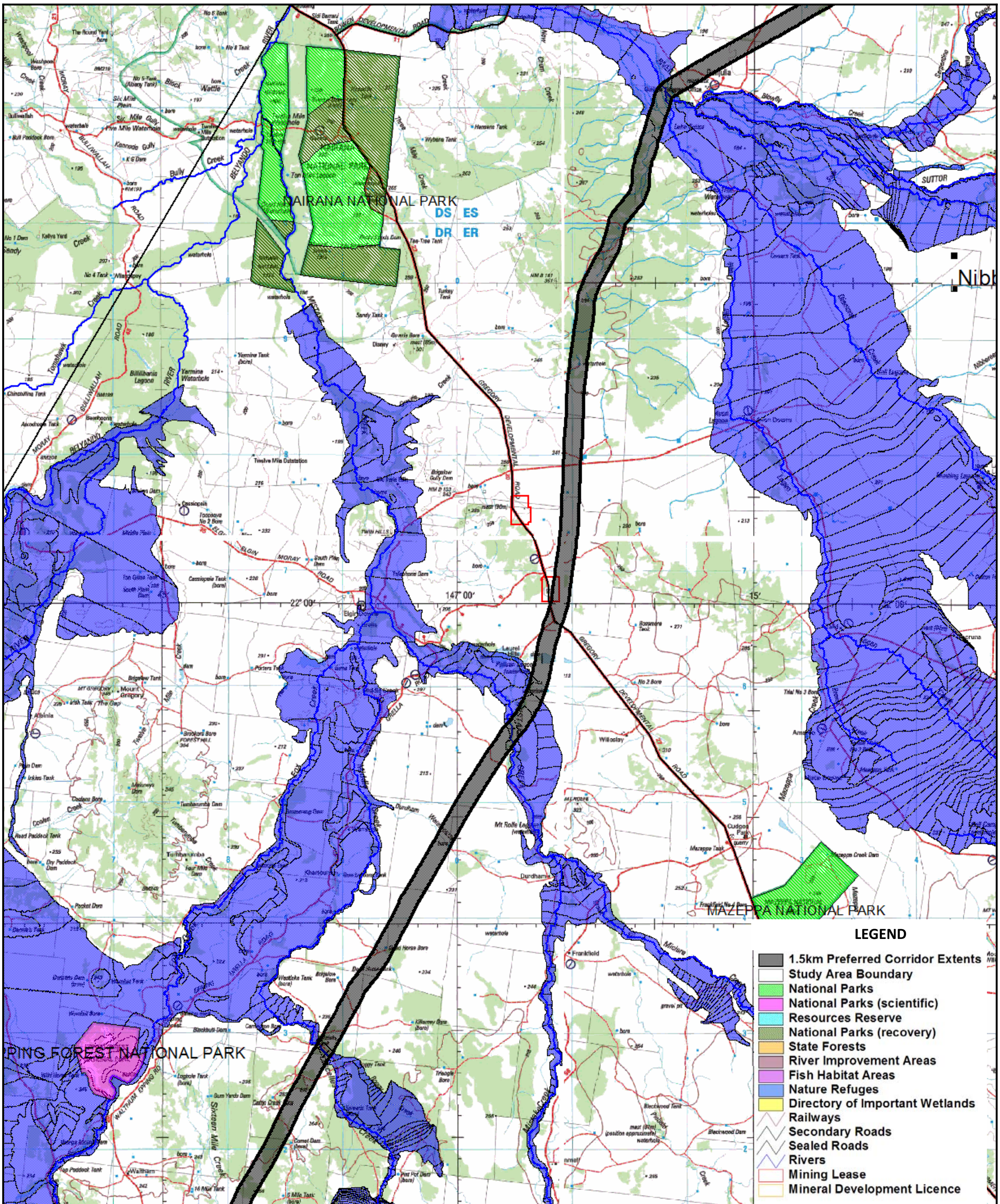
Waratah Coal
THE NEW ENERGY IN COAL

Rev	Date	Description	ORIG	CHK
A	22/02/10	Concept Design	BH	NH

Waratah Coal Pty Ltd

Galilee Basin Coal Railway
Pre Feasibility Study
Quantm Route Analysis
Figure 6-1a - 1.5km Preferred Corridor Layout (CH 0m – 100km)
GALILEE BASIN, QUEENSLAND, Australia

