

3.5 Hydrology & Hydraulics

3.5.1 Purpose

The purpose of this section is to provide results from the analysis and assessment of the impact of the proposed Carmichael Rail Alignment (Option 11 Revision 1) on the existing major floodplains, river, and creek crossings. The hydrology assessments were carried out on the Option 11 Revision 1 rail alignment which has subsequently been updated to Option 11 Revision 2, as a result of these studies. The analysis provides recommendations of the cross drainage infrastructure required to minimise impacts to existing flow paths, minimise impacts on existing infrastructure and properties, and to meet the conditions set in the EIS and PDC.

The design approach used in this analysis was based on best practise principles and experience gained from similar projects within the region. Consideration was given to publicly available requirements from the Coordinator General for these projects, to provide comparable and reasonable design criteria.

The following sections outline the methodologies employed for the hydrologic and hydraulic analyses respectively.

3.5.2 References, Codes & Standards

For details on references codes and standards, refer to the Drainage Design Report in Appendix B.

3.5.3 Project Overview

The proposed Carmichael Rail Alignment traverses terrain which is best described as very flat and dominated by vast floodplains. These floodplains are primarily used for grazing on natural pastures. The landscape is semi-arid with predominantly ephemeral streams (typically flowing between December and April). During the wet seasons, high rainfall intensities are expected, and the ephemeral rivers and creeks are prone to extended periods of inundation associated with tropical low pressure systems.

The major catchments crossing the proposed rail alignment form part of the larger Burdekin River basin (129,700 km²).

The proposed Carmichael Rail Line crosses six significant floodplains: North Creek, Belyando River, Mistake Creek/Gowrie Creek, Logan Creek, Diamond Creek and Grosvenor Creek. In addition to these floodplains, the proposed alignment crosses several catchments of varying sizes.

A typical feature of the landscape within the floodplains is groupings of numerous shallow depressions or Gilgai. An aerial photograph depicting typical Gilgai is shown below in Figure 3.9. Floodplains typically have dense buffel grass vegetation with thicker, more mature trees located along creek banks.



Figure 3.9 Aerial Photograph Showing Typical Landscape Conditions (Gilgai)

3.5.4 Project Design Criteria

The Project Design Criteria for hydrology and hydraulics can be found in the Hydrology and Hydraulics Design Criteria (CARP12033-SPE-C-001).

3.5.5 Site Inspection

A site inspection has been undertaken to confirm the location of major and minor watercourse crossings and conduct a visual assessment of the flow and drainage patterns within the contributing catchments. A description of each major water crossing including extent of vegetation, land use, drainage patterns, flow type, debris and a description of the bed sedimentation material was recorded. Information regarding the anecdotal evidence of historic flood levels was identified where available. Full details can be found in the Appendix A - Site Inspection Report (CARP12033-REP-G-009).

3.5.6 Catchment Delineation

The watercourse locations were identified from topographical maps. Catchment boundaries have been delineated based on the following data sources:

- › 1 in 250,000 topographical maps from Geoscience Australia
- › Aerial photography undertaken during the LiDAR data collection (collected within 1 km corridor along the proposed rail line and extra coverage areas at major watercourses)
- › Shuttle Radar Topography Mission data
- › Drainage mapping from Australian Geo-fabric 2011.

An overview of the delineated major catchments for the proposed Carmichael Rail Alignment is provided in Figure 3.10.

