Chapter 16

Hydrology and Hydraulics

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Figures

16. HYDROLOGY AND HYDRAULICS

16.1 Introduction

This chapter:

- presents information on the hydrology of the project area and surrounding catchments and the impacts on the hydraulics (flood extents, depths and velocities) of the project area catchments from project activities
- assesses the impacts of the project on the hydraulics (flood extents, depths and velocities) in the vicinity of project activities and surrounding infrastructure
- determines flood protection levees for representative project development stages to provide an appropriate level of mine flood immunity
- determines the need for, and impact of, diversions on flooding and channel stability.

Information in this chapter is based on the technical report "Hydrology and Hydraulics" provided in **Appendix 17** and Mine Water Management Strategy provided in **Appendix 11.**

16.2 Methodology

The methodology used to assess the hydrology of the project's catchments and impacts of project activities on hydraulics included the following tasks:

- review of relevant reports and investigations including collation and critical assessment of previous relevant reports and investigations undertaken in the vicinity of the Project area over the last 10 years
- data collection and review including hydro-meteorological data, survey data, flooding data and cadastral information
- hydrologic investigation:
  - estimation of peak discharges in the waterways in the vicinity of the project
  - consideration of available methods (e.g. flood frequency analysis and rainfall-runoff hydrologic modelling) to obtain an estimate of design floods
  - assessment of a range of design storms including: 100 and 1,000 year ARI flood events, including Probable Maximum Flood (PMF).
- river hydraulic modelling:
  - development of a hydraulic model for Suttor River using SOBEK software and hydraulic models of its unnamed tributaries in the project area using HEC-RAS software. The SOBEK model was specifically written for the analysis of complex flow patterns in broad river floodplains and is well suited to the requirements of this study.
- surface water impact assessment:
  - design floods developed from the hydrological investigation were simulated in the hydraulic models to compare pre- and post- development stages. The output from this modelling work was used to assess surface water impacts including impacts on flood levels and flow velocities.
- levee investigations:

- review of the need for levees based on an assessment of the risk of overtopping and the flood heights obtained from the hydraulic model.

- diversions:
  - assessment of the need for, and impact of, diversions on channel geomorphology and stability.

16.3 Study Area and Catchments

The catchments in which the project area is located are described and illustrated in **Chapter 15**. The project is located in the headwaters of the Suttor River catchment which is a tributary of the Burdekin River. The Suttor River catchment covers an area of approximately 65,000 km^2 although the catchment area upstream of the proposed mine site is around 900 km^2 on the Suttor River and 750 km^2 on Suttor Creek.

Other waterways within the project area include two unnamed tributaries that drain west to the Suttor River. These tributaries are ephemeral and do not hold permanent water. There is also a natural palustrine wetland on the western side of the project area in the floodplain of the Suttor River, as described in **Chapter 15**.

The flood model covers all areas of the mine at risk from regional flooding of the Suttor River. Therefore it does not include the North Pit or South Pit 2. North Pit and associated waste rock dump are situated in the upper catchment of Kangaroo Creek at an elevation above any floodplain and the small gullies in these areas are not of sufficient size to warrant flood modelling. South Pit 2 and associated waste rock dump were determined from previous investigations for the GAP rail line to be beyond the extent of any flood flows from Suttor Creek (CoalConnect, 2009[1]).

16.4 Hydrology

16.4.1 Methodology

The methodology which was adopted for the hydrological analysis includes the following main components.

- produce a hydrologic rainfall-runoff model of the catchments affected by the project
- verify the model to known historical events, flood frequency analysis and/or previous study results if data are available
- simulate design rainfall for a range of probabilities up to the 1,000 year ARI event, including the Probable Maximum Precipitation (PMP) event
- adopt appropriate design flood hydrographs for input into the hydraulic model.

A description of the model (XP-RAFTS), catchment delineation and catchment roughness is provided in **Appendix 17**. The model was calibrated against historical flood events and/or previous flood peak estimates using the streamflow gauge records at the Eaglefield Gauge Station (DNRM Gauge No. 120304A) on the Suttor River and daily rainfall data and pluviographic data from the Bureau of Meteorology (BOM) for the March 1988, February 2008 and March 2012 flood events. Model parameters for runoff routing and rainfall losses are described in **Appendix 17**.

