HANCOCK PROSPECTING PTY LTD

Alpha Coal Project Supplementary Environmental Impact Statement

Y | Railway Corridor – BFS Drainage Engineering Report

HANCOCK COAL PTY LTD

calibre

Calibre Rail

Alpha Coal Project
Rail Bankable Feasibility Study

BFS Drainage
Engineering Report

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1.0 INTRODUCTION

This report provides a summary of the drainage design associated with the railway alignment undertaken for Hancock Coal Pty Ltd (HCPL) as part of the Bankable Feasibility Study (BFS) on the Alpha Coal Project (ACP). The report summarises the philosophy, criteria and methodology used in the drainage design used to derive BFS quantities.

Implementation of the Alpha Coal Project primarily comprises:

- Coal mining operations to be located at Alpha mine;
- Port operations to be located at Abbot Point;
- A railway system of approximately 510 km in route length between the mine and the port including the loop at the mine, marshalling yard and associated track work near the port and a port loop; and
- The infrastructure associated with the entire project.

A railway layout and locality plan for the Alpha Coal Project is illustrated in Figure 1 below.

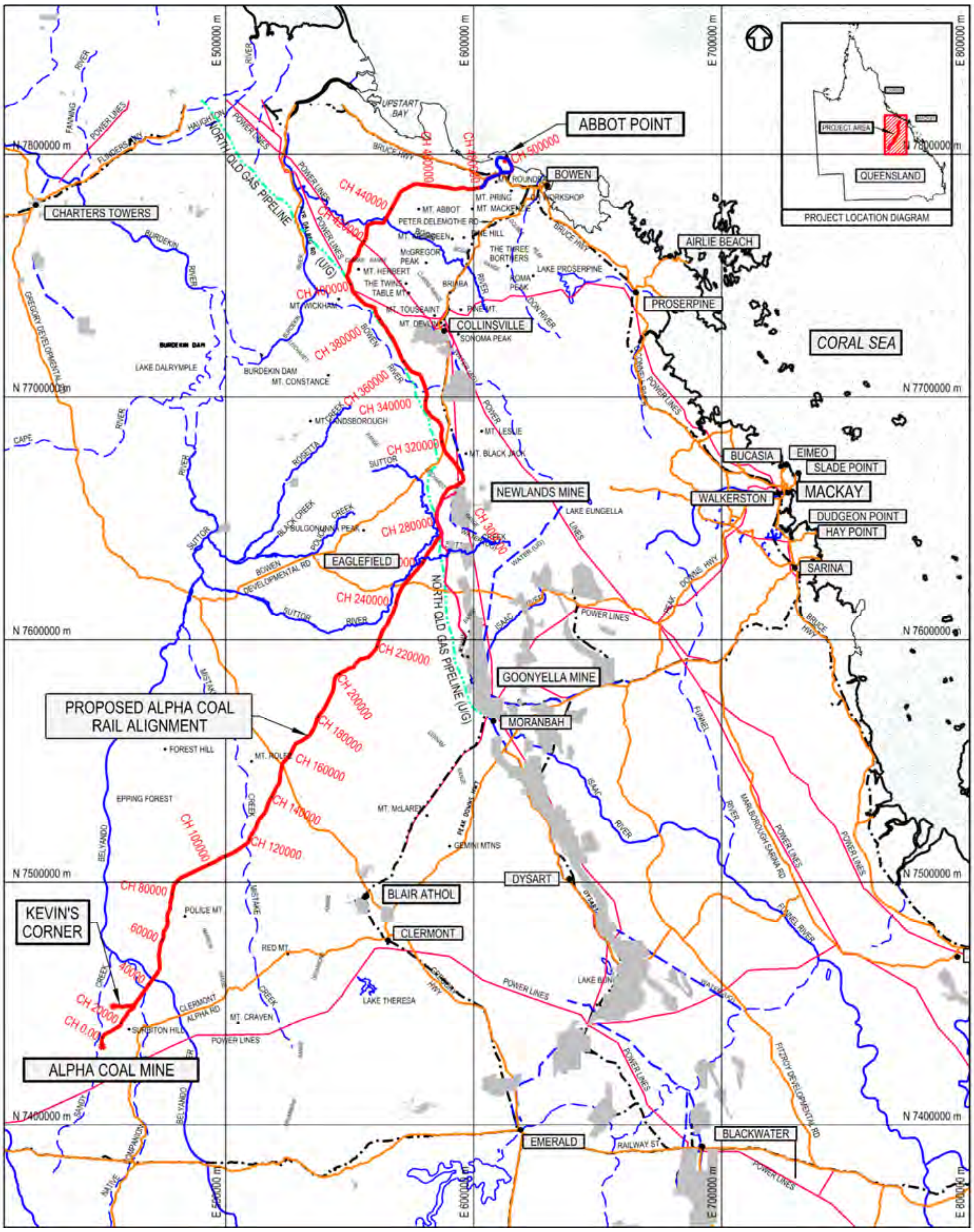


Figure 1 – Proposed Alpha Coal Railway Alignment

1.1 Bridging Study

Prior to the BFS Calibre undertook preliminary drainage design as part of the Bridging Study reported in, 'Pre-BFS Bridging Study Report Rail Infrastructure' CJV9036-REP-G-002. This was a preliminary design iteration based on very limited topographical and other information.

1.2 BFS Design Iterations

Drainage design for the BFS was undertaken in two main stages, Design Iteration 1 and Design Iteration 2. Prior to Design Iteration 1 a preliminary 'Base Case' iteration was also undertaken based on slightly more accurate input data than in the Bridging Study. Design Iteration 1 was undertaken to prepare a preliminary estimate reported to HCPL in July 2010. Design Iteration 2 involved further design development incorporating various alignment changes. In particular the design approach in floodplains focused on minimising flow concentration and mimicking natural flow regimes by providing closely spaced culverts through the rail embankment. Design Iteration 2 quantities are reported as part of the BFS report and estimate. No specific detailed hydrology investigation site visits were undertaken during the study. Hydrology field information gathered during other discipline site visits such as for example the geology site visits was however used.

It is noted that at this BFS stage explicit account of third party infrastructure e.g. accounting for backwater/tailwater impacts of Queensland Rail or road drainage has generally not been taken into account in the design computations in sections where the proposed rail is within close proximity of such facilities. This issue will be further investigated at the detailed design stage. The cooperation of third party infrastructure owners in providing required information will be critical to the success of this activity. All proposed design solutions presented in this BFS report will be subject to further design development and value engineering at the detailed design stage.

1.3 Climate

The climate in the study area varies given the extensive length of the railway. It varies from between semi-arid to semi tropical along the route. From a hydrology and drainage perspective it is important to note that the rainfall intensity generally increases from the mine site towards the coast. The wettest period is generally during the summer months from December to March. Cyclones and monsoonal rains can occur during the wet season and these may sometimes lead to flooding.

Figure 2 indicates the number of cyclones recorded over a 20 year period between 1986 and 2006. Note the six cyclones tracking at Alpha within a 400km radius.

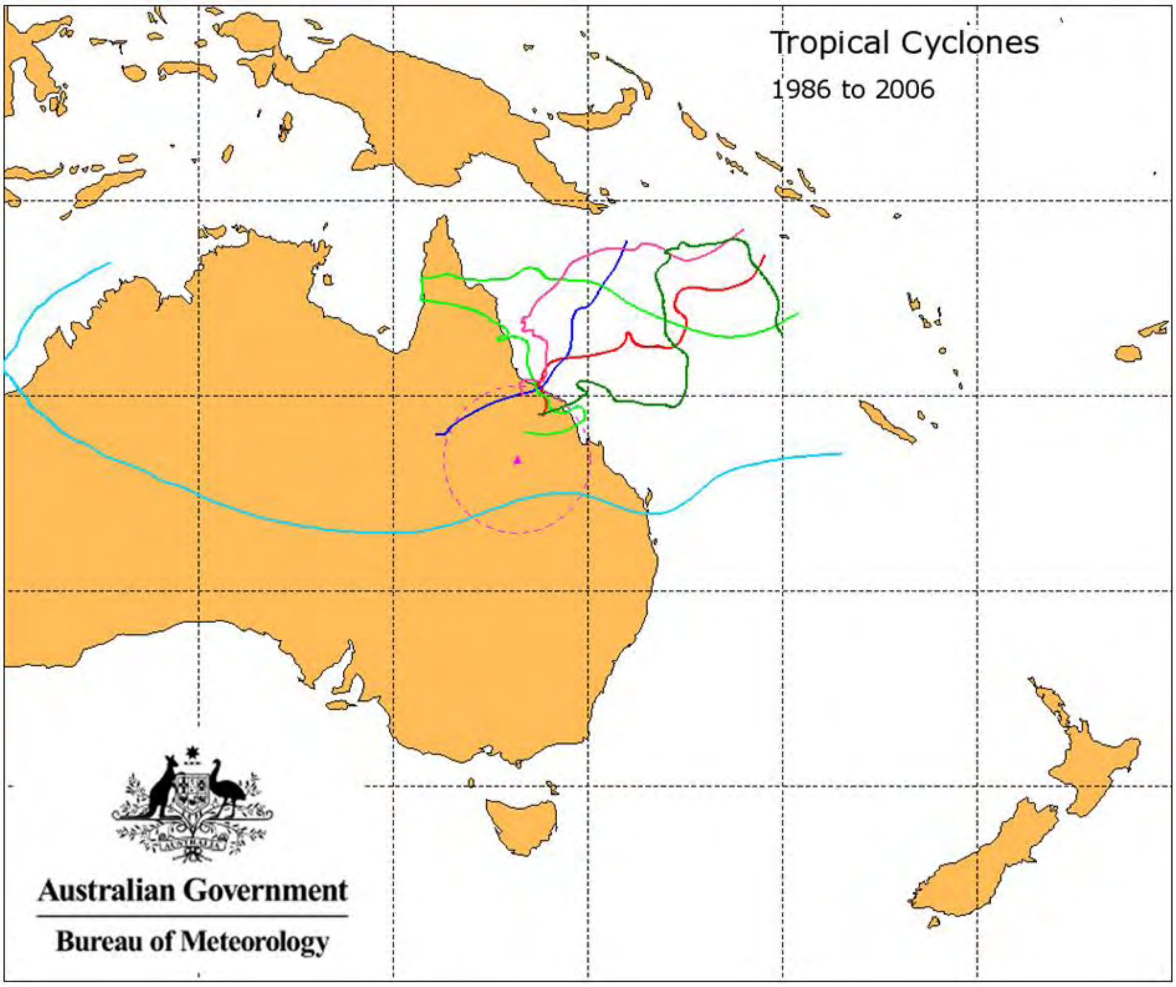


Figure 2 – Cyclone activities recorded in the east region of Australia within 400km of Alpha between 1986 and 2006.

Figure 3 indicates the number of cyclones recorded over a 20 year period between 1986 and 2006 affecting the project area. Note the high number of cyclones tracking at Abbot Point within 400 km.

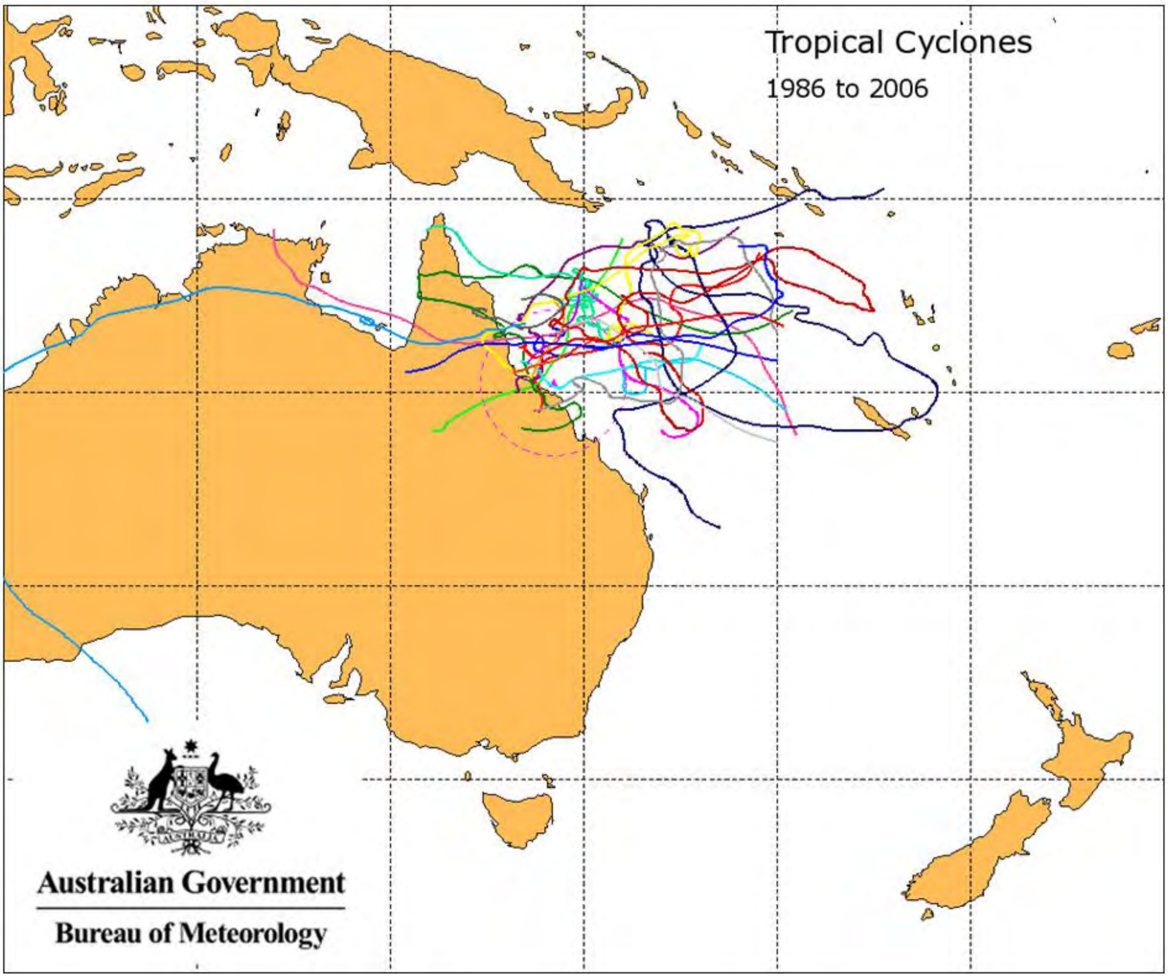


Figure 3 – Cyclone activities recorded in the east region of Australia within 400km of Abbot Point between 1986 and 2006.

The data in table 1 is representative of a range of climate conditions that may be expected to occur along the railway alignment:

Location	Alpha Mine Site				Abbott Point			
Longitude	148.31 E				148.04 E			
Latitude	23.13 S				19.54 S			
Elevation (m)	327 m				5 m			
Temperature (°C)								
Mean Annual Maximum	34.9				31.7			
Mean Annual Minimum	6.7				10.8			
Highest Recorded	45				44			
Mean no days ≥ 30^0C	183.6				136			
Lowest Recorded	-3.5				2.2			
Rainfall								
Mean annual (mm)	660				1010			
Mean annual no of rain days	57				75			
Highest recorded daily rain (mm)	186				406			
Highest annual rainfall (mm)	1295				1976			
Evaporation								
Mean annual evaporation (mm)	2100 mm				1700 mm			
By Month	Mean daily max. temp. (°C)	Mean daily min temp. (°C)	Mean monthly rainfall (mm)	Mean No. days of rain ≥1mm	Mean daily max. temp. (°C)	Mean daily min temp. (°C)	Mean Monthl y rainfall (mm)	Mean No. days of rain ≥1mm
January	34.3	21.6	117.6	6.6	31.5	23.9	178.3	8.3
February	33	21.1	115.7	6.1	31.3	23.9	242.9	10.3
March	32	19.4	73.7	4.3	30.9	22.8	75.7	6.4
April	29.5	15.7	38.5	2.5	29.3	20.9	62.3	5.5
May	26.1	11.5	34.8	2.4	27.1	18.1	42.9	3.8
June	23.1	8.1	34.1	2.4	24.9	15.1	23.9	2.9
July	23.1	6.7	24.9	1.9	24.5	13.5	19.3	2.0
August	25.3	8.2	19	1.7	25.4	14.3	22.4	1.6
September	28.8	12.1	19.3	1.7	27.4	16.4	7.2	1.3
October	32	16.3	35.4	2.9	29.3	19.9	13.4	2.1
November	34	19	57.1	4.0	30.5	22.2	35.4	3.8
December	34.9	20.8	91.8	5.3	31.4	23.5	135.1	6.6

Table 1 – Selection of climate data (Alpha Mine Site to Abbott Point)

2.0 DESIGN PHILOSOPHY

The main philosophy behind the rail drainage design is to:

- Maintain existing natural flow paths;
- Prevent banking up of water due to flooding;
- Ensure properties are not flooded.

The design approach follows best practice principles currently being applied on similar heavy haul projects throughout Australia.

Culverts and bridge crossings will be provided wherever cover requirements allow. Stream training may be required as part of drainage structure works to reinstate stable drainage channels once installation is complete and/ or guide water through newly installed structures. Earth levees will be used to ensure the efficient function of drainage infrastructure such as culverts, drains and bridges by containing design flows within catchments. Unlined earth drains will be provided for diverting catchment flows wherever embankment cover requirements do not allow culverts and also for protecting cuttings from scour.

All proposed drainage arrangements, such as location, culvert skew and invert levels, will be “ground truthed” and value engineered at the detailed design stage to provide the most cost effective solution given design constraints.

2.1 Environmental Considerations

The effect of the proposed railway embankments on the existing native vegetation and farming lands is considered in the design process. Alteration of natural drainage paths is minimised to prevent the adverse effects of water shadow. Water shadow occurs when the natural drainage path is altered to allow for construction of rail embankments resulting in an alteration of the downstream hydrological regime with possible adverse environmental consequences.

2.1.1 Water Shadow in Areas of Embankment Fill

600 mm diameter CSP 'environmental' culverts will be provided at a nominal spacing of 400 m where construction of the proposed rail formation might cut off existing flow paths and cause water shadow downstream where cover requirements allow. Environmental culverts also allow for the passage of small fauna. Environmental culverts are distinct from engineered culverts that are provided at defined stream crossings.

2.1.2 Water shadow in Areas of Earthwork Cuttings

The potential for water shadow to occur above and below cutting areas also exists on the rail alignment. Water shadow can occur in such situations when drainage flow paths are no longer able to cross the cutting area and surcharge the ground surface on the downstream side of the cutting and the natural water table drops. The potential extent of the water shadow is a function of the grading and direction of the fall of the land, and existing geological conditions. The water table may either only drop a short depth to expose water on the face of the cutting, or it may drop below the invert of the cutting. Sketch CJVP10007-DWG-G-953 in Appendix A helps to illustrate this phenomenon.

2.1.3 Floodplain Relief Culverts

The nature of floodplains is that flood water is not concentrated in one main channel at high depth, but rather water spreads out slowly over a wide area at shallow depth once the main channel banks have been breached.

It is therefore proposed that in the major flood plains, (such as at the Native Companion Creek, Belyando River and other similar floodplains), 900 mm diameter relief culverts will be provided at approximately 50 m centres or closer. Each relief culvert location will be provided with rip rap protection to prevent scour and aid the lateral spread of flow from the culvert outlet. The culvert outlet flow should naturally disperse at an angle of 45 degrees. Rip rap will also assist in the lateral spread of the flow and the joining of flow from adjacent outlets. Outlets at 50 m intervals will ensure that the flow is spread over the full width within 25 m of the culvert outlets. The relief culverts will be located in depressions where water will likely pond against the railway embankment. It is also proposed to keep vegetation disturbance downstream of the railway alignment to an absolute minimum to restore natural flow paths as quickly as possible. Minor earthworks to direct flows to these culverts will be undertaken were required. Sketch CJVP10007-DWG-G-952 in Appendix A illustrates this solution.

3.0 DESIGN CRITERIA

3.1 Risk

The drainage design undertaken for this study is based on a risk based approach. A risk based approach implies the acceptance of a certain level of risk of failure of the designed element. Assessment and understanding of the level of risk allows acceptable design criteria to be adopted for the design elements.

In drainage design the failure risk can be expressed as a percentage of one or more exceedences of the design event occurring within the design life of the drainage structure. The risks for various Average Recurrence Intervals (ARI)'s and design periods are illustrated in Table 2 below.

Period of Time (years)	Average Recurrence Interval of Flood (years)							
	2	5	10	20	50	100	200	500
10	99.3	86.5	63.2	**39.3**	**18.1**	9.5	4.9	2.0
20	100.0	98.2	86.5	**63.2**	**33.0**	18.1	9.5	3.9
25	100.0	99.3	91.8	**71.3**	**39.3**	22.1	11.8	4.9
30	100.0	99.8	95.0	**77.7**	**45.1**	25.9	13.9	5.8
40	100.0	100.0	98.2	**86.5**	**55.1**	33.0	18.1	7.7
50	100.0	100.0	99.3	**91.8**	**63.2**	39.3	22.1	9.5

Table 2 – Percentage Chance of a Flood Being Exceeded during Various Periods of Time

From Table 2, it can be seen that the risk of a design flood being exceeded decreases with the ARI of the flood and increases with the length of time over which the railway might be operational. For example a project with a design life of 25 years has 71.3% and 39.3% chances of the 20 and 50 year ARI event storms being exceeded respectively, whilst for a 50 year project the respective probabilities increase to 91.8% and 63.2%. The table also shows there is a real chance that large storm events (e.g. the 50-year or 100yr ARI storm events) can occur within short design periods.

The drainage criteria adopted for this study summarised below is similar to that used on similar heavy haul railway projects in Australia. This criteria is based on assuming the proposed railway will have a 50 yr design life. The ACP mine design life is 30 yrs. The railway is assumed to have a longer design life due to future potential resource developments and third party use.

3.2 Drainage Design Criteria

The general drainage criteria (excluding bridges) adopted for this study is summarised in Table 3 below. The bridge hydraulic design criteria is summarised in Table 4, (bridge structural design criteria is reported in the Bridge Report, CJVP10007-REP-S-001).

Design Aspect	Design Criteria
Culvert Classification	Major culverts: culvert locations with a 50 years ARI design flow ≥ 50 m^3/sec. Minor culverts: culvert locations with a 50 year ARI design flow < 50 m^3/sec.
Design Flood	Minor culverts shall pass the 20 year ARI design event flow. Major culverts shall pass the 50 year ARI design event flow.
Freeboard	Min. 300 mm to the formation surface for design event.
Headwater	Max. headwater to be 1.5 x culvert diameter.
Max. Outlet Velocity	5.0 m/sec for design event. ***
Scour Protection	Capable of passing 20 years ARI design flood without damage. Rock sizing to be designed in accordance with AUSTROADS Waterway Design, 1994.
Culvert Type & Size	CSP (galvanised corrugated steel pipes) wrapped in a suitable impermeable membrane (Nylex XL45 or similar) shall be the default type. Culvert skew to be minimised as much as possible. Pipe culverts shall be provided with minimum 600 mm earthwork cover. Min. diameter to 900mm for engineering culverts. Min. diameter to 600mm for environmental culverts. Environmental and rail level crossing culverts are not included in the drainage calculations; however estimates are allowed for in the drainage quantities, (environmental culverts placed approximately every 400 m where cover allows). All CSP culverts to be designed for no uplift during the design flood.
Diversion drains	Unlined diversion drains shall be used to divert catchment flows from one catchment to another, where culverts cannot be used through the rail formation. These should cater for the 20 year ARI design flood without overtopping or scour. Drain design should minimise drain scour

Design Aspect	Design Criteria
	for the design event.
Cut off drains	Unlined cut off drains (with a minimum 20 year ARI design flow capacity) should be provided on the upstream side of the railway in cuttings to prevent surface water runoff entering the cuttings and causing scour and washouts.
Levees	Designed to ensure that there is 100 mm freeboard above the culvert headwater design level

Table 3 – General drainage design criteria

Design Aspect	Design Criteria
Design Flood	Bridges shall pass the 50 year ARI design event flow.
Freeboard	Min. 500 mm to bridge soffit for 50 Year ARI design flow. Min. 300 mm to TOF (embankments and guide banks) for 50. Year ARI design flow.
Max Velocity	3.8 m/s to enable to adopt a practical limit of 1 tonne rock class protection for economy.
Scour Protection	Provide rock protection to cater for 50 Year ARI design flow velocities. Rock sizing to be designed in accordance with AUSTROADS Waterway Design, 1994.
Maximum backwater	1.5 m with reduction at sensitive locations.***
Guide banks	To be designed in accordance with AUSTROADS Waterway Design, 1994.

Table 4 – Bridge hydraulic design criteria

***** - See section 3.2.1 for further discussion.**

3.2.1 Recommended Changes to Design Criteria

As highlighted in sections 2.0 and 3.1 the current design approach and criteria follows best practice principles currently being applied on similar heavy haul projects throughout Australia. It is understood that some stakeholders in the Alpha Coal Project have highlighted that the current design criteria maximum values for culvert outlet velocity, and culvert and bridge design (backwater) afflux outlined are too high and would result in the following:

- Potential excessive scour through and downstream of the structure - high velocities will require extensive rock protection;
- Potential decrease in flood immunity of structures upstream of the alignment;
- Potential changes in flood flow patterns and flooding behaviour across floodplains;
- Potential extensive damage to railway formation (washouts) when overtopping occurs during a flood event that exceeds the design event, because of the large differences in headwater and tailwater at the time of overtopping.

The stakeholders are recommending maximum culvert outlet velocity and backwater values of 3 m/s and 0.5 m respectively.

The current maximum bridge design backwater criteria is 1.5 m (**with reduction at sensitive locations)** as commonly adopted on similar projects. The current design **average** backwater value is about 0.5 m for the 20 proposed waterway bridges along the alignment, (see Appendix B – bridge design schedule). It is also noted that the current backwater computations do not include the floodplain relief culverts which would have the effect of reducing computed backwater due to the extra waterway area.

In light of the stakeholder recommendations and normal design development, it is proposed that in general a backwater (afflux) target value of no greater than 0.5 m be adopted for detailed design. In some areas, a much smaller afflux (or even no afflux) may be appropriate. This may be in areas where there are already flood prone properties and even a small increase in level could cause a significant increase in damage. The afflux to be adopted for design will be determined after survey of potentially flood prone structures in the vicinity of the alignment, consideration of potential disruptions to flow behaviour during flood events, and interviews with landholders.

In specific circumstances where it is considered that an afflux of greater than 0.5 metres can be tolerated, a design report will be prepared, documenting the reasons for adopting a higher afflux at the waterway crossing. This design report will address the following:

- Areal extent of the increase in water levels upstream.
- The potential reduction in flood immunity of upstream dwellings and structures caused by the railway and proposed cross drainage.
- Impacts on the current land uses.
- Potential for redirection of flows, and ponding of flow upstream.
- The additional drainage works required to reduce afflux to 0.5 m or lower, and the estimated cost of the additional works.
- The erodibility of the natural channel or waterway downstream of the culverts or bridge, and the vulnerability of the proposed cross drainage to failure by erosion and undermining.
- The outlet velocity for the design event in relation to the natural channel velocity.
- Design parameters for downstream erosion protection.
- Summary results of hydraulic calculations.
- Assessment of the risk of overtopping of rail line and the afflux at the point of overtopping.
- Consequences of overtopping of the rail formation by a flood in excess of the design event, and a description of any measures taken to limit the damage due to overtopping.

Affected landholders will be consulted, and their responses will be documented in the report.

The current maximum culvert outlet velocity is 5.0 m/s as commonly adopted on similar projects. The current design **average** velocity value over the entire alignment is about 3.3 m/s. It is also highlighted that all culvert inlets and outlets will be protected from scour with rock armour. Rock protection has been sized in accordance with Austroads Waterways Design Guide (1994) guidelines as shown in the design table in Appendix D. The purpose of the rock protection is to dissipate the flow and further reduce the velocity from the culvert outlet value.

In light of the stakeholder recommendations and normal design development, it is proposed that an outlet velocity target value of 3 m/sec (or less) be adopted where possible, during the detailed design stage. The acceptable outlet velocity will depend on the erodibility of the channel, the flow velocities in the natural channel, the level of scour protection and the consequences of failure of the cross drainage works due to scour and undermining. The design process will include stakeholder input, geotechnical advice and detailed site inspection.

The hydraulic design of all cross drainage structures will refer to all applicable design guidelines and standards.

4.0 HYDROLOGY

4.1 Natural Hydrological Conditions

The majority of the study area is located within the greater Burdekin River basin catchment. Most of the lower study area, (generally the first 270 km from the mine) is characterised by a dry and semi-arid landscape with ephemeral streams. Most of the rivers and streams typically flow between December and April. The floodplain areas common in the lower study area are characterised by poorly defined flows paths which sometimes only extend to a few hundred millimetres. Soils with varying amounts of silts, sand and clay found in these lower areas generally correspond to lower runoff rates in rain events.

The far north part of the study area (generally from chainage 440 to 510 km), is located within the Don River catchment. The topography in the northern part of the study area (generally from chainage 270 to 510 km), is markedly steeper compared to the lower areas. The steeper rocky areas and hills have a faster response to rainfall compared to the flatter and floodplain areas.

Natural pastures form the dominant vegetation type in the study area. The type, size and density of vegetation in any region is typically dictated by the availability of water, and provides a good indicator of the runoff flows to be expected. Mature trees are commonly found in well defined streams and river channels. Flat floodplains will generally support lower forms of vegetation such as scrub.

4.2 Design Flood Estimation Methods

Three design flood estimation methods, (as per the procedures recommended in Australian Rainfall and Runoff 2001 guidelines), were used in the Study to derive flood flows to size the proposed hydraulic structures as described below.

4.2.1 Queensland Department of Traffic and Main Roads Rational Method

This is the primary method used to estimate design flows for all stream crossings in the study. It is generally considered adequate to estimate design flows for small to medium sized catchments, (generally up to about 25 km2). The majority of the rail corridor catchments fall within this category. The other two methods described below were only used for major catchment analysis.

The method used is outlined in the, 'Queensland Department of Traffic and Main Roads Road Drainage Manual', 2010 publication. The primary parameters assumed for use in the Study for the majority of the catchments are summarised below.

- Catchment relief – hilly to steep;
- Catchment storage – well defined watercourses;
- Ground characteristics – grazing land and open forest.

For the majority of the catchments along the rail corridor the rainfall intensity, frequency and duration (IFD) data required for input into the rational method computation was assumed from one of four locations (from the mine to the port) along the alignment. IFD data used in the study was derived using the software program AUSIFD.

4.2.2 RORB Rainfall Runoff Modelling

This method was used to estimate design flows for the major catchments along the rail corridor, for example at all the proposed bridge locations. RORB is a rainfall runoff routing model commonly used for catchment analysis in Australian hydrological practice. It is generally considered suitable for use in estimating design flows for larger and more complex catchments. The assumed study model parameters are outlined below based on Australian Rainfall and Runoff 2001 guidelines for Queensland.

- Initial Loss = 30 mm - loss parameter;
- Continuing Loss = 2.5 mm/hr - loss parameter;
- kc = 0.88*(catchment area)$^{0.53}$ - (kc is a measure of the storage in the catchment);
- m = 0.80 - (m is a measure of the catchment's non-linearity).

For this study the RORB input files were created using CatchSim software. CatchmentSIM is a stand-alone GIS based terrain analysis program that is designed to help setup hydrologic models. The program is used to automatically delineate subcatchment(s) and calculate their associated spatial and topographic characteristics to assist in assigning suitable hydrologic modelling parameters.

4.2.3 Flood Frequency Analysis of River Gauging Data

This method is a statistical analysis of stream gauge data to produce a relationship between flood magnitude and probability of exceedance of the design event being considered. It was used to estimate design flows for the six rail corridor catchments where data was available. The gauging data used for the analysis was obtained from the

Queensland Department of Environment and Resource Management (DERM) online database.

For this study annual series analysis assuming a Log Pearson Type III probability distribution was undertaken for each location with gauging data. The data from the following gauging stations was used:

- Gauge No. - 120305A - Native Companion Creek;
- Gauge No. - 120306A - Mistake Creek;
- Gauge No. - 120220A - Pelican Creek;
- Gauge No. ¬- 120304A - Suttor Creek;
- Gauge No. - 120005B - Bogie River;
- Gauge No. - 120209A - Bowen River.

4.2.4 Drainage Survey Information

Catchment characteristics required for use with the design methods discussed above were determined from topographical data sourced from the Burdekin catchment basin digital elevation model (DEM), with an accuracy of ±10 m obtained from the Queensland Department of Environment and Resource Management. The DEM was supplemented with LIDAR data provided by HCPL with an accuracy of ±0.5 m covering a 4 km wide corridor based on a preliminary Bridging Study rail alignment.

Higher accuracy survey information is particularly important for hydraulic computations for structure sizing. It is noted that for some sections of the rail alignment survey data of adequate accuracy was not available. This was due to subsequent route realignments beyond the initial LIDAR data 4km corridor or the complex nature of some crossing locations requiring data beyond the available data limit extents. Major waterway areas where extra survey has been requested from HCPL include the following; Bogie River, and Rosella Creeks 1 & 2, Belyando River, Lestree Creek and Eaglefield Creek/Suttor River. Two dimensional flood modelling was not carried out as the data required for the modelling had not been provided and is not anticipated until February 2011.

5.0 FLOODPLAINS

5.1 General

The work undertaken on the floodplains traversed by the railway has been limited by the available data. Further information, including, addition survey and the gathering of regional flood and rainfall data is currently being collated. Detailed design of the interaction between the railway and the floodplains will be undertaken using this addition information.

As noted in section 4.1 the proposed rail alignment traverses a number of floodplain areas, (generally within the first 270 km from the mine). The landuse in these areas is primarily used for grazing and open forest. The floodplain areas are characterised by poorly defined flows paths which sometimes only extend to a few hundred millimetres. To minimise general flooding in these areas it is currently proposed to supplement the engineered culverts and bridges with environmental and floodplain relief culverts as described in section 2.0. Minor earthworks to direct flows to these culverts will be undertaken where required.

Floodplain relief culverts will consist of 900 mm diameter relief culverts provided at approximately 50 m centres or closer. The current BFS design allows for about 1050 barrels of floodplain culverts. Environmental culverts will consist of 600 mm diameter culverts provided at a nominal spacing of 400 m where construction of the proposed rail formation might cut off existing flow paths and cause water shadow downstream where cover requirements allow. The current BFS design allows for about 460 barrels of environmental culverts. All culvert locations will be provided with rip rap protection to prevent scour and aid the lateral spread of flow from the culvert outlet. The rip rap protection has been sized in accordance with AUSTROADS Waterway Design, 1994.

Proposed BFS culvert schedules for the floodplain relief and environmental culverts are shown in Appendix B of this report.

The major creeks and river systems with floodplain areas along the alignment are described in turn below. A tabular summary is also provided in Table 5 below. Appendix B contains catchment plans for the entire alignment.

5.1.1 Native Companion Creek

The catchment area of this creek at the proposed rail alignment is approximately 5125 km^2. It crosses the rail alignment at approximate chainage 38690 m. The 2010 GHD Alpha Coal Project (Rail) Surface Water report classified this stream as a major waterway with a stream order classification of 15.

The estimated design 50 yr ARI event flow is approximately 470 m^3/s for the design of the primary drainage structure. Stream Gauge No 120305A has been used for this estimate. The estimated predevelopment (without rail) 50 yr ARI event flood level is about Rl 278.2 m AHD. This flood level is estimated to have an inundation width of approximately 380 m along the rail alignment. It is noted that any flow higher than Rl 278.2 m at approximate chainage 38.2 km will result in water spilling into the Belyando floodplain.

It is currently proposed that a bridge is the primary hydraulic structure at the main channel crossing. The estimated post development (with rail) 50 yr ARI event flood level is about Rl 278.4 m AHD. This flood level is estimated to have an inundation width of approximately 390 m along the rail alignment.

To supplement the bridge structure and maintain sheet flow throughout the floodplain it is currently proposed that 900 mm diameter relief culverts be provided at approximately 50m centres as per the floodplain relief culvert schedule in Appendix B. This will reduce the post development inundation width and flood level reported above.

5.1.2 Belyando River

The catchment area of this river at the proposed rail alignment is approximately 5625 km^2. It crosses the rail alignment at approximate chainage 44000 m. The 2010 GHD Alpha

Coal Project (Rail) Surface Water report classified this stream as a major waterway with a stream order classification of 46.

The estimated design 50 yr ARI event flow is about 510 m^3/s for the design of the primary drainage structures. Stream Gauge No 120305A has been used for this estimate given the hydrological similarity with the Native Companion Creek catchment. The estimated predevelopment (without rail) 50 yr ARI event flood level is about Rl 273.2 m AHD. This flood level is estimated to have an inundation width of approximately 4480 m along the rail alignment.