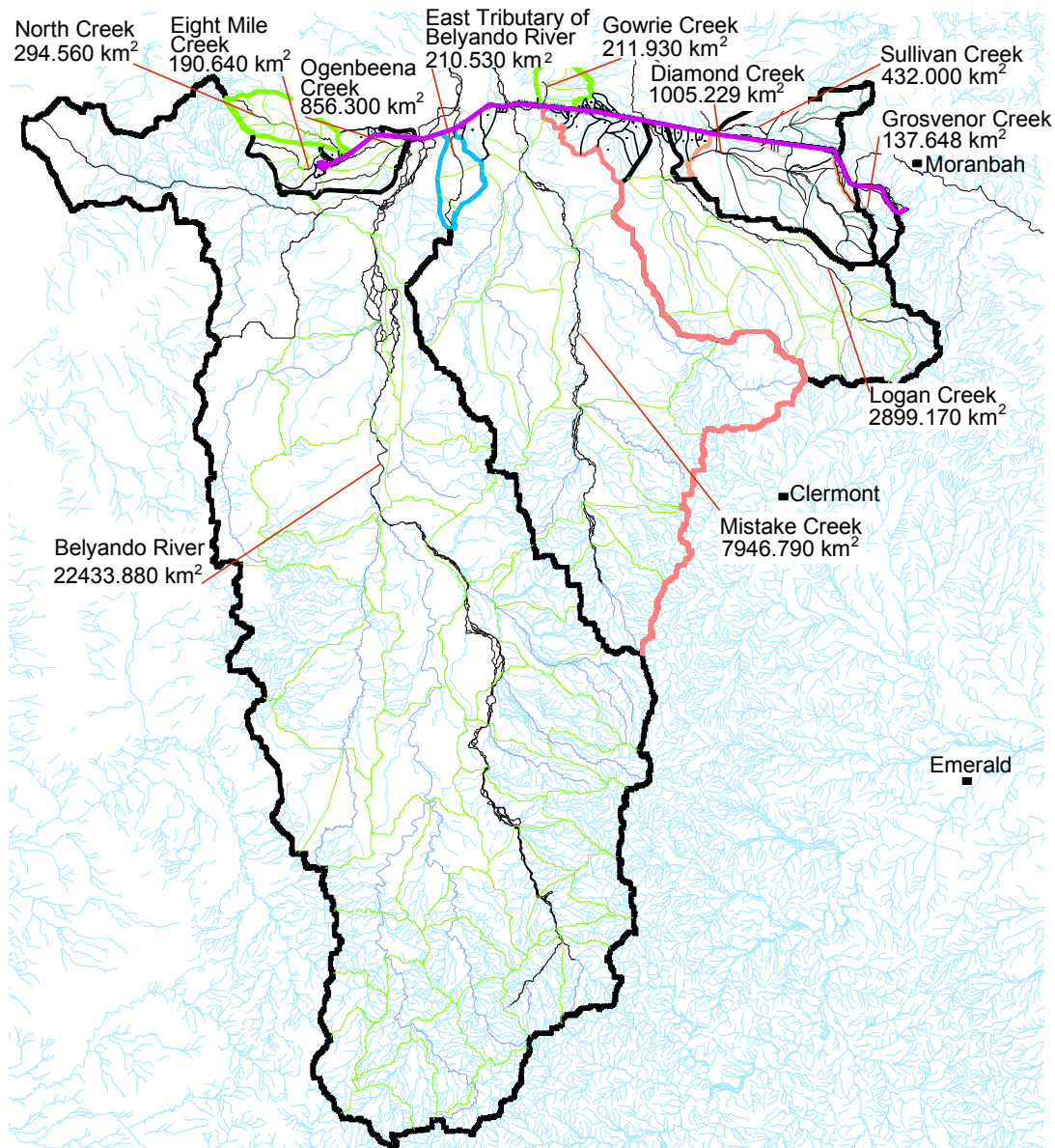


Figure 3.10 Major catchments

3.5.7 Hydrological Analysis

For the purposes of hydrologic analysis, catchments have been categorised as below:

- › Minor - catchment area less than 25 km²
- › Mid - catchment area between 25 km² to 100 km²
- › Major - catchment area greater than 100 km².

The Rational method as per the Queensland Urban Drainage Manual (QUDM) has been used for minor catchments of less than 25 km². For catchment areas greater than 25 km², XP-RAFTS rainfall-runoff modelling software has been used to estimate design flows. A full summary of the hydrology undertaken for the Project can be found in the Drainage Design Report in Appendix B.

A total of 53 waterway crossings have been identified in SP1 and 57 waterway crossings have been identified in SP2. A summary of identified watercourse crossing numbers is given in Table 3.5.

Table 3.5 Summary of Waterway Crossings

Catchment Type	Number of Waterways
Minor	81
Mid	3
Major	26*

*Major catchments may include multiple stream paths
Numbers exclude small waterways with catchments less than 25 km²

3.5.8 Hydraulics

A guide for the selection of structures for each waterway is shown in Table 3.6. It should be noted that Major Floodplain Structures are composed of Major Bridge Structures and Major Drainage Structures (culverts) and subject to their respective design criteria as outlined below. Each Major Bridge Structure was assessed on a case-by-case basis to assess the most appropriate structure type at each location.