The simulated flood hydrograph from the model was compared with the recorded discharge at Eaglefield river gauge station on the Suttor River. The calibrated model correlates suitably with the peak

[1] CoalConnect (2009), Gap50 Design Report, Brisbane, Queensland

flows at Eaglefield and is therefore considered suitable for interpretive use in the project flooding assessment.

16.4.2 Design Rainfall Events

The 100 and 1,000 year annual recurrence intervals (ARIs) rainfall design events together with the Probable Maximum Precipitation (PMP) were derived. The derivation of the design rainfall intensities is provided in **Appendix 17**. **Table 16-1** provides the rainfall intensities for the Suttor River catchment based on the method adopted. Sensitivity analysis was carried out to represent the estimated impacts of future climate change by increasing peak rainfall intensities increased by 20% (refer **Chapter 12**).

Table 16-1 Design Rainfall Intensities for Suttor River Catchment

Duration (hours)	Intensity (mm/hr)		
	100 year	100 year with climate change	1,000 year
3.0	37.43	44.92	55.59
6.0	23.14	27.77	34.37
12	14.34	17.21	21.30
18	11.20	13.44	16.64
24	9.38	11.25	13.93
48	6.23	7.48	9.01
72	4.69	5.63	6.84

The PMP event estimates are based on procedures developed by the BOM. PMP is defined by the World Meteorological Organization (1986) as 'the greatest depth of precipitation for a given duration meteorologically possible for a given size storm area at a particular location at a particular time of year'. The methodology used to predict PMP is provided in **Appendix 17**.

The final PMP estimates for Suttor River catchment area are summarised in **Table 16-2**. These are point estimates and apply for catchment areas up to 150,000 km^2, which is appropriate for the catchment area being assessed.

Table 16-2 Estimate of PMP Rainfall

Storm duration (hours)	PMP Estimate	
	Depth (mm)	Intensity (mm/hr)
24	970	40.42
36	1,140	31.67
48	1,310	27.29
72	1,610	22.36

16.4.3 Flood Frequency Analysis

Peak discharge data at the Eaglefield Gauge Station (refer **Chapter 15**) on the Suttor River has been collected and includes a 46 year recording period from 1967 to 2012. Flood frequency analysis was carried out using the streamflow records to validate the RAFTS model predictions for different design events. This verification has been conducted to confirm that the adopted model parameters are consistent with the regional catchment response to rainfall.

The 24 hour design storm was found to be critical for the Suttor River catchment at Eaglefield gauge location and **Table 16-3** provides the comparison of the model prediction against the flood frequency analysis.

Table 16-3 Model Comparison Against the Flood Frequency Analysis

ARI (years)	Peak discharge (m^3/s)	
	XP-RAFTS model	Flood frequency analysis
100	2072	2091
200	2461	2446

The table shows that the model parameters from the calibrated model produce design event discharges very similar to the flood frequency analysis. The agreement between flood peaks of the model and the regional flood frequency analysis allows greater confidence to be placed in the calibrated hydrologic model.

16.4.4 Design Discharges

The design flood peaks from model have been estimated and a summary of the results at relevant sites in the project area are shown in **Table 16-4**.

Table 16-4 Summary of Design Flood Peaks for Suttor River

Watercourse	Location	Flood peak (m^3/s)		
		100 yr ARI	1,000 yr ARI	PMF
Suttor River	Upstream boundary of model	856	1,425	4,950
Rockingham Creek	Western tributary of Suttor River upstream of project	515	875	2,502
Northern upper tributary	Upper tributary of Suttor River that intersects West Pit 1 upstream of GAP rail crossing	73	131	408
Southern upper tributary	Upper tributary of Suttor River that intersects South Pit 1 upstream of GAP rail crossing	136	238	727

16.4.5 Regional Council Flood Studies

The Mackay Isaac Whitsunday Regional Plan (MIWRP) references statewide floodplain mapping (http://www.qldreconstruction.org.au/maps/floodplain-areas) that has been completed for all relevant sub-basins across Queensland. The MIWRP states that "this mapping provides a high-level extent of potentially floodable land within the region which may provide sufficient flood information for the majority of the sub-basin. More detailed local flood investigations around and within key settlements should be carried out to adopt a flood event that can satisfy the requirements of State Planning Policy 1/03."