DRG NO: 10.60.002-014-1a



0 10 20 Km

Map Grid of Australia – Zone 55

Geocentric Datum of Australia 1994

Waratah Coal

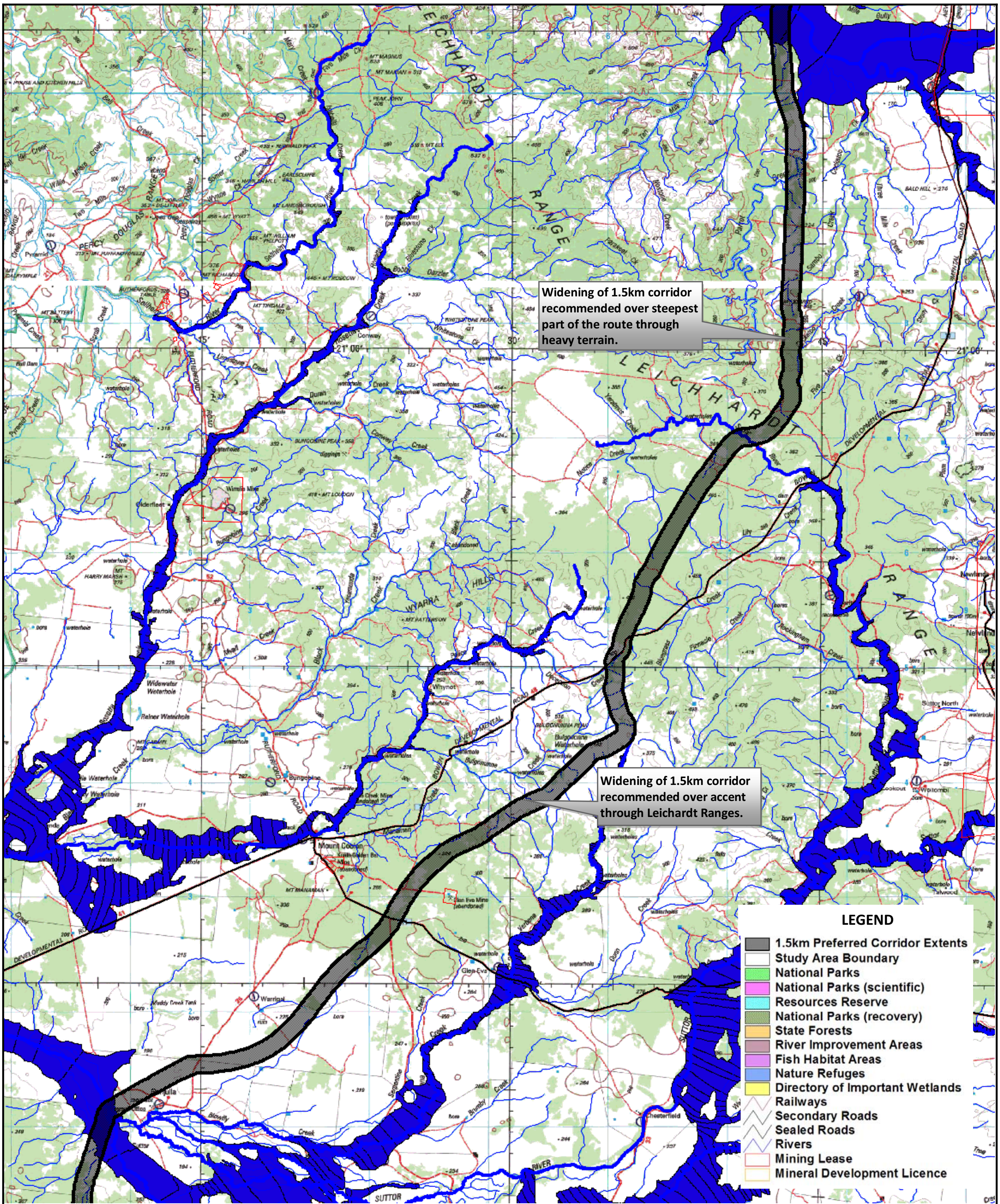
THE NEW ENERGY IN COAL

A	22/02/10	Concept Design	BH	NH
Rev	Date	Description	ORIG	CHK

Waratah Coal Pty Ltd

Galilee Basin Coal Railway
Pre Feasibility Study
Quantm Route Analysis
Figure 6.1b - 1.5km Preferred Corridor Layout
(CH 100m – 220km)
GALILEE BASIN, QUEENSLAND, Australia