Table 3.6 Waterway Cross Drainage Structure Classification

Catchment Flow Characteristic	Cross Drainage Classification
Defined floodplains which are subject to EIS approval	Major Floodplain Structure
Design flow rate Q ₅₀ > 250 m ³ /s	Major Bridge Structure
Design flow rate Q ₅₀ > 50 m ³ /s	Major Drainage Structure
Design flow rate Q ₅₀ < 50 m ³ /s	Minor Drainage Structure

3.5.9 1D Hydraulic Modelling

1D hydraulic modelling was adopted for the watercourse crossings with well-defined channels and floodplains. Structures were sized to ensure afflux limits, headwater levels and outlet velocities remained within the Project Design Criteria. A total of 71 HEC-RAS models have been generated for the proposed rail alignment.

With the recommended waterway drainage structures along the proposed rail line, afflux levels adjacent to the railway predominantly meet the design criteria, with minor localised areas of inundation exceeding 0.5m. These areas are small in extent, localised to areas adjacent to the alignment and have no impact upon existing infrastructure.

3.5.10 2D Hydraulic Modelling

Based on site assessments, predicted flow regimes, requirements of the Coordinator General and previous study recommendations, 2D hydraulic modelling was adopted for the following major waterways:

- › North Creek
- › Ogenbeena Creek Upper, Ogenbeena Creek Lower, Belyando River and East tributary of Belyando
- › Mistake Creek and Gowrie Creek
- › Logan Creek
- › Diamond Creek
- › Grosvenor Creek.

In order to assess complex floodplain interactions, a full hydrodynamic 2D model for each system was generated using the software package XP-SWMM+XP2D. This software has the ability to model large grid scale features such as complex floodplains while also allowing sub grid-scale features such as culverts and bridges to be modelled with a greater degree of accuracy.

3.5.10.1 North Creek

There is a confluence of North Creek and Eight Mile Creek downstream of the proposed alignment. This confluence has been included in the 2D model. Further downstream from the North Creek model, Eight Mile Creek joins into Ogenbeena Creek and eventually into the Belyando River. Eight Mile and North Creeks have catchment areas of approximately 190 km² and 294 km² respectively. The terrain generally slopes from northwest to southeast.



Figure 3.11 North Creek - Downstream (looking south) (approximately 2 km south of proposed alignment at Ch 170.3 km)

With the recommended waterway drainage structures as shown in Table 3.7 along the proposed rail line, afflux levels adjacent to the railway predominantly meet the design criteria, with minor localised areas of inundation exceeding 0.5m (maximum of 0.7m). These areas are small in extent, localised to areas adjacent to the alignment and have no impact upon existing infrastructure.

Table 3.7 North Creek Proposed Cross Drainage Infrastructure

Chainage (km)	Waterway Name	Drainage Structure
167.482		15/ 1200 mm RCP
168.085		13/ 1200 mm RCP
168.758		20/ 1200 mm RCP
169.257		18/ 1200 mm RCP
170.458	North Creek	5 x 20m span bridge
171.593		40/ 1500 mm RCP

3.5.10.2 Belyando River

Belyando River is a major crossing, consisting of multiple branches. The channels are well defined but the floodplain flow is quite complex. The inundation extent is significant within the floodplain during high flow events.

Ogenbeena Creek, which is a tributary of Belyando River, flows from south to north and has a very shallow channel. Belyando River eventually joins the Suttor River downstream of the proposed railway line.



Figure 3.12 Ogenbeena Creek (lower) - Downstream (flood marks on trees, approximately 1.5m above bank)



Figure 3.13 Belyando (Middle Branch) - Downstream

Belyando River has a catchment area of approximately 22,433 km², Ogenbeena Creek (lower) has a catchment area of approximately 856 km² and the east tributary of the Belyando River has a catchment area of approximately 210 km².

With the recommended waterway drainage structures as in Table 3.8 along the proposed rail line, afflux levels adjacent to the railway predominantly meet the design criteria, with minor localised areas of inundation exceeding 0.5m. These areas are small in extent, localised to areas adjacent to the alignment and have no impact upon existing infrastructure.

Table 3.8 Belyando River Proposed Cross Drainage Infrastructure

Chainage (km)	Waterway Name	Drainage Structure
139.432		50/ 1500 mm RCP
139.736	East Tributary of Belyando River	5 x 20m span bridge
145.962	Belyando River	4 x 20m span bridge
149.063		4 x 20m span bridge
149.558		4 x 20m span bridge
150.648	Ogenbeena Creek (lower crossing)	4 x 20m span bridge
153.020	Ogenbeena Creek (upper crossing)	3 x 20m span bridge

3.5.10.3 Mistake Creek and Gowrie Creek

Mistake Creek and Gowrie Creek form a combined system which has been analysed as a single consolidated 2D model.