Figure 16-1 provides a map of the statewide floodplain assessment in the vicinity of the project area. As recommended in the MIWRP, a detailed local flood investigation has been conducted for tor the purposes of this EIS and the modelling and model results are described in this chapter. **Figure 16-1** shows that the potential floodplains of the Suttor River, Suttor Creek and Kangaroo Creek. There are no project activities planned within the Suttor Creek or Kangaroo Creek floodplain (other than linear infrastructure crossing Kangaroo Creek in the central infrastructure corridor) and hence site specific flood modelling has not been conducted. There are project activities planned within the potential Suttor River floodplain and this chapter describes the local, site specific floodplain modelling for the Suttor River.

16.5 Flood Modelling

16.5.1 Suttor River

The project has the potential to cause changes to flood extents, depths and velocities. Flood models were established to predict the:

- impact of mine pits and waste rock dumps on surrounding property and infrastructure
- proximity of floodwaters to waste rock dumps and residual voids.

The 100 year ARI, 1,000 year ARI and PMF design flood events were assessed.

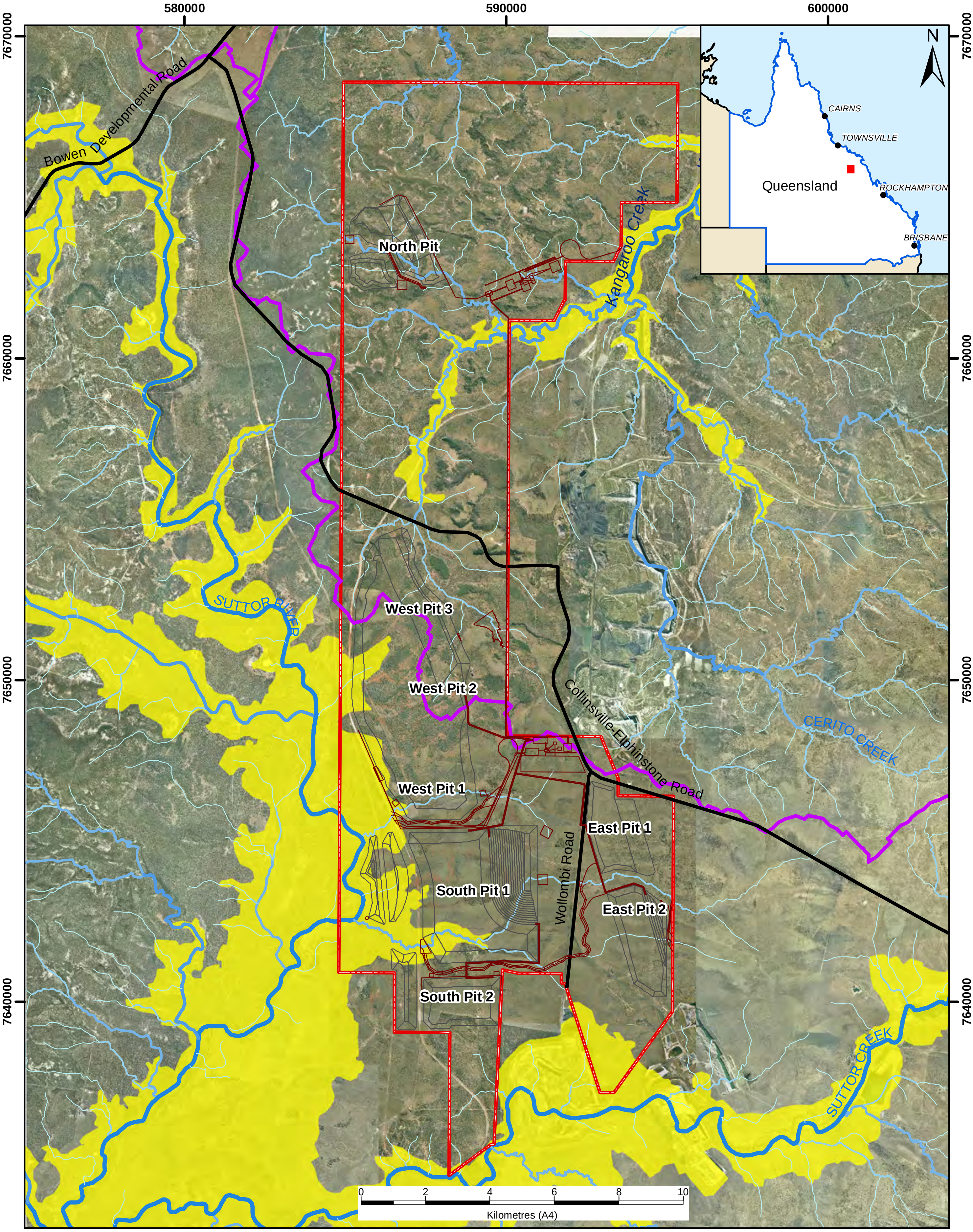
Elevation data used in this study was in the form of 1 m contours which were converted into a 15 m digital elevation model (DEM) for the study area. The GAP railway alignment was constructed after the elevation data was captured for the study area. The vertical alignment of the railway embankment was obtained and included in the DEM. Model parameters for roughness and model boundary conditions are described in **Appendix 17**.