It is currently proposed that a bridge and culverts are the primary hydraulic structures at the main channel crossing. The estimated post development (with rail) 50 yr ARI event flood level is about Rl 273.2 m AHD. This flood level is estimated to have an inundation width of approximately 4480 m along the rail alignment.

To supplement the main crossing structures above to maintain sheet flow it is proposed that 900 mm diameter relief culverts will be provided at approximately 25 m centres as per the floodplain relief culvert schedule in Appendix B. This will reduce the post development inundation width and flood level reported above. Closer relief culvert spacing compared to the Native Companion Creek crossing is recommended as this location is viewed as a major floodplain.

5.1.3 Lestree Hill Creek

The catchment area of this creek at the proposed rail alignment is approximately 139 km^2. It crosses the rail alignment at approximate chainage 59741 m.

The estimated design 50 yr ARI event flow is about 231 m^3/s. Predevelopment flood levels have not yet been determined at this location.

It is currently proposed that culverts are the primary hydraulic structure at the main channel crossing. The estimated post development (with rail) 50 yr ARI event flood level is about Rl 280 m AHD. This flood level is estimated to have an inundation width of approximately 2200 m along the rail alignment.

To supplement the culvert structure and maintain sheet flow throughout the floodplain it is currently proposed that 900 mm diameter relief culverts be provided at approximately 50m centres as per the floodplain relief culvert schedule in Appendix B. This will reduce the post development inundation width and flood level reported above.

5.1.4 Sixteen Mile Creek

The catchment area of this creek at the proposed rail alignment is approximately 156 km^2. It crosses the rail alignment at approximate chainage 93679 m. The 2010 GHD Alpha Coal Project (Rail) Surface Water report classified this stream as a minor waterway with a stream order classification of 1.

The estimated design 50 yr ARI event flow is about 259 m^3/s. Predevelopment flood levels have not yet been determined at this location.

It is currently proposed that culverts are the primary hydraulic structure at the main channel crossing. The estimated post development (with rail) 50 yr ARI event flood level is about Rl 284 m AHD. This flood level is estimated to have an inundation width of approximately 100 m along the rail alignment.

To supplement the culvert structure and maintain sheet flow throughout the floodplain it is currently proposed that 900 mm diameter relief culverts be provided at approximately 50m centres as per the floodplain relief culvert schedule in Appendix B. This will reduce the post development inundation width and flood level reported above.

5.1.5 Mistake Creek

The catchment area of this creek at the proposed rail alignment is approximately 2555 km^2. It crosses the rail alignment at approximate chainage 118160 m. The 2010 GHD Alpha Coal Project (Rail) Surface Water report classified this stream as a major waterway with a stream order classification of 31.

The estimated design 50 yr ARI event flow is about 800 m^3/s. Stream Gauge No 120306A has been used for this estimate. The estimated predevelopment (without rail) 50 yr ARI event flood level is about Rl 242.6 m AHD. This flood level is estimated to have an inundation width of approximately 200 m along the rail alignment.

It is currently proposed that a bridge is the primary hydraulic structure at the main channel crossing. The estimated post development (with rail) 50 yr ARI event flood level is about Rl 242.7 m AHD. This flood level is estimated to have an inundation width of approximately 200 m along the rail alignment.

To supplement the bridge structure and maintain sheet flow throughout the floodplain it is currently proposed that 900 mm diameter relief culverts be provided at approximately 50m centres as per the floodplain relief culvert schedule in Appendix B. This will reduce the post development inundation width and flood level reported above.

5.1.6 Piebald Creek

The catchment area of this creek at the proposed rail alignment is approximately 467 km^2. It crosses the rail alignment at approximate chainage 134638 m.

The estimated design 50 yr ARI event flow is about 527 m^3/s. The estimated predevelopment (without rail) 50 yr ARI event flood level is about Rl 233.70 m AHD. This flood level is estimated to have an inundation width of approximately 900 m along the rail alignment.

It is currently proposed that culverts are the primary hydraulic structure at the main channel crossing. The estimated post development (with rail) 50 yr ARI event flood level is about Rl 233.8 m AHD. This flood level is estimated to have an inundation width of approximately 1100 m along the rail alignment.

To supplement the culvert structure and maintain sheet flow throughout the floodplain it is currently proposed that 900 mm diameter relief culverts be provided at approximately 50 m centres as per the floodplain relief culvert schedule in Appendix B. This will reduce the post development inundation width and flood level reported above.

5.1.7 Miclere Creek

The catchment area of this creek at the proposed rail alignment is approximately 1026 km^2. It crosses the rail alignment at approximate chainage 141478 m. The 2010 GHD Alpha Coal Project (Rail) Surface Water report classified this stream as a minor waterway with a stream order classification of 8.

The estimated design 50 yr ARI event flow is about 949 m^3/s. The estimated predevelopment (without rail) 50 yr ARI event flood level is about Rl 231.70 m AHD. This flood level is estimated to have an inundation width of approximately 3500 m along the rail alignment.

It is currently proposed that culverts are the primary hydraulic structure at the main channel crossing. The estimated post development (with rail) 50 yr ARI event flood level is about Rl 232.6 m AHD. This flood level is estimated to have an inundation width of approximately 3800 m along the rail alignment.

To supplement the culvert structure and maintain sheet flow throughout the floodplain it is currently proposed that 900 mm diameter relief culverts be provided at approximately 50m centres as per the floodplain relief culvert schedule in Appendix B. This will reduce the post development inundation width and flood level reported above.

5.1.8 Brown Creek

The catchment area of this creek at the proposed rail alignment is approximately 1123 km^2. It crosses the rail alignment at approximate chainage 170280 m. The 2010 GHD Alpha Coal Project (Rail) Surface Water report classified this stream as a major waterway with a stream order classification of 14.

The estimated design 50 yr ARI event flow is about 907 m^3/s. The estimated predevelopment (without rail) 50 yr ARI event flood level is about Rl 221.3 m AHD. This flood level is estimated to have an inundation width of approximately 1080 m along the rail alignment.

It is currently proposed that a bridge is the primary hydraulic structure at the main channel crossing. The estimated post development (with rail) 50 yr ARI event flood level is about Rl 222 m AHD. This flood level is estimated to have an inundation width of approximately 1380 m along the rail alignment.

To supplement the bridge structure and maintain sheet flow throughout the floodplain it is currently proposed that 900 mm diameter relief culverts be provided at approximately 50m centres as per the floodplain relief culvert schedule in Appendix B. This will reduce the post development inundation width and flood level reported above.

5.1.9 Logan Creek

The catchment area of this creek at the proposed rail alignment is approximately 1477 km^2. It crosses the rail alignment at approximate chainage 175560 m. The 2010 GHD Alpha Coal Project (Rail) Surface Water report classified this stream as a major waterway with a stream order classification of 1.

The estimated design 50 yr ARI event flow is about 779 m^3/s. The estimated predevelopment (without rail) 50 yr ARI event flood level is about Rl 220.7 m AHD. This flood level is estimated to have an inundation width of approximately 2420 m along the rail alignment.

It is currently proposed that a bridge is the primary hydraulic structure at the main channel crossing. The estimated post development (with rail) 50 yr ARI event flood level is about Rl 221.4 m AHD. This flood level is estimated to have an inundation width of approximately 2900 m along the rail alignment.

To supplement the bridge structure and maintain sheet flow throughout the floodplain it is currently proposed that 900 mm diameter relief culverts be provided at approximately 50m centres as per the floodplain relief culvert schedule in Appendix B. This will reduce the post development inundation width and flood level reported above.

5.1.10 Diamond Creek

The catchment area of this creek at the proposed rail alignment is approximately 1534 km^2. It crosses the rail alignment at approximate chainage 196010 m. The 2010 GHD Alpha Coal Project (Rail) Surface Water report classified this stream as a major waterway with a stream order classification of 4.

The estimated design 50 yr ARI event flow is about 985 m^3/s. The estimated predevelopment (without rail) 50 yr ARI event flood level is about Rl 205.3 m AHD. This flood level is estimated to have an inundation width of approximately 3030 m along the rail alignment.

It is currently proposed that a bridge is the primary hydraulic structure at the main channel crossing. The estimated post development (with rail) 50 yr ARI event flood level is about Rl 206.2 m AHD. This flood level is estimated to have an inundation width of approximately 3820 m along the rail alignment.

To supplement the bridge structure and maintain sheet flow throughout the floodplain it is currently proposed that 900 mm diameter relief culverts be provided at approximately 50m centres as per the floodplain relief culvert schedule in Appendix B. This will reduce the post development inundation width and flood level reported above.

5.1.11 Myra Creek

The catchment area of this creek at the proposed rail alignment is approximately 392 km^2. It crosses the rail alignment at approximate chainage 197873 m. The 2010 GHD Alpha Coal Project (Rail) Surface Water report classified this stream as a major waterway with a stream order classification of 4.

The estimated design 50 yr ARI event flow is about 316 m^3/s. The estimated predevelopment (without rail) 50 yr ARI event flood level is about Rl 206.3 m AHD. This flood level is estimated to have an inundation width of approximately 1000 m along the rail alignment.

It is currently proposed that culverts are the primary hydraulic structure at the main channel crossing. The estimated post development (with rail) 50 yr ARI event flood level is about Rl 206.8 m AHD. This flood level is estimated to have an inundation width of approximately 1500 m along the rail alignment.

To supplement the culvert structure and maintain sheet flow throughout the floodplain it is currently proposed that 900 mm diameter relief culverts be provided at approximately 50m centres as per the floodplain relief culvert schedule in Appendix B. This will reduce the post development inundation width and flood level reported above.

5.1.12 Nibbereena Creek

The catchment area of this creek at the proposed rail alignment is approximately 193 km^2. It crosses the rail alignment at approximate chainage 200,515 m.

The estimated design 50 yr ARI event flow is about 514 m^3/s. The predevelopment (without rail) 50 yr ARI event flood level has not been determined at this location.

It is currently proposed that culverts are the primary hydraulic structure at the main channel crossing. The estimated post development (with rail) 50 yr ARI event flood level is about Rl 208.1 m AHD. This flood level is estimated to have an inundation width of approximately 1200 m along the rail alignment.

To supplement the culvert structure and maintain sheet flow throughout the floodplain it is currently proposed that 900 mm diameter relief culverts be provided at approximately 50m centres as per the floodplain relief culvert schedule in Appendix B. This will reduce the post development inundation width and flood level reported above.

5.1.13 Eaglefield Creek

The catchment area of this creek at the proposed rail alignment is approximately 886 km^2. It crosses the rail alignment at approximate chainage 225943 m. The 2010 GHD Alpha Coal Project (Rail) Surface Water report classified this stream as a major waterway with a stream order classification of 32.

The estimated design 50 yr ARI event flow is about 847 m^3/s. The predevelopment (without rail) 50 yr ARI event flood level has not been determined at this location.

It is currently proposed that culverts are the primary hydraulic structure at the main channel crossing. The estimated post development (with rail) 50 yr ARI event flood level is about Rl 227.9 m AHD. This flood level is estimated to have an inundation width of approximately 800 m along the rail alignment. It is noted that in extreme events, water will spill across the floodplain between Eaglefield Creek and the Suttor River.

To supplement the culvert structure and maintain sheet flow throughout the floodplain it is currently proposed that 900 mm diameter relief culverts be provided at approximately 50m centres as per the floodplain relief culvert schedule in Appendix B. This will reduce the post development inundation width and flood level reported above.

5.1.14 Suttor Creek

The catchment area of this creek at the proposed rail alignment is approximately 768 km^2. It crosses the rail alignment at approximate chainage 262070 m. The 2010 GHD Alpha Coal Project (Rail) Surface Water report classified this stream as a major waterway with a stream order classification of 9.

The estimated design 50 yr ARI event flow is about 1583 m^3/s. Stream Gauge No 120304A has been used for this estimate. The estimated predevelopment (without rail) 50 yr ARI event flood level is about Rl 272.1 m AHD. This flood level is estimated to have an inundation width of approximately 1400 m along the rail alignment.

It is currently proposed that a bridge is the primary hydraulic structure at the main channel crossing. The estimated post development (with rail) 50 yr ARI event flood level is about Rl 272.9 m AHD. This flood level is estimated to have an inundation width of approximately 1500 m along the rail alignment.

To supplement the bridge structure and maintain sheet flow throughout the floodplain it is currently proposed that 900 mm diameter relief culverts be provided at approximately 50m centres as per the floodplain relief culvert schedule in Appendix B. This will reduce the post development inundation width and flood level reported above. Refer to the Alpha Coal Project - Rail BFS Earthworks and Drainage drawings (CJVP10007-DWG-101) for plan profiles showing indicative floodplain relief culvert locations.

Crossing Name	Chainage (m)	Catchment Area (km^2)	Estimated Q_{50} (m^3/s)	Floodplain relief culverts proposed (Yes/No)	Primary Drainage Structure	Pre-dev Flood Level (Rl m AHD)	Post-dev Flood Level (Rl m AHD)	Est Backwater (afflux) (m)	Pre-dev Flood Width (m)	Post-dev Width (m)	Additional Comments
*****Native Companion Creek	38,690	5125	470	Y	Bridge	278.2	278.4	0.2	380	390	Gauge No 120305A used for analysis
*****Belyando River	44,000	5625	510	Y	Bridge & culverts	273.2	273.2	0	4480	4480	Gauge No 120305A used for analysis
Lestree Hill Creek	59,741	139	231	Y	Culvert	-	280.0	-	-	2200	
Sixteen Mile Creek	93,679	156	259	Y	Culvert	-	284	-	-	100	
Mistake Creek	118,160	2555	800	Y	Bridge	242.6	242.7	0.2	200	200	Gauge No 120306A used for analysis
Piebald Creek	134,638	467	527	Y	Culvert	233.7	233.8	0.1	900	1100	
Miclere Creek	141,478	1026	949	Y	Culvert	231.7	232.6	0.9	3500	3800	
*****Brown Creek	170,280	1123	907	Y	Bridge	221.3	222	0.8	1080	1380	
*****Logan Creek	175,560	1477	779	Y	Bridge	220.7	221.4	0.7	2420	2900	
*****Diamond Creek	196,010	1534	985	Y	Bridge	205.3	206.2	0.9	3030	3820	
*****Myra Creek	197,873	392	316	Y	Culvert	206.3	206.8	0.5	1000	1500	
Nibbereena Creek	200,515	193	514	Y	Culvert	-	208.1	-	-	1200	
*****Eaglefield Creek	225,943	886	847	Y	Culvert	-	227.9		-	800	
*****Suttor Creek	262,070	768	1583	Y	Bridge & culverts	272.7	273.3	0.6	1400	1500	Stream Gauge No 120304A used for analysis

Table 5 – Floodplain location and characteristics summary

The figures in this table are representative of the best available data and analysis methods during the BFS, however, further analysis of a number of these streams is required during detailed design to incorporate new information supplied by aerial survey, land-holders and field investigations.

* - From recent discussions with land-holders it is understood, in extreme events, certain stream and catchments, identified above, interact with one another, these include;

- Native Companion Creek and Belyando River;
- Logan Creek and Brown Creek; and
- Eaglefield Creek and Suttor River.

In the above 3 cases, flood widths may vary greatly from what has been calculated from the available data in the BFS. During detailed design, the above 3 systems will be reanalysed and modelled using the new information and the interaction between the individual streams in each system captured.

Adopting the recommended changes to the velocity and afflux design criteria where warranted as described in section 3.2.1 will further serve to minimise potential adverse impacts such as erosion and extent and duration of flooding.

5.2 Flood studies

An extensive search of publicly available information on flooding in the project area was undertaken as part of the BFS design process. It is noted that no existing flood study reports were found.

The 2010 GHD report titled, "Alpha Coal Project (Rail) Surface Water" aimed at investigating the surface water values of the project area in support of the projects Environmental Impact Assessment. This report provides an overview of waterway environmental values for the entire alignment. It also provides maps and a spreadsheet with stream orders and waterway classifications for all waterways along the alignment.

Use was made of DERM river/creek gauge data where available. Flood Frequency Analysis of the river gauging data was undertaken to determine the drainage structure sizing. As this method was deemed to result in the most accurate design flow estimates derived within the constraints of the study, the other three design flow methods described in section 4.2 were selected for use on the basis of how closely they matched these estimates in the area were applicable.

As noted in section 6.2.1 the BFS bridge lengths and heights reported were derived using the AFFLUX design software as per AUSTROADS Waterway Design, 1994. The Afflux software output includes estimated bridge outlet velocity, natural water level and backwater or afflux. This output assists to understand the likely real world impacts of proposed infrastructure. Appendix B of this report includes the simulation results of the proposed waterway bridges along the alignment.

5.3 Work in progress

It is acknowledged that input from landholders and other stakeholders in terms of their experiences and records of past flood events provides an invaluable set of information that must be considered in the detailed design phase. HCPL is therefore currently in the process of engaging with landholders along the railway alignment to obtain this information with the assistance of a specialist hydrological consultant. The exercise is also being used to inform landowners of the proposed railway design including mitigation measures such as floodplain relief culverts and scour protection to minimise the likely adverse impacts of flooding on their properties.

HCPL is also in the process of gathering additional aerial survey information were required to support the flood modelling exercise planned during the detailed design stage as outlined in section 5.4.

5.4 Work planned

A number of activities are planned to address flooding concerns in subsequent design stages of this project as outlined below:

- All the proposed design solutions presented at this BFS stage will be subject to further design development at the detailed design stage. This will include "ground truthing" and value engineering to provide the most cost effective solution given design constraints.
- Continue with the stakeholder consultation exercise described in section 5.3 to include other stakeholders who may be affected by the proposed railway and not consulted in the current process.
- The information gathered from the landholder consultation exercise will be used to ensure the proposed flood modelling described below is accurate and most update.
- It is proposed that during the detailed design stage of the project the proposed solutions in the major floodplain areas listed below are revisited and checked by running 2 dimensional flow models (for example MIKE FLOOD) which will assist to better understand floodplain flows:
  - Native Companion Creek;
  - Belyando River;
  - Lestree Hill Creek;
  - Sixteen Mile Creek;
  - Mistake Creek;
  - Piebald Creek;
  - Miclere Creek;
  - Brown Creek;
  - Logan Creek;
  - Diamond Creek;
  - Myra Creek;
  - Eaglefield Creek;
  - Suttor Creek;

  The modelling will not only aid understanding of likely flood depths but also the inundation duration which may be a more important factor in some areas. The model results will be used adjust the current drainage structure design to minimise adverse impacts on existing infrastructure i.e. reduce backwater and flow velocities.

6.0 WATERWAY BRIDGES

20 waterway bridge sites have been identified and sized for the Alpha Coal Project railway as summarised in Table 6. Figure 4 below shows the location of all proposed waterway bridges and significant culvert structure location sites on the rail alignment. Appendix B contains the waterway bridge and culvert schedules with additional bridge information. All proposed bridge sites have 50 yr ARI design event flows greater than 300 m3/s. At some of the bridge sites the proposed bridge structure will be complemented with culvert structures to cater for the 50 yr ARI design event flow.

Sacrificial low points consisting of reinforced embankments, (cement stabilised fill and/or rip rap or similar may be used for embankment reinforcement), adjacent to brides or other locations may be provided at some strategic locations to cater for extreme storm events. This issue will be further investigated during the detailed design phase.

Crossing Name	Chainage (m)	Nominal Length (m)	Nominal Height (m)	Supplementary culverts required (yes/no)	Guide banks required (yes/no)
Native Companion Creek	38,690	60	9	yes	no
Belyando River	44,000	156	7.5	yes	no
Mistake Creek	118,160	100	9	yes	yes
Brown Creek	170,280	140	5	yes	yes
Logan Creek	175,560	120	7	yes	no
Diamond Creek	196,010	180	6	yes	yes
Suttor Creek	262,070	80	12.5	yes	no
Rosella Creek 1	334,868	80	10	no	no
Rosella Creek 2	336,872	80	13	no	yes
Bowen River	344,780	320	21	yes	no
Pelican Creek	366,371	80	15	no	no
Table Mountain Creek	384,890	80	20	no	yes
Herbert Creek	421,672	40	10	no	yes
Capsize Creek	426,971	40	8	yes	no
Bogie River	436,480	360	13	yes	no
Sandy Creek	457,475	60	14	no	no
Finley Creek	464,605	60	13.5	no	no
Elliot River	467,847	80	11.5	yes	yes
Splitters Creek	483,793	40	12	yes	no
Saltwater Creek	497,030	100	4.5	no	no

Table 6 – Bridge location summary

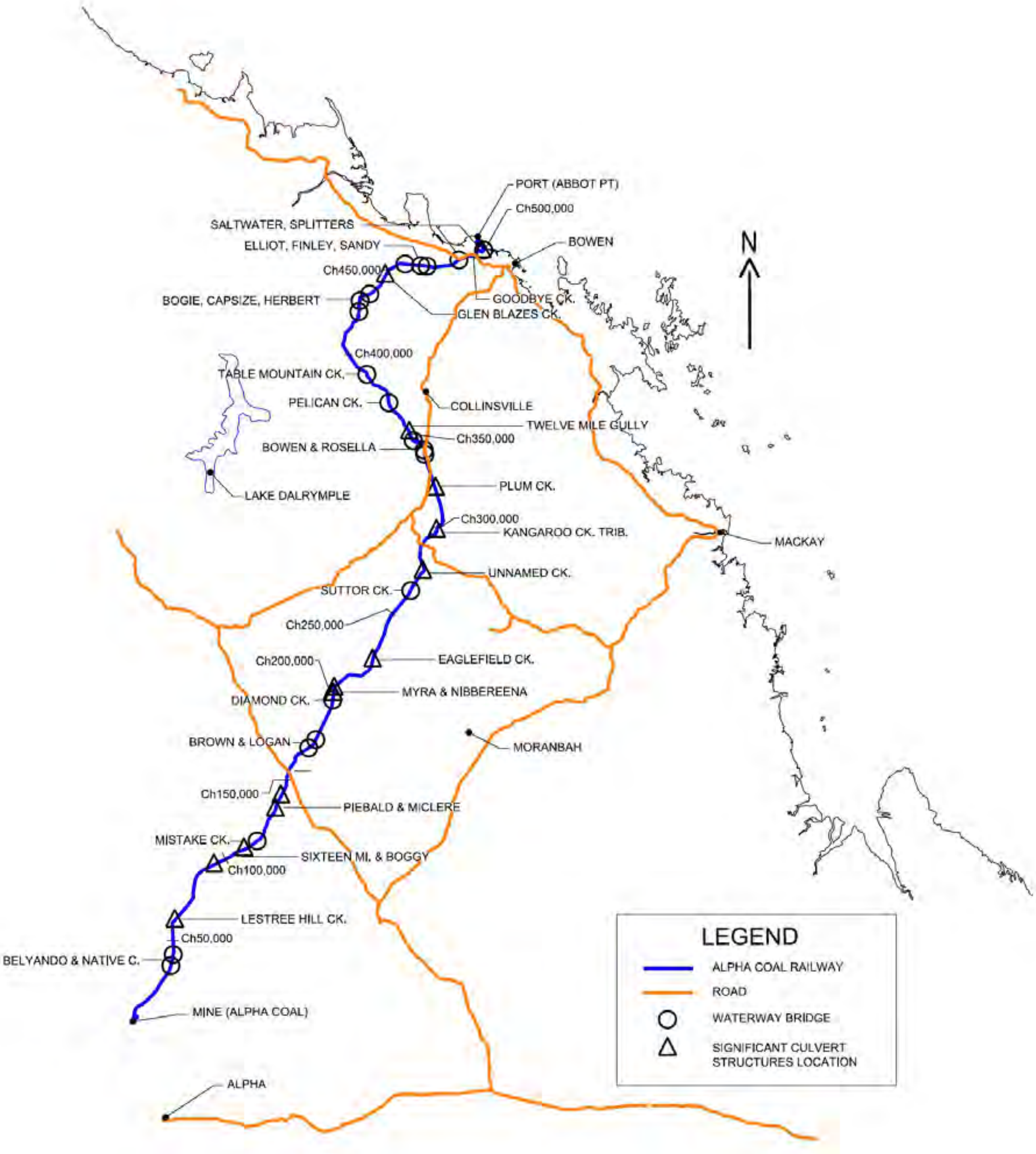


Figure 4 – Waterway bridge and significant culvert structure locations

6.1 Bridge Hydrology

The design flow computation method for sizing the bridge structure opening at each location was based on one of four alternatives as follows:

- Flood frequency analysis was used at the six bridge locations with data noted in Section 4.2.3. These were deemed to be the most accurate design flow estimates to be derived within the constraints of the Study and the other three methods described below were selected for use on the basis of how closely they matched these estimates in the area were applicable;
- Main channel capacity analysis was used where conventional flow estimation methods were not considered directly applicable due to extensive floodplains such as at the Native Companion Creek and Belyando River crossings;
- The Rational method was used at bridges located in floodplains in the southern half of the rail alignment at the following locations; Brown Creek, Logan Creek and Diamond Creek;
- RORB model derived design flows were used for the majority of the northern bridges (from chainage 250 km to port).

6.2 Bridge Hydraulic Computations

6.2.1 AFFLUX Modelling

The bridge lengths and heights reported in this Study were derived using the AFFLUX design software as per AUSTROADS Waterway Design, 1994. As no hydrology specific site investigation was undertaken as part of this study all the Afflux calculations were based on an assumed Manning's “n” value of 0.06 throughout the entire modelled crossing section at each bridge. Each crossing location calculation will be refined at the detailed design stage after detailed site investigations have been undertaken.

The AFFLUX modelling also assumed the following bridge type characteristics:

- Spill through abutments at 1.5 H:1V slope;
- In low lying areas, (generally south of chainage 250 km) bridges to use 12 m spans, 0.9 m wide piers for an approximate total structural depth of 1 m;
- In the steeper areas, (generally north of chainage 250 km) bridges to use 20 m spans, 1.8 m wide piers for an approximate total structural depth of 1.7 m.

6.2.2 Guide Bank Design

Bridge guide banks are proposed at some bridge locations as shown on the bridge drawings. These have been sized according to AUSTROADS Waterway Design, 1994 guidelines.

6.2.3 Scour and Ultimate Limit State (ULS) Velocity Estimates

As the BFS scope did not include ground-breaking geotechnical investigations, detailed scour assessment has not been undertaken as part of this study. Nominal estimates based on desktop geotechnical studies and engineering judgement were made for the bridge foundation designs.

The bridge design code (AS 5100.02) requires bridge structures to be able to withstand without catastrophic failure, the effects of floods up to the 2000 year ARI event. AUSTROADS Waterway Design, 1994 guidelines states that it is not necessary to estimate the 2000 year ARI event but to estimate the likelihood of the bridge being overtopped. The point of overtopping then becomes the critical condition. The guideline further recommends that bridges in cyclonic regions in the north of Australia should be designed for the overtopping event given the uncertainty of flood estimates.

For this Study the approach taken to estimate the bridge design velocities for the ultimate limit state design was to determine the velocity at bridge overtopping using the AFFLUX software with an allowance for scour as noted above. It is noted that in some locations the likelihood of overtopping is very unlikely or not possible due to the natural topography where the land forms slope away from rivers or creeks on higher ground. It is also estimated that in some of the major flood plain areas the magnitude of the overtopping event would be in excess of the 2000 year ARI event because of catchment storage. In such instances engineering judgement and experience was used to estimate a design velocity to use. Where applicable the ARI of the overtopping event was estimated using the procedures recommended in AUSTROADS Waterway Design. Design rainfall estimates for this analysis were estimated using the Centre for Cooperative Research in Catchment Hydrology CRC Forge software program. Table 7 below provides a summary of the preliminary ULS design velocity assumed for each bridge and the estimated ARI of the overtopping event of each bridge where applicable.

Crossing Name	Assumed ULS design velocity (m/s)	Overtopping event (yes/no)	Est ARI of overtopping event (yrs)
Native Companion Creek	1.8	no	n/a
Belyando River	3.8	no	n/a
Mistake Creek	3.6	yes	>2000
Brown Creek	3.1	no	n/a
Logan Creek	3.2	no	n/a
Diamond Creek	3.8	yes	<1000
Suttor Creek	4.1	no	n/a
Rosella Creek 1	5.3	yes	<1000
Rosella Creek 2	5.3	yes	>2000
Bowen River	4.0	yes	<2000
Pelican Creek	5.5	no	n/a
Table Mountain Creek	8.8	yes	>2000
Herbert Creek	6.1	no	n/a
Capsize Creek	5.4	yes	=2000

Crossing Name	Assumed ULS design velocity (m/s)	Overtopping event (yes/no)	Est ARI of overtopping event (yrs)
Bogie River	3.7	no	n/a
Sandy Creek	4.1	yes	>2000
Finley Creek	3.6	no	n/a
Elliot River	6.1	no	n/a
Splitters Creek	4.9	no	n/a
Saltwater Creek	TBC	TBC	TBC

Table 7 – Preliminary ULS Bridge Design Estimates

6.2.4 Locations recommended for two dimensional flow modelling

Whilst all proposed solutions presented in this BFS will be subject to further design development at the detailed design stage. It is highly recommended that during the detailed design stage of the project the proposed solutions in the major floodplain areas listed below be revisited and checked by running 2 dimensional flow models (for example MIKE FLOOD) which will assist to better understand floodplain flows once additional survey information has been obtained for the river and creek systems including:

- Native Companion Creek;
- Belyando River;
- Lestree Hill Creek;
- Sixteen Mile Creek;
- Mistake Creek;
- Piebald Creek;
- Miclere Creek;
- Brown Creek;
- Logan Creek;
- Diamond Creek;
- Myra Creek;
- Eaglefield Creek;
- Suttor Creek;
- Salt Water Creek plus the Port loop.

Bridge structural information inclusive of rock protection, drawings references etc is reported in the Bridge Report, CJVP10007-REP-S-001.

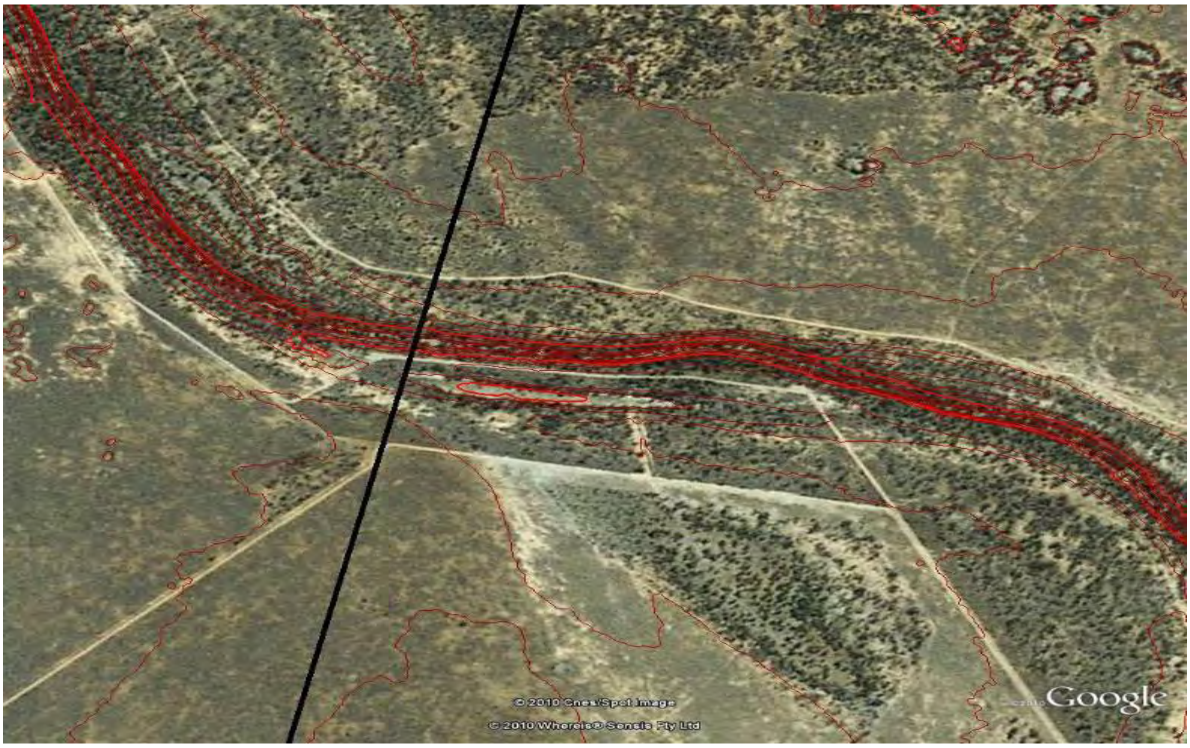
The subsections in Section 5.3 below show the Google Earth view of each proposed bridge site, photographs of the existing sites at or near the proposed crossing, and provides additional information on some of the bridge sites where pertinent. The black line across the photographs represents the approximate Design Iteration 2 rail alignment.

6.3 Additional individual site information

6.3.1 Native Companion Creek

At Native Companion Creek, the hydraulic structure sizing at the main creek crossing is based on the main channel capacity. It is currently proposed that a 60 m wide bridge be installed at the main channel crossing (approximate chainage 38 km). It is noted that any flow higher than Rl 278.2 m at approximate chainage 38.2 km will result in water spilling into the Belyando floodplain.

To supplement the bridge structure and maintain sheet flow throughout the floodplain it is currently proposed that 900 mm diameter relief culverts be provided at approximately 50m centres as per the floodplain relief culvert schedule in Appendix B.



Bridge Tag	Bridge-30
Crossing Name	Native Companion Creek
Chainage (m)	38,690
Catchment area (km^2)	5,125
Bridge length (m)	60
Supplementary Culverts?	Yes
Nominal Height (m)	9
Catchment Length (km)	174
Landholder	Eulimbie – Rostron
Equal area slope (m/km)	0.89

6.3.2 Belyando River

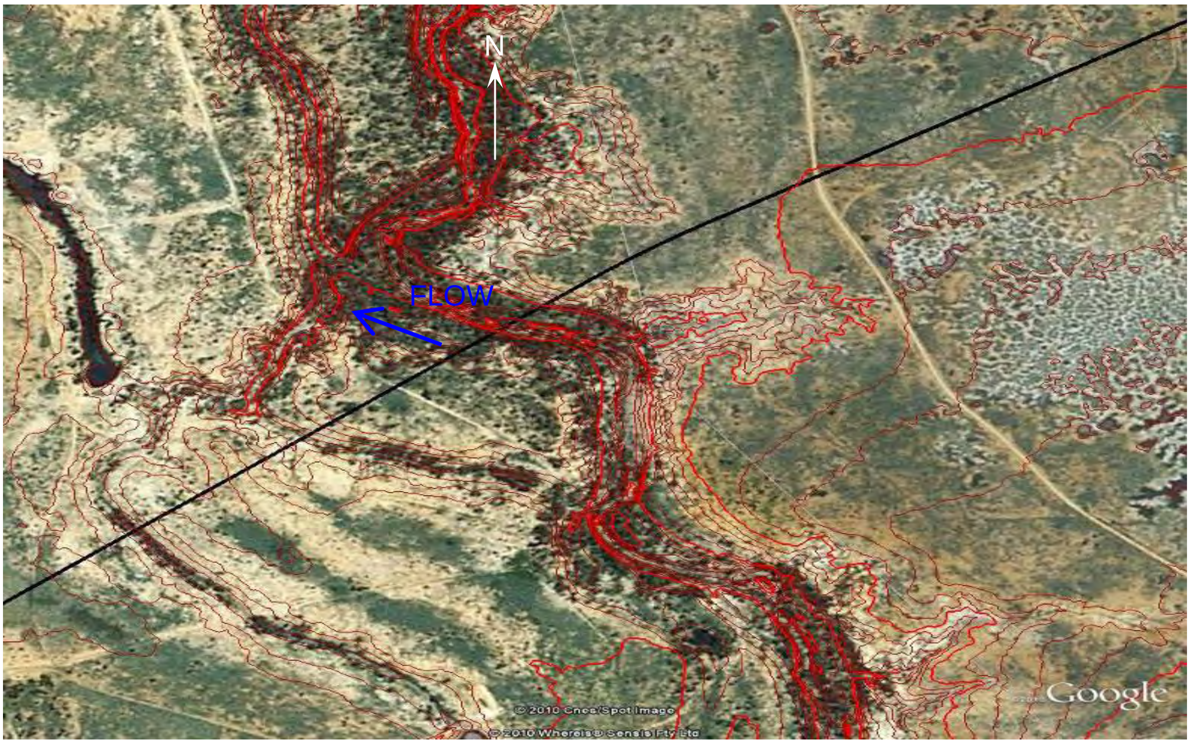
At Belyando River the hydraulic structure design at the main river crossing is based on the main channel capacity. It is currently proposed that a 150 m wide bridge and 50 No. 3 m diameter culverts will be placed at approximately 10 m centres at the main river crossing.