DRG NO: 10.60.002-014-1b



0 25 Km

Map Grid of Australia – Zone 55

Geocentric Datum of Australia 1994

N W E S

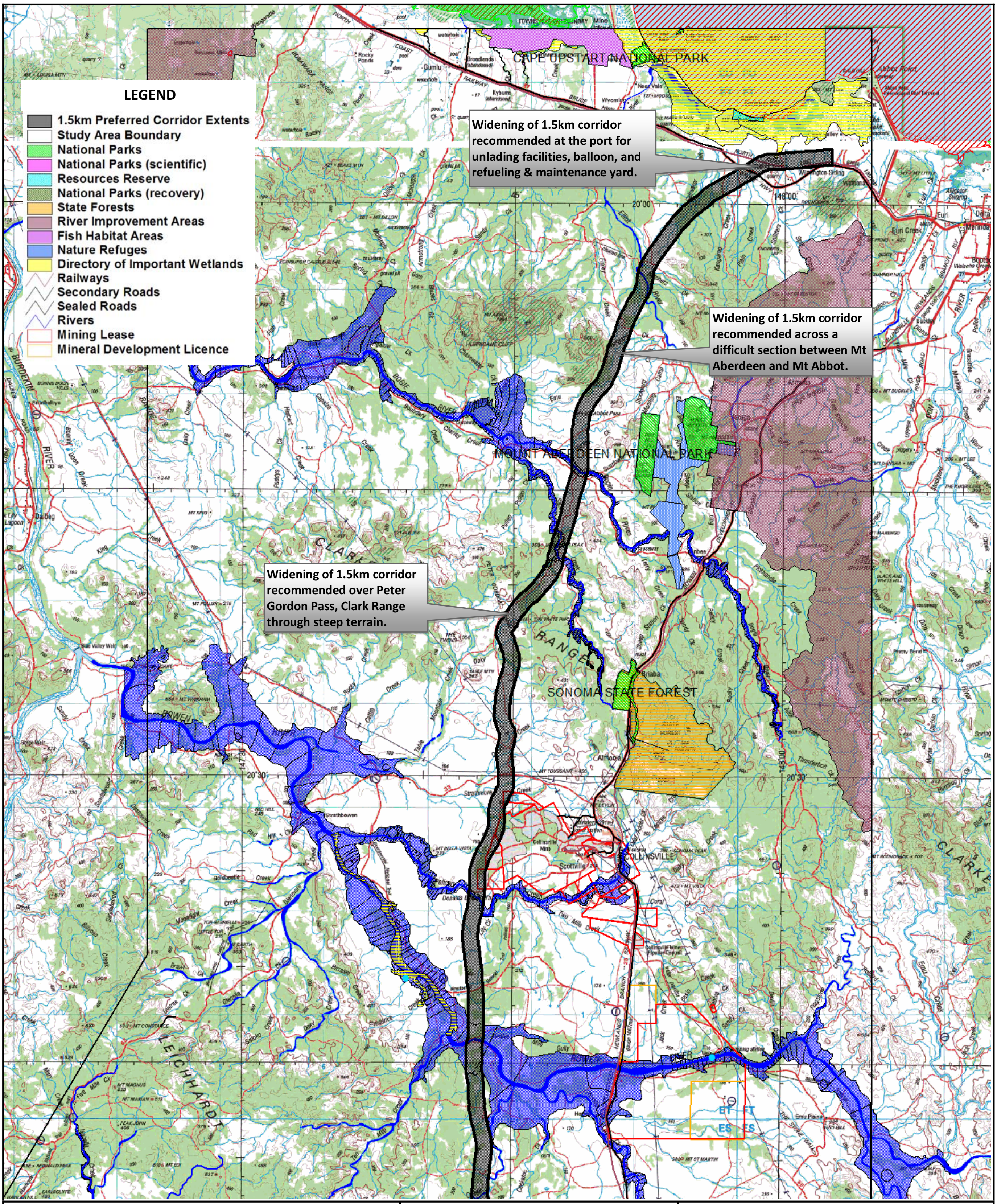
Waratah Coal
THE NEW ENERGY IN COAL

A	22/02/10	Concept Design	BH	NH
Rev	Date	Description	ORIG	CHK

Waratah Coal Pty Ltd

Galilee Basin Coal Railway
Pre Feasibility Study
Quantm Route Analysis
Figure 6.1c - 1.5km Preferred Corridor Layout
(CH 220m – 330km)
GALILEE BASIN, QUEENSLAND, Australia

DRG NO: 10.60.002-014-1c



0 10 20 Km

Map Grid of Australia – Zone 55

Geocentric Datum of Australia 1994

Waratah Coal
THE NEW ENERGY IN COAL

A	22/02/10	Concept Design	BH	NH
Rev	Date	Description	ORIG	CHK

Waratah Coal Pty Ltd

Galilee Basin Coal Railway
Pre Feasibility Study
Quantm Route Analysis
Figure 6.1 d - 1.5km Preferred Corridor Layout (CH 330m – 441.5km)
GALILEE BASIN, QUEENSLAND, Australia

DRG NO: 10.60.002-014-1d