Figure 16-2 shows the extent of the hydraulic model established for the Suttor River. The model extent has been optimised to include all floodplain area within the PMF extent.

There are a small number of structures within the model extent and all of them relate to the GAP rail line. **Table 16-5** presents the list of structures and their details.

Table 16-5 Summary of GAP Rail Hydraulic Structures

ID	Type	Details	Invert level (upstream) (mAHD)	Length (m)
1	Bridge	2 x 20 m spans		
2	Bridge	2 x 20 m spans		
3	Culvert	4 x 0.9 RCP	292.0	14.7
4	Culvert	1 x 0.9 RCP	293.0	17.6
5	Culvert	4 x 0.9 RCP	289.4	24.6
6	Culvert	6 x 0.9 RCP	290.3	24.6
7	Culvert	1 x 2.5 x 2.5 m RCBC	290.8	29.7
8	Culvert	1 x 0.45 RCP	292.8	22.2



Legend

- Project Area
- Waste Rock Dumps and Pits
- Mine Infrastructure
- Sub-catchment divide
- Formed Roads

Drainage (Stream Order)

1 2 3 4 5

Queensland Interim Floodplain Assessment Overlay

Queensland Interim Floodplain Assessment	
Figure 16-1	**Byerwen Coal Project**
Date: *4/02/2013*	**Author:** samuel.ferguson
	Map Scale: 1:154,368
Revision: R1	**Coordinate System:** GDA 1994 MGA Zone 55