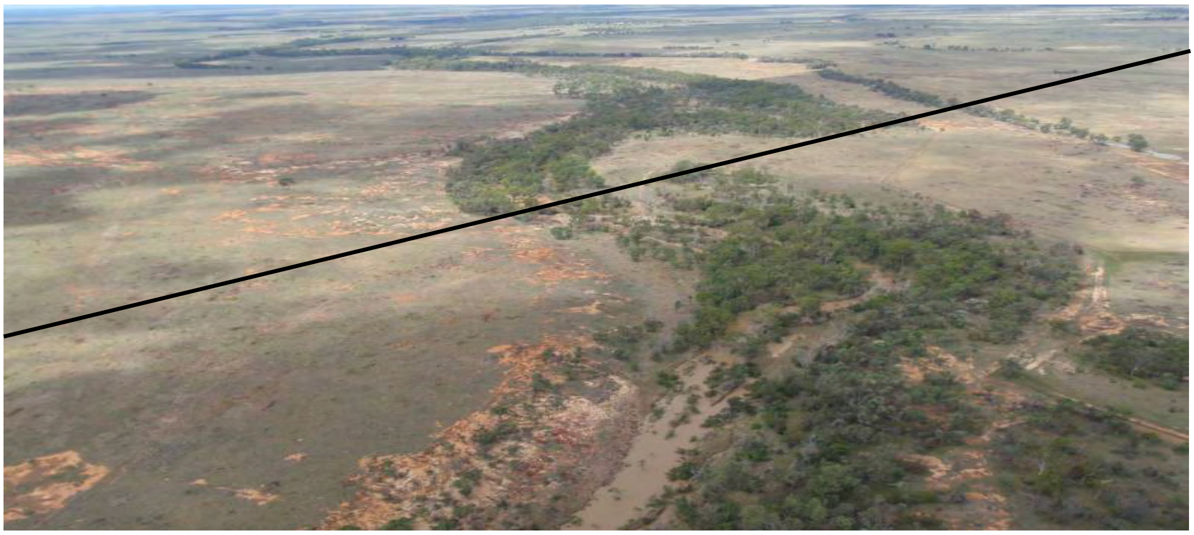
To supplement the main crossing structures above to maintain sheet flow it is proposed that 900 mm diameter relief culverts will be provided at approximately 25 m centres as per the floodplain relief culvert schedule in Appendix B. Closer relief culvert spacing compared to the Native Companion Creek crossing is recommended as this location is viewed as a major floodplain. Outlets at 25 m intervals will ensure that the flow is spread over the full width within about 13 m of the culvert outlets. Detailed hydraulic modelling will be undertaken once more accurate survey information is provided.

Bridge Tag	Bridge-29
Crossing Name	Belyando River
Chainage (m)	44,000
Catchment area (km^2)	5,625
Bridge length (m)	156
Supplementary Culverts?	Yes
Nominal Height (m)	7.5
Catchment Length (km)	173
Landholder	Eulimbie - Rostron
Equal area slope (m/km)	0.81

6.3.3 Mistake Creek

The hydraulic structure at the main crossing is sized on the basis of a design flow estimate derived using Flood Frequency Analysis of Mistake Creek gauging station data. To supplement the bridge structure and maintain sheet flow it is proposed that 900 mm diameter relief culverts be provided at approximately 50 m centres as per the floodplain relief culvert schedule in Appendix B. Guide banks will be required to decrease the risk of abutment scour.





Bridge Tag	Bridge-27
Crossing Name	Mistake Creek
Chainage (m)	118,160
Catchment area (km^2)	2,555
Bridge length (m)	100
Supplementary Culverts?	Yes
Nominal Height (m)	9
Catchment Length (km)	103
Landholder	Charlton - Bush
Equal area slope (m/km)	1.25

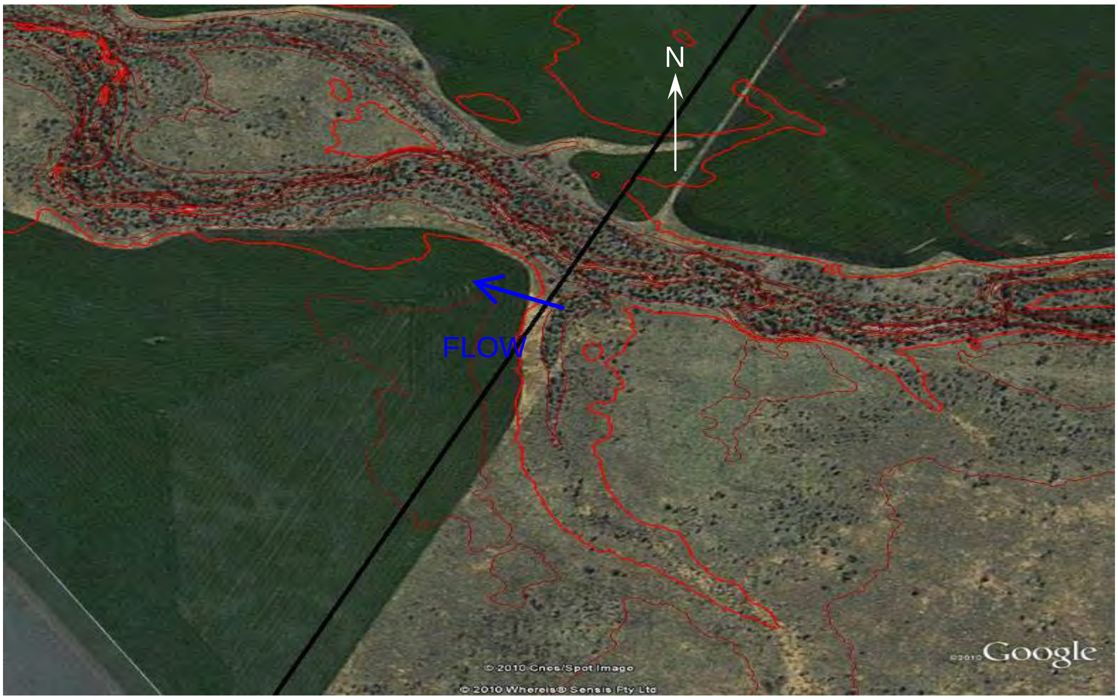
6.3.4 Brown Creek

The hydraulic structure at the main crossing is sized on the basis of a design flow estimate derived using the Rational method. To supplement the bridge structure and maintain sheet flow it is proposed that 900 mm diameter relief culverts be provided at approximately 50 m centres as per the floodplain relief culvert schedule in Appendix B. Guide banks will be required to decrease the risk of abutment scour.

Bridge Tag	Bridge-23
Crossing Name	Brown Creek
Chainage (m)	170,280
Catchment area (km^2)	1,123
Bridge length (m)	140
Supplementary Culverts?	Yes
Nominal Height (m)	5
Catchment Length (km)	65
Landholder	Amaroo - Hodgkinson
Equal area slope (m/km)	1.25

6.3.5 Logan Creek

The hydraulic structure at the main crossing is sized on the basis of a design flow estimate derived using the Rational method. To supplement the bridge structure and maintain sheet flow it is proposed that 900 mm diameter relief culverts be provided at approximately 50 m centres as per the floodplain relief culvert schedule in Appendix B.



Bridge Tag	Bridge-22
Crossing Name	Logan Creek
Chainage (m)	175,560
Catchment area (km^2)	1,477
Bridge length (m)	120
Supplementary Culverts?	Yes
Nominal Height (m)	7
Catchment Length (km)	117
Landholder	Talki Station - Lund
Equal area slope (m/km)	1.59

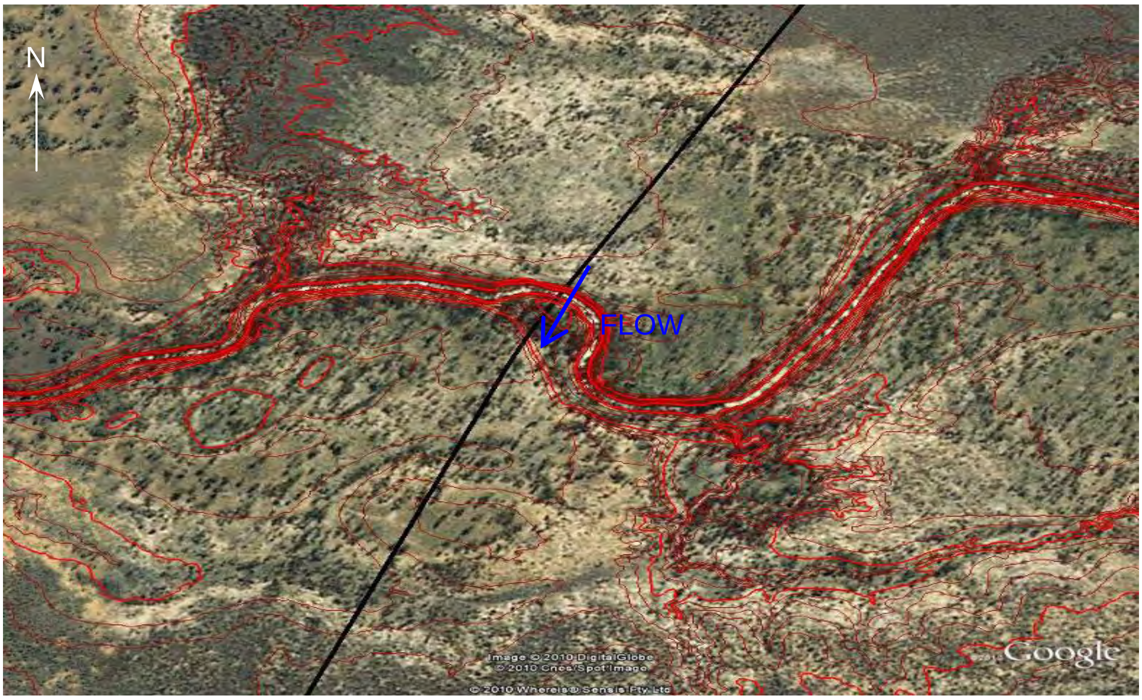
6.3.6 Diamond Creek

The hydraulic structure at the main crossing is sized on the basis of a design flow estimate derived using the Rational method. To supplement the bridge structure and maintain sheet flow it is proposed that 900 mm diameter relief culverts be provided at approximately 50 m centres as per the floodplain relief culvert schedule in Appendix B. Guide banks will be required to decrease the risk of abutment scour.

Bridge Tag	Bridge-21
Crossing Name	Diamond Creek
Chainage (m)	196,010
Catchment area (km^2)	1,534
Bridge length (m)	180
Supplementary Culverts?	Yes
Nominal Height (m)	6
Catchment Length (km)	67
Landholder	Avon Downs - Simmons
Equal area slope (m/km)	0.34

6.3.7 Suttor Creek

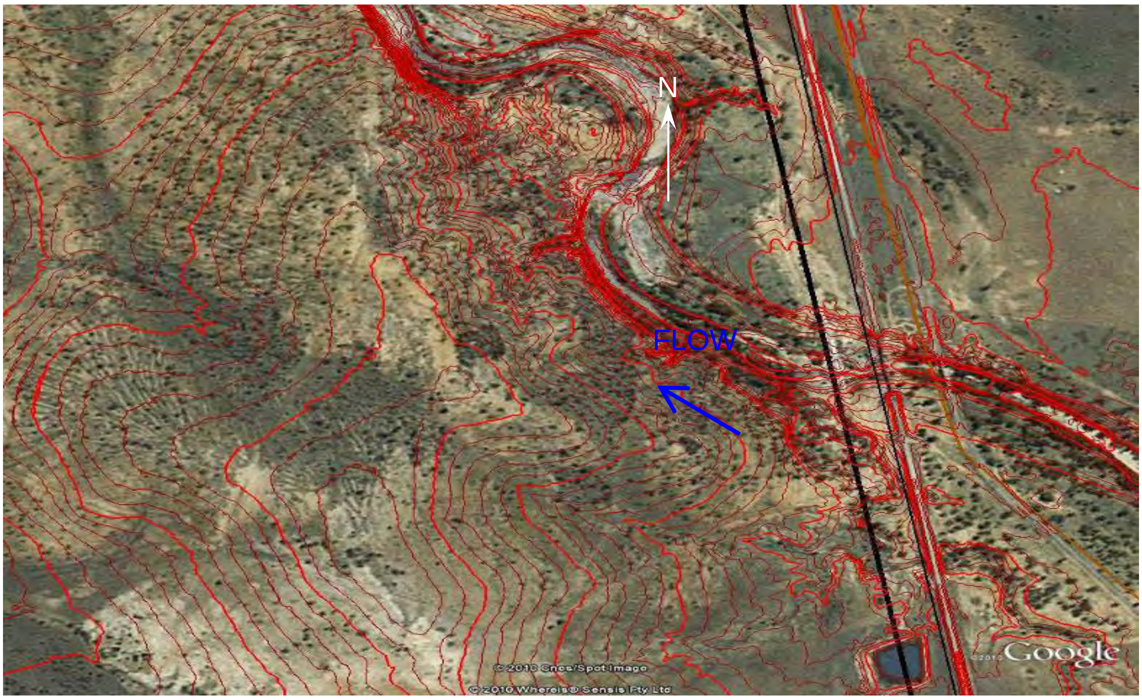
It is currently proposed that an 80 m wide bridge is constructed over the main channel and 15 No. 3.6 m diameter culverts be placed in the adjacent secondary crossing. The hydraulic structures at the main crossing are sized on the basis of a design flow estimate derived using Flood Frequency Analysis of Suttor Creek gauging station data. To supplement the main crossing structures above and maintain sheet flow it is proposed that 900 mm diameter relief culverts be provided at approximately 50 m centres as per the floodplain relief culvert schedule in Appendix B.



Bridge Tag	Bridge-17
Crossing Name	Suttor Creek
Chainage (m)	262,070
Catchment area (km^2)	768
Bridge length (m)	80
Supplementary Culverts?	Yes
Nominal Height (m)	12.5
Catchment Length (km)	40
Landholder	Border Eaglefield / Wollombi
Equal area slope (m/km)	2.14

6.3.8 Rosella Creek 1

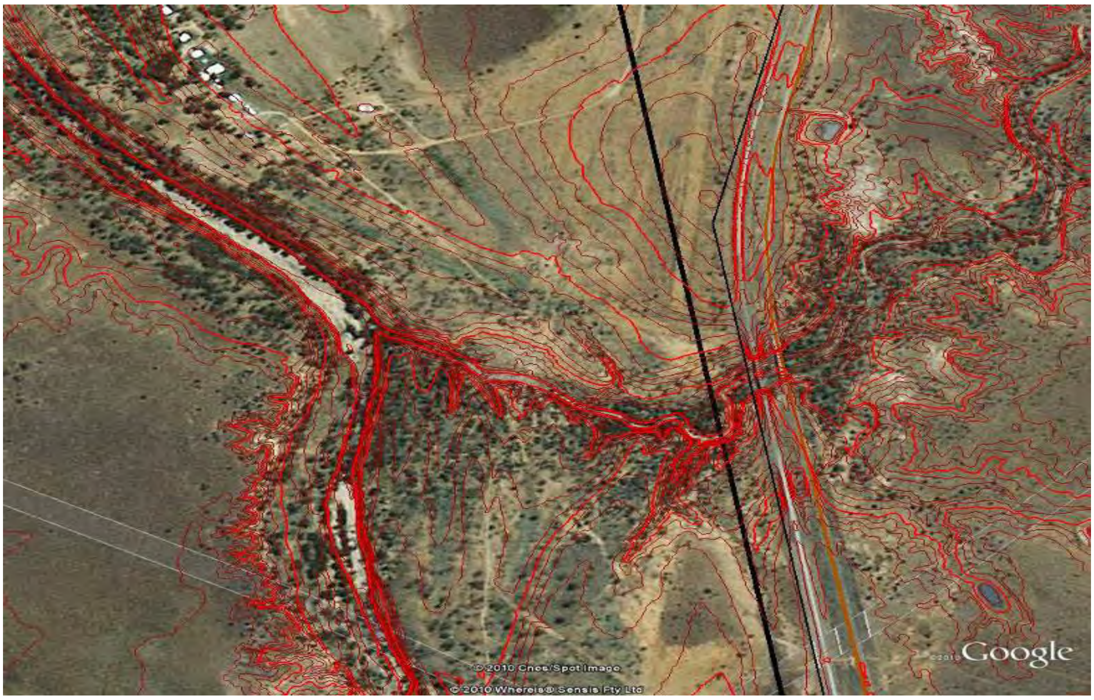
The hydraulic structure at the main crossing is sized on the basis of a design flow estimate derived using the RORB rainfall runoff model. The current proposed bridge location is less than 100 m offset from existing road/rail bridges.



Bridge Tag	Bridge-15
Crossing Name	Rosella Creek 1
Chainage (m)	334,868
Catchment area (km^2)	1,270
Bridge length (m)	80
Supplementary Culverts?	No
Nominal Height (m)	10
Catchment Length (km)	83
Landholder	Havilah - Colinta
Equal area slope (m/km)	1.86
Notes	Main branch of Rosella Creek

6.3.9 Rosella Creek 2

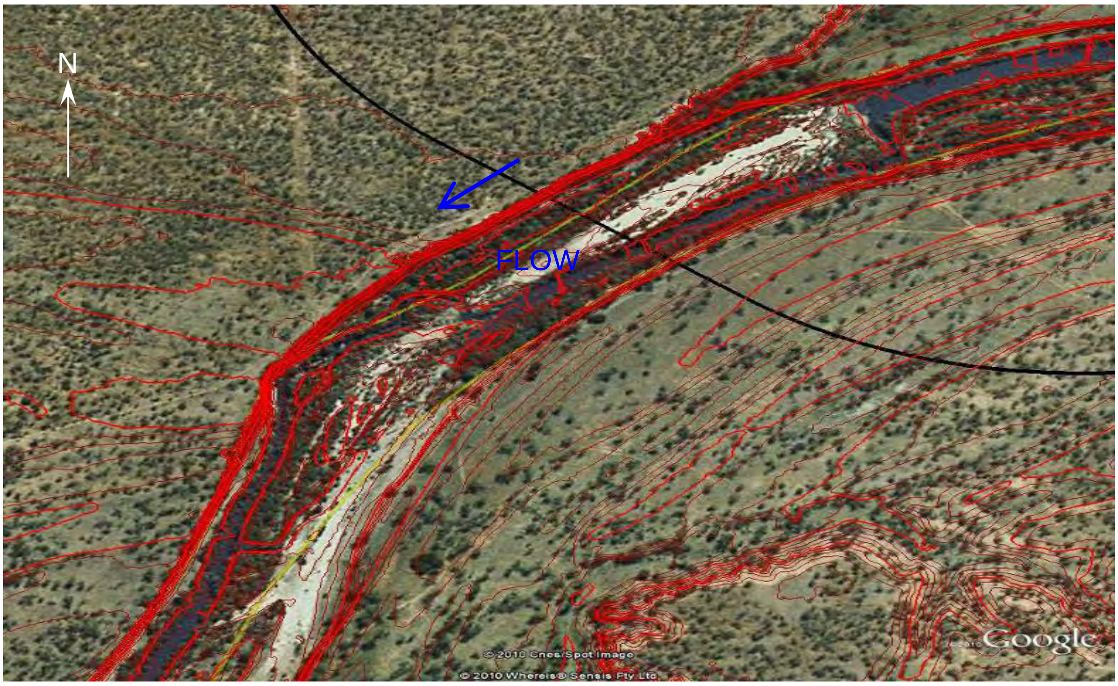
The hydraulic structure at the main crossing is sized on the basis of a design flow estimate derived using the RORB rainfall runoff model. A guide bank will be required to decrease the risk of abutment scour on the right hand abutment (looking downstream). The current proposed bridge location is less than 100 m offset from existing road/rail bridges.



Bridge Tag	Bridge-14
Crossing Name	Rosella Creek 2
Chainage (m)	336,872
Catchment area (km^2)	157
Bridge length (m)	80
Supplementary Culverts?	No
Nominal Height (m)	13
Catchment Length (km)	28
Landholder	Havilah - Colinta
Equal area slope (m/km)	1.52
Notes	May also be known as Havilah Creek.

6.3.10 Bowen River

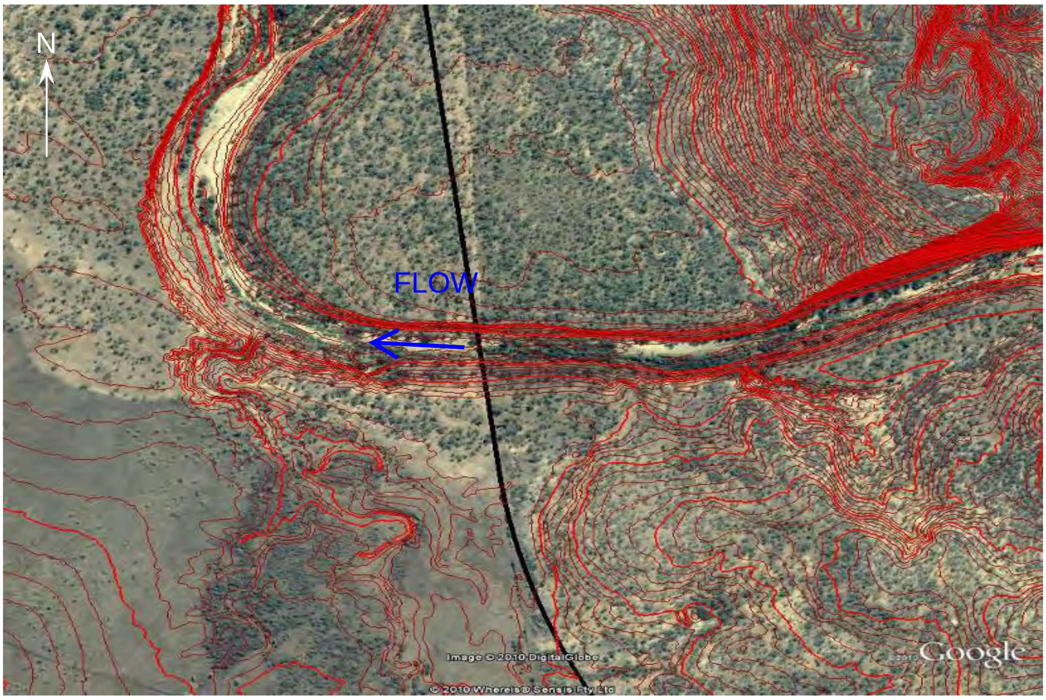
The hydraulic structure at the main crossing is sized on the basis of a design flow estimate derived using Flood Frequency Analysis of Bowen River gauging station data. To supplement the bridge structure and maintain sheet flow it is proposed that 1 No. 3 m diameter relief culvert be provided approximately 300 m left (looking downstream) of the bridge.

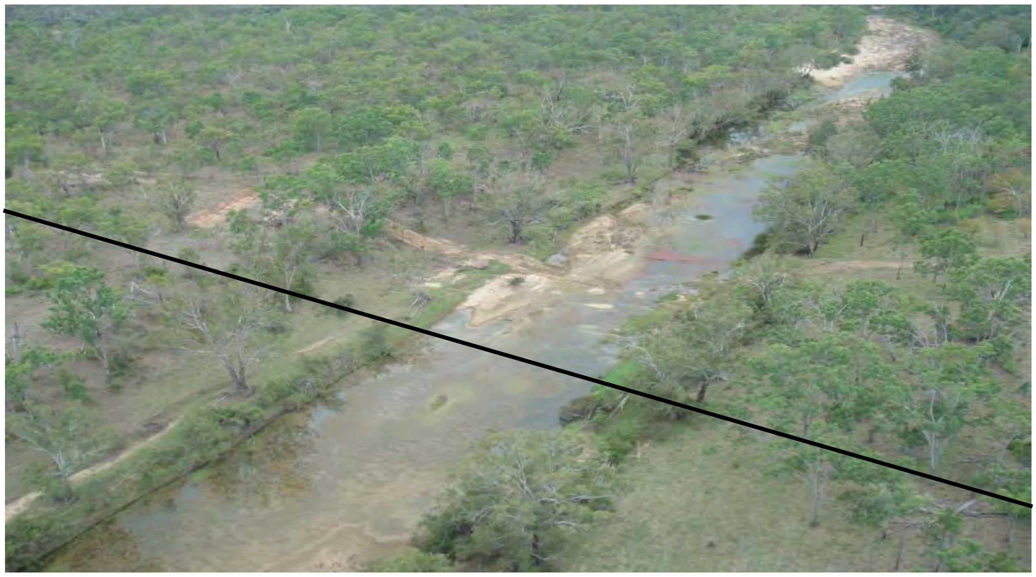


Bridge Tag	Bridge-13
Crossing Name	Bowen River
Chainage (m)	344,780
Catchment area (km^2)	4,310
Bridge length (m)	320
Supplementary Culverts?	Yes
Nominal Height (m)	21
Catchment Length (km)	124
Landholder	Border Havilah / Biralee - MacNicol
Equal area slope (m/km)	1.04

6.3.11 Pelican Creek

The hydraulic structure at the main crossing is sized on the basis of a design flow estimate derived using Flood Frequency Analysis of Pelican Creek gauging station data.

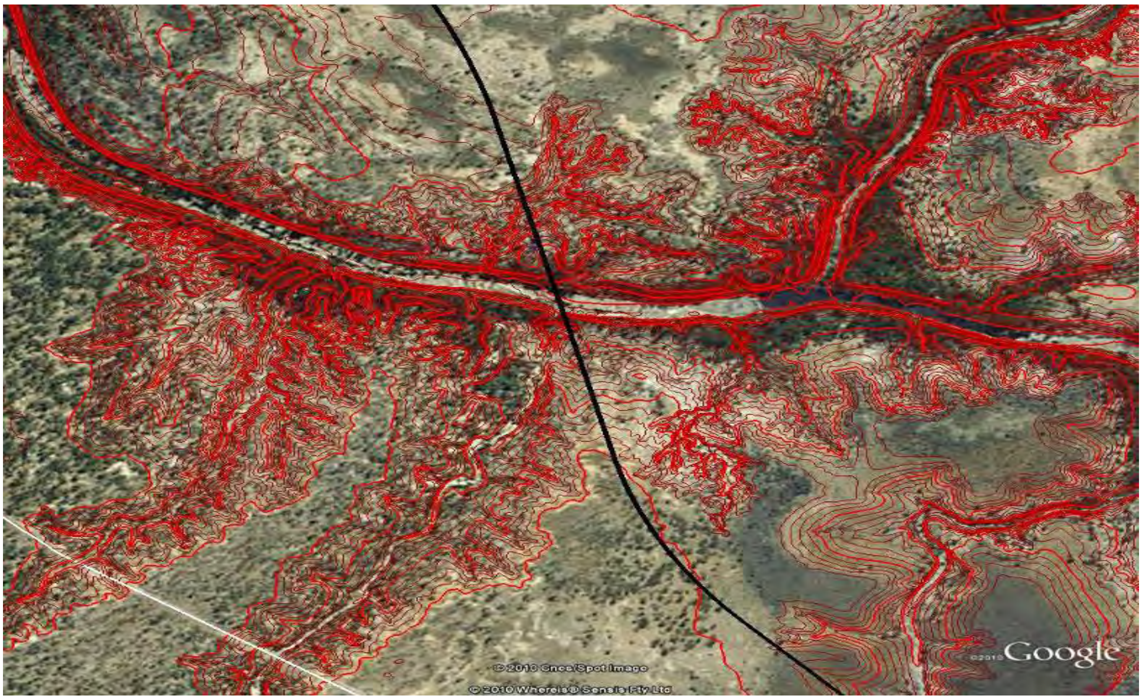




Bridge Tag	Bridge-12
Crossing Name	Pelican Creek
Chainage (m)	366,371
Catchment area (km^2)	554
Bridge length (m)	80
Supplementary Culverts?	No
Nominal Height (m)	15
Catchment Length (km)	51
Landholder	Border Myuna / Strathmore
Equal area slope (m/km)	3.67

6.3.12 Table Mountain Creek

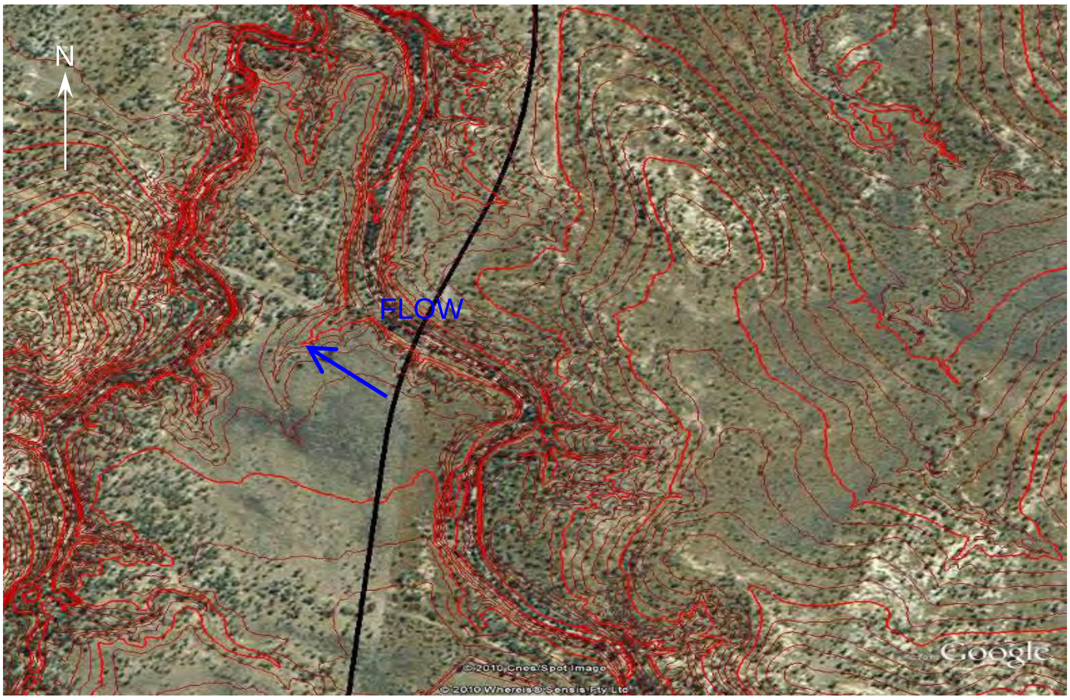
The hydraulic structure at the main crossing is sized on the basis of a design flow estimate derived using the RORB rainfall runoff model. A guide bank will be required to decrease the risk of abutment scour on the right hand abutment (looking downstream).

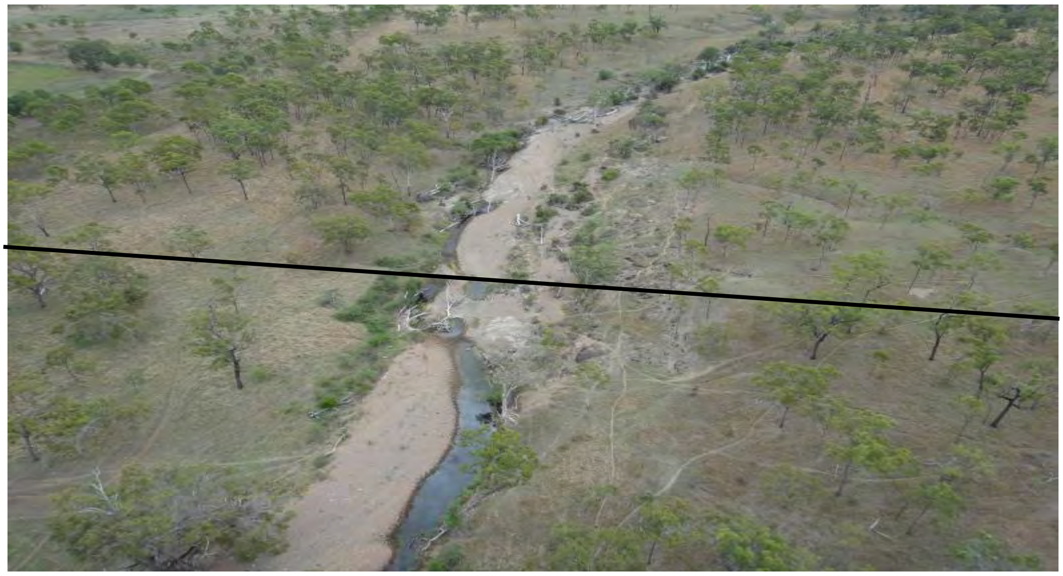


Bridge Tag	Bridge-11
Crossing Name	Table Mountain Creek
Chainage (m)	384,890
Catchment area (km^2)	623
Bridge length (m)	80
Supplementary Culverts?	No
Nominal Height (m)	20
Catchment Length (km)	40
Landholder	Strathmore
Equal area slope (m/km)	2.94

6.3.13 Herbert Creek

The hydraulic structure at the main crossing is sized on the basis of a design flow estimate derived using the RORB rainfall runoff model. Guide banks will be required to decrease the risk of abutment scour.

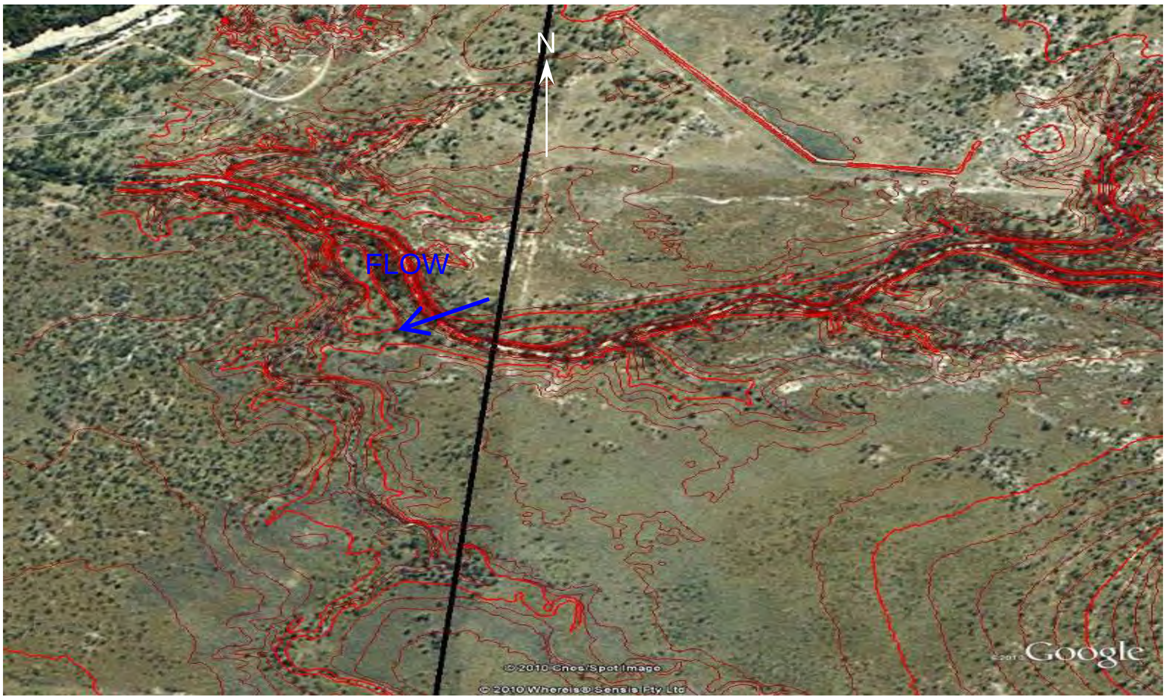




Bridge Tag	Bridge-10
Crossing Name	Herbert Creek
Chainage (m)	421,672
Catchment area (km^2)	49
Bridge length (m)	40
Supplementary Culverts?	No
Nominal Height (m)	10
Catchment Length (km)	17
Landholder	Border De Salis / Castleview
Equal area slope (m/km)	9.54

6.3.14 Capsize Creek

The hydraulic structure at the main crossing is sized on the basis of a design flow estimate derived using the RORB rainfall runoff model. To supplement the bridge structure and maintain sheet flow it is proposed that 1 No. 900 mm diameter relief culvert be provided approximately 60 m right (looking downstream) of the bridge.