Mistake Creek comprises of multiple, well-defined channels and a complex floodplain interaction. Mistake Creek joins the Belyando River a significant distance downstream of the Mistake Creek 2D model. The terrain is very flat with significant low-land floodplains. Gowrie Creek has a catchment area of approximately 211 km² and Mistake Creek has catchment area of approximately 7946 km².



Figure 3.14 Mistake Creek Upstream of Crossing (Approx. 12 km south of Proposed Alignment at Ch 115 km)

With the recommended waterway drainage structures as shown in Table 3.9 along the proposed rail line, afflux levels adjacent to the railway predominantly meet the design criteria, with minor localised areas of inundation exceeding 0.5m. These areas are small in extent, localised to areas adjacent to the alignment and have no impact upon existing infrastructure.

Table 3.9 Mistake/Gowrie Creek Proposed Cross Drainage Infrastructure

Chainage (km)	Waterway Name	Drainage Structure
113.447	Gowrie Creek	4 x 20m span bridge
113.645		20/ 1200 mm RCP
114.310		30/ 1200 mm RCP
118.977		40/ 1200 mm RCP
119.323		10/ 1200 mm RCP
120.483		23/ 1200 mm RCP
120.732	Mistake Creek	5 x 20m span bridge
121.260		12/ 1500 mm RCP
121.415		5 x 20m span bridge
122.148		95/ 1200 mm RCP
122.623		30/ 1200 mm RCP
123.525		30/ 1200 mm RCP
124.292		34/ 1200 mm RCP

3.5.10.4 Logan Creek

Logan Creek's main channel is well defined and has a flat, wide floodplain. Logan Creek has a contributing catchment area of approximately 2899 km².



Figure 3.15 Logan Creek at Avon Downs

With the recommended waterway drainage structures as per Table 3.10 along the proposed rail line, afflux levels adjacent to the railway predominantly meet the design criteria, with minor localised areas of inundation exceeding 0.5m. These areas are small in extent, localised to areas adjacent to the alignment and have no impact upon existing infrastructure.

Table 3.10 Logan Creek Proposed Cross Drainage Infrastructure

Chainage (km)	Waterway Name	Drainage Structure
82.088		18/ 1200 mm RCP
82.712	Logan Creek	7 x 20m span bridge
83.758		80/ 1500 mm by RCP
84.560		40/ 900 mm RCP
86.122		3 x 20m span bridge
86.307		10/ 900 mm RCP
86.810		15/ 1200 mm RCP
87.701		52/ 1200 mm RCP

3.5.10.5 Diamond Creek

Diamond Creek main channel has a long, wide floodplain which it shares with Diamond Creek Tributary. The Creek has a contributing catchment area of approximately 944 km². There is a confluence of Diamond Creek and a tributary downstream of the proposed alignment. The terrain generally slopes from southeast to northwest.



Figure 3.16 Diamond Creek 1 at Kilcummin-Diamond Downs Road (approximately 3 km, south of proposed alignment at Ch 62.6 km)

With the recommended waterway drainage structures as per Table 3.11 along the proposed rail line, afflux levels adjacent to the railway meet the design criteria.

Table 3.11 Diamond Creek Proposed Cross Drainage Infrastructure

Chainage (km)	Waterway Name	Drainage Structure
62.364		55/ 1500 mm RCP
63.200	Diamond Creek	5 x 20m span bridge
63.942		20/ 1500 mm RCP

3.5.10.6 Grosvenor Creek

Grosvenor Creek has a catchment area of approximately 137 km² and flows from south to north. The channels for Grosvenor Creek are well defined and the floodplain flow is complex due to braided channels. The terrain is predominantly very flat with significant lowland floodplains.

The total required cross drainage infrastructure required for Grosvenor creek along the proposed alignment is shown below in Table 3.12. With the recommended waterway drainage structures along the proposed rail line, afflux levels adjacent to the railway meet the design criteria.

Table 3.12 Grosvenor Creek Proposed Cross Drainage Infrastructure

Chainage (km)	Waterway Name	Drainage Structure
17.550		18/ 1200 mm RCP
18.430	Grosvenor Creek	72/ 1500 mm RCP
18.660		19/ 1500 mm RCP

3.5.11 Longitudinal Drainage

Longitudinal drains along the rail line embankment have been proposed for both SP1 and SP2. Longitudinal drains have been designed to accommodate the calculated peak flows plus a freeboard of 0.1m.