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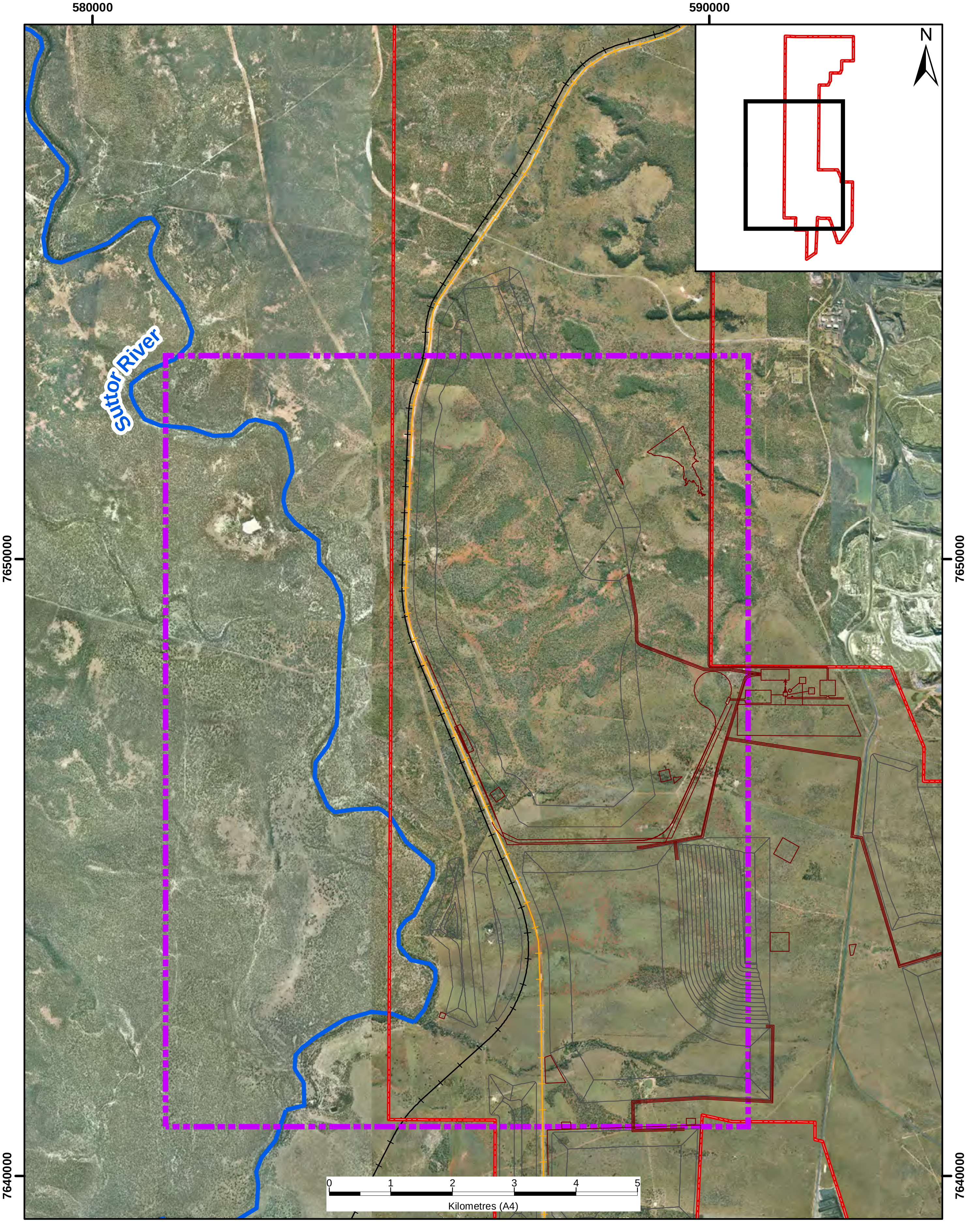

Legend

- Project Area
- Flood Model Extent
- Waste Rock Dumps and Pits
- Mine Infrastructure
- Alpha Coal Project Rail Line
- GAP Rail Line