Bridge Tag	Bridge-09
Crossing Name	Capsize Creek
Chainage (m)	426,971
Catchment area (km^2)	112
Bridge length (m)	40
Supplementary Culverts?	No
Nominal Height (m)	8
Catchment Length (km)	25
Landholder	Castleview - Watts
Equal area slope (m/km)	4.12

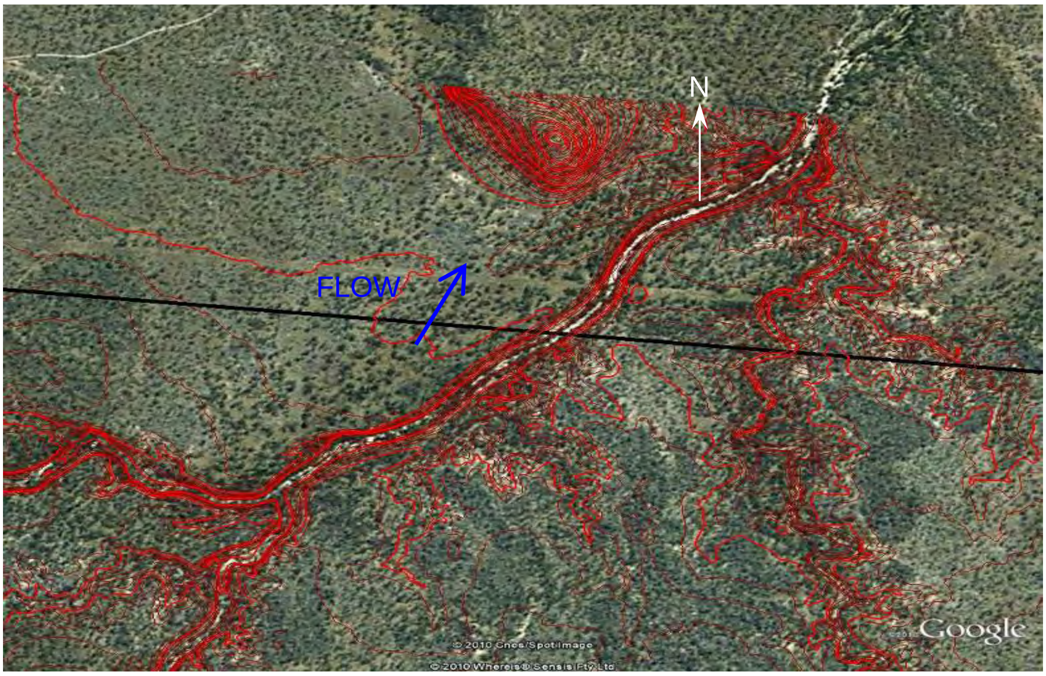
6.3.15 Bogie River

The hydraulic structure at the main crossing is sized on the basis of a design flow estimate derived using Flood Frequency Analysis of Pelican Creek gauging station data. To supplement the bridge structure and maintain sheet flow it is proposed that 1 No. 900 mm diameter relief culvert be provided approximately 200 m right (looking downstream) of the bridge.

Bridge Tag	Bridge-08
Crossing Name	Bogie River
Chainage (m)	436,480
Catchment area (km^2)	974
Bridge length (m)	360
Supplementary Culverts?	Yes
Nominal Height (m)	13
Catchment Length (km)	81
Landholder	Castleview - Watts
Equal area slope (m/km)	2.86

6.3.16 Sandy Creek

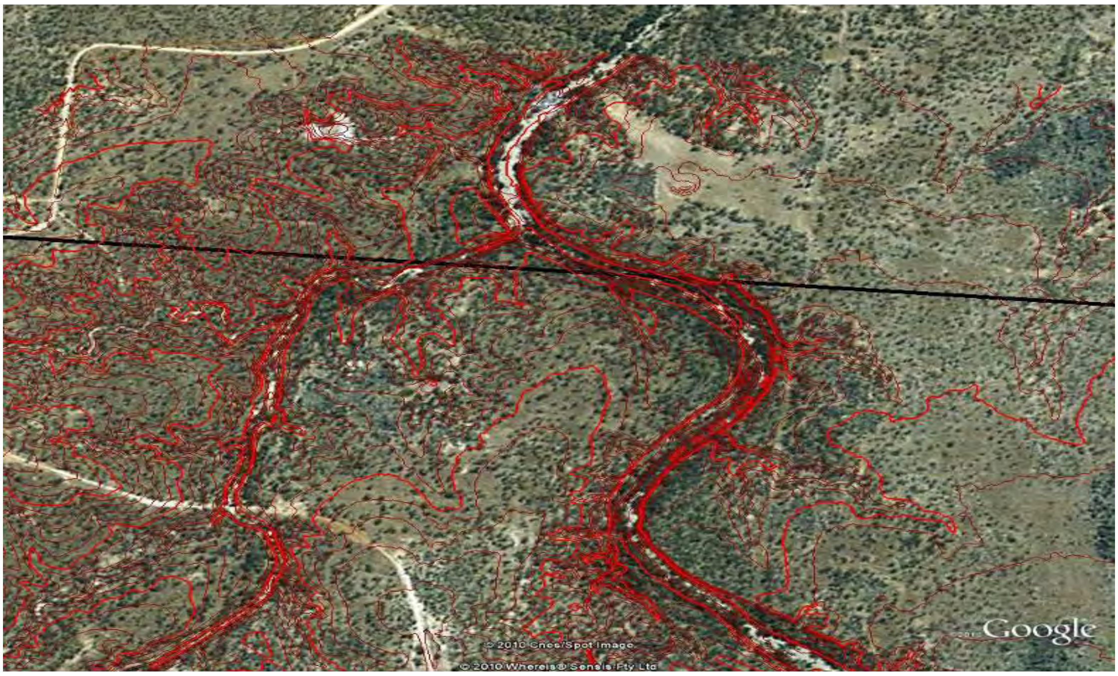
The hydraulic structure at the main crossing is sized on the basis of a design flow estimate derived using the RORB rainfall runoff model.

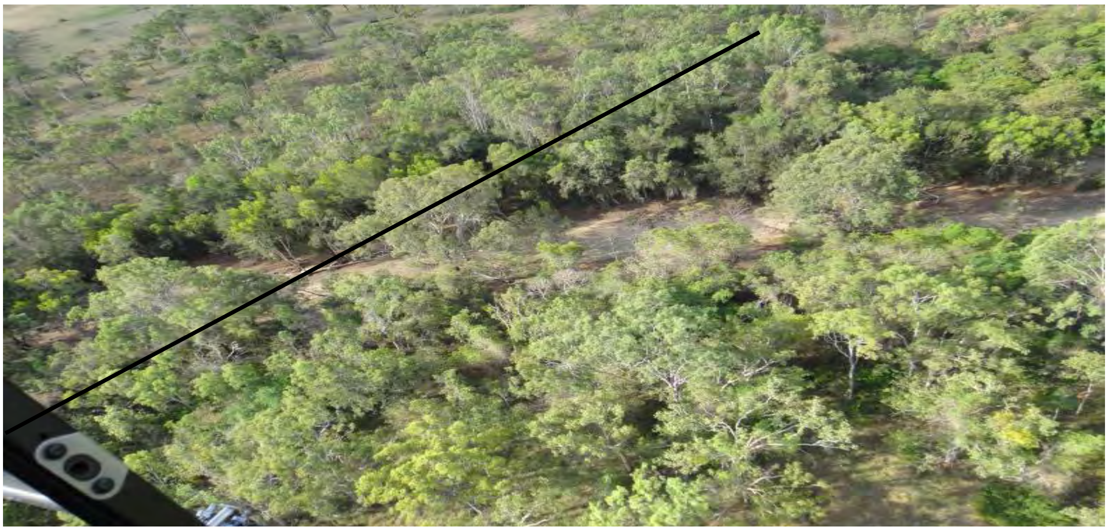


Bridge Tag	Bridge-07
Crossing Name	Sandy Creek
Chainage (m)	457,475
Catchment area (km^2)	57
Bridge length (m)	60
Supplementary Culverts?	No
Nominal Height (m)	14
Catchment Length (km)	16
Landholder	Nevada - Hartwell
Equal area slope (m/km)	12.49

6.3.17 Finley Creek

The hydraulic structure at the main crossing is sized on the basis of a design flow estimate derived using the RORB rainfall runoff model.

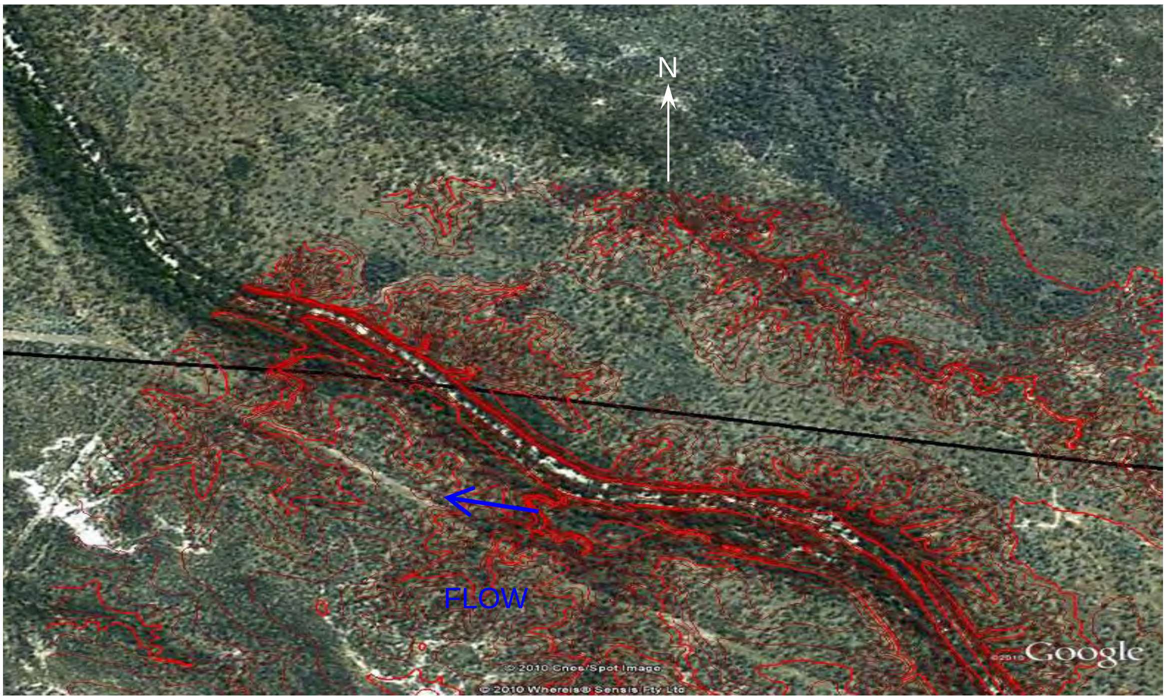




Bridge Tag	Bridge-06
Crossing Name	Finley Creek
Chainage (m)	464,605
Catchment area (km^2)	56
Bridge length (m)	60
Supplementary Culverts?	No
Nominal Height (m)	13.5
Catchment Length (km)	15
Landholder	Nevada - Hartwell
Equal area slope (m/km)	8.29

6.3.18 Elliot River

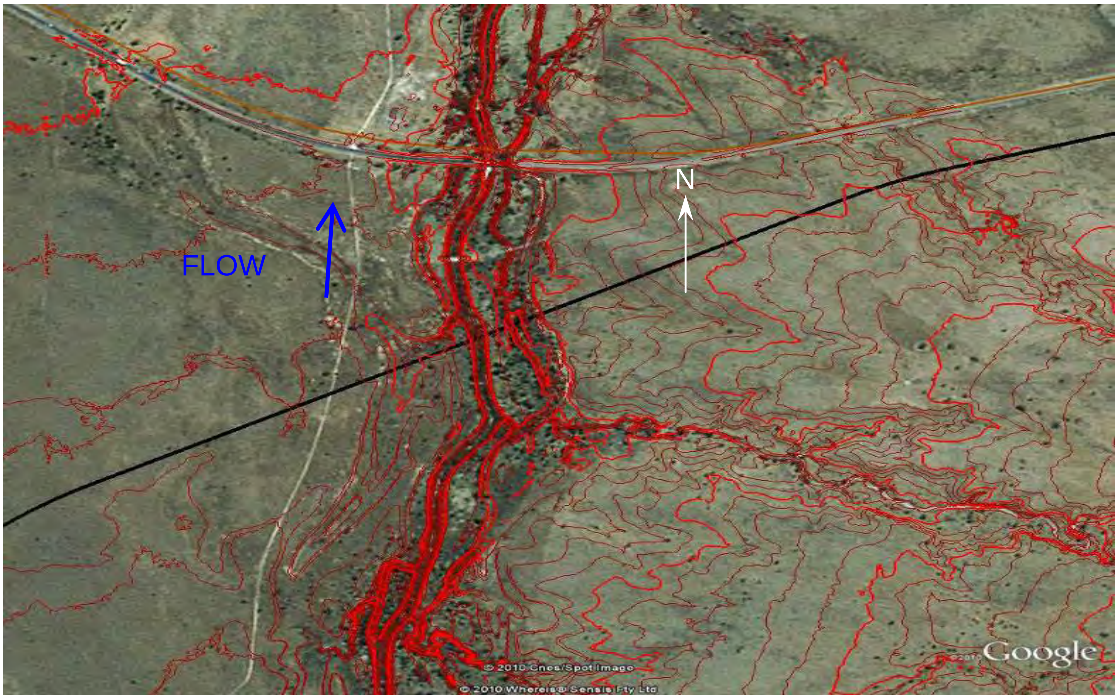
The hydraulic structure at the main crossing is sized on the basis of a design flow estimate derived using the RORB rainfall runoff model. A guide bank will be required to decrease the risk of abutment scour on the right hand abutment (looking downstream). To supplement the bridge structure and maintain sheet flow it is proposed that 1 No. 900 mm diameter relief culvert be provided approximately 60 m left (looking downstream) of the bridge.



Bridge Tag	Bridge-05
Crossing Name	Elliot River
Chainage (m)	467,847
Catchment area (km2)	148
Bridge length (m)	80
Supplementary Culverts?	No
Nominal Height (m)	11.5
Catchment Length (km)	28
Landholder	Border Nevada / Salisbury Plains
Equal area slope (m/km)	4.10

6.3.19 Splitters Creek

It is currently proposed that a 40 m wide bridge is constructed over the main channel and 20 No. 2.4 m diameter culverts be placed in the adjacent secondary crossing. The hydraulic structures at the main crossing are sized on the basis of a design flow estimate derived using the RORB rainfall runoff model. To supplement the main crossing structures above and maintain sheet flow it is proposed that 2 No. 900 mm diameter relief culverts be provided at approximately 50 m centres. The current proposed bridge location is within about 500 m offset from an existing road bridge.



Bridge Tag	Bridge-04
Crossing Name	Splitters Creek
Chainage (m)	483,793
Catchment area (km2)	75
Bridge length (m)	40
Supplementary Culverts?	Yes
Nominal Height (m)	12
Catchment Length (km)	16
Landholder	Border Salisbury Plains / State Dev Area
Equal area slope (m/km)	6.14

6.3.20 Saltwater Creek

The proposed bridge location is in a complex tidal estuarine environment and the current bridge length of 100 m is based on assuming the same length as the adjacent QR bridge (100 m offset).

Bridge Tag	Bridge-01
Crossing Name	Saltwater Creek
Chainage (m)	497,030
Catchment area (km2)	TBC
Bridge length (m)	100
Supplementary Culverts?	No
Nominal Height (m)	4.5
Catchment Length (km)	TBC
Landholder	-
Equal area slope (m/km)	TBC

7.0 SIGNIFICANT CULVERT STRUCTURE LOCATIONS

Design Iteration 2 identified 14 significant culvert structure location sites outlined in Table 8 below. Figure 4 above shows the location of all proposed waterway bridges and significant culvert structure location sites on the alignment. All proposed significant culvert structure sites have estimated 50 yr ARI design event flows in excess of 200 m3/s and all major culverts are sized to pass the 50 yr ARI design event flow. The design flow estimate at each significant culvert location is based on the Rational method. It is proposed that Zinc coated Corrugated Steel Pipes (CSPs) are the default structure type at the major culvert crossings where bridge structures are not required. Alternative structure types such as arch structures may be considered at some of these locations in subsequent project stages.

Creek Name	Approximate Chainage (m)	Culvert Diameter (mm)	No. of barrels
Lestree Hill Creek	59,741	1800	43
Sixteen Mile Creek	93,679	3000	15
Boggy Creek	109,663	2100	38
Piebald Creek	134,638	2700	37
Miclere Creek	141,478	3000	52
Myra Creek	197,873	2400	38
Nibbereena Creek	200,515	2700	54
Eaglefield Creek	225,943	2700	59
Unnamed Creek	274,153	2100	30
Kangaroo Creek tributary	297,985	2400	25
Plum Creek	319,524	1800	40
Twelve Mile Gully	352,021	1800	38
Glen Blazes Creek	446,643	3600	6
Goodbye Creek	497,115	900*1500 mm (RCBC)	50

Table 8 – Summary of the major culvert locations

8.0 GENERAL MAINLINE DRAINAGE DESIGN

8.1 Culvert sizing

Culverts were sized using a Calibre Global Pty Ltd developed spreadsheet which is based on the culvert design computer program “HY8”. This program is based on the universally accepted design procedures recommended by the US Department of Transportation, Federal Highways Administration (FHWA), and Hydraulic Design of Highway Culverts publication. Culverts were primarily designed assuming inlet control, with outlet velocities limited to 5 metres per second and scour protection provided at all culvert inlets and outlets. Appendix B contains the waterway bridge and culvert schedules.

Approximately 127 km in total culvert length is required for the proposed Alpha Coal rail drainage network. Most of this length is required at the many standard culvert sites proposed throughout the alignment as illustrated on the rail profile drawings. Standard culvert sites are proposed at all defined natural flow paths that are not bridge locations or included in the significant culvert structure location table above. These locations will generally have estimated 50 yr ARI design event flows well below 200 m^3/s.

Zinc coated Corrugated Steel Pipes (CSPs) wrapped in a suitable protective material such as Nylex 45 or similar are proposed as the standard culvert type. These will be used at all culvert locations except in the following circumstances:

- Trenchcoat CSP culverts will be used at all locations where the standard CSP culvert may be at high risk of corrosion. This will be in any saline environments near the coast and in the acidic black soil environments along the alignment;
- Reinforced Concrete Box (RCB) culverts are proposed in the wetlands near the port loop due to the low headroom available. Marine grade concrete will be used to provide corrosion protection from the saline environment.

About 7km of the estimated total culvert length is a proposed allowance for ‘environmental culverts. 600 mm diameter CSP 'environmental' culverts will be provided where construction of the proposed rail formation may cut off existing flow paths and cause water shadow downstream.

The limited number of access/haul road culverts allowed for in the BFS estimate was not designed as rigorously as the rail culverts and will be further analysed in detailed design. The allowance provided is considered adequate for this level of study.

Refer to the Alpha Coal Project - Rail BFS Earthworks and Drainage drawings (CJVP10007-DWG-101) for details of the proposed drainage design inclusive of drains, culvert locations and levees.

8.2 Drains

There will be locations along the proposed alignment where natural flow paths will be cut off by the railway embankment and culverts are unable to be installed because of embankment height restrictions and cover requirements.

In such instances the flow path will be diverted to the nearest downstream catchment where a drainage structure can be constructed. The number of diversions has been minimised where practical to avoid the negative effects of water shadow.

Cut-off drains will be provided on the upstream side of the railway/road in cuttings to prevent surface water runoff entering the cuttings and causing scour and washouts. These drains work by diverting flows around the crest of the cut face and preventing water flowing down the face of the cutting. This reduces the erosion of the cut face and minimises the volume of water flowing down the formation drains within the cutting, helping to protect the rail formation. Drop structures will be installed in cuttings where a cut off drain cannot be used to divert stream flow around the top of the cutting.

In general all drains will be unlined and are designed to cater for the 20yr ARI design storm. In order to minimise drain construction costs the drain design will aim to keep the design flow velocities below the erodible limits of the drain material, for example 1.2 m/s in stiff gravel soils and 1.8 m/s in loam to gravel graded soils. This will generally be achieved by limiting drain gradients to below 0.35%, rock protected drop structures will be used to achieve this where necessary. The proposed typical drain arrangements are shown in Appendix C.

8.3 Levees

Numerous earth levees are proposed along the railway alignment to ensure that proposed culverts operate efficiently by containing elevated water levels within each catchment to the culvert design water level. This also ensures that culvert design water levels in downstream catchments are not exceeded thereby surpassing the culvert design capacities. Levees also minimise downstream water shadow as stream flows are better retained to their natural paths.

Levees are designed to ensure that there is 100 mm freeboard above the culvert headwater design level. Levees will extend from the formation at the nominated height until the levee intersects the natural ground at the nominated design height.

8.4 Culvert scour protection

It is proposed that all culvert inlets and outlets will be protected from scour with rock armour as per the culvert design criteria outlined in Chapter 3. An allowance has also been made for rock protection that may be required at locations where there is a high risk of erosion e.g. at drop structures etc. Rock protection has been sized in accordance with Austroads Waterways Design Guide (1994) guidelines as shown in the design table in Appendix D.

8.5 Stream flow detector locations

During Design Iteration 2, 51 No. stream flow detectors (SFDs) locations were identified along the railway alignment to provide an early warning system to rising storm water levels prior to the railway embankment becoming overtopped. It should be noted that the SFD locations proposed do not monitor all areas of potential washouts. Locating SFDs along the railway is therefore a subjective risk assessment exercise and further work will be carried out during the detailed design stage. It is recommended that early warning systems that include monitoring of upstream water levels and/or rain events further upstream of the rail line considered for adoption to ensure safety and minimise operational disruption and physical damage.

The SFDs proposed are located at the larger flow creeks with low embankments, situated in sag curves, and where other infrastructure could be impacted e.g. bridge sites.

8.6 Culvert uplift failure

There is currently no guidance from Australian Standards or culvert manufacturers on how to deal with the issue of potential culvert uplift failure. A number of field studies have investigated the mechanisms of culvert uplift failure on existing railways in the Pilbara, Western Australia. These have identified the following contributory factors to uplift failure:

- Weight of the culvert;
- Weight of the water within the culvert;
- Weight of the water displaced by the culvert;

- Weight of the backfill over the culvert;
- Effective projection length, plate thickness and skew;
- Bevelled inlets have been observed to directly influence the likelihood of uplift failure;
- Uplift failure is most likely to occur during high flow;
- The risk of uplift failure is highest when the culvert entrance becomes blocked.

The studies found that the uplift force caused by buoyancy is in direct proportion to the projection length of the culvert from the embankment. As a result a table of acceptable projection length guidelines to avoid uplift failure was produced as shown in Appendix E. Culvert skew is also to be minimised as much as practicable, (with a guideline limit of 30º from normal), to reduce projection length.

As it was found that bevelling the culvert entrance reduces resistance to bending, this practice is not proposed as part of the design for the Alpha Coal Project. All designed culverts will be checked for failure using the method outlined in Appendix E generated from the field studies. Tie downs by means of anchor blocks will be sized as required.

8.7 Culvert piping failure

The risk of failure by piping of a well constructed embankment of Type 2 material over a proof compacted foundation is considered low given that the hydraulic head will be greater than one metre in height for a relatively short period of time with a potential flow path in excess of 10 m. Therefore the most likely location for piping seepage is around culverts and concrete works.

To prevent possible piping failure, cement stabilised fill will be used to form the culvert invert bedding for about the first 1.5m at the inlet, together with about a 1.25 m deep cut-off wall, at the entrance of all installations. These measures have been found to perform well in clayey/silty/sandy soils (Sherard et al, 1963), and are commonly employed on similar heavy haul projects in the Pilbara.

8.8 Marshalling yard internal drainage

The proposed internal trunk drainage system in the marshalling will be an underground reinforced concrete pipe (RCP) network system. Surface water runoff from the yard will enter the reticulation network via a network of stormwater grates and pits. An estimate of the material quantities required for this network has been allowed in the BFS drainage estimate. Appropriate water treatment systems will be further investigated at the detailed design stage as required.

9.0 CONCLUSIONS AND RECOMMENDATIONS

The drainage design for the Alpha Coal Project BFS has been undertaken following best practice principles currently being applied on similar heavy haul projects throughout Australia. The level of design is considered appropriate for this level of Study.

All the proposed design solutions presented at this BFS stage will be subject to further design development at the detailed design stage. This will include "ground truthing " and value engineering to provide the most cost effective solution given design constraints. This will include taking explicit account of third party infrastructure e.g. accounting for backwater/tailwater impacts of Queensland Rail, road drainage and other infrastructure. The cooperation of third party infrastructure owners in providing required information will be critical to the success of this activity.

The future design of hydraulic structures will consider the requirement of appropriate fish passage as outlined in the Fish Habitat Management operational Policy 008, (DEEI 2009) and Fisheries Guidelines for Fish –Friendly Structures (DEEDI 2006) as applicable.

It is highly recommended that during the detailed design stage of the project the proposed solutions in the major floodplain areas listed below be revisited and checked by running 2 dimensional flow models (for example MIKE FLOOD) which will assist to better understand floodplain flows once additional survey information has been obtained:

- Native Companion Creek;
- Belyando River;
- Lestree Hill Creek;
- Sixteen Mile Creek;
- Mistake Creek;
- Piebald Creek;
- Miclere Creek;
- Brown Creek;
- Logan Creek;
- Diamond Creek;
- Myra Creek;
- Eaglefield Creek;
- Suttor Creek;
- Salt Water Creek plus the Port loop.

An invaluable set of information that must be considered in the detailed design phase is the input from landholders and other stakeholders on their experiences and records of past flood events. It is recommended that the current landholder consultation process be extended to include all other stakeholders to gather historical data and also agree and negotiate acceptable impact limits.

10.0 REFERENCES

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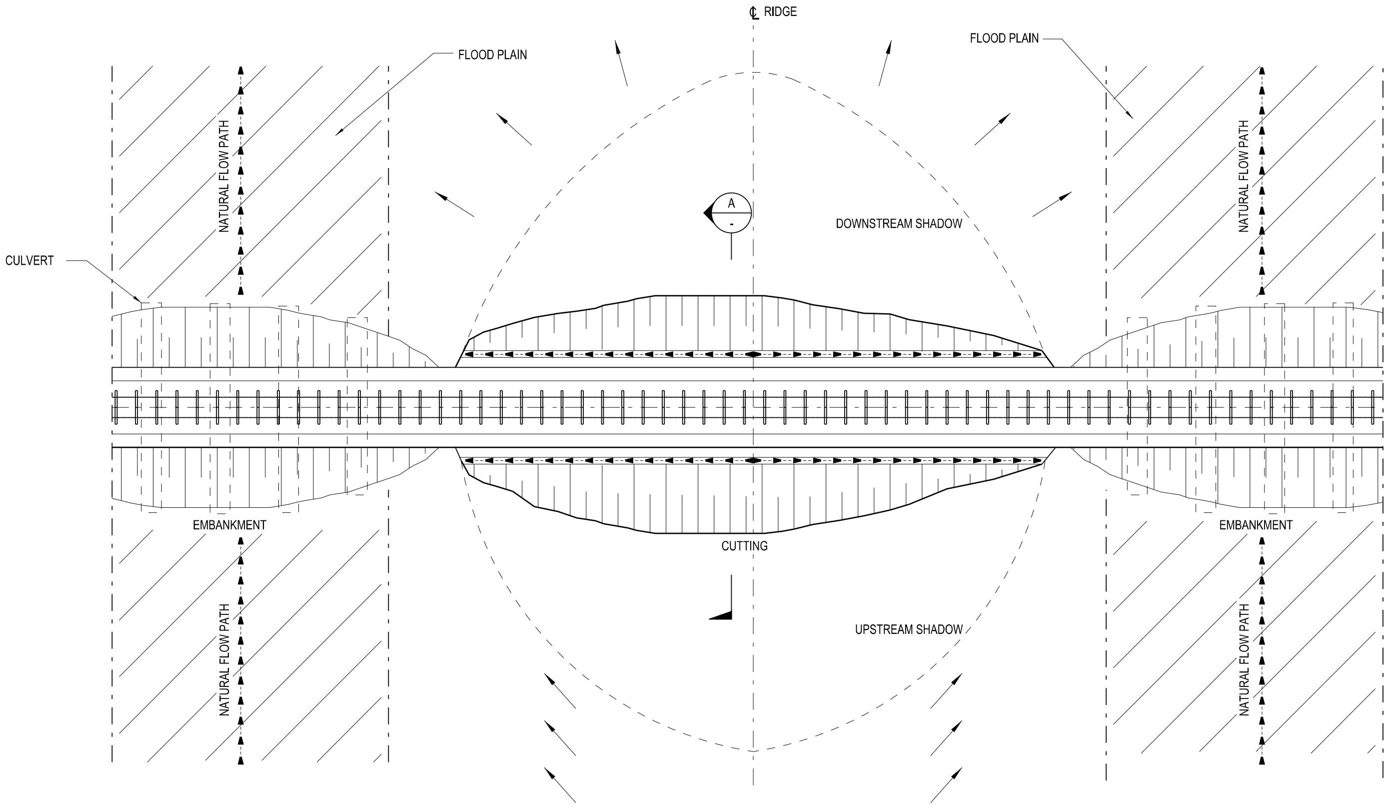
APPENDIX A - ENVIRONMENTAL CONSIDERATION DRAWINGS

The following Water Shadow In Cuttings & Floodplain Relief Culvert drawings form part of this Drainage Report for the BFS.

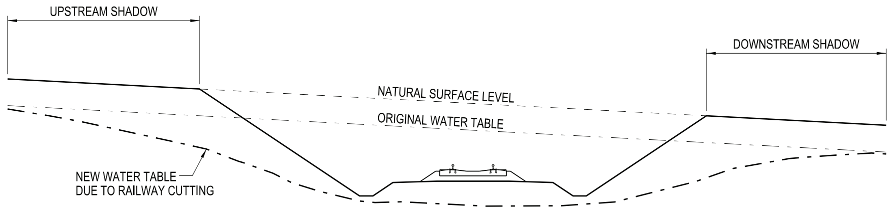
Ref	Document Number	Client Number	Title
[1]	CJVP10007-DWG-G-953	HC-CRL-24100-DRG-0459	DRAINAGE DETAILS - DRAINAGE SHADOW DETAILS
[2]	CJVP10007-DWG-G-952	HC-CRL-24100-DRG-0458	DRAINAGE DETAILS - TYPICAL FLOOD PLAIN DRAINAGE METHODOLOGY

NOT TO BE SCALED

NOT TO BE SCALED



DRAINAGE SHADOW PLAN
SCALE NTS



SECTION A / -
SCALE NTS

NOTES:

1. THIS DRAWING SHALL BE READ INCONJUNCTION WITH THE DRAINAGE ENGINEERING REPORT CJVP10007-REP-C-001 FOR EXPLANATION OF SHADOW AREAS.

REV	BY	DATE	DESCRIPTION	CKD	APP
0	TDR	28.02.11	ISSUED FOR BFS	TDR	
A	WQ	24.11.10	ISSUED FOR INFORMATION	BTC	

DRAWN	W. QUIOZON	24.11.10
DRAFTING CHECK	T. RANKIN	28.02.11
DESIGNER	B. CRISP	28.02.11
ENG. APPROVED	D. MILLER	28.02.11
ENG. MANAGER	M. McDONNELL	28.02.11
PROJECT MANAGER	T. LUBICZ	28.02.11
CLIENT APPROVED	G. MULLENS	28.02.11

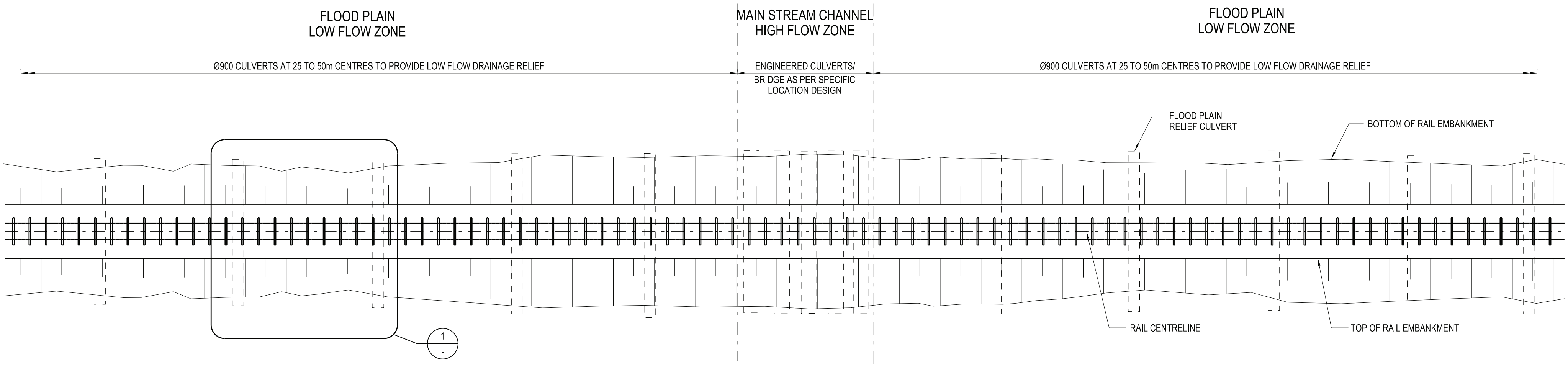
calibre

HANCOCK COAL PTY LTD

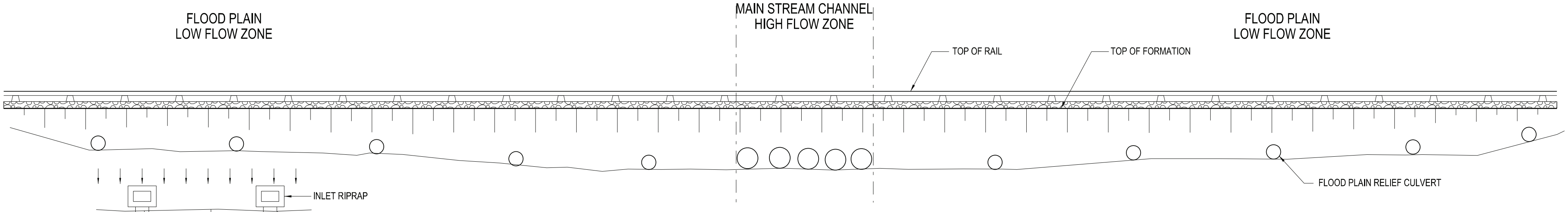
ALPHA COAL PROJECT - RAIL BFS
RAIL ALIGNMENT - MINE TO ABBOT POINT
DRAINAGE DETAILS
DRAINAGE SHADOW DETAILS

SHEET SIZE A1
PN No CJVP10007
SCALE NTS

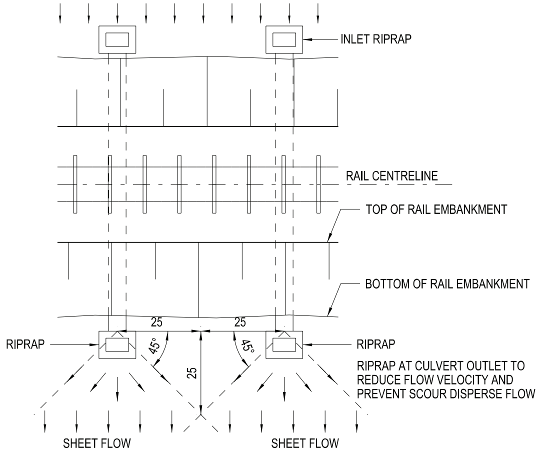
CALIBRE DRAWING No. CJVP10007-DWG-G-953
HANCOCK COAL REFERENCE No. HC-CRL-24100-DRG-0459
REV 0



DRAINAGE LAYOUT FOR TREATMENT ACROSS FLOOD PLAINS - PLAN
SCALE NTS



DRAINAGE LAYOUT FOR TREATMENT ACROSS FLOOD PLAINS - ELEVATION
SCALE NTS



DETAIL 1/-
SCALE NTS

NOTES:
1. REFER TO DETAIL DRAWINGS AND LAYOUT PLANS FOR QUANTITY, SIZE AND ACTUAL LOCATION OF CULVERTS AND CONSTRUCTION DETAILS.