Longitudinal drainage requirements along the rail line formation at cut and fill sections of the rail line are shown in the alignment plan and sections, including typical drainage channel details, on Drawing No. CARP12033-1000-DWG-Y-024 in Volume 4.

3.5.12 Drainage Diversions

Portions of the SP2 rail line alignment pass through cuttings. Stream diversions were required where cuttings go through existing minor watercourses. The diversions channel flow to a proposed cross drainage structure. Diversion drainage channels have been designed to convey flows to adjacent catchments. A summary of the required diversions are provided in Table 3.13.

Table 3.13 Proposed Diversion Drain Locations

Diverted Catchment Chainage (km)	Receiving Catchment Chainage (km)
2.670	3.870
3.550	3.870
4.100	3.870
5.680	7.100
8.132	8.680
8.150	8.680
8.950	8.680
42.030	43.920
42.450	43.920
42.710	43.920

The diversion channels have been designed to accommodate the calculated peak flows plus a freeboard of 0.1m. Diversion drainage requirements along the rail line formation at the cut sections are shown in alignment plan and sections with typical drainage channel details are on Drawing No. CARP12033-1000-DWG-Y-024 in Volume 4.

3.5.13 Scour Protection

Design of scour protection at the bridge abutments, for the local scour at the pier locations and embankment protection adjacent to bridges and culvert inlet and outlets has been based on the guidelines provided within the Austroads (1994) Waterway Design Manual. Embankment scour protection has been provided for locations adjacent to bridges and culvert headwalls. Scour protection has been specified as dumped rip-rap around piers and culvert inlets and outlets, and rock armouring of embankments where required.

Scour protection measures proposed near the bridge structures, at bridge pier locations and downstream of culverts to be adopted are shown on Drawing No. CARP12033-DWG-S-040 in Volume 4.

3.5.14 Assumptions and Limitations

The following assumptions and limitations are relevant to the works completed to date:

- › Sensitivity Testing has not been completed on the hydrologic and hydraulic input parameters used. Parameters have been selected based on best practice guidelines and site observations.
- › Calibration of hydrologic or hydraulic modelling was limited due to lack of available historic data.
- › Additional impact of climate change predictions have not been incorporated into the proposed design.
- › LiDAR survey data extents for both 1D and 2D models have resulted in some modelling limitations (as described in the Drainage Design Report). As such, the accuracy of some of the modelling was limited by the extents of the LiDAR survey.
- › Inundation durations have not been confirmed at the time of this study.

3.5.15 Summary and Recommendations

Detailed hydrologic and hydraulic modelling has been completed for the floodplains and all watercourses that are crossed by the proposed Carmichael Rail Alignment based on the design and available data. A full description of results and proposed infrastructure for the Project can be found in the Drainage Design Report in Appendix B.

With the recommended waterway drainage structures, afflux levels adjacent to the proposed railway generally meet the design criteria, with minor localised areas of inundation exceeding 0.5m; these areas are limited in extent, localised to areas adjacent to the alignment and have minimal impact upon existing infrastructure and velocities. Afflux and velocity results for the post-development case meet the nominated Project Design Criteria requirements at most of the critical locations.

The total amount of cross drainage infrastructure required to meet the Project Design Criteria are provided in Table 3.14 and Table 3.15.

Table 3.14 Culvert Summary (SP1 and SP2)

Culvert	Number of barrels
900 mm RCP	449
1200 mm RCP	1677
1500 mm RCP	245
1500 x 900 mm RCBC	6
2400 x 1500 mm RCBC	4

Table 3.15 Waterway Bridge Summary (SP1 and SP2)

Bridge span length	20.2m
Number of spans	66
Total bridge length	1333.2m

The 2000 year ARI event was modelled to extract peak water surface levels and velocities for the limit state loading structural bridge design.

The current study recommendations will be refined when further hydrologic and hydraulic analysis is undertaken during the detailed design phase of the Project.

It is recommended that the following works be undertaken during the detailed design, including:

- › Sensitivity analysis of input parameters for the detailed design case
- › Further calibration of the models
- › Analysis of the impacts of climate change predictions
- › Drainage structures should be further optimised
- › Additional LiDAR capture is recommended to provide more accurate inputs for the modelling.