Flood Model Extent	
Figure 16-2	Byerwen Coal Project
Date: 4/02/2013	Author: samuel.ferguson Map Scale: 1:80,000
Revision: R1	Coordinate System: GDA 1994 MGA Zone 55
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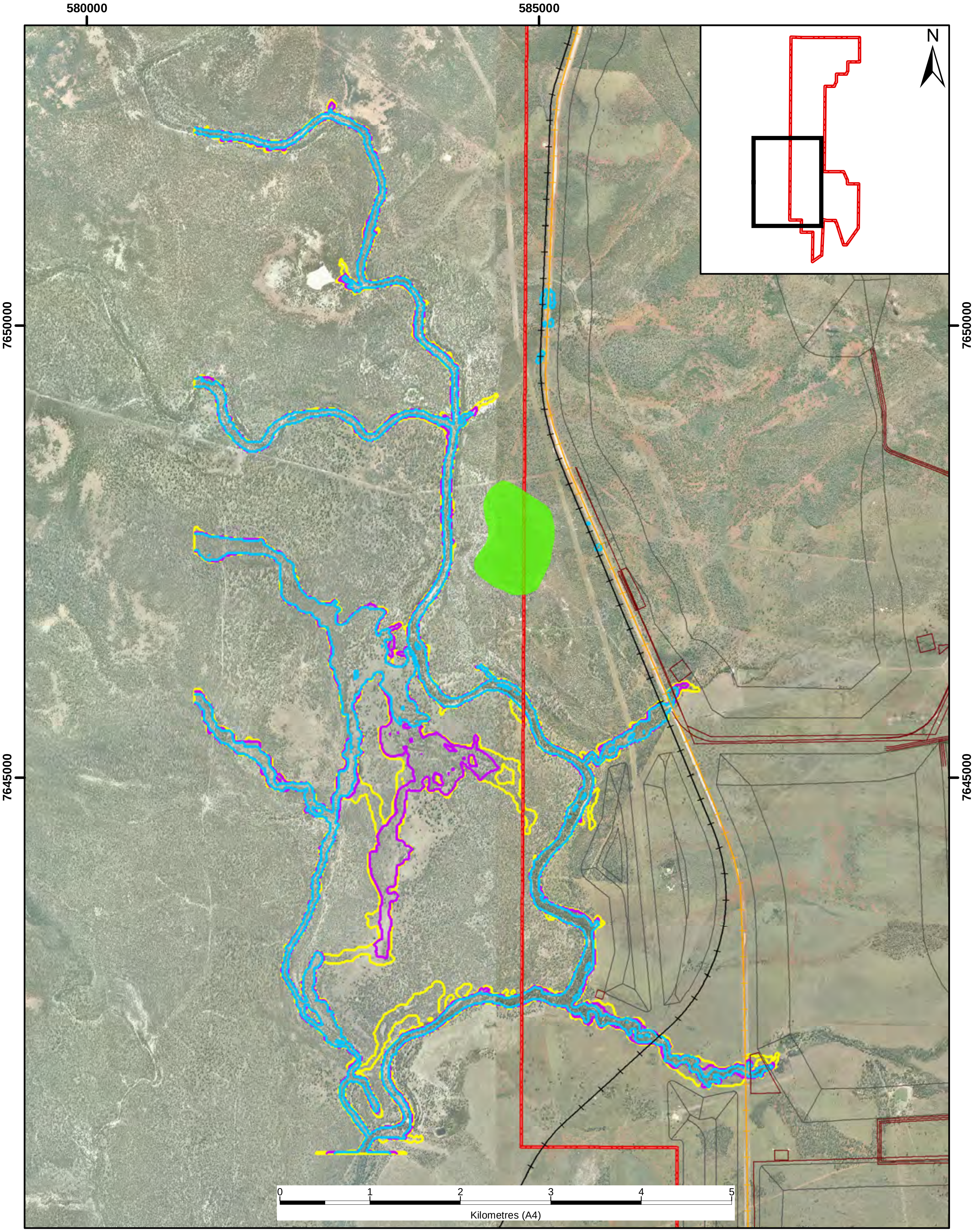
16.5.2 Palustrine Wetland

A small palustrine wetland is located near the western mining lease boundary of the site. This wetland has a catchment area of 4.2 km^2 contained within the project area.

Figure 16-3 presents the pre-development inundation extents for the 1, 2 and 5 year ARI flood events. The figure shows that the palustrine wetland located to the west of the operational areas of the site is not inundated during these more frequent flood events. This indicates that flooding from the Suttor River is not the main source of water for the wetland.

The GAP rail embankment and associated culverts are located between the wetland the project operational areas.

Potential impacts to the hydrology of the wetland are described in **Section 16.7.4**.



Legend

- Project Area
- Waste Rock Dumps and Pits
- Mine Infrastructure
- Alpha Coal Project Rail Line
- GAP Rail Line
- Palustrine Wetland
- Year 1 Flood Extent
- Year 2 Flood Extent
- Year 5 Flood Extent

Pre-development Wetland Flood Inundation for 1, 2 and 5 Year ARI Events

Figure 16-3

Byerwen Coal Project

Date: *4/02/2013*

Author: samuel.ferguson

Map Scale: 1:55,000

Revision: R1

Coordinate System: GDA 1994 MGA Zone 55

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16.5.3 Pre-development Flood Modelling

The Suttor River hydraulic model depth and velocity results for the ‘pre-development’ conditions are shown in:

- **Figure 16-4** and **Figure 16-5** for the 100 year ARI flood event
- **Figure 16-6** and **Figure 16-7** for the 1,000 year ARI flood event
- **Figure 16-8** and **Figure 16-9** for the PMF flood event.

The flow capacity of the main Suttor River channel is exceeded in all three storm events modelled with flow entering the floodplain.