REFERENCES

REVISIONS

REV	BY	DATE	DESCRIPTION	CKD	APP
0	TDR	28.02.11	ISSUED FOR BFS	TDR	
B	WQ	03.12.10	ISSUED FOR INFORMATION	BTC	
A	BTC	17.11.10	ISSUED FOR INFORMATION	BTC	

DRAWN	W. QUIOZON	17.11.10
DRAFTING CHECK	T. RANKIN	28.02.11
DESIGNER	B. CRISP	28.02.11
ENG. APPROVED	D. MILLER	28.02.11
ENG. MANAGER	M. McDONNELL	28.02.11
PROJECT MANAGER	T. LUBICZ	28.02.11
CLIENT APPROVED	G. MULLENS	28.02.11

calibre

HANCOCK COAL PTY LTD

ALPHA COAL PROJECT - RAIL BFS
RAIL ALIGNMENT - MINE TO ABBOT POINT
DRAINAGE DETAILS
TYPICAL FLOOD PLAIN DRAINAGE METHODOLOGY

SHEET SIZE A1
PN No CJVP10007
SCALE NTS

CALIBRE DRAWING No. CJVP10007-DWG-G-952
HANCOCK COAL REFERENCE No. HC-CRL-24100-DRG-0458
REV 0

APPENDIX B - WATERWAY BRIDGE AND CULVERT CATCHMENT PLANS AND SCHEDULES

1. Catchment Plans
2. Waterway Bridge Schedule
3. Standard Culvert Schedule
4. Floodplain Relief Culvert Schedule

2. Standard Culvert Schedule

GENERAL CULVERT SCHEDULE (excludes floodplain relief & environmental culverts)										
Catchment Name	Approx Chainage (m)	A (km^2)	L (km)	Se (m/km)	Q_{20} (m^3/s)	Q_{50} (m^3/s)	Qdesign (m^3/s)	"Structure Type	Diameter (mm)	No. of Barrels
P1001	3,246	1.74	1.9	9.6	23.5	30.6	23.5	CSP	1200	9
P1002	6,970	0.94	1.1	14.4	17.3	22.6	17.3	CSP	1500	5
P1003	7,800	2.54	2.5	12.6	27.5	36.4	27.5	CSP	1500	8
P1004	2,933	2.73	2.7	13.0	29.6	39.1	29.6	CSP	1800	5
P1005	1,358	1.21	1.3	6.0	18.4	24.2	18.4	CSP	1200	8
P1006	1,034	1.15	1.2	9.8	20.2	26.8	20.2	CSP	1800	5
P1009	13,208	5.09	2.5	8.2	55.2	73.0	73.0	CSP	1500	19
P1011	15,250	19.99	6.0	6.8	106.5	139.8	139.8	CSP	2100	19
P1012	16,643	20.92	7.5	15.0	103.1	135.7	135.7	CSP	1500	29
P1014	24,154	7.20	3.3	9.3	66.1	86.4	86.4	CSP	1500	30
P1015	28,083	27.24	7.9	3.5	104.7	137.7	137.7	CSP	1350	46
P1016	32,569	21.84	11.2	2.3	59.4	78.1	78.1	CSP	1500	22
P1017	32,569	2.94	2.7	1.1	18.7	24.6	18.7	CSP	1500	5
P1018	35,237	5.73	3.5	1.0	30.5	40.1	30.5	CSP	1200	12
P1025	49,233	3.50	1.9	10.4	47.2	61.6	47.2	CSP	1200	38
P1026	51,892	34.19	10.2	2.3	108.6	142.9	142.9	CSP	2100	21
P1034	59,741	139.17	24.2	2.4	174.6	230.9	230.9	CSP	1800	43
P1040	68,370	58.51	17.1	2.9	125.6	165.5	165.5	CSP	2100	25
P1046	75,630	2.50	2.5	15.3	27.1	35.9	27.1	CSP	1200	12
P1048	77,356	0.08	0.2	23.6	3.5	4.5	3.5	CSP	900	3
P1048A	77,524	0.05	0.3	23.6	2.0	2.6	2.0	CSP	900	2
P1050	79,723	41.54	9.3	3.0	132.0	173.6	173.6	CSP	2400	18

2. Standard Culvert Schedule

GENERAL CULVERT SCHEDULE (excludes floodplain relief & environmental culverts)										
Catchment Name	Approx Chainage (m)	A (km^2)	L (km)	Se (m/km)	Q_{20} (m^3/s)	Q_{50} (m^3/s)	Qdesign (m^3/s)	"Structure Type	Diameter (mm)	No. of Barrels
P1052	81,480	1.06	1.5	20.7	17.5	22.8	17.5	CSP	1200	8
P1053	82,269	0.25	0.9	19.6	5.0	6.6	5.0	CSP	1200	2
P1054	82,386	1.42	1.4	10.7	23.3	30.4	23.3	CSP	2100	3
P1055	85,032	2.33	2.1	12.7	31.4	41.0	31.4	CSP	1200	16
P1056	86,303	14.46	6.3	6.8	71.3	93.8	93.8	CSP	2100	12
P1057	91,193	17.29	6.4	4.3	74.6	98.2	98.2	CSP	2100	15
P1059	93,679	156.41	25.8	1.9	197.5	258.8	258.8	CSP	3000	12
P1060	95,512	8.19	3.9	4.9	52.1	68.6	68.6	CSP	1500	15
P1061	99,033	7.10	4.2	5.3	45.1	59.5	45.1	CSP	1200	26
P1062	100,639	54.98	15.6	2.6	118.0	155.5	155.5	CSP	2100	19
P1063	109,663	78.35	8.9	1.2	249.0	327.4	327.4	CSP	2100	38
P1065	114,925	6.01	3.6	5.0	42.5	55.9	42.5	CSP	1800	10
P1067	118,952	10.23	4.0	2.2	59.3	78.0	78.0	CSP	1800	17
P1068	120,081	0.32	0.2	3.5	13.6	17.9	13.6	CSP	1500	4
P1069	120,901	3.56	2.2	6.6	38.6	51.1	38.6	CSP	1500	10
P1071	124,599	21.24	5.8	3.1	97.5	128.4	128.4	CSP	1800	22
P1072	128,757	1.68	2.1	1.1	13.5	17.8	13.5	CSP	900	14
P1073	132,186	10.11	5.9	2.8	43.6	57.4	43.6	CSP	900	39
P1074	134,638	466.58	49.2	1.5	398.3	526.6	526.6	CSP	2700	30
P1075	135,218	0.56	1.2	7.4	8.5	11.3	8.5	CSP	1350	3
P1077	137,812	6.27	4.0	2.0	33.4	43.8	33.4	CSP	900	29
P1079	141,478	1026.13	73.6	1.2	714	948.6	948.6	CSP	3000	38

2. Standard Culvert Schedule

GENERAL CULVERT SCHEDULE (excludes floodplain relief & environmental culverts)										
Catchment Name	Approx Chainage (m)	A (km^2)	L (km)	Se (m/km)	Q_{20} (m^3/s)	Q_{50} (m^3/s)	Qdesign (m^3/s)	"Structure Type	Diameter (mm)	No. of Barrels
P1082	147,100	42.28	11.9	2.8	115.0	151.2	151.2	CSP	1500	40
P1083	151,349	5.48	2.4	8.6	59.4	78.5	78.5	CSP	1200	29
P1085	164,027	37.26	12.2	2.2	89.1	117.5	117.5	CSP	1500	46
P1085A	161,908	6.72	3.7	4.1	47.6	62.6	47.6	CSP	1500	10
P1086	165,033	6.72	3.7	4.1	47.6	62.6	47.6	CSP	900	36
P1087	165,894	1.07	1.4	9.6	16.2	21.4	16.2	CSP	900	13
P1088	167,609	1.26	1.3	8.9	20.8	27.1	20.8	CSP	1200	8
P1094	171,799	58.05	15.8	1.2	113.4	148.7	148.7	CSP	1200	56
P1103	197,873	392.44	67.2	1.2	236	316.0	316.0	CSP	3000	14
P1104	200,515	192.71	16.8	1.1	391.8	514.3	514.3	CSP	2700	54
P1104A	201,345	1.11	1.2	1.4	15.2	19.5	15.2	CSP	1500	4
P1104B	201,639	0.41	0.7	2.1	8.2	10.4	8.2	CSP	900	7
P1104D	202,459	0.27	0.7	4.5	5.6	7.3	5.6	CSP	900	5
P1105	205,471	4.81	2.1	1.1	45.3	59.0	45.3	CSP	1500	14
P1106	206,002	4.81	1.6	1.1	54.0	69.0	69.0	CSP	1500	19
P1107	206,814	4.81	1.6	1.1	54.0	69.0	69.0	CSP	1500	21
P1107A	207,935	0.48	0.3	0.5	13.5	17.4	13.5	CSP	900	11
P1108	208,606	2.32	1.0	5.0	46.4	59.3	46.4	CSP	1200	21
P1108B	209,459	1.49	0.9	10.4	32.4	41.5	32.4	CSP	1200	15
P1108C	211,014	1.73	1.2	5.1	29.2	37.6	29.2	CSP	1500	8
P1109	211,353	0.81	1.0	3.6	13.8	17.7	13.8	CSP	1200	7
P1109A	211,684	0.75	1.1	0.5	10.3	13.3	10.3	CSP	1200	4

2. Standard Culvert Schedule

GENERAL CULVERT SCHEDULE (excludes floodplain relief & environmental culverts)										
Catchment Name	Approx Chainage (m)	A (km^2)	L (km)	Se (m/km)	Q_{20} (m^3/s)	Q_{50} (m^3/s)	Qdesign (m^3/s)	"Structure Type	Diameter (mm)	No. of Barrels
P1109B	212,449	2.37	1.2	0.4	26.6	33.9	26.6	CSP	1500	6
P1110	214,136	78.65	18.2	0.7	127.7	167.3	167.3	CSP	2400	21
P1111	216,334	2.24	2.1	1.8	21.0	27.4	21.0	CSP	900	18
P1112	221,850	53.25	9.0	1.4	175.4	228.6	228.6	CSP	2700	44
P1116	225,943	886.48	66.5	1.4	632	846.9	846.9	CSP	2700	48
P1118	236,809	12.15	13.8	1.4	24.7	32.4	24.7	CSP	1200	18
P5001	255,586	1.85	1.9	6.4	25.3	32.6	25.3	CSP	1200	12
P5002	256,383	33.43	10.7	4.3	110.1	143.5	143.5	CSP	1800	22
P5003	259,813	6.24	5.3	7.9	34.3	44.6	34.3	CSP	1500	9
P5004	260,273	2.88	2.8	8.3	27.0	35.3	27.0	CSP	1200	10
P5005	263,053	2.90	5.2	5.4	14.8	19.2	14.8	CSP	1200	6
P5011	266,602	9.70	4.1	3.4	63.6	112.3	112.3	CSP	1500	30
P5012	268,849	19.30	6.0	4.9	98.2	128.0	98.2	CSP	1200	45
P5014	274,139	73.21	16.4	3.1	164.1	215.0	215.0	CSP	2100	30
P5015	275,388	2.18	1.8	4.6	29.9	38.5	29.9	CSP	1200	13
P5016	276,324	1.34	1.1	5.7	22.6	29.1	22.6	CSP	1200	11
P5017	278,242	27.31	12.5	3.4	77.4	101.2	101.2	CSP	1500	29
P5018	279,739	1.08	1.2	14.8	20.7	26.5	20.7	CSP	900	22
P5019	280,486	1.23	0.9	12.1	28.0	36.0	28.0	CSP	1200	12
P5020	282,455	7.94	6.0	8.4	40.4	52.7	52.7	CSP	1800	20
P5022	285,966	0.42	1.1	11.5	7.8	9.9	7.8	CSP	900	6
P5023	286,936	1.54	2.5	13.8	17.3	22.1	17.3	CSP	1200	8

2. Standard Culvert Schedule

GENERAL CULVERT SCHEDULE (excludes floodplain relief & environmental culverts)										
Catchment Name	Approx Chainage (m)	A (km^2)	L (km)	Se (m/km)	Q_{20} (m^3/s)	Q_{50} (m^3/s)	Qdesign (m^3/s)	"Structure Type	Diameter (mm)	No. of Barrels
P5024	287,995	1.50	2.0	15.1	20.5	26.4	20.5	CSP	1200	11
P5027	289,408	0.03	0.4	12.5	1.0	1.3	1.0	CSP	900	1
P6003	290,356	40.38	9.8	4.1	145.1	189.8	189.8	CSP	2100	24
P6004	290,763	1.15	2.3	18.1	15.7	20.2	15.7	CSP	1200	6
P6007	291,242	0.11	0.1	0.0	3.5	4.5	3.5	CSP	900	3
P6008	291,336	0.03	0.2	43.3	1.4	1.8	1.4	CSP	900	2
P6009	291,454	0.18	0.7	41.0	4.9	6.4	4.9	CSP	900	4
P6010	291,550	0.01	0.1	49.0	0.5	0.7	0.5	CSP	900	1
P6011	291,613	0.05	0.2	43.7	2.3	3.0	2.3	CSP	900	2
P6012	291,908	0.09	0.3	27.9	3.9	5.0	3.9	CSP	900	3
P6013	292,183	0.44	1.1	28.7	9.1	11.9	9.1	CSP	1200	4
P6016	294,062	4.04	3.5	7.7	33.2	42.6	33.2	CSP	1500	7
P6017	295,061	0.53	1.0	24.0	11.5	14.8	11.5	CSP	1200	5
P6018	295,934	2.88	1.7	12.5	45.5	58.3	45.5	CSP	1500	10
P6024	297,608	0.45	1.5	25.1	7.6	9.8	7.6	CSP	1200	3
P6025	297,971	116.83	27.1	4.4	189.8	256.4	256.4	CSP	2400	25
P6026	298,467	11.09	6.1	8.9	56.5	90.4	90.4	CSP	1800	15
P6029	300,393	5.77	4.4	18.5	42.2	54.6	42.2	CSP	1200	16
P6030	300,656	0.12	1.2	34.0	2.2	3.7	2.2	CSP	900	2
P6045	301,185	0.12	1.1	54.6	2.5	3.3	2.5	CSP	900	2
P6045A	301,145	0.01	0.0	54.6	0.4	0.5	0.4	CSP	900	1
P6046	301,608	1.02	1.8	39.5	17.2	22.2	17.2	CSP	1200	12

2. Standard Culvert Schedule

GENERAL CULVERT SCHEDULE (excludes floodplain relief & environmental culverts)										
Catchment Name	Approx Chainage (m)	A (km^2)	L (km)	Se (m/km)	Q_{20} (m^3/s)	Q_{50} (m^3/s)	Qdesign (m^3/s)	"Structure Type	Diameter (mm)	No. of Barrels
P6048	302,064	0.19	1.4	72.5	3.5	4.5	3.5	CSP	900	4
P6049	302,197	0.11	0.2	95.9	8.2	7.2	8.2	CSP	900	7
P6051	302,752	0.14	0.3	137.0	6.5	8.4	6.5	CSP	900	7
P6054	303,542	0.28	0.7	31.6	8.0	10.3	8.0	CSP	900	10
P6057	304,260	0.08	0.3	35.0	3.2	4.1	3.2	CSP	900	3
P6058	304,358	11.93	7.1	9.5	56.7	73.9	73.9	CSP	1500	16
P6058A	304,680	0.08	1.0	20.7	1.4	1.8	1.4	CSP	900	2
P6060	305,670	0.70	2.0	20.0	9.6	12.3	9.6	CSP	900	8
P6062	306,042	1.05	1.6	12.0	16.5	21.2	16.5	CSP	900	22
P6064	307,992	11.38	4.4	7.2	74.7	96.9	96.9	CSP	1500	21
P6066	308,886	7.07	1.8	6.7	96.9	124.6	124.6	CSP	1500	27
P6067	309,531	1.37	1.9	10.2	18.8	24.2	18.8	CSP	1200	9
P6070	311,960	11.08	7.4	5.1	44.1	57.3	44.1	CSP	1500	10
P6071	312,073	0.02	0.2	10.3	1.0	1.3	1.0	CSP	900	1
P6072	312,202	0.33	1.2	17.1	6.2	7.9	6.2	CSP	900	5
P6073	313,297	7.56	4.5	6.4	49.6	64.3	49.6	CSP	1500	12
P6074	315,036	4.60	3.3	7.4	37.8	48.4	37.8	CSP	1500	10
P6081	316,922	0.29	0.8	47.0	7.7	10.0	7.7	CSP	900	6
P6082	317,383	1.34	1.2	13.5	24.8	31.7	24.8	CSP	1500	6
P6083	318,209	1.52	1.6	11.1	22.4	28.6	22.4	CSP	1500	6
P6085	319,510	109.98	26.1	2.5	178.6	233.9	233.9	CSP	1800	40
P6086	319,673	0.45	0.9	13.8	9.8	12.5	9.8	CSP	900	8

2. Standard Culvert Schedule

GENERAL CULVERT SCHEDULE (excludes floodplain relief & environmental culverts)										
Catchment Name	Approx Chainage (m)	A (km^2)	L (km)	Se (m/km)	Q_{20} (m^3/s)	Q_{50} (m^3/s)	Qdesign (m^3/s)	"Structure Type	Diameter (mm)	No. of Barrels
P6088	323,386	0.03	0.1	38.1	1.6	2.0	1.6	CSP	900	2
P6089	323,744	38.07	13.1	3.9	108.0	141.1	141.1	CSP	1800	22
P6090	324,709	0.92	1.6	10.7	13.5	17.2	13.5	CSP	1200	5
P6091	329,655	32.61	8.0	3.3	129.8	168.7	168.7	CSP	1800	25
P6093	331,919	2.42	2.2	10.7	33.2	42.6	33.2	CSP	1500	14
P6095	333,454	2.30	2.7	15.1	25.8	33.0	25.8	CSP	1200	15
P6100	335,786	0.10	0.4	41.4	3.9	5.1	3.9	CSP	900	4
P6103	336,382	0.67	1.6	5.0	9.2	11.8	9.2	CSP	1200	5
P6105	337,263	0.06	0.2	33.6	3.1	4.0	3.1	CSP	900	3
P6106	337,524	0.03	0.1	2.0	1.3	1.6	1.3	CSP	900	1
P6107	338,494	0.07	0.4	36.9	2.5	3.2	2.5	CSP	900	3
P6109	340,440	0.23	0.7	9.6	5.5	7.0	5.5	CSP	900	5
P6110	340,649	1.32	1.6	6.5	18.2	23.3	18.2	CSP	900	20
P6114	342,511	0.28	0.9	3.5	4.7	6.0	4.7	CSP	900	4
P7002	348,502	3.28	2.5	0.7	21.6	28.0	21.6	CSP	1200	10
P7003	350,637	50.55	17.5	3.0	102.8	134.9	134.9	CSP	1800	22
P7005	352,007	46.31	8.8	4.6	184.3	239.6	239.6	CSP	1800	38
P7005B	352,795	0.08	0.2	29.6	3.7	4.7	3.7	CSP	900	4
P7006	353,640	1.44	2.1	13.9	19.7	25.4	19.7	CSP	1200	18
P7012	356,783	0.34	1.1	13.7	19.4	8.0	19.4	CSP	1200	8
P7012B	356,972	1.27	1.5	13.7	20.1	25.8	20.1	CSP	1200	8
P7016	357,616	0.98	1.3	9.9	16.6	21.4	16.6	CSP	1200	7

2. Standard Culvert Schedule

GENERAL CULVERT SCHEDULE (excludes floodplain relief & environmental culverts)										
Catchment Name	Approx Chainage (m)	A (km^2)	L (km)	Se (m/km)	Q_{20} (m^3/s)	Q_{50} (m^3/s)	Qdesign (m^3/s)	"Structure Type	Diameter (mm)	No. of Barrels
P7017	357,931	2.20	3.1	24.1	24.7	31.5	24.7	CSP	1200	10
P7018	358,189	0.25	1.3	23.8	4.3	5.5	4.3	CSP	900	4
P7019	359,141	0.74	0.9	13.9	16.2	20.7	16.2	CSP	1200	6
P7027A	361,440	0.08	0.2	20.7	3.8	5.0	3.8	CSP	900	4
P7027	361,802	0.02	0.1	24.8	1.3	1.7	1.3	CSP	900	1
P7028	362,001	0.13	0.2	21.4	6.6	8.5	6.6	CSP	900	5
P7029	362,500	0.37	0.5	12.4	12.0	15.5	12.0	CSP	1200	5
P7030	362,962	0.07	0.1	33.2	3.9	5.0	3.9	CSP	900	7
P7031	363,496	0.26	0.5	19.8	8.5	10.9	8.5	CSP	900	7
P7037	371,632	1.23	2.3	2.4	10.1	13.0	10.1	CSP	1200	5
P7038	372,673	21.92	8.4	3.6	78.8	103.0	103.0	CSP	1500	23
P7039	373,185	3.39	2.5	6.0	38.0	48.5	38.0	CSP	1500	10
P7040	374,162	1.35	1.4	6.9	21.4	27.4	21.4	CSP	900	22
P7041	375,139	1.38	1.1	12.0	27.7	35.3	27.7	CSP	1200	14
P7042	376,297	0.41	0.5	18.9	13.3	17.1	13.3	CSP	1200	7
P7043	376,836	0.36	0.5	16.9	12.4	15.9	12.4	CSP	900	15
P7045	379,214	0.58	1.2	7.2	9.1	11.7	9.1	CSP	900	8
P7055	383,982	0.21	0.9	5.2	4.0	5.0	4.0	CSP	900	4
P7056	385,356	12.55	6.2	4.5	59.6	77.7	77.7	CSP	1500	17
P5021	283,050	5.80	2.6	5.5	65.0	83.1	83.1	CSP	1500	18
P7001	344,286	0.01	0.0	1.0	25.0	25.0	25.0	CSP	3000	1
P8001	386,958	0.16	0.4	28.7	5.6	7.3	5.6	CSP	1650	1

2. Standard Culvert Schedule

GENERAL CULVERT SCHEDULE (excludes floodplain relief & environmental culverts)										
Catchment Name	Approx Chainage (m)	A (km^2)	L (km)	Se (m/km)	Q_{20} (m^3/s)	Q_{50} (m^3/s)	Qdesign (m^3/s)	"Structure Type	Diameter (mm)	No. of Barrels
P8001B	388,368	0.59	0.9	28.7	13.9	17.8	13.9	CSP	1500	3
P8002	389,468	2.64	2.5	2.1	21.7	27.8	21.7	CSP	1350	6
P8003	389,669	11.76	7.3	6.1	49.4	64.4	49.4	CSP	1650	9
P8006	390,860	5.59	3.6	10.6	46.0	58.9	46.0	CSP	2100	5
P8010	393,542	0.96	1.5	5.2	13.2	16.9	13.2	CSP	1200	5
P8011	394,150	6.16	5.8	4.6	29.3	38.1	29.3	CSP	1200	11
P8012	395,372	1.12	1.5	12.0	17.6	22.6	17.6	CSP	2100	2
P8014	396,828	6.56	4.8	5.9	39.2	50.9	39.2	CSP	2100	4
P8016	399,078	38.01	10.9	8.1	136.5	178.6	178.6	CSP	2400	12
P8017	400,393	3.88	3.1	8.3	51.5	67.3	67.3	CSP	2100	7
P8021	403,306	0.99	1.4	12.9	22.1	28.7	22.1	CSP	2100	2
P8022	403,454	7.82	4.4	5.0	69.7	91.9	91.9	CSP	2100	9
P8023	406,687	1.84	1.8	8.4	33.4	43.6	33.4	CSP	1350	10
P8025A	407,902	0.52	1.3	15.0	11.7	15.2	11.7	CSP	900	9
P8026	408,879	9.15	6.0	8.7	71.0	94.2	94.2	CSP	2100	9
P8027	409,245	1.68	2.3	17.8	30.5	39.8	30.5	CSP	1500	7
P8028	409,918	0.21	0.5	18.8	8.1	10.7	8.1	CSP	1500	2
P8030	410,974	0.32	0.7	32.3	11.3	14.8	11.3	CSP	1350	4
P8031	411,139	0.19	0.8	21.2	5.9	7.6	5.9	CSP	1350	2
P8033	411,450	0.15	0.5	31.5	6.5	8.5	6.5	CSP	1200	3
P8037	412,409	27.08	13.5	8.0	126.6	168.8	168.8	CSP	2700	9
P8039	413,170	1.75	2.3	8.0	26.9	35.0	26.9	CSP	1800	4

2. Standard Culvert Schedule

GENERAL CULVERT SCHEDULE (excludes floodplain relief & environmental culverts)										
Catchment Name	Approx Chainage (m)	A (km^2)	L (km)	Se (m/km)	Q_{20} (m^3/s)	Q_{50} (m^3/s)	Qdesign (m^3/s)	"Structure Type	Diameter (mm)	No. of Barrels
P8040	413,461	8.75	2.7	5.7	134.3	174.7	174.7	CSP	3000	7
P8041	414,386	0.26	0.5	10.0	9.5	12.4	9.5	CSP	1350	3
P8042	414,903	0.05	0.2	32.8	3.1	4.1	3.1	CSP	1350	1
P8045	415,198	4.15	3.5	16.6	55.1	72.1	72.1	CSP	2100	7
P8046	415,280	1.05	2.3	6.2	13.9	18.2	13.9	CSP	1500	3
P8052	417,421	0.68	1.1	7.5	15.1	19.7	15.1	CSP	1500	4
P8053	417,730	0.19	0.4	22.0	8.3	10.9	8.3	CSP	1200	4
P8054	418,479	0.27	0.8	17.5	8.1	10.5	8.1	CSP	1200	3
P8058	420,360	3.64	4.1	10.6	38.5	50.2	38.5	CSP	1650	7
P8059	420,919	0.47	0.2	16.8	27.3	35.9	27.3	CSP	1500	6
P8060	422,423	1.12	1.9	3.8	17.2	22.4	17.2	CSP	1350	6
P8062	423,806	0.24	0.3	34.7	12.2	16.0	12.2	CSP	1500	3
P8063	427,306	8.81	7.3	4.4	55.2	73.2	73.2	CSP	1800	12
P8064	428,091	3.34	3.5	4.5	35.3	46.1	35.3	CSP	2100	4
P8065D	430,145	3.21	0.7	2.6	96.1	125.1	125.1	CSP	2400	9
P9004B	436,122	0.03	0.1	3.2	1.9	2.5	1.9	CSP	1200	1
P9004C	436,369	0.10	0.6	33.3	3.6	4.7	3.6	CSP	1200	2
P9004D	436,632	0.08	0.5	61.8	1.5	1.5	1.5	CSP	900	1
P9005	437,340	0.06	0.3	42.5	2.9	3.7	2.9	CSP	1350	1
P9006	437,548	0.08	0.5	33.9	3.3	4.3	3.3	CSP	1350	1
P9007	437,702	0.06	0.3	27.5	2.6	3.5	2.6	CSP	1200	1
P9008	437,978	0.17	0.5	12.3	6.2	8.1	6.2	CSP	1350	2

2. Standard Culvert Schedule

GENERAL CULVERT SCHEDULE (excludes floodplain relief & environmental culverts)										
Catchment Name	Approx Chainage (m)	A (km^2)	L (km)	Se (m/km)	Q_{20} (m^3/s)	Q_{50} (m^3/s)	Qdesign (m^3/s)	"Structure Type	Diameter (mm)	No. of Barrels
P9008A	438,482	0.61	0.5	7.5	22.6	29.5	22.6	CSP	1650	4
P9008B	439,338	0.68	0.5	4.3	24.2	31.7	24.2	CSP	1650	4
P9008C	440,524	0.33	0.3	17.5	15.4	20.2	15.4	CSP	900	12
P9010	442,058	0.49	1.0	15.5	13.6	17.5	13.6	CSP	900	11
P9011	442,429	0.09	0.4	18.6	3.7	4.8	3.7	CSP	1200	2
P9014	442,677	0.01	0.2	41.6	0.8	1.1	0.8	CSP	900	1
P9015	442,730	0.01	0.0	38.5	0.5	0.7	0.5	CSP	900	1
P9016	443,008	0.99	2.0	19.5	17.9	23.4	17.9	CSP	2100	2
P9017	443,244	0.37	1.0	20.0	9.8	12.8	9.8	CSP	1350	3
P9022	443,779	0.39	1.2	58.1	10.8	14.0	10.8	CSP	1350	3
P9023	444,179	0.20	0.6	28.9	7.6	10.0	7.6	CSP	900	7
P9028	445,069	0.42	1.2	30.9	10.9	14.3	10.9	CSP	1350	3
P9029	445,324	0.39	1.1	70.9	12.2	15.9	12.2	CSP	1800	2
P9030	445,431	0.35	1.0	74.8	11.3	14.8	11.3	CSP	1800	2
P9032	445,877	0.02	0.0	83.1	1.0	1.4	1.0	CSP	900	1
P9033	446,577	0.01	0.0	233.4	0.8	1.0	0.8	CSP	900	1
P9034	446,629	27.93	9.8	8.1	160.6	213.5	213.5	CSP	3600	6
P9035	446,810	0.24	0.6	26.1	8.6	11.3	8.6	CSP	1500	2
P9035A	448,018	0.01	0.0	20.7	0.4	0.5	0.4	CSP	600	1
P9035B	448,071	0.00	0.0	5.9	0.1	0.2	0.1	CSP	600	1
P9036	448,344	1.15	3.3	17.2	13.6	17.7	13.6	CSP	1500	3
P9037	448,538	0.25	0.7	27.1	8.5	11.0	8.5	CSP	1350	3

2. Standard Culvert Schedule

GENERAL CULVERT SCHEDULE (excludes floodplain relief & environmental culverts)										
Catchment Name	Approx Chainage (m)	A (km^2)	L (km)	Se (m/km)	Q_{20} (m^3/s)	Q_{50} (m^3/s)	Qdesign (m^3/s)	"Structure Type	Diameter (mm)	No. of Barrels
P9038	448,658	0.02	0.1	29.4	1.5	2.0	1.5	CSP	1200	1
P9039	448,773	0.02	0.1	28.3	1.2	1.5	1.2	CSP	900	1
P9040	448,871	0.43	1.1	24.8	11.8	15.3	11.8	CSP	1200	5
P9042	449,453	0.33	0.7	27.7	11.2	14.5	11.2	CSP	900	9
P9043	449,639	0.02	0.2	18.9	1.3	1.7	1.3	CSP	900	1
P9043A	449,598	0.01	0.1	34.3	0.4	0.5	0.4	CSP	600	1
P9045	450,098	0.51	1.5	28.3	11.4	14.8	11.4	CSP	900	9
P9046	450,387	0.30	0.9	10.9	7.8	10.2	7.8	CSP	1500	2
P9048	451,112	1.33	2.1	15.3	24.1	31.4	24.1	CSP	2400	2
P9050	451,442	0.36	0.8	8.7	9.8	12.7	9.8	CSP	1350	3
P9052	452,277	1.55	1.9	9.3	28.1	36.7	28.1	CSP	2400	2
P9054	453,055	0.37	0.8	16.9	11.0	14.3	11.0	CSP	1350	3
P9056	453,473	0.99	1.9	6.7	15.1	19.7	15.1	CSP	1500	4
P9058	454,394	0.68	1.1	3.3	14.1	18.3	14.1	CSP	1500	3
P9060	457,336	2.11	2.0	3.3	32.3	42.1	32.3	CSP	1500	8
P9062	458,891	6.55	7.1	4.0	41.0	54.4	41.0	CSP	2100	4
P9063	459,051	0.01	0.1	38.9	0.5	0.7	0.5	CSP	900	1
P9064	459,125	0.02	0.1	28.2	1.1	1.4	1.1	CSP	900	1
P9065	459,201	0.01	0.1	54.6	0.4	0.5	0.4	CSP	600	1
P9066	459,249	0.64	1.3	6.4	13.3	17.3	13.3	CSP	1500	3
P9069	459,890	2.28	2.7	2.9	26.8	35.1	26.8	CSP	1500	6
P9070	460,669	0.16	0.6	6.8	5.0	6.6	5.0	CSP	1200	2

2. Standard Culvert Schedule

GENERAL CULVERT SCHEDULE (excludes floodplain relief & environmental culverts)										
Catchment Name	Approx Chainage (m)	A (km^2)	L (km)	Se (m/km)	Q_{20} (m^3/s)	Q_{50} (m^3/s)	Qdesign (m^3/s)	"Structure Type	Diameter (mm)	No. of Barrels
P9071	460,769	0.36	0.8	12.1	10.9	14.1	10.9	CSP	1350	3
P9072	461,109	12.06	13.2	15.3	64.2	85.4	85.4	CSP	2100	8
P9073	461,458	0.06	0.2	14.7	3.1	4.0	3.1	CSP	1350	1
P9074	462,530	0.07	0.2	20.0	3.6	4.7	3.6	CSP	900	3
P9075	462,810	0.12	0.2	16.7	6.8	8.9	6.8	CSP	900	6
P9076	463,709	0.52	0.9	3.0	12.5	16.4	12.5	CSP	1500	3
P9078	464,702	0.05	0.2	27.6	2.6	3.4	2.6	CSP	1200	1
P9081	465,001	0.06	0.3	22.2	2.8	3.7	2.8	CSP	1350	1
P9082	465,184	15.15	10.5	4.7	80.6	107.3	107.3	CSP	3600	3
P9091	467,500	13.35	8.9	2.7	71.0	94.5	94.5	CSP	3600	3
P9092	468,511	0.26	0.5	12.7	9.2	12.0	9.2	CSP	1500	2
P9093	467,886	148.12	29.3	3.3	1.5	1.5	1.5	CSP	900	1
P9094	469,006	0.02	0.1	24.3	1.2	1.5	1.2	CSP	900	1
P9095	470,027	3.08	5.4	3.5	21.3	28.2	21.3	CSP	1800	3
P9095A	469,898	0.01	0.1	3.5	0.9	1.1	0.9	CSP	900	1
P9095B	469,961	0.01	0.1	3.5	0.7	0.9	0.7	CSP	900	1
P9098	472,782	2.54	2.6	3.8	30.0	39.2	30.0	CSP	900	26
P9099	474,009	5.57	5.1	6.2	46.2	61.3	46.2	CSP	2700	3
P9099A	474,107	0.04	0.2	20.1	2.3	3.1	2.3	CSP	1200	1
P9100	474,236	6.27	6.4	9.8	45.8	60.2	45.8	CSP	2400	3
P9101	474,524	0.31	1.0	8.0	7.6	10.0	7.6	CSP	900	6
P9102	474,806	0.37	0.8	8.8	10.0	13.0	10.0	CSP	1350	3

2. Standard Culvert Schedule

GENERAL CULVERT SCHEDULE (excludes floodplain relief & environmental culverts)										
Catchment Name	Approx Chainage (m)	A (km^2)	L (km)	Se (m/km)	Q_{20} (m^3/s)	Q_{50} (m^3/s)	Qdesign (m^3/s)	"Structure Type	Diameter (mm)	No. of Barrels
P9105	476,134	2.59	3.5	3.7	25.0	33.1	25.0	CSP	1800	4
P9108	476,456	0.21	1.3	14.7	4.4	5.7	4.4	CSP	1500	1
P9108A	476,591	0.02	0.1	16.2	1.2	1.6	1.2	CSP	900	1
P9109	476,705	0.15	0.9	6.6	3.6	4.7	3.6	CSP	1200	2
P9110	476,869	3.60	3.7	4.4	34.8	45.9	34.8	CSP	2400	3
P9111	477,302	0.13	0.5	7.1	4.5	5.9	4.5	CSP	1200	2
P9112	477,543	0.54	2.2	5.0	7.2	9.4	7.2	CSP	1350	2
P9112A	477,700	0.02	0.2	23.0	1.1	1.4	1.1	CSP	900	1
P9113	477,767	1.47	3.2	4.4	15.5	20.3	15.5	CSP	2100	2
P9115	478,444	0.44	0.9	9.6	12.1	15.7	12.1	CSP	1800	2
P9116	479,072	0.96	1.7	8.7	17.4	22.7	17.4	CSP	1800	3
P9118	479,627	16.87	10.2	7.2	89.8	119.5	119.5	CSP	2700	6
P9120	481,014	5.49	5.5	2.7	38.0	50.2	38.0	CSP	2100	4
P9121	481,451	14.12	7.8	3.6	81.2	107.9	107.9	CSP	2700	6
P9122	481,651	0.02	0.1	16.2	1.1	1.4	1.1	CSP	900	1
P9123	481,811	0.04	0.3	7.6	1.8	2.4	1.8	CSP	900	2
P9124	482,345	0.59	1.6	6.1	10.6	13.9	10.6	CSP	1200	4
P9125	483,448	4.77	4.6	3.6	39.7	52.6	39.7	CSP	1500	9
P9126	484,679	0.22	0.8	5.3	5.3	6.9	5.3	CSP	1200	2
P9128	485,302	0.03	0.2	20.0	320.0	320.0	320.0	CSP	2400	24
P9129	485,554	0.05	0.3	15.6	2.0	2.6	2.0	CSP	900	2
P9130	485,708	0.60	1.6	21.5	12.4	16.2	12.4	CSP	1800	2

2. Standard Culvert Schedule

GENERAL CULVERT SCHEDULE (excludes floodplain relief & environmental culverts)										
Catchment Name	Approx Chainage (m)	A (km^2)	L (km)	Se (m/km)	Q_{20} (m^3/s)	Q_{50} (m^3/s)	Qdesign (m^3/s)	"Structure Type	Diameter (mm)	No. of Barrels
P9131	485,983	0.50	1.1	14.9	12.1	15.9	12.1	CSP	1200	5
P9135	486,988	2.44	2.7	33.2	44.3	57.8	44.3	CSP	1500	11
P9142	488,411	0.51	1.2	50.9	14.5	19.0	14.5	CSP	1200	7
P9143	488,497	0.32	0.9	39.9	10.4	13.6	10.4	CSP	1200	5
P9144	488,785	0.07	0.4	23.8	3.0	4.0	3.0	CSP	900	3
P9145	488,960	0.43	0.9	67.7	14.9	19.5	14.9	CSP	900	12
P9148	489,232	0.06	0.5	35.8	2.2	2.9	2.2	CSP	600	5
P9149	489,320	0.01	0.2	51.0	0.5	0.7	0.5	CSP	600	2
P9150	489,387	0.23	1.0	51.6	7.0	9.1	7.0	CSP	1800	2
P9152	489,550	0.02	0.2	22.7	1.2	1.5	1.2	CSP	900	1
P9153	489,615	0.40	0.9	41.3	12.8	16.7	12.8	CSP	1500	3
P9154	490,033	0.22	0.8	37.2	7.2	9.5	7.2	CSP	900	6
P9156	490,768	1.24	2.2	68.3	25.7	33.4	25.7	CSP	1200	11
P9157	490,970	0.03	0.3	26.4	1.2	1.6	1.2	CSP	900	1
P9158	491,033	0.17	0.8	26.9	5.2	6.8	5.2	CSP	900	4
P9160	491,137	0.04	0.2	21.0	1.9	2.4	1.9	CSP	900	2
P9163	491,579	0.99	3.1	54.8	15.1	19.7	15.1	CSP	1500	4
P9163B	492,417	0.01	0.2	11.5	0.7	0.9	0.7	CSP	900	1
P9164	495,464	13.09	6.7	22.2	116.7	153.9	153.9	CSP	1800	22
P9165	496,037	1.09	2.0	1.0	12.9	16.8	12.9	CSP	1500	3
P9165A	496,483	0.61	1.5	0.8	8.0	10.5	8.0	CSP	900	9
P9166	497,101	26.87	9.8	6.3	154.5	205.4	205.4	RCBC	900*1500	50

2. Standard Culvert Schedule

GENERAL CULVERT SCHEDULE (excludes floodplain relief & environmental culverts)										
Catchment Name	Approx Chainage (m)	A (km^2)	L (km)	Se (m/km)	Q_{20} (m^3/s)	Q_{50} (m^3/s)	Qdesign (m^3/s)	"Structure Type	Diameter (mm)	No. of Barrels
P9128B	485,302	0.03	0.2	20.0	2.5	2.5	2.5	CSP	900	2
PORT1	499,276	0.10	0.7	2.857	2.4	3.1	2.4	CSP	1200	1
PORT2	501,315	0.15	1.3	2.29	2.3	3.0	2.3	CSP	1200	1
PORT3	502,982	0.66	1.5	2.599	10.1	13.1	10.1	CSP	900	9
PORT4	503,611	0.56	0.7	1.429	13.7	17.9	13.7	CSP	900	12

1. Waterway Bridge Schedule

WATERWAY BRIDGE SCHEDULE														
Crossing Name	Approx Chain	Nominal Bridge Length (m)	No. Piers (-)	Bridge height H_{nom} (m)	Supplementary culvert Diameter (mm)	Approx No. Barrels	Catchment area (km^2)	Q_{50} (m^3s^{-1})	V_{50} (ms^{-1})	Q nat stage (m)	Backwater (m)	TWL_{Q50} (RL) m	Bridge Structural depth (m)	Min Rail ToF m (Hydraulics)
Native Companion Creek	38,690	60	4	9			5125	470.0	1.8	278.2	0.2	278.4	1.0	279.9
Belyando River	44,000	156	12	7.5	3000	49	5625	510		273.2			1.0	275.7
Mistake Creek	118,160	100	7	9			2555	800.0	1.8	242.6	0.2	242.7	1.0	244.2
Brown Creek	170,280	140	11	5			1123	907.0	2.8	221.3	0.8	222.0	1.0	223.4
Logan Creek	175,560	120	9	7			1477	779.0	2.4	220.7	0.7	221.4	1.0	222.8
Diamond Creek	196,010	180	14	6			1534	985.0	2.6	205.3	0.9	206.2	1.0	207.6
Suttor Creek	262,070	80	6	12.5	3600	12	768	1583.0	3.4	272.1	1.2	273.3	1.0	274.8
Rosella Creek 1	334,868	80	3	10			1270	1470.0	3.6	136.8	0.9	137.7	1.7	139.9
Rosella Creek 2	336,872	80	3	13			157	437.0	2.2	129.4	0.3	129.7	1.7	131.9
Bowen River	344,780	320	15	21	3000	1	4310	11000.0	3.1	125.6	0.2	125.7	1.7	127.9
Pelican Creek	366,371	80	3	15			554	1550.0	3.3	114.1	0.2	114.3	1.7	116.5
Table Mountain Creek	384,890	80	3	20			623	1635.0	3.7	77.2	0.7	77.9	1.7	80.1
Herbert Creek	421,672	40	1	10			49	313.0	3.3	94.9	0.4	95.3	1.7	97.5
Capsize Creek	426,971	40	1	8	900	1	112	557.0	3.4	81.0	0.6	81.6	1.7	83.8

1. Waterway Bridge Schedule

WATERWAY BRIDGE SCHEDULE														
Crossing Name	**Approx Chain**	**Nominal Bridge Length (m)**	**No. Piers (-)**	**Bridge height H_{nom} (m)**	**Supplementary culvert Diameter (mm)**	**Approx No. Barrels**	**Catchment area (km^2)**	**Q_{50} (m^3s^{-1})**	**V_{50} (ms^{-1})**	**Q nat stage (m)**	**Backwater (m)**	**TWL_{Q50} (RL) m**	**Bridge Structural depth (m)**	**Min Rail ToF m (Hydraulics)**
Bogie River	436,480	360	17	13	900	1	974	4000.0	2.2	87.5	0.0	87.5	1.7	89.7
Sandy Creek	457,475	60	2	14			57	436.0	2.4	36.0	0.1	36.1	1.7	38.3
Finley Creek	464,605	60	2	13.5			56	480.0	3.8	32.1	1.2	33.2	1.7	35.4
Elliot River	467,847	80	3	11.5	900	1	148	1179.0	3.4	32.0	0.6	32.6	1.7	34.8
Splitters Creek	483,793	40	1	12	900 & 2400 resp	2 & 24 resp	75	515.0	2.0	15.9	0.0	15.9	1.7	18.1
Saltwater Creek	497,030	100	4	4.5				TBC	TBC	TBC	TBC	TBC	1.7	at grade

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DRAWN	W. QUIOZON	01.06.11
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DESIGNER		
ENG. APPROVED		
ENG. MANAGER		
PROJECT MANAGER		
CLIENT APPROVED		

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HANCOCK COAL PTY LTD

ALPHA COAL PROJECT - RAIL BFS
RAIL ALIGNMENT - MINE TO ABBOT POINT
DRAINAGE CATCHMENT PLANS
SHEET 1 OF 7

SHEET SIZE A1
PN No CJVP10007
SCALE 1:100000

CALIBRE DRAWING No. CJVP10007-DWG-G-186
HANCOCK COAL REFERENCE No. HC-CRL-24100-DRG-0483
REV A

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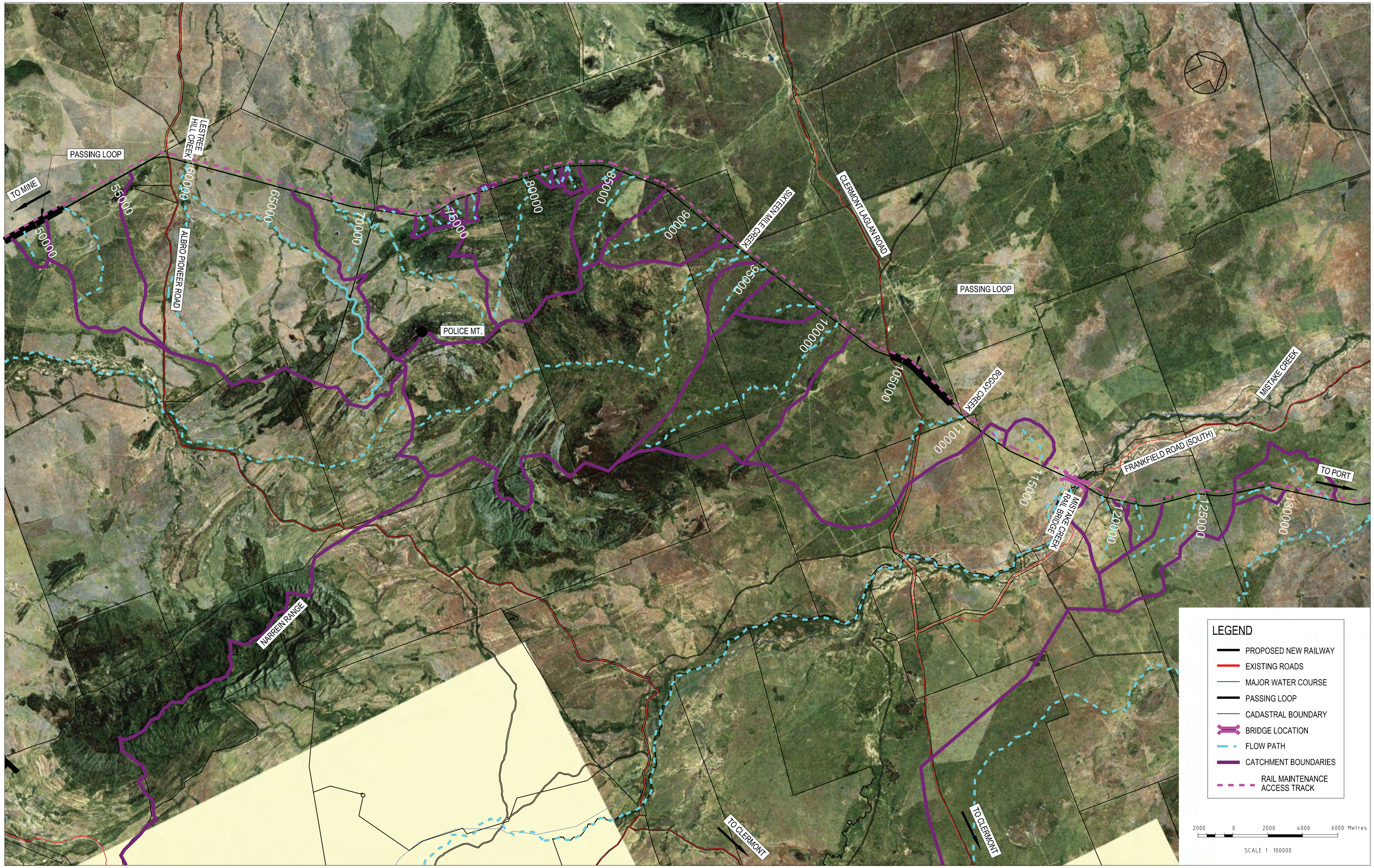

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HANCOCK COAL PTY LTD

ALPHA COAL PROJECT - RAIL BFS
RAIL ALIGNMENT - MINE TO ABBOT POINT
DRAINAGE CATCHMENT PLANS
SHEET 2 OF 7

SHEET SIZE A1

PN No CJVP10007

SCALE 1:100000

CALIBRE DRAWING No. CJVP10007-DWG-G-187

HANCOCK COAL REFERENCE No. HC-CRL-24100-DRG-0484

REV A

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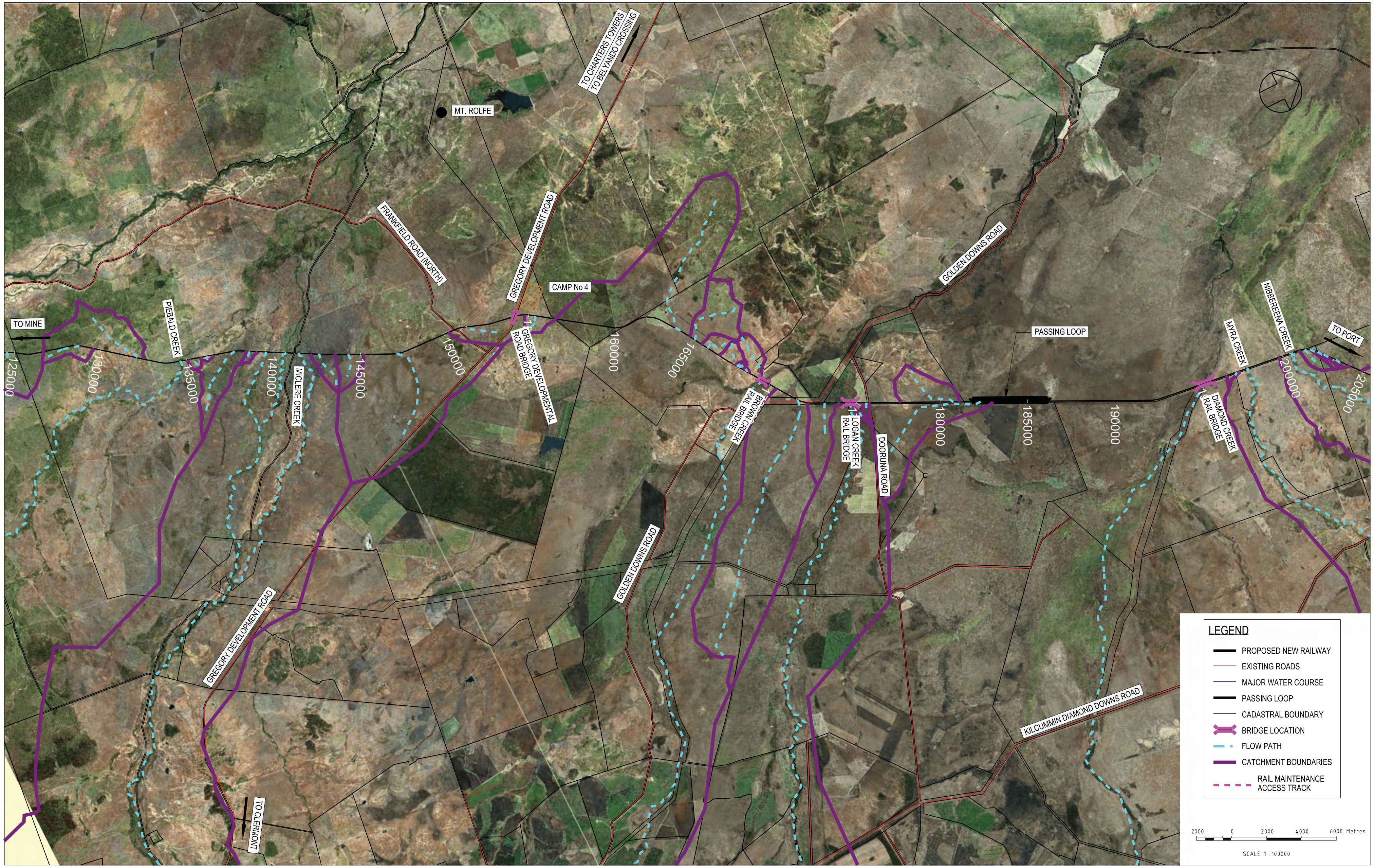

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ENG. MANAGER		
PROJECT MANAGER		
CLIENT APPROVED		

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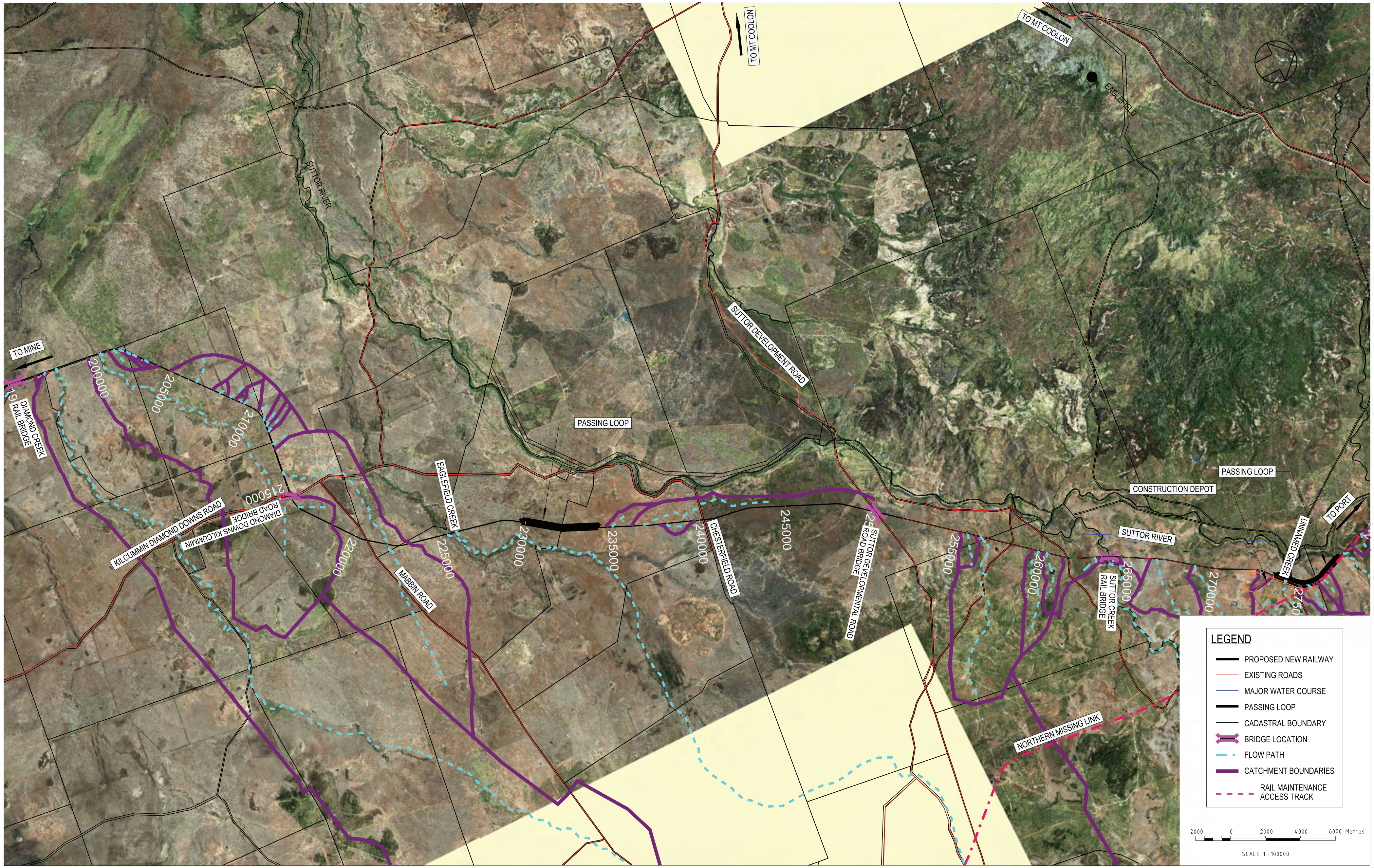
HANCOCK COAL PTY LTD

ALPHA COAL PROJECT - RAIL BFS
RAIL ALIGNMENT - MINE TO ABBOT POINT
DRAINAGE CATCHMENT PLANS
SHEET 3 OF 7

SHEET SIZE A1
PN No CJVP10007
SCALE 1:100000

CALIBRE DRAWING No. CJVP10007-DWG-G-188
HANCOCK COAL REFERENCE No. HC-CRL-24100-DRG-0485
REV A



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HANCOCK COAL PTY LTD

ALPHA COAL PROJECT - RAIL BFS
RAIL ALIGNMENT - MINE TO ABBOT POINT
DRAINAGE CATCHMENT PLANS
SHEET 4 OF 7

SHEET SIZE A1
PN No CJVP10007
SCALE 1:100000

CALIBRE DRAWING No. CJVP10007-DWG-G-189
HANCOCK COAL REFERENCE No. HC-CRL-24100-DRG-0486
REV A

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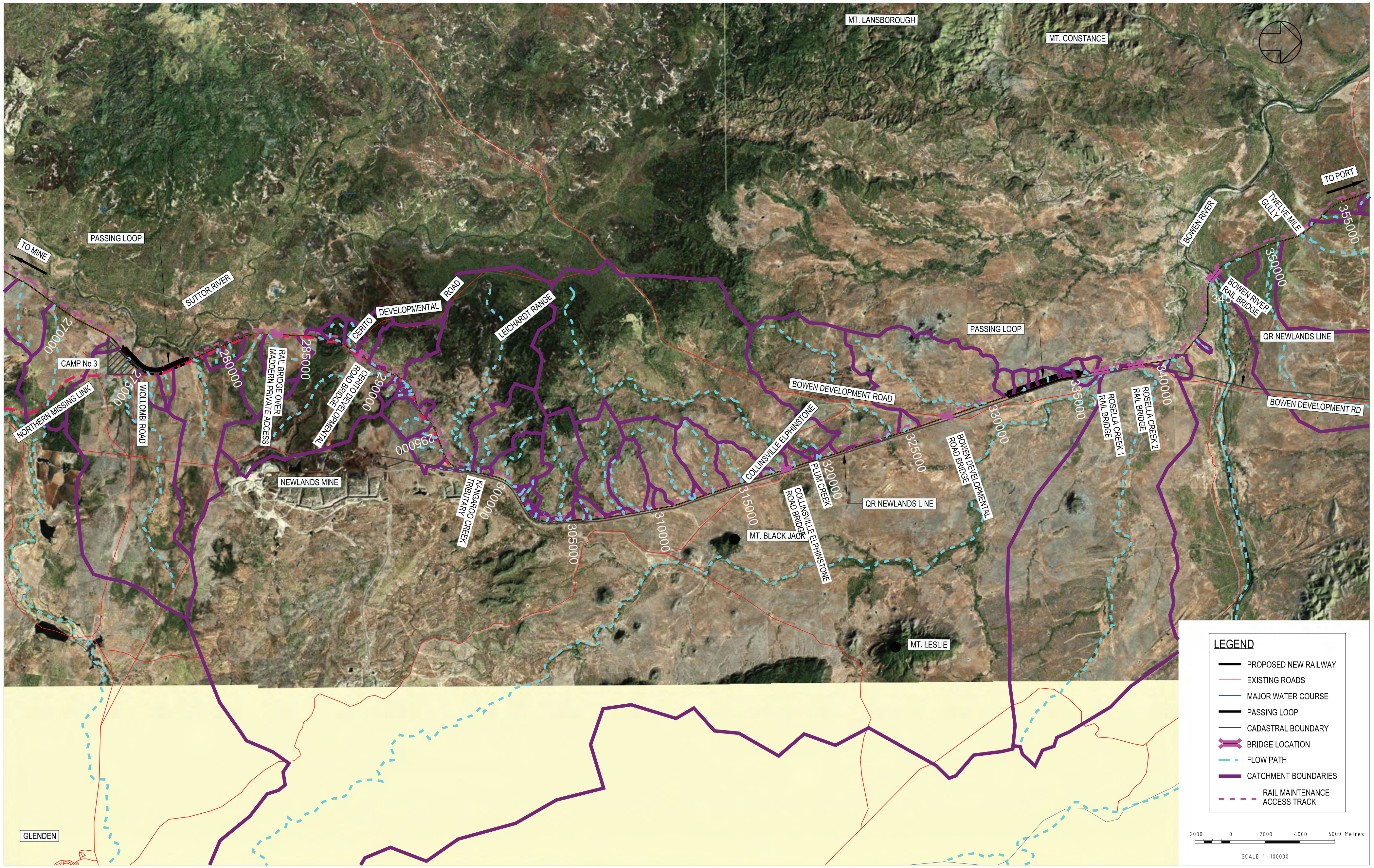

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PROJECT MANAGER		
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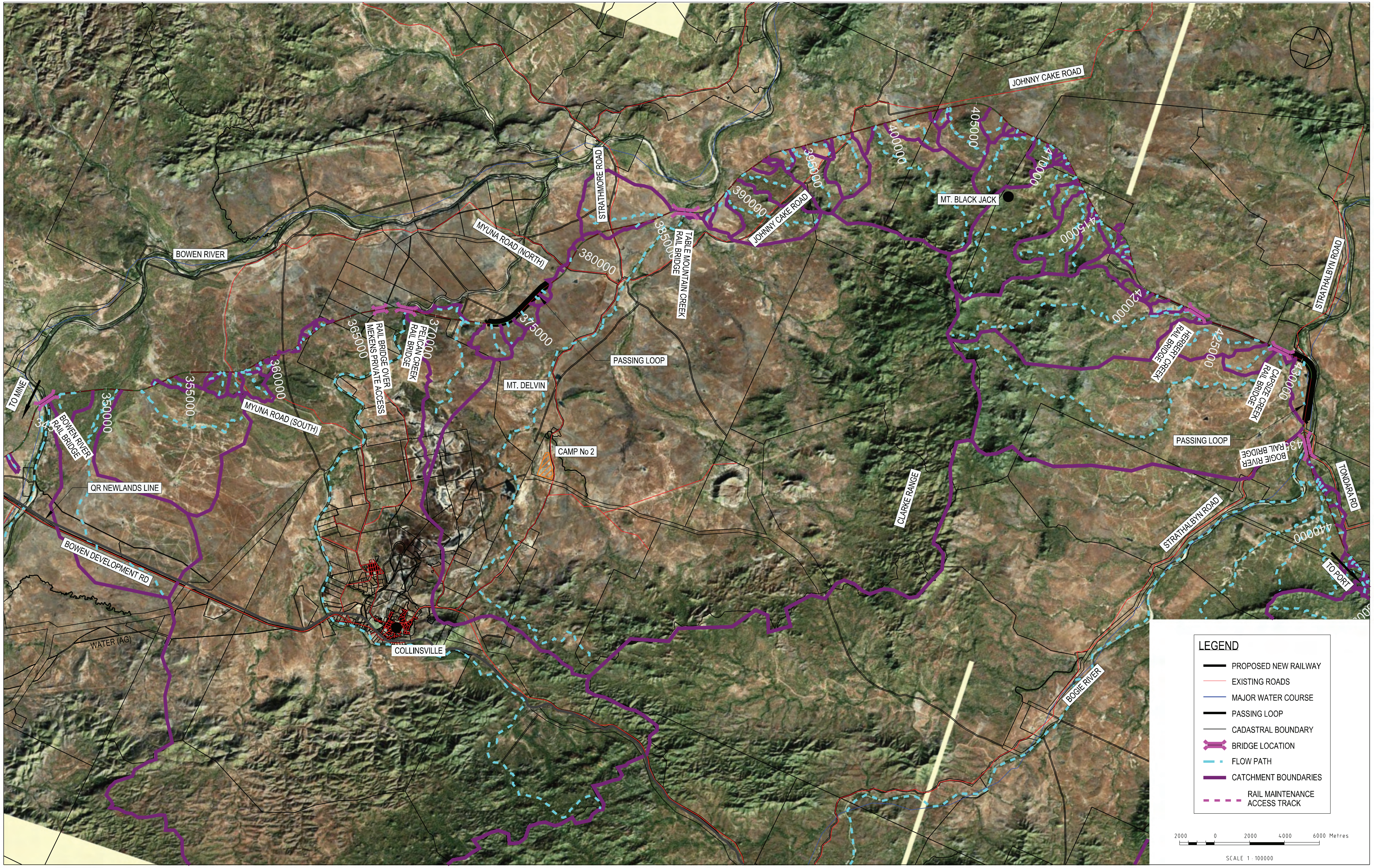
HANCOCK COAL PTY LTD

ALPHA COAL PROJECT - RAIL BFS
RAIL ALIGNMENT - MINE TO ABBOT POINT
DRAINAGE CATCHMENT PLANS
SHEET 5 OF 7

SHEET SIZE A1
PN No CJVP10007
SCALE 1:100000

CALIBRE DRAWING No. CJVP10007-DWG-G-190
HANCOCK COAL REFERENCE No. HC-CRL-24100-DRG-0487
REV A



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HANCOCK COAL PTY LTD

ALPHA COAL PROJECT - RAIL BFS
RAIL ALIGNMENT - MINE TO ABBOT POINT
DRAINAGE CATCHMENT PLANS
SHEET 6 OF 7

SHEET SIZE A1
PN No CJVP10007
SCALE 1:100000

CALIBRE DRAWING No. CJVP10007-DWG-G-191
HANCOCK COAL REFERENCE No. HC-CRL-24100-DRG-0488
REV A

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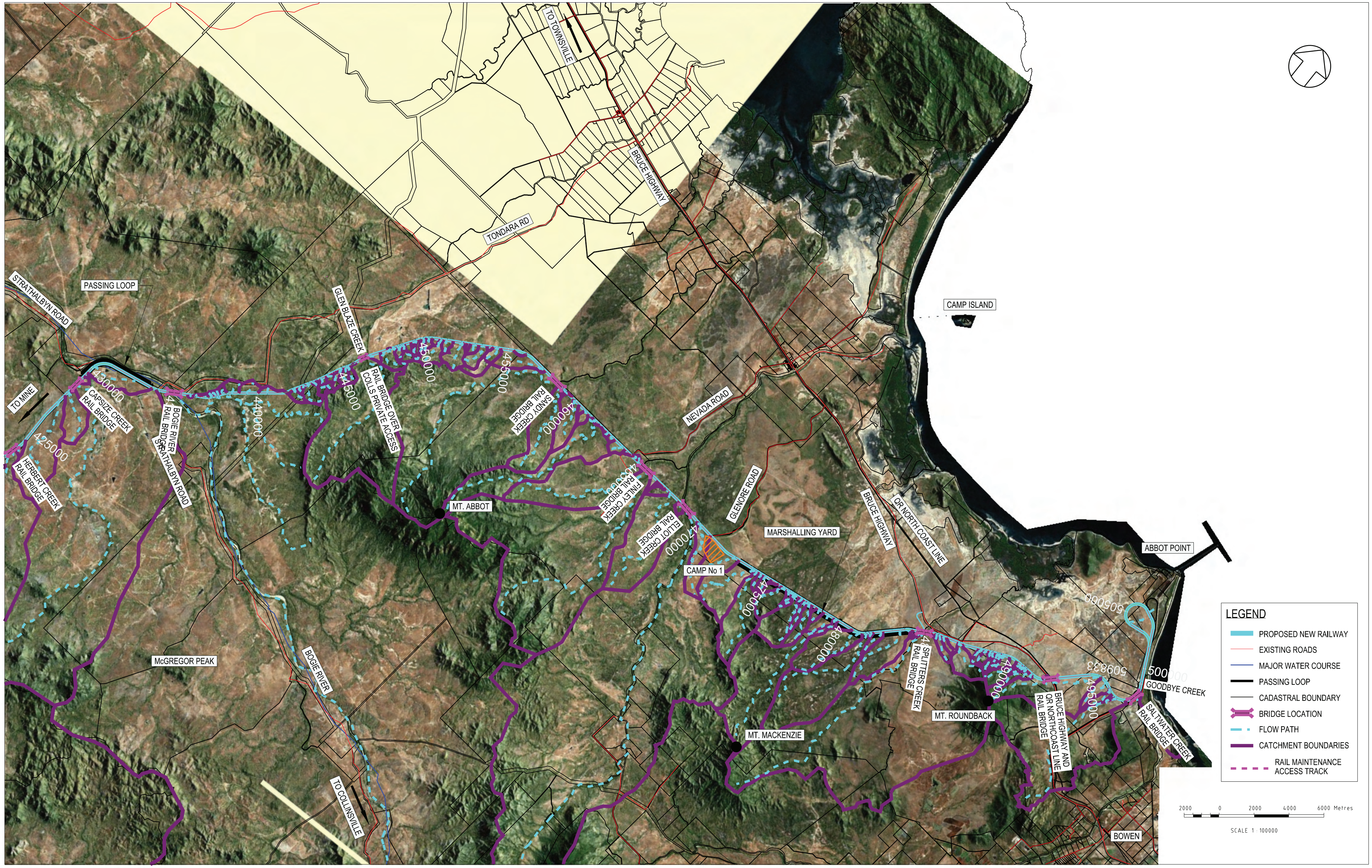

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PROJECT MANAGER		
CLIENT APPROVED		

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HANCOCK COAL PTY LTD

ALPHA COAL PROJECT - RAIL BFS
RAIL ALIGNMENT - MINE TO ABBOT POINT
DRAINAGE CATCHMENT PLANS
SHEET 7 OF 7

SHEET SIZE A1
PN No CJVP10007
SCALE 1:100000

CALIBRE DRAWING No. CJVP10007-DWG-G-192
HANCOCK COAL REFERENCE No. HC-CRL-24100-DRG-0489
REV A

3. Floodplain Relief Culvert Schedule

FLOODPLAIN RELIEF CULVERT SCHEDULE		
Assume culverts placed at 50 m centres except in Belyando river floodplain case @ 25 m centres		
Approximate Start Chainage	**Approximate End Chainage**	**Approximate No. Of Barrels**
26900	37950	211
38500	41500	120
44500	46500	80
59300	59700	8
59800	61200	28
68100	68350	5
68500	70200	34
75700	76600	18
79800	80150	7
85100	86200	22
86400	86800	8
89800	90750	19
94000	94700	14
94950	95450	10
115550	116950	28
133350	134550	24
134750	134900	3
139500	143100	72
146150	148200	39
162800	163800	20
169700	170250	11
172850	174700	37
175000	176500	30
192450	195250	56

3. Floodplain Relief Culvert Schedule

FLOODPLAIN RELIEF CULVERT SCHEDULE		
Assume culverts placed at 50 m centres except in Belyando river floodplain case @ 25 m centres		
Approximate Start Chainage	**Approximate End Chainage**	**Approximate No. Of Barrels**
195400	196200	16
196750	197800	21
198800	199200	8
220950	221500	11
221000	222450	29
224650	227200	41
263525	263675	3
264150	264550	8

APPENDIX C - STANDARD DRAINAGE STRUCTURES

The following Standard Drainage Structures Arrangements drawings forms part of this Drainage Report for the BFS.

Ref			Title
[1]	CJVP10007-TYP-Y-010	HC-CRL-24100-DRG-0200	STANDARD - TYPICAL DRAINAGE DETAILS – DIVERSION DRAIN AND BUND DETAILS
[2]	CJVP10007-TYP-Y-012	HC-CRL-24100-DRG-0005	CSP CULVERT GENERAL ARRANGEMENTS
[3]	CJVP10007-DWG-S-102	HC-CRL-24100-DRG-0265	NATIVE COMPANION CREEK RAIL BRIDGE - BR30 PLAN - CH 37,850
[4]	CJVP10007-DWG-S-101	HC-CRL-24100-DRG-0264	NATIVE COMPANION CREEK RAIL BRIDGE - BR30 LONGITUDINAL SECTION - CH 37,850
[5]	CJVP10007-DWG-S-130	HC-CRL-24100-DRG-0293	BOWEN RIVER RAIL BRIDGE - BR13 PLAN - CH 346,450
[6]	CJVP10007-DWG-S-129	HC-CRL-24100-DRG-0292	BOWEN RIVER RAIL BRIDGE - BR13 LONGITUDINAL SECTION - CH 346,450

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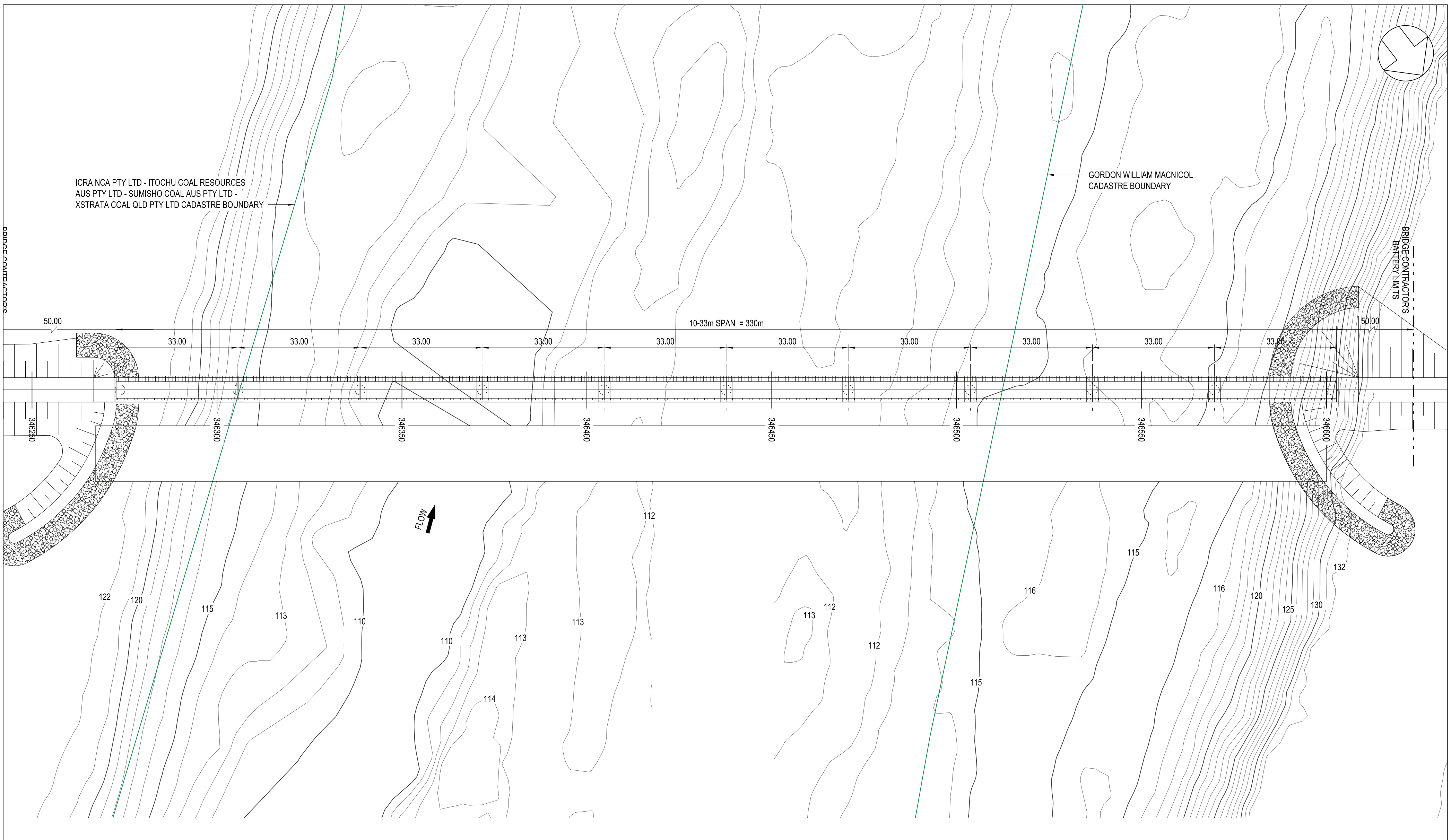

BOWEN RIVER RAIL BRIDGE PLAN

SCALE 1:500

10 0 10 20 30 Metres

SCALE 1 500

REV	BY	DATE	DESCRIPTION	CKD	APP
0	WQ	28.02.11	ISSUED FOR BFS	TR	DM
A	WQ	24.08.10	PREVIOUSLY CJVP10007-SKE-S-198 - ISSUED FOR INFORMATION	DM	

DRAWN	W. QUIOZON	24.08.10
DRAFTING CHECK	T. RANKIN	28.02.11
DESIGNER	A. DEANE	28.02.11
ENG. APPROVED	D. MILLER	28.02.11
ENG. MANAGER	M. McDONNELL	28.02.11
PROJECT MANAGER	T. LUBICZ	28.02.11
CLIENT APPROVED	G. MULLENS	28.02.11

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HANCOCK COAL PTY LTD

ALPHA COAL PROJECT - RAIL BFS
RAIL ALIGNMENT - MINE TO ABBOT POINT
BOWEN RIVER RAIL BRIDGE - BR13
PLAN - CH 346,450

SHEET SIZE A1
PN No CJVP10007
SCALE 1:500
CALIBRE DRAWING No. CJVP10007-DWG-S-130
HANCOCK COAL REFERENCE No. HC-CRL-24100-DRG-0293
REV 0

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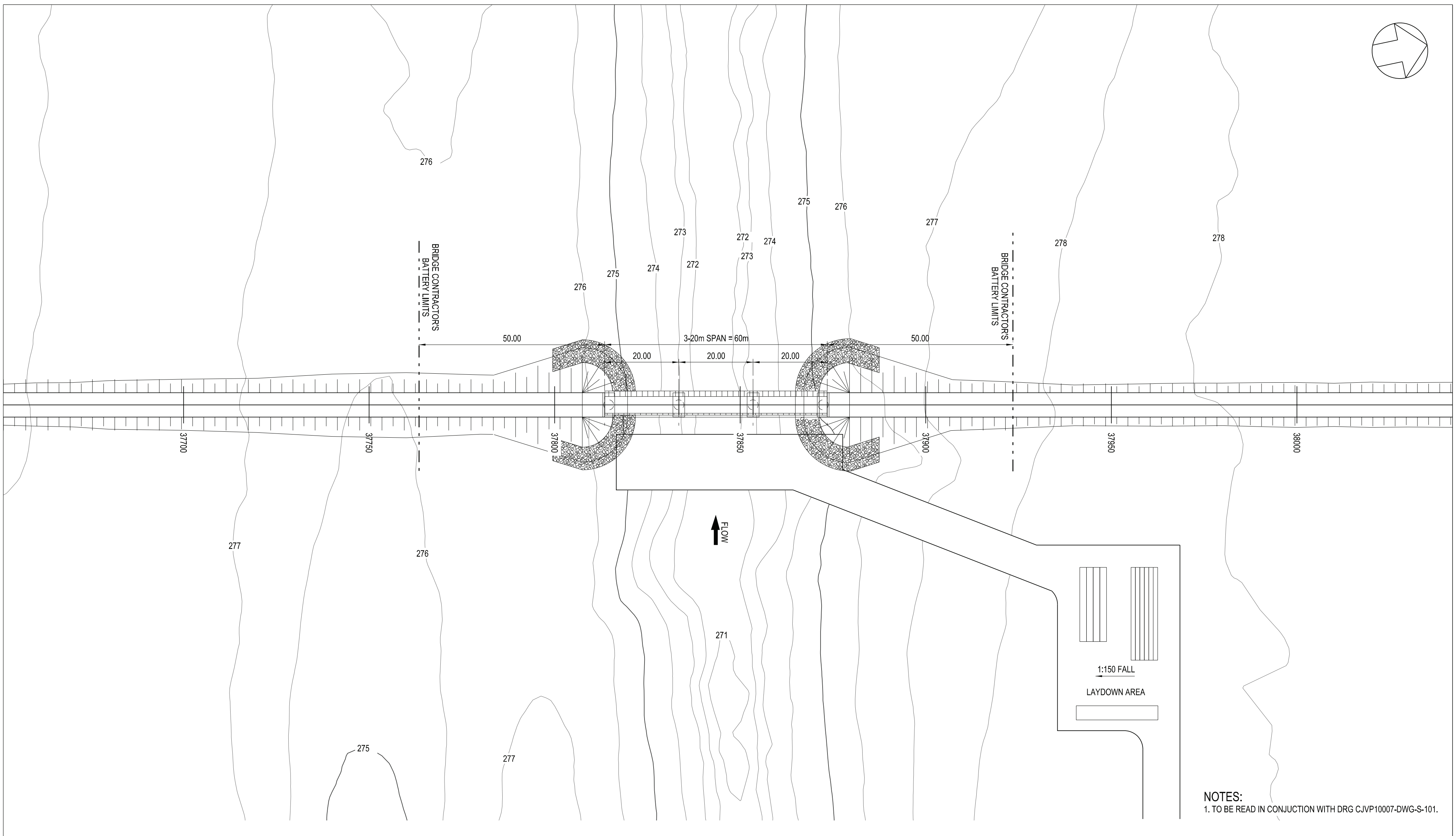

NOTES:
1. TO BE READ IN CONJUCTION WITH DRG CJVP10007-DWG-S-101.

NATIVE COMPANION CREEK RAIL BRIDGE PLAN
SCALE 1:500

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A	WQ	19.07.10	PREVIOUSLY CJVP10007-SKE-S-162 - ISSUED FOR INFORMATION	DM	

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DRAFTING CHECK	T. RANKIN	28.02.11
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ENG. APPROVED	D. MILLER	28.02.11
ENG. MANAGER	M. McDONNELL	28.02.11
PROJECT MANAGER	T. LUBICZ	28.02.11
CLIENT APPROVED	G. MULLENS	28.02.11

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HANCOCK COAL PTY LTD

ALPHA COAL PROJECT - RAIL BFS
RAIL ALIGNMENT - MINE TO ABBOT POINT
NATIVE COMPANION CREEK RAIL BRIDGE - BR30
PLAN - CH 37,850

SHEET SIZE A1
PN No CJVP10007
SCALE 1:500

CALIBRE DRAWING No. CJVP10007-DWG-S-102
HANCOCK COAL REFERENCE No. HC-CRL-24100-DRG-0265
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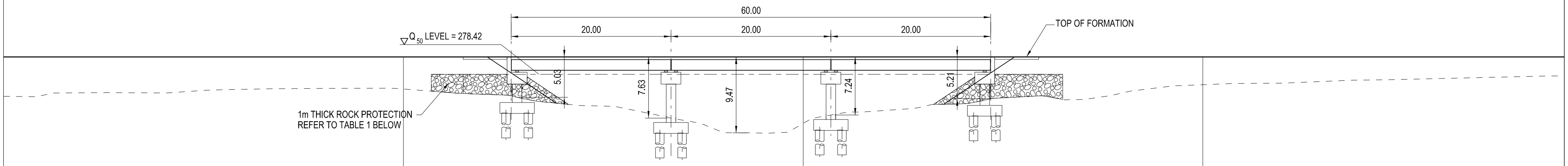

DATUM R.L. 260

VERTICAL GRADE	-0%		
VERTICAL CURVE			
HORIZONTAL ALIGNMENT	TAN 8123.261		
ARC LENGTH			
DESIGN LEVEL	280.60	280.60	280.60
NATURAL SURFACE LEVEL (NSL)	276.59	272.30	277.14
DEPTH (-CUT/+FILL)	4.01	9.47	3.46
CHAINAGE	37800.00	37850.00	37900.00

NATIVE COMPANION CREEK RAIL BRIDGE LONGITUDINAL SECTION

SCALE 1:250

NOTES:

1. GIRDER FOR 20m SPAN REFER TO DRG CJVP10007-TYP-S-026.
2. PIER COLUMN DETAIL REFER TO DRG CJVP10007-TYP-S-014.

TABLE1: NATIVE COMPANION CREEK ROCK PROTECTION

ROCK CLASS	ROCK SIZE (mm)	ROCK MASS (kg)	MIN PERCENTAGE OF ROCK LARGER THAN
1/4	750	500	0
	550	250	50
	300	35	90

5 0 5 10 15 Metres
SCALE 1 : 250

REFERENCES

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0	WQ	28.02.11	ISSUED FOR BFS	TR	DM
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DRAWN	W. QUIOZON	19.07.10
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ENG. APPROVED	D. MILLER	28.02.11
ENG. MANAGER	M. McDONNELL	28.02.11
PROJECT MANAGER	T. LUBICZ	28.02.11
CLIENT APPROVED	G. MULLENS	28.02.11

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HANCOCK COAL PTY LTD

ALPHA COAL PROJECT - RAIL BFS
RAIL ALIGNMENT - MINE TO ABBOT POINT
NATIVE COMPANION CREEK RAIL BRIDGE - BR30
LONGITUDINAL SECTION - CH 37,850

SHEET SIZE A1
PN No CJVP10007
SCALE 1:250
CALIBRE DRAWING No. CJVP10007-DWG-S-101
HANCOCK COAL REFERENCE No. HC-CRL-24100-DRG-0264
REV 0

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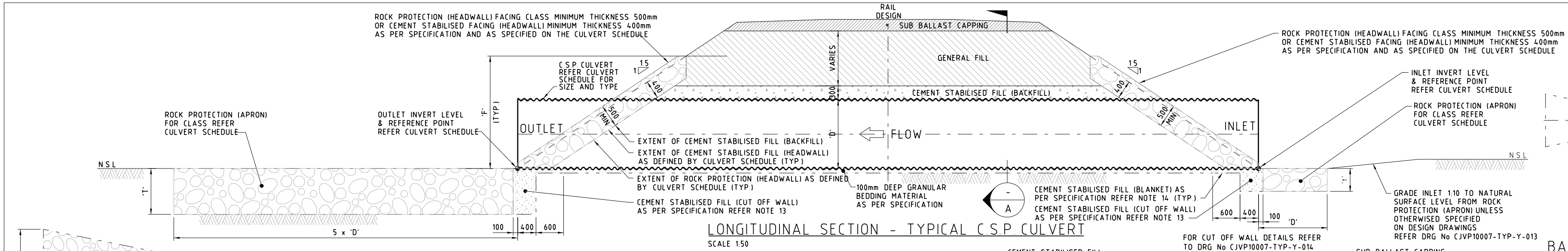
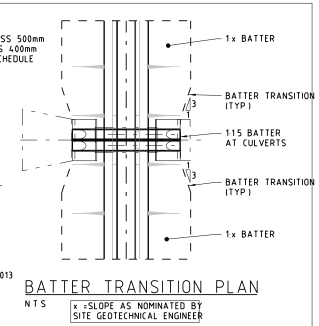
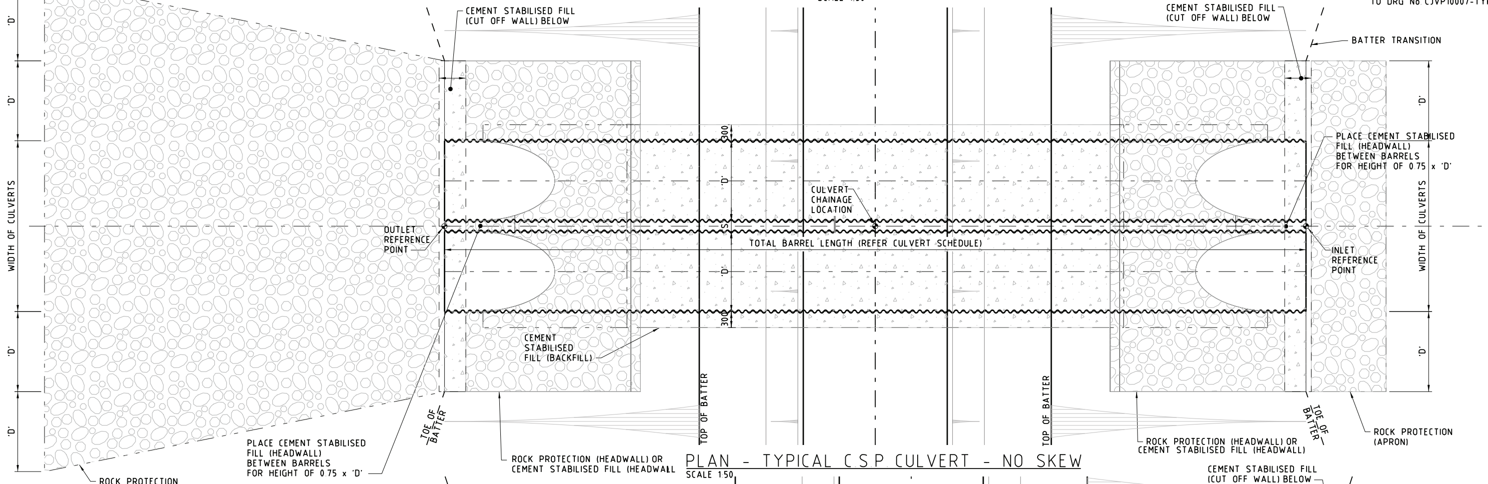


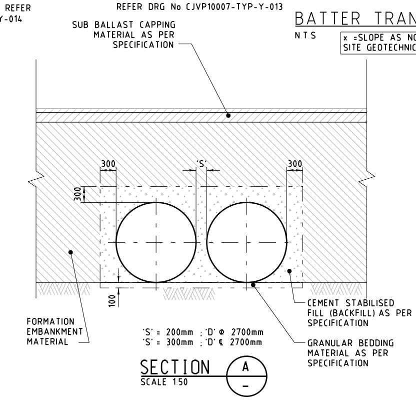
LONGITUDINAL SECTION - TYPICAL CSP CULVERT
SCALE 1:50



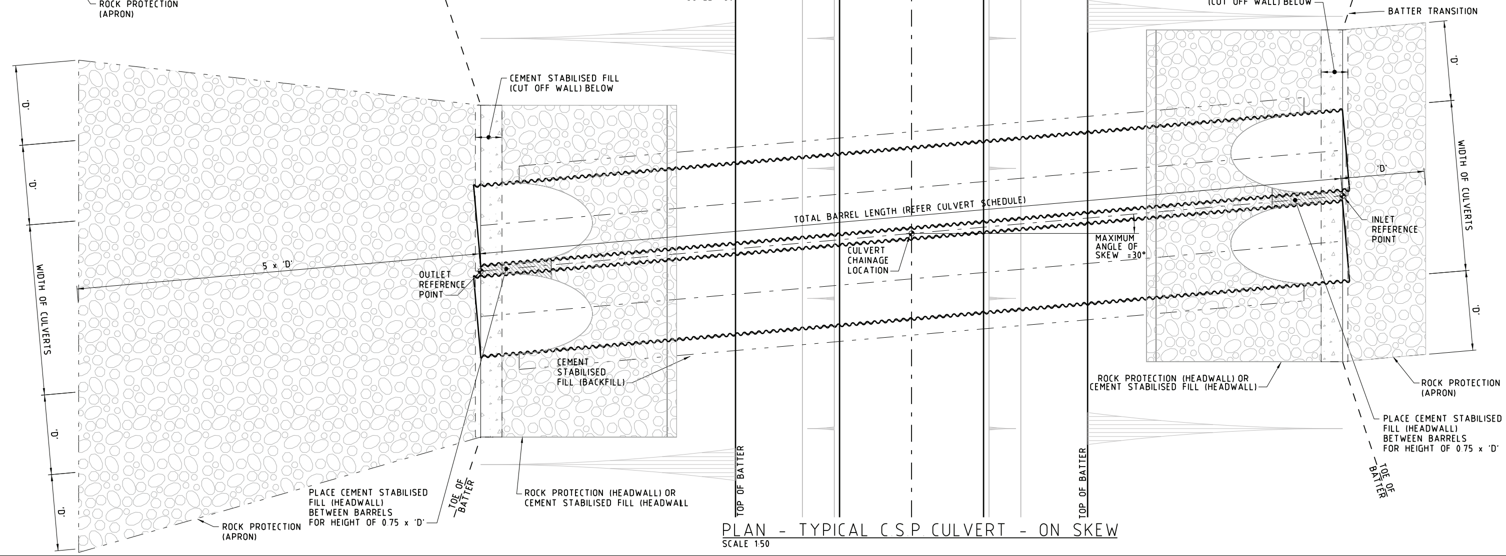
BATTER TRANSITION PLAN
NTS
x = SLOPE AS NOMINATED BY SITE GEOTECHNICAL ENGINEER



PLAN - TYPICAL CSP CULVERT - NO SKEW
SCALE 1:50



SECTION A
SCALE 1:50



PLAN - TYPICAL CSP CULVERT - ON SKEW
SCALE 1:50

NOTES:

1. ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE SPECIFIED.
2. ALL STEEL HELCOR PIPES SHALL BE EXTERNALLY WRAPPED IN NYLEX XL45 GEOMEMBRANE OR APPROVED EQUIVALENT.
3. CEMENT STABILISED FILL POURS SHALL BE PLACED ONLY AFTER INITIAL SET HAS OCCURED IN UNDERLYING POUR.
4. PIPES SHALL HAVE A MINIMUM COVER OF 600mm DURING INSTALLATION TO ALLOW FOR CONSTRUCTION TRAFFIC AND SHOULD BE RESTRAINED TO PREVENT FLOATATION AND MOVEMENT DURING INSTALLATION.
5. CEMENT STABILISED FILL SHALL BE WORKED AS REQUIRED TO ALLEVIATE VOIDS/CAVITIES.
6. 'D' REPRESENTS CULVERT DIAMETER;
   'S' REPRESENTS CULVERT SPACING - 'S' = 200mm : 'D' Φ 2700mm OR 'S' = 300mm : 'D' ℄ 2700mm;
   'F' REPRESENTS HEIGHT OF HEADWALL = 1.5 x 'D' + 200mm OR UNDERSIDE OF SUB BALLAST CAPPING AT FORMATION EDGE WHICHEVER IS LOWER;
   'T' REPRESENTS OUTLET ROCK PROTECTION APRON DEPTH - REFER CULVERT SCHEDULE FOR CLASS;
   't' REPRESENTS INLET ROCK PROTECTION APRON DEPTH - REFER CULVERT SCHEDULE FOR CLASS;
7. OUTLET AND INLET ROCK PROTECTION APRON DEPTH 'T' & 't' CLASS DIMENSIONS:
   - FACING = 500mm MIN.
   - LIGHT = 750mm MIN.
   - 1/4 TONNE = 1000mm MIN.
   - 1/2 TONNE = 1250mm MIN.
   - 1 TONNE = 1600mm MIN.
8. EXCAVATION BATTER SLOPE SHALL BE THE MAXIMUM SAFE WORKING SLOPE IN ACCORDANCE WITH STATUTORY REGULATIONS.
9. CUT OFF WALL DEPTH SHALL MATCH ROCK PROTECTION APRON DEPTH 'T', 't' OR REFUSAL WHEN EXCAVATING IN ROCK WITH A 30 TONNE EXCAVATOR.
10. WHERE NATURAL DOWNSTREAM INVERT LEVELS ARE ADJUSTED DURING PRELIMINARY WORKS, THE LEVELS SHALL BE REINSTATED TO THE STATISFACTION OF THE SITE ENGINEER, PRIOR TO INSTALLATION OF CULVERTS.
11. WHERE CONNECTING INTO EXISTING CULVERTS OR WHERE EXISTING AND NEW CULVERTS INLET & OUTLET ROCK PROTECTION APRONS JOIN, THE CONTRACTOR SHALL PICK UP EXISTING UPSTREAM AND DOWN STREAM INVERT LEVELS.
    THE CONTRACTOR SHALL SUPPLY THIS SURVEY INFORMATION TO THE ENGINEER PRIOR TO INSTALLATION OF CULVERT EXTENSION FOR CONFIRMATION OF LINE AND LEVEL.
12. EXPOSED FACES OF CEMENT STABILISED FILL (HEADWALL) SHALL BE WOOD FLOAT FINISHED TO PRODUCE A UNIFORM SURFACE WITHOUT SURFACE PITTING OR CAVITIES. MAXIMUM SURFACE IRREGULARITIES SHALL BE 5mm ABRUPT OR 15mm IN A 3m STRAIGHT EDGE.
13. IF ADDITIONAL CUT OFF WALL WIDTH IS REQUIRED (eg TO SUIT BUCKET WIDTH OF EXCAVATOR), THE CUT OFF WALL WIDTH SHALL PROTUDE 150mm MAX. IN FRONT OF INLET/OUTLET OF CULVERT REFERENCE POINT.
    ANY ADDITIONAL WIDTH SHALL PROTUDE UNDER THE CULVERT TO INCREASE THE 400mm WIDTH. ANY MODIFICATIONS SHALL BE APPROVED BY THE SITE ENGINEER.
14. 600mm x 100mm CEMENT STABILISED FILL (BLANKET) SHALL BE PLACED BEHIND CUT OFF WALL WHEN USING ROCK PROTECTION (HEADWALL) ONLY. TYPICAL BOTH INLET AND OUTLET ENDS. LENGTH TO MATCH CUT OFF WALL.
15. REFER TO CULVERT SCHEDULE FOR CULVERTS REQUIRING TIE DOWNS, AND SEE REF. DRG. 1 FOR TIE DOWN DETAILS.

1000 0 1000 2000 3000 Millimetres

SCALE 1:50

REFERENCES
CJVP10007-TYP-Y-014
CJVP10007-TYP-Y-013

REV	BY	DATE	DESCRIPTION	CKD	APP
0	TB	28.02.11	ISSUED FOR BFS	TB	TR
A	WQ	10.11.10	PREVIOUSLY CJVP10007-HC24100-G-022 ISSUED FOR REVIEW	BTC	

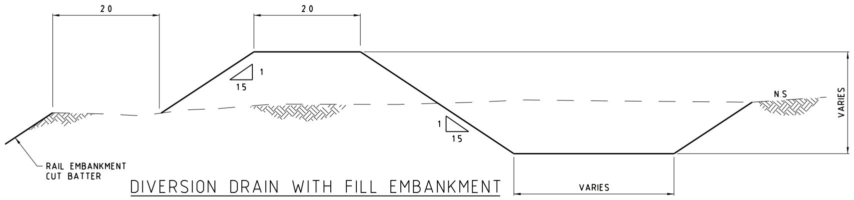
DRAWN	W. QUIOZON	10.11.10
DRAFTING CHECK	T. RANKIN	28.02.11
DESIGNER	T. BUCKLEY	28.02.11
ENG. APPROVED	D. MILLER	28.02.11
ENG. MANAGER	M. McDONNELL	28.02.11
PROJECT MANAGER	T. LUBICZ	28.02.11
CLIENT APPROVED	G. MULLENS	28.02.11

calibre

HANCOCK COAL PTY LTD

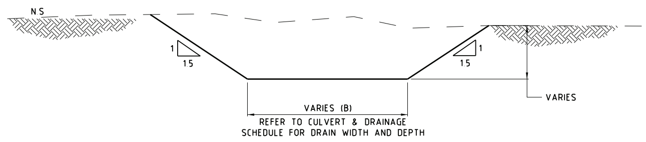
ALPHA COAL PROJECT - RAIL BFS
RAIL ALIGNMENT - MINE TO ABBOT POINT
STANDARD - TYPICAL DRAINAGE DETAILS SHEET 3
CSP CULVERT GENERAL ARRANGEMENTS

SHEET SIZE	A1
PN No	CJVP10007
SCALE	AS SHOWN
CALIBRE DRAWING No.	CJVP10007-TYP-Y-012
HANCOCK COAL REFERENCE No.	HC-CRL-24100-DRG-0005
REV	0



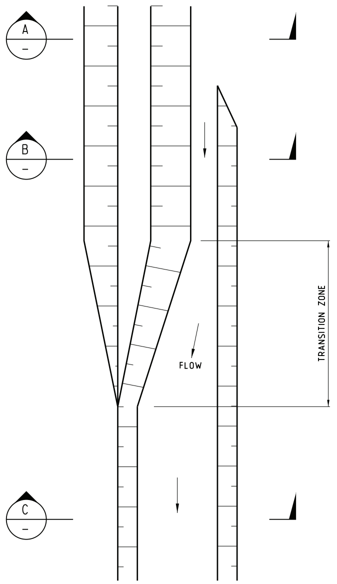
DIVERSION DRAIN WITH FILL EMBANKMENT

SCALE 1:50



DIVERSION DRAIN IN CUT

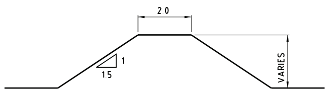
SCALE 1:50



PLAN

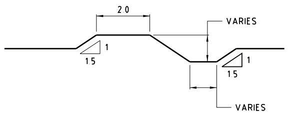
DIVERSION DRAIN INTERFACE

SCALE 1:100



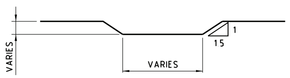
SECTION A

1:100



SECTION B

1:100



SECTION C

1:100

SP1 Ch 430000 – 507600

	Ch from	Ch To	Length of Drain	Depth	Base Width
			m	m	m
9001-9004	434450		550	1.50	2.85
9004F-9004C	436762		379	1.00	1.00
9009-9010	441979		71	0.90	0.00
9013-9012	442591		41	0.40	0.00
9012-9011	442519		39	0.70	0.00
9020-9019	443475		30	0.40	0.00
9019-9018	443435		35	0.50	0.00
9018-9017	443393		103	0.65	0.00
9021-9022	443700		80	0.80	1.00
9025-9024	444678		38	0.45	0.00
9024-9023	444430		130	1.00	0.00
9026-9027	444658		28	0.30	0.00
9027-9028	444763		37	0.60	0.00
9031-9030	445535		55	0.60	0.00
9041-9042	449268		132	1.25	2.30
9044-44A-9045	449757		333	1.15	2.50
9046A-9046	450508		78	0.75	0.00
9046B-9048	450898		202	1.00	2.90
9053-9054	452721		229	1.00	1.50
9057-9058	454116		84	1.00	1.00
9068-9066	459357		57	1.00	3.20
9067-Env	459325		35	0.55	0.00
9073A-9072	461480		100	1.10	0.00
9079-9080	464813		46	0.50	0.00
9080-9081	464900		58	0.60	0.00
9083-9082	465253		38	1.00	0.00
9085-Env	465714		60	0.90	0.00
9086-9084	466330		592	1.30	2.80
9087-9088	466680		156	0.90	1.00
9088-9089	466836		239	1.00	1.75
9089-9090	467109		176	1.15	1.75
9090-9091	467438		72	1.20	2.50
9096-9097	471410		430	1.15	2.85
9097-Env	471990		410	1.30	2.85
9104-9105	475913		235	1.30	2.80
9114-9115	478055		345	1.00	1.90
9119-9120	480595		245	1.10	2.90
9126A-9126	484457		193	1.00	1.00
9128-9127	485316		116	0.75	1.00
9133-9132	486412		136	1.00	1.00
9132-9131	486200		150	1.00	2.00
9134-9135	486853		139	0.85	1.00
9137-9136	487482		202	1.00	1.65
9136-9135	487215		135	1.00	2.40
9138-9139	487771		147	1.00	2.00
9139-9140	487918		58	1.00	2.30
9140-9141	487976		58	1.10	2.85
9141-9142	488034		391	1.10	2.85
9147-9146	489150		112	0.85	0.00
9146-9145	489038		54	0.75	1.00
9151-9152	489500		41	0.45	0.00
9155-9154	490160		113	1.00	2.10
9159-9160	491110		41	0.70	0.00
9162-9163	491437		63	0.85	0.00
9165B-9166	497050		65	0.60	5.50
Total for SP1			8182		

SP2 Ch 328000 - 430000

	Ch from	Ch To	Length of Drain	Depth	Base Width
			m	m	m
P6092 - P6093	331220	331840	620	1.70	7.00
P6094 - P6095	332880	333470	590	1.00	5.80
P6096 - P6100	334340	335720	1380	1.50	4.25
P6101 - P6103	336190	336400	210	1.00	6.50
P6106A - P6107	337620	338370	750	1.00	4.00
P6106A - P6107 east	337620	338260	640	1.00	4.00
P6109 old - P6110	339760	340460	700	0.75	5.00
P6110A - P6110	340720	340980	260	0.50	1.50
P7008 - P7006			0		
P7009 - P7012	355920	356780	860	1.00	7.00
P7021 - P7019	360400	361110	710	1.00	2.00
P7027A - P7025	361260	361460	200	0.30	1.00
P6087 - 88	321575		1825	0.50	3.00
P7044 - 45	378109		1119	1.00	8.00
P7046 - 47	380380		739	1.00	9.00
P7023 - Over Ridge	360280		562	1.00	2.00
P7032 -33 Over ridge	364420		875	1.50	9.00
P7034 - 36 Over ridge	365640		550	1.00	3.00
P7035 - 36 Over ridge	366320		134	1.00	1.00
P7057 - 58 Outlet	386620		28	0.50	1.25
P7058 - 59	386720		32	0.50	1.00
P7060 - 59	368800		100	1.00	2.00
P6087 - 88	321575		1825	0.50	3.00
P7047 - 56 Over Ridge	381120		899	1.00	5.00
P7047A - 55	382786		1210	1.00	7.00
8001A-1B	388202		176	1.00	2.65
8013-14	396337		216	1.00	3.75
8015-16	398178		778	1.75	4.00
8018-17	401547		597	1.20	3.00
8019-8020	402025		567	0.75	3.00
8020-8021	402592		708	1.25	3.00
8024-25	407518		342	1.00	3.65
8025--25A	407860		56	1.00	3.65
8029-8030A	410600		343	1.00	2.65
8030A-8030	410943		45	1.00	2.65
8032-8031	411247		94	0.60	1.00
8033B-8033A	411581		41	0.75	1.00
8033A-8033	411540		76	0.75	1.35
8036-8037	412031		191	0.90	1.00
8038-8037	412760		335	0.75	2.20
8043-8042	414969		52	0.55	0.00
8044-8045	415058		78	0.80	0.00
8048-8047	416215		315	1.00	3.25
8047-Env	415900		380	1.00	3.50
8049-8050	416606		36	0.80	1.00
8050-8051	416642		328	1.00	1.00
8051-8052	417042		278	1.00	2.35
8055-8056	419966		64	2.00	1.90
8056-8057	420130		126	2.00	4.65
8057-5058	420256		118	2.00	4.70
8064A-8064	428223		50	0.65	1.00
8065C-65B	429418		200	0.80	1.00
8065B-8065	429066		301	1.20	2.40
Total for SP2			23708		

SP3 Ch 216000 – 328000

	Ch from	Ch To	Length of Drain	Depth	Base Width
			m	m	m
P1104C - 4B	202100	201640	460	1.00	3.10
P1104E - 4D	203265	202495	770	1.00	2.00
P1106A - 8B	209280	209495	215	1.00	5.00
P1119 - P1116 (1118)	238160	236700	1460	1.50	7.00
P5006 - 06A	263460	263740	280	1.00	2.00
P5010 - 07	264600	263960	640	1.00	9.00
P5012 - 11	268863	268500	363	0.60	2.00
P5013 - 14	273050	274150	1100	1.00	6.60
P5021 - 20	282850		609	2.00	20.00
P5026 - 5027	288870	289100	230	1.50	13.00
P6001 - 03	289480	290140	660	1.00	1.50
P6006 - 07	291140	291300	160	3.00	19.00
P6015 - 16	293640	294120	480	1.25	6.00
P6019 - 24	297320	297620	300	1.50	8.00
P6027 - 26	298620	298460	160	1.75	10.00
P6043 - 30	300880	300660	220	0.50	3.50
P6052 - 51	303000	302810	190	0.75	1.00
P6063 - 64	307940	308000	60	1.00	1.00
P6065 - 66	308480	308890	410	1.00	3.50
P6068 - 67	309900	309520	380	1.50	5.00
P6084 - 83	319500	319220	280	1.30	5.00
Total for SP3			9427		

SP4 Ch 93500 – 216000

	Ch from	Ch To	Length of Drain	Depth	Base Width
			m	m	m
P1076-1077	136200	137140	940	0.70	7.00
P1078-1077	138620	138040	580	1.00	6.00
P1079a-1079	139600	141480	1880	1.00	6.00
P1084-1083	155380	151560	3820	1.50	6.50
P1090-1088	168000	167620	380	1.00	2.30
P1091-92	168480	168740	260	1.00	1.00
P1092 - 93 Out	169300	169560	260	1.75	9.25
P1095-1096	173400	174840	1440	1.50	7.50
P1098-1096	175780	174860	920	0.70	7.00
P1099 - 100 Out	180660	182440	1780	1.60	21.00
Total for SP4			12260		

SP5 Ch 0 – 93500

	Ch from	Ch To	Length of Drain	Depth	Base Width
			m	m	m
P1007-P1009	12320	13180	860	1.40	6.00
P1010 - P1011	14720	15260	540	1.75	8.70
P1013a - 12 Out	19150	16620	2530	1.70	15.00
P1019 - 20	37760	37841	81	1.00	3.00
P1042 - P1040	71900	70700	1200	1.00	2.50
P1044 - P43	73920	72580	1340	1.50	6.00
P1045 - P1046	75080	75620	540	1.00	5.00
P1047 - P1046	76620	75660	960	1.50	7.10
P1049 Catch	77900	78440	540	0.75	3.50
P1051 - 52	80840	81500	660	1.50	6.30
P1058-1059	92700	93460	760	1.00	5.50
Total for SP5			10011		

DIVERSION DRAIN SCHEDULE

TOTAL DRAIN LENGTH 63.58km

NOTES

1. ALL DIMENSIONS IN METRES UNLESS NOTED OTHERWISE
2. ALL EARTHWORKS SHALL BE CONSTRUCTED IN ACCORDANCE WITH THE SPECIFICATION
3. GRADE ALL FORMATION DRAINS & CUT OFF DRAINS TO DAYLIGHT AWAY FROM THE FORMATION
4. DIVERSION DRAIN DIMENSIONS TO BE SIZED TO DESIGN FLOWS DIMENSIONS SHOWN ARE MINIMUM DIMENSIONS REFER DESIGN DRAWINGS FOR ACTUAL DIMENSIONS

2 1 0 2 4 6 Metres — SCALE 1:100

1 0 1 2 3 Metres — SCALE 1:50

REV	BY	DATE	DESCRIPTION	CKD	APP
0	TB	28.02.11	ISSUED FOR BFS	TB	TR
B	DW	10.12.10	ISSUED FOR REVIEW	BTC	
A	WQ	10.11.10	PREVIOUSLY CJVP10007-HC24100-G-020 ISSUED FOR INFORMATION	BTC	

REFERENCES

REVISIONS

DRAWN	W. QUIOZON	10.11.10
DRAFTING CHECK	T. RANKIN	28.02.11
DESIGNER	T. BUCKLEY	28.02.11
ENG. APPROVED	D. MILLER	28.02.11
ENG. MANAGER	M. McDONNELL	28.02.11
PROJECT MANAGER	T. LUBICZ	28.02.11
CLIENT APPROVED	G. MULLENS	28.02.11

calibre

HANCOCK COAL PTY LTD

ALPHA COAL PROJECT - RAIL BFS
RAIL ALIGNMENT - MINE TO ABBOT POINT
STANDARD - TYPICAL DRAINAGE DETAILS SHEET 1
DIVERSION DRAIN AND BUND DETAILS

SHEET SIZE A1

PN No CJVP10007

SCALE AS SHOWN

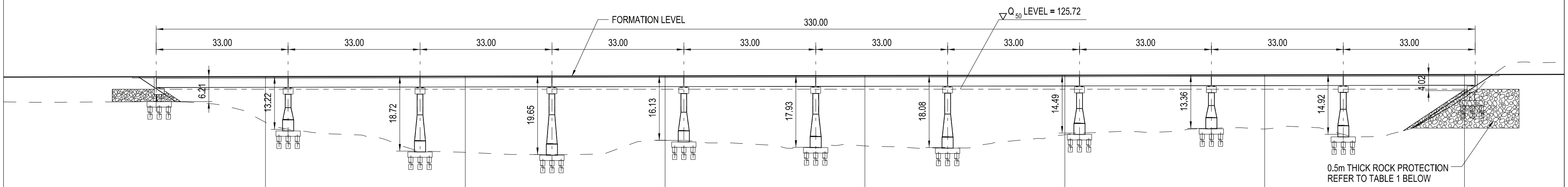
CALIBRE DRAWING No. CJVP10007-TYP-Y-010

HANCOCK COAL REFERENCE No. HC-CRL-24100-DRG-0200

REV 0

NOT TO BE SCALED

NOT TO BE SCALED



DATUM R.L. 90

VERTICAL GRADE / VERTICAL CURVE	0.17%						
HORIZONTAL ALIGNMENT / ARC LENGTH	TAN 704.827						
DESIGN LEVEL (T.O.F.)	128.88	128.97	129.05	129.14	129.22	129.31	129.40
NATURAL SURFACE LEVEL (NSL)	117.44	109.91	112.95	111.53	114.90	115.73	123.63
DEPTH (-CUT/+FILL)	11.44	19.06	16.11	17.61	14.90	13.58	5.76
CHAINAGE	346300.00	346350.00	346400.00	346450.00	346500.00	346550.00	346600.00

BOWEN RIVER RAIL BRIDGE LONGITUDINAL SECTION

SCALE 1:500

NOTES:

1. GIRDER FOR 33m SPAN REFER TO DRG CJVP10007-TYP-S-003.
2. PIER COLUMN DETAIL REFER TO DRG CJVP10007-TYP-S-014.

TABLE1: BOWEN RIVER ROCK PROTECTION

ROCK CLASS	ROCK SIZE (mm)	ROCK MASS (kg)	MIN PERCENTAGE OF ROCK LARGER THAN
1/4	750	500	0
	550	250	50
	300	35	90

10 0 10 20 30 Metres

SCALE 1:500

REV	BY	DATE	DESCRIPTION	CKD	APP
0	WQ	28.02.11	ISSUED FOR BFS	TR	DM
A	WQ	24.08.10	PREVIOUSLY CJVP10007-SKE-S-031 - ISSUED FOR INFORMATION	DM	

REFERENCES

REVISIONS

DRAWN	W. QUIOZON	24.08.10
DRAFTING CHECK	T. RANKIN	28.02.11
DESIGNER	A. DEANE	28.02.11
ENG. APPROVED	D. MILLER	28.02.11
ENG. MANAGER	M. McDONNELL	28.02.11
PROJECT MANAGER	T. LUBICZ	28.02.11
CLIENT APPROVED	G. MULLENS	28.02.11

calibre

HANCOCK COAL PTY LTD

ALPHA COAL PROJECT - RAIL BFS
RAIL ALIGNMENT - MINE TO ABBOT POINT
BOWEN RIVER RAIL BRIDGE - BR13
LONGITUDINAL SECTION - CH 346,450

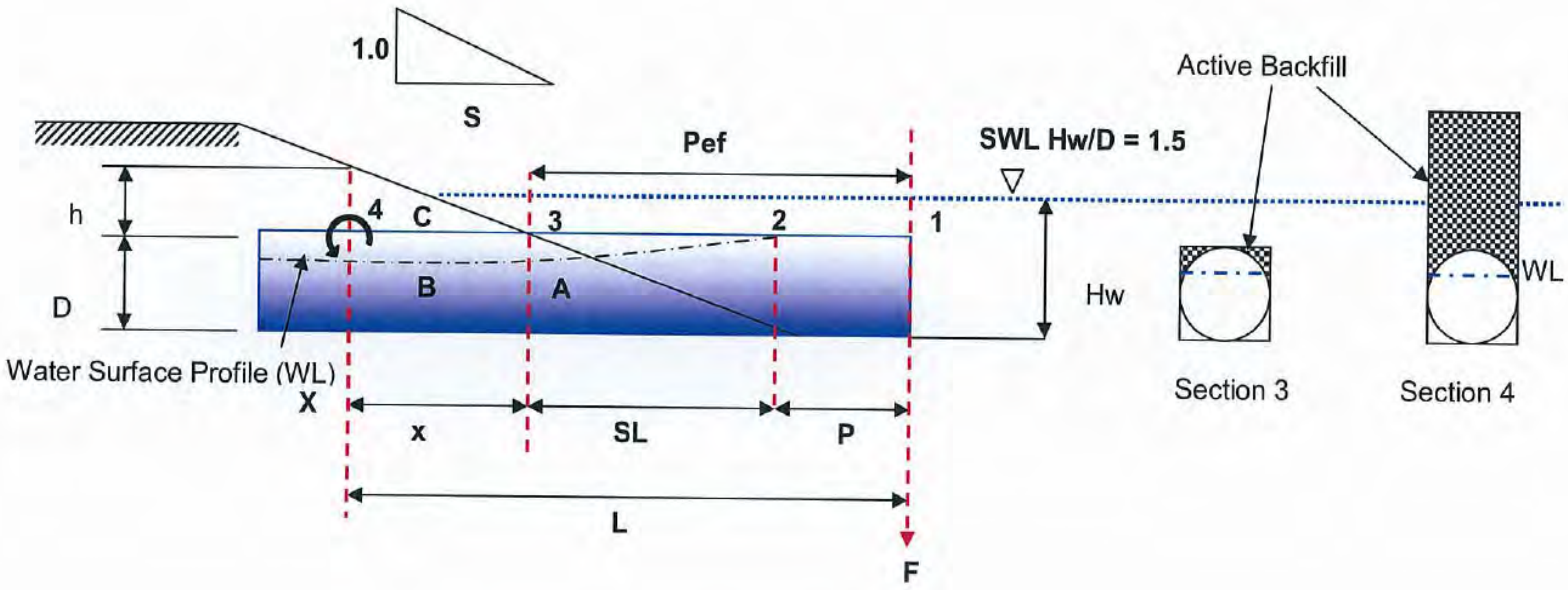
SHEET SIZE: A1
PN No: CJVP10007
SCALE: 1:500
CALIBRE DRAWING No.: CJVP10007-DWG-S-129
HANCOCK COAL REFERENCE No.: HC-CRL-24100-DRG-0292
REV: 0

APPENDIX D -
AUSTROADS SCOUR PROTECTION AND ROCK PROTECTION SIZING TABLE

Outlet Velocity (m/s)		Rock	
Min	Max	Class	Thickness
0	0.1	None	0
0.1	2.6	Facing	0.5
2.6	2.9	Light	0.75
2.9	3.9	1/4 tonne	1
3.9	4.5	1/2 tonne	1.25
4.5	5.1	1.0 tonne	1.6
5.1	5.7	2.0 tonne	2
5.7	6.4	4.0 tonne	2.5

Rock class	Rock size* (m)	Rock mass (kg)	Minimum percentage of rock larger than
Reno Mattresses	0.20 0.15 0.10	N/A	0 50 90
Facing	0.40 0.30 0.15	100 35 2.5	0 50 90
Light	0.55 0.40 0.20	250 100 10	0 50 90
¼ tonne	0.75 0.55 0.30	500 250 35	0 50 90
½ tonne	0.90 0.70 0.40	1000 450 100	0 50 90
1 tonne	1.15 0.9 0.55	2000 1000 250	0 50 90

APPENDIX E - CULVERT STRUCTURAL STRENTGH



Note: Effective Projection (P_{eff}) is measured along the top of the pipe.
$P_{eff} = SL + P$

Attachment 6 - Projection Guide

This guide provides the projection from the formation at which the culvert has an FOS=2, with the culvert flowing 75% full
The dimension given is the length (P) from the formation toe to culvert outlet

Table 2

Assume : 70% Flow (0.7D) or 75% Full Pipe with Hw/D = 1
Embankment Slope = 1V:2H
Profile 125 x 25

	Weight				
DIA	**1.6**	**2**	**2.5**	**3**	**3.5**
1200	NR	0.72	1.27	1.85	2.47
1350		0.35	0.85	1.38	1.94
1500			0.46	0.95	1.46
1650			0.09	0.55	1.02
1800				0.17	0.61
1950					0.23
2100					
2250					
2400					
2550					
2700	NR				
2850	NR				
3000	NR	NR			
3300	NR	NR			
3600	NR	NR	NR		

Table 3

Assume : 70% Flow (0.7D) or 75% Full Pipe with Hw/D = 1
Embankment Slope = 1V:2H
Profile 68 x 13

	Weight				
DIA	**1.6**	**2**	**2.5**	**3**	**3.5**
900	2.44	3.20	4.20	5.30	6.63
1050	1.99	2.69	3.56	4.50	5.52
1200	1.58	2.23	3.03	3.85	4.75
1350	NR	1.80	2.55	3.32	4.12
1500	NR	1.41	2.12	2.83	3.56
1650	NR	NR	1.72	2.38	3.08
1800	NR	NR	NR	1.97	2.62

(green)	Safe Projection - No Tie Down Required
(grey)	Projection Requires Tie Downs
NR	Not Recommended by Manufacturer

Table 4

Assume : 70% Flow (0.7D) or 75% Full Pipe with Hw/D = 1
Embankment Slope = 1V:1.5H
Profile 125 x 25

	Weight				
DIA	**1.6**	**2**	**2.5**	**3**	**3.5**
1200	NR	1.34	1.90	2.47	3.09
1350	0.62	1.04	1.55	2.08	2.64
1500	0.36	0.75	1.24	1.72	2.24
1650	0.10	0.48	0.94	1.40	1.87
1800		0.21	0.65	1.09	1.54
1950			0.38	0.80	1.23
2100			0.11	0.52	0.93
2250				0.25	0.64
2400					0.37
2550					0.09
2700	NR				
2850	NR				
3000	NR	NR			
3300	NR	NR			
3600	NR	NR	NR		

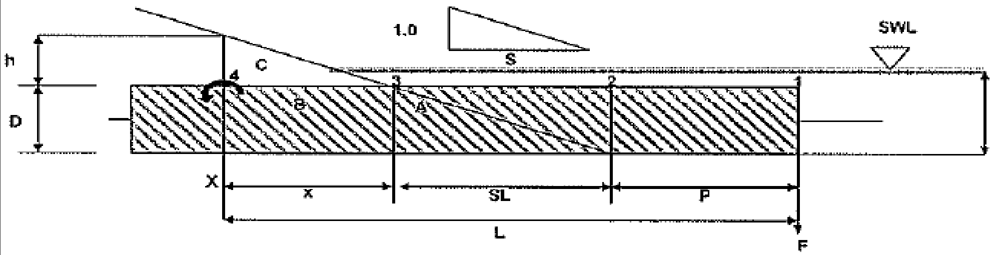
Table 5

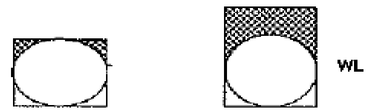
Assume : 70% Flow (0.7D) or 75% Full Pipe with Hw/D = 1
Embankment Slope = 1V:1.5H
Profile 68 x 13

	Weight				
DIA	**1.6**	**2**	**2.5**	**3**	**3.5**
900	2.93	3.69	4.69	5.79	7.12
1050	2.55	3.26	4.14	5.07	6.09
1200	2.22	2.88	3.69	4.50	5.40
1350	NR	2.52	3.28	4.04	4.85
1500	NR	2.21	2.92	3.64	4.37
1650	NR	NR	2.60	3.27	3.96
1800	NR	NR	NR	2.93	3.58

(green)	Safe Projection - No Tie Down Required
(grey)	Projection Requires Tie Downs
NR	Not Recommended by Manufacturer

Culvert Bouyancy Calculation
Water Pipe in Embankment plus Projection
Calculation Based on uplift to SL + P





INPUT

Pipe Diameter =	D	3.600	m
Wall Thickness =	WT	3.5	
Profile =		125 x 25	
Pipe Weight=		3.577	kn/m
Pipe Area =	pi() *d2/4	10.18	sm
Headwater =	HW	3.6	m
Headwater/Dia =	HW/D	1.00	
Water Level /D =	WL/D	0.75	
Water inside pipe =	WL	2.7	
Water Area =		8.19	sm
Percentage of Full Pipe =		80.4%	
Batter Slope =	S	1.5	
	m=	0.7	
CSP Projection =	P	0.00	m
Slope distance =	S_L = S x D	5.4	m
Total Projection=	S_L+P = L	5.4000	m
Total length =	L	6.9	m
Length in Bank=	x	1.5	m

CONSTANTS

Water Density =	dw	9.8	kn/cum
Earth Density =	ds	20	kn/cum
Moment of Inertia =	I =	6.39E+10	mm4
Neutral Axis =	y=	1800	mm
	Z=	3.55E+07	
Ult Stress =	Fy=	250	Mpa
Allowable bending (Cylinder) =	M =Z*Fy =	4440	kn-m
Corrugation Factor =	Cf =	22	
Allowable bending (CSP) =		201.8	kn-m
Holddown Force =		-12.43	kn

TIE DOWN REQUIRED YES

TIE DOWN FORCE REQUIRED 12.43 kn

YES

CALCULATION

Calculate uplift forces on pipe at 0.75 x D Full

	Factor				
Area of Void =	0.1535	D^2	=	1.990 sm	
Uplift on Pipe =	0.1535	*dwxD²-Wp	=	15.925 kn/m	
	1.50	D²-Wp	=	15.925 kn/m	
Overturning Moment =	1.50	D²-Wp * (S_L +P)²/2	=	232.2 kn-m	(1)

Calculate resisting force at 3

Area of soil =		4*D²/8-PI*D²/8			
	0.107	*D²	=	1.4 sm	
Soil Pressure at 3 (P_3) =	0.107	*D²(ds-d)	=	14.2 kn/sm	
Total soil Resistance =		(P_3 * S_L)/6	=	12.8 kn	
Moment of Soil Resistance =	0.0228	*D²*S_L²	=	8.6 kn-m	(2)
Moment at Point 3 =			=	223.8 kn-m	(3)=(1) -(2)

Moments about point X

Uplift due to buoyancy =	0.1535	*D²*d_w*(x+S_L+P)²/2

Restoring Moments

From A	0.0179	*(ds-dw)*D²*S_L
From B	0.1073	*(ds-dw)*D²*x²/2
From C	0.1667	mx²*ds
Weight of Pipe =	0.500	Wp*(x+S_L+P)²

Let

A=	0.1535	*D2*dw/2	=	9.751
B=		(ds-dw)*D²	=	132.2
L=		(SL+P)	=	5.4
N=	0.25	*D*m*ds	=	12
P=		(A-0.053*B-0.5wp)	=	0.870
Q=		(2*A*L-0.018*B*S_L-wp*L)	=	73.23
R=		(A*L2-0.02*B*S_L-wp*L2/2)	=	215.90

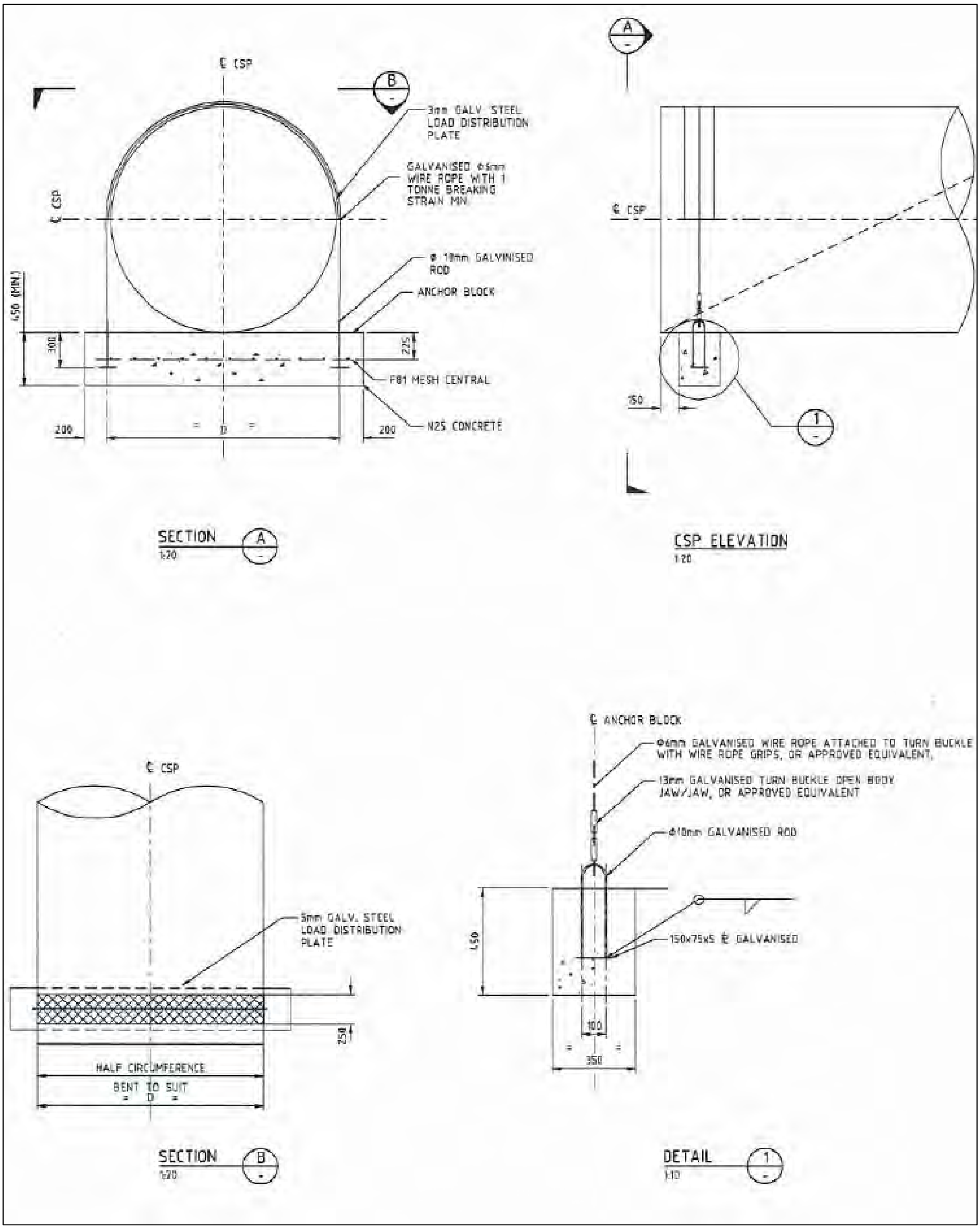
FOS =2.0

When x=0, M=R = 223.6kn-m
For Mmax, X = -b +/-(b2-4ac)0.5/2a

a=	1	1
b=	-2P/3N	-0.05
c=	Q/3N	2.03
x=	-b+(b2+4ac)0.5/2a	1.47
	-b-(b2+4ac)0.5/2a	-1.38

Maximum Bending Moment

Mmax =	-Nx³+Px²+Q	287.3 kN-m
Allowable Bending Moment =		201.8 kN-m
Excess Bending Moment =		-85.5 kN-m
Holddown Force Required =	M/L	-12.432000000 kN



℄ CSP
3mm GALV. STEEL LOAD DISTRIBUTION PLATE
GALVANISED Φ6mm WIRE ROPE WITH 1 TONNE BREAKING STRAIN MIN.
℄ CSP
Φ 10mm GALVINISED ROD
ANCHOR BLOCK
450 (MIN.)
300
225
F81 MESH CENTRAL
200
D
200
N25 CONCRETE
SECTION A
1:20
A
℄ CSP
150
1
CSP ELEVATION
1:20
℄ CSP
5mm GALV. STEEL LOAD DISTRIBUTION PLATE
250
HALF CIRCUMFERENCE
BENT TO SUIT
D
SECTION B
1:20
℄ ANCHOR BLOCK
Φ6mm GALVANISED WIRE ROPE ATTACHED TO TURN BUCKLE WITH WIRE ROPE GRIPS, OR APPROVED EQUIVALENT.
13mm GALVANISED TURN BUCKLE OPEN BODY JAW/JAW, OR APPROVED EQUIVALENT
Φ10mm GALVANISED ROD
450
150x75x5 ℄ GALVANISED
100
350
DETAIL 1
1:10

APPENDIX F - AUSTRALIAN STANDARDS FOR CULVERT DESIGN AND INSTALLATION

- AS1111 – ISO Metric Hexagon Commercial Bolts and Screws - 2000
- AS1397 – Steel sheet and strip – Hot-dipped zinc-coated or aluminium/zinc-coated – 2001
- AS1597 Precast reinforced concrete box culverts
- AS1761 – Helical lock-seam corrugated steel pipes – 1985
- AS1762 – Helical lock-seam corrugated steel pipes – Design and installation – 1984
- AS1789 – Electroplated coatings – Zinc on iron and steel - 2003
- AS2041 – Buried corrugated metal structures – 1998
- AS3750.9 – Paints for steel structures – Organic zinc-rich primer – 1994
- AS3750.15 – Paints for steel structures – Inorganic zinc silicate paint – 1998
- AS5100.2 – Bridge design – Design loads – 2004
- AS 4058-1992 "Precast concrete pipes.

APPENDIX G - COVER REQUIREMENTS FOR CORRUGATED STEEL PIPES

Calculation of required depth of cover for corrugated steel pipes. AS 1762

Yellow blocks denote Inputs		
Weight of Soil	22	kN/m3
Compaction	92.00%	As per specification
Kf (ref Fig 2.1 AS 1762)	0.75	
		-0.0001x3 + 0.0382x2 - 3.3795x + 100.95
Haulpack CAT 777D		
Max gross wt (Ref Cat Performance Handbook Edition 33)	163293	kg
2/3 on rear axle (Ref Cat Performance Handbook Edition 33)	108862	kg
2/3 on rear axle	1067.93622	kN
Tyre pressure (Ref Bridgestone Earth moving Tyres)	700	kPa
Footprint Area	0.763	m2
Assumed footprint dims (width & length)	0.54777	m (a)
	1.27596	m (b)
Area (check)	0.698932609	m2
Adjustment for tread pattern (Ref Bridgestone Earth moving Tyres)	0.69497288	
Min Cover during construction	0.6	m
Alpha Ref pg 20 AS 2566	1.31	
Load distrib thru soil (Ref pg 22 AS 2566)	0.725:1	
P	534.0	kN
A_{LL}	3.0	m2
P_{LL}	229.9	kPa
P_{DL}	13.2	kPa
P_V	182.3	kPa
Culvert diameter	600	mm
Ic minimum	7.2	
Assumed profile	125 * 25	based on Ic minimum
Assumed thickness (Ref Ingal data attached)	3.5	mm
r (Ref Ingal data attached)	8.98	
A (Ref Ingal data attached)	3.84	mm2/m
(Ss/r)^2	4 10^3	
Fc	250.0	Mpa
Fa	125	Mpa
Compression in pipe wall	54.7	kN/m
Wall stress	14.2448	Mpa
	Stress < Allowable	
Raw FOS	**17.55030285**	
AS1762 FOS	**8.775151426**	
Use this block to iterate for maximum cover	12.73490131	m

Calculation of required depth of cover for corrugated steel pipes. AS 1762

Stress < Allowable

Summary		
Pipe dia	600	mm
Profile	125 * 25	
Wall thickness	3.5	mm
Min cover	0.6	m
Max cover (if calculated)	12.73490131	m

APPENDIX H -
GHD ENVIRONMENTAL ASSESSMENT

CLIENTS | PEOPLE | PERFORMANCE

Hancock Coal Pty Ltd

Report for Alpha Coal Project (Rail) Supplementary Environmental Impact Statement

Appendix H - Review of Floodplain Environmental Impacts

August 2011

INFRASTRUCTURE | MINING & INDUSTRY | DEFENCE | PROPERTY & BUILDINGS | ENVIRONMENT

This Review of Floodplain Environmental Impacts ("Report"):

1. *has been prepared by GHD Pty Ltd ("GHD") for Hancock Coal Pty Ltd to accompany the Rail Corridor BFS Drainage Engineering Report prepared by Calibre ;*
2. *may only be used and relied on by Hancock Coal Pty Ltd;*
3. *must not be copied to, used by, or relied on by any person other than Hancock Coal Pty Ltd without the prior written consent of GHD;*
4. *may only be used for the purpose of the Alpha Coal Project (and must not be used for any other purpose).*

GHD and its servants, employees and officers otherwise expressly disclaim responsibility to any person other than Hancock Coal Pty Ltd arising from or in connection with this Report.

To the maximum extent permitted by law, all implied warranties and conditions in relation to the services provided by GHD and the Report are excluded unless they are expressly stated to apply in this Report.

The services undertaken by GHD in connection with preparing this Report were limited to those specifically detailed in section 1.2 of this Report.

The opinions, conclusions and any recommendations in this Report are based on assumptions made by GHD when undertaking services and preparing the Report ("Assumptions"), including (but not limited to) the scope defined within Section 1.2 of this Report.

GHD expressly disclaims responsibility for any error in, or omission from, this Report arising from or in connection with any of the Assumptions being incorrect.

Subject to the paragraphs in Section 4 of the Report, the opinions, conclusions and any recommendations in this Report are based on conditions encountered and information reviewed at the time of preparation and may be relied on until 6 months, after which time, GHD expressly disclaims responsibility for any error in, or omission from, this Report arising from or in connection with those opinions, conclusions and any recommendations.

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1. Introduction

1.1 Purpose of Report

GHD have been commissioned by Hancock Coal Pty Ltd (Hancock) to conduct a review of potential environmental impacts within flood plain catchments and drainage systems identified within the Rail Corridor Bankable Feasibility Study (BFS) Drainage Engineering Report initial drainage report prepared by Calibre for the Alpha Coal Project (Rail) (the Project).

1.2 Scope of Report

The Project will traverse a number of watercourses (drainage systems) and associated flood plains. The Calibre Rail, Alpha Coal Project (Rail) Bankable Feasibility Study provides estimates of the surface water flooding characteristics (prior to detailed drainage modelling), including changes to peak flows for a 1 in 50 year ARI (Average Recurrence Interval).

The scope of this report includes a review of potential environmental impacts within the flood plain areas traversed by the rail corridor and an outline of the environmental assessment criteria for incorporation into the detailed design, so that consequential impacts are maintained at acceptable levels for existing land users and other affected stakeholders. Also provided in this report is an outline of the methodology that will be implemented to achieve the aims and objectives of the assessment criteria.

2. Environmental Impacts

2.1 Environmental Features

Key environmental features considered during the drainage design process are identified below.

- soil type;
- riparian vegetation cover;
- geomorphological characteristics and conditions;
- evidence of recent flood events (through a site survey and local knowledge);
- erosion and bank stability;
- likelihood of species habitat;
- fish movement;
- sensitive receiving environments;
- stream flow connectivity;
- catchment characteristics and land use practices; and
- water quality.

Figure 1 below, illustrates the type of natural drainage environments which are traversed by the rail alignment. Impacts upon such features will be assessed during the final drainage design process as outlined in the following sections.

Figure 1 Table Mountain Creek

3. Assessment Criteria

3.1 Assessment Parameters

An environmental assessment criterion has been developed to monitor and minimise flooding and drainage variations, exceeding the existing conditions with the potential to adversely impact upon land surrounding the rail corridor. This assessment criterion has been developed for the 50 year ARI design event. From an environmental perspective, changes to the surrounding environment can be examined, predicted and monitored by using the following design aspects:

- inundation extent,
- inundation duration,
- inundation frequency (for the purposes of developing environmental assessment criteria, inundation frequency is assessed as part of the inundation extent above),
- afflux,
- flow velocity, and
- flow connectivity.

When considering the design aspects listed above, it is important to understand the site context. For the purpose of this assessment criterion, three (3) primary receiving environments have been used to assess environmental impacts on surroundings land within the floodplain:

1) Existing infrastructure and urban land – This includes roads, vehicle access tracks, cattle yards, hardstand areas, houses, sheds, water tanks, wind mills, wells, earth dams, and other built infrastructure.
2) Pastoral, grazing and cultivated lands – All land within the floodplain that does not fall under existing infrastructure or environmentally sensitive areas. This includes existing fences, gates, cattle tracks.
3) Environmentally sensitive areas – This includes designated watercourses, protected riparian regional ecosystems (listed as ‘of concern’ or ‘endangered’ under the Vegetation Management Act), referable wetlands and essential habitat for conservation significant terrestrial and aquatic fauna (protected under the Environmental Protection and Biodiversity Conservation Act and Nature Conservation Act).

Table 1 outlines the environmental assessment criteria within a floodplain across the three (3) receiving environments identified above.

Table 1 Environmental Assessment Criteria - Floodplain

Assessment Aspect	SURROUNDING LAND CATEGORY		
	Existing Infrastructure/Asset	**Pasture, Grazing and Cultivated Land**	**Environmentally Sensitive Areas**
Surrounding land category definition	*This includes urban land, roads, vehicle access tracks, cattle yards, hardstand areas, houses, sheds, water tanks, wind mills, wells, earth dams, and other built infrastructure.*	*All land within the floodplain that does not fall under existing infrastructure or environmentally sensitive areas. This includes existing fences, gates, cattle tracks.*	*This includes the designated watercourses, protected riparian regional ecosystems, naturally occurring waterholes, billabongs, wetlands, recognised protected terrestrial aquatic fauna habitat.*
Inundation Extent	Do not inundate existing infrastructure/asset that was not inundated during the existing conditions in the 50 year ARI design event. For roads, maintain existing trafficability, as defined in Section 9.2.2 of Waterway Design, AustRoads, 1994.	Subject to landholder agreement. As a guide, acceptable increase in inundation extent (above the existing conditions for a given return period up to the 50 year ARI event) will be proposed where such an increase will not alter rural land uses and result in significant impacts upon: – valued pasture land (e.g. buffel grass); – other valued agricultural land uses such as cultivated land (e.g. crops); and – flood-free ground and evacuation access for cattle.	Subject to case-specific environmental conditions. As a guide: Flood extent not to overtop catchment boundaries that were previously not overtopped during the existing conditions 50 year ARI design event.

Assessment Aspect	SURROUNDING LAND CATEGORY		
	Existing Infrastructure/Asset	**Pasture, Grazing and Cultivated Land**	**Environmentally Sensitive Areas**
Inundation Duration	Duration of inundation over existing infrastructure/assets not to exceed 20% of existing flood duration conditions during the 50 year ARI design event.	Subject to landholder agreement. As a guide, acceptable increase in inundation duration (above the existing conditions for a given return period up to the 50 year ARI event) will be proposed where such an increase will not alter rural land uses and result in significant impacts upon: – valued pasture land (e.g. buffel grass); – other valued agricultural land uses such as cultivated land (e.g. crops); and – flood-free ground and evacuation access for cattle	Subject to case-specific environmental conditions. Alteration in duration for the 50 year ARI design event not to irreversibly affect sensitive environmental conditions.
Flow Velocity	Where proposed development increases velocity at the existing infrastructure/asset, limit design velocities for the 50 year ARI event to: 1.5 m/s where erodible/dispersive soils are present. 2.5 m/s for normal soil conditions Otherwise, provide with appropriate mitigation measures at affected existing infrastructure/asset locations.	At culvert locations: Downstream of culverts, where velocity is measured at the apron lip, design velocity for the 50 year ARI event is not to exceed: • 1.5 m/s where erodible/dispersive soils are present. • 2.5 m/s for normal soil conditions. At bridge locations: Maximum velocity during the 50 year ARI design event not to exceed existing flow conditions' maximum velocity by more than 20%. This rule applies at a distance equal to the total a bridge span downstream of the bridge (e.g. if the bridge spans 30 m in total, the velocity change is measured 30 m downstream from the bridge centreline). Otherwise, appropriate erosion and scour control mitigation measures are to be applied.	Subject to case-specific environmental conditions. Critical velocity specified for protected /sensitive species migrating through culverts (refer to terrestrial and aquatic fauna passes guideline in DMR RDDM). Existing geomorphology conditions and processes not to be irreversibly affected.

Assessment Aspect	SURROUNDING LAND CATEGORY		
	Existing Infrastructure/Asset	**Pasture, Grazing and Cultivated Land**	**Environmentally Sensitive Areas**
Flow Connectivity	n/a	Minimise water shadow effect downstream of the rail alignment. Provide flow path continuum (waterway connectivity) where farm water supply dams (e.g. earth dams, turkey nests) are located downstream of the rail alignment.	Subject to case-specific environmental conditions. Flow connectivity provided for sensitive habitats/species. Water shadow effect not to irreversibly affect the sensitive environmental areas downstream of the rail alignment.
Afflux	Maximum allowable afflux for the 50 year ARI design event: For dwellings: 0.1 m For railway corridor: 0.2 m For road: apply trafficability criteria (refer above) Other: no greater than 0.5 m Note: Not greater than the above limits unless specific circumstances where it is considered that an afflux greater than specified above can be tolerated subject to stakeholder agreement.	No greater than 0.5 m unless in specific circumstances where it is considered that an afflux greater than 0.5 m can be tolerated in conjunction with the criteria described in the sections above, and with landholder agreement.	Subject to case-specific environmental conditions. As a guide, refer to above.

4. Methodology / Process

The following process is recommended when undertaking the drainage design during the conceptual and detail design phases. The methodology provided below is indicative and should be adapted given data availability.

4.1 Desktop Analysis and Liaising

Step 1: The first step entails carrying out a detail desktop analysis. The desktop analysis should distil the current understanding of the hydrologic regime within the study area. Existing reports should be reviewed (including the EIS), design and criteria should be established given the railway design objectives and environmental design criteria. Outputs of this analysis should include:

- Definition of a draft works definitions document that details the design criteria that can satisfy both the railway design and the environmental design criteria;
- Register of major crossings and understanding of the key catchments intercepted by the linear infrastructure alignment;
- Record of existing flood studies/reports in the area of interest from organisations such as DERM, BoM, and/or Local Government Agencies.
- Existing data from flow gauges situated within the catchments affected.

Step 2: The second step is to liaise with key stakeholders in the design process. These should include the rail designer, the approvals manager, environmental scientist, and community consultation liaison officer. Outcomes of this process should include:

- Understanding of the limitations to the horizontal and vertical preliminary rail alignment;
- Understanding of the key environmental sensitive areas, habitats and species that are potentially affected by interfering to the waterway ecosystem;
- Understanding of the key information requirements from the drainage design team feeding into the approval process;
- Understanding of the limitations from the land-owner perspective including access requirements.

An update to the draft works definition document may be required after liaison with key stakeholders. The draft document should be reviewed by the stakeholders and agreed on.

4.2 Hydrologic Modelling and Preliminary Sizing of Cross-drainage structures

Step 3: The third step entails carrying out the hydrological modelling using available topographical information. Catchment delineation, identification of cross-drainage locations, flowpath delineation, and design rainfall determination should be carried out amongst many. The outcomes of this process should provide with design flow estimates at each of the identified crossings. Validation of results by calibrating models to nearby gauge stations is a critical component of this stage.

Step 4: The fourth step requires the preliminary sizing of cross drainage infrastructure given the design constraints detailed in the works definition document (Refer Section 4.1 above) without any hydraulic modelling be undertaken.

Should further detailed topographical information be expected, the above steps should be repeated and updated estimates be produced.

4.3 Field Investigations

Step 5: Carry out a field investigation visiting the major waterways as well as areas that have been identified as critical or sensitive during Step 1 (refer above). As part of the field investigation, notes and photographic evidence should be gathered on the channel geometry, key geomorphological features of crossings (e.g. riffles, pools), dominant soil types in the riparian zone, vegetation type and coverage, appropriate manning's n values given the channel characteristics. Site visit should be undertaken in combination with the environmental officer. Liaison with the land-owners and local councils should be made to obtain anecdotal or reported evidence of flood incidents.

4.4 Finalise Hydrologic Analysis and Carry out Hydraulic Analysis

Step 6: Finalise the hydrologic analysis following the site visit where necessary.

Step 7: Carry out hydraulic analysis given available topographic information and the latest rail alignment. The analysis should consider appropriate tools given the flood mechanics at each crossing. Appropriate complexity in the analysis must be considered depending on the required information. For example, should the flowpaths break into the floodplain, 1D or 2D hydrodynamic modelling may be necessary to provide information on peak velocities at different locations.

Step 8: Results from the hydraulic analysis must be presented to rail designer, the approvals manager, environmental scientist, and community consultation liaison officer and seek feedback.

4.5 Carry out iterations and finalise design phase

Step 9: Based on the feedback provided in Step 8 (refer above), revisit the hydraulic analysis. Steps 7 and 8 should be repeated until results are meeting the works definition document expectations.

Step 10: Complete the drainage design phase by producing the drainage design report that includes amongst others sections on:

- Design assumptions
- Hydrologic analysis
- Hydraulic analysis
- Crossing register
- Relevant drainage structure drawings
- Safety in design considerations

4.6 Environmental Design Report

Step 11: An environmental drainage design report is to prepared that addresses the environmental requirements as identified in the EIS. The report should describe how the proposed drainage design satisfies the environmental design criteria for each of the areas of interest including existing infrastructure/assets, grazing land and environmentally sensitive areas. Any residual risk to the environment should be detailed and appropriate mitigation measures described.

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Document Status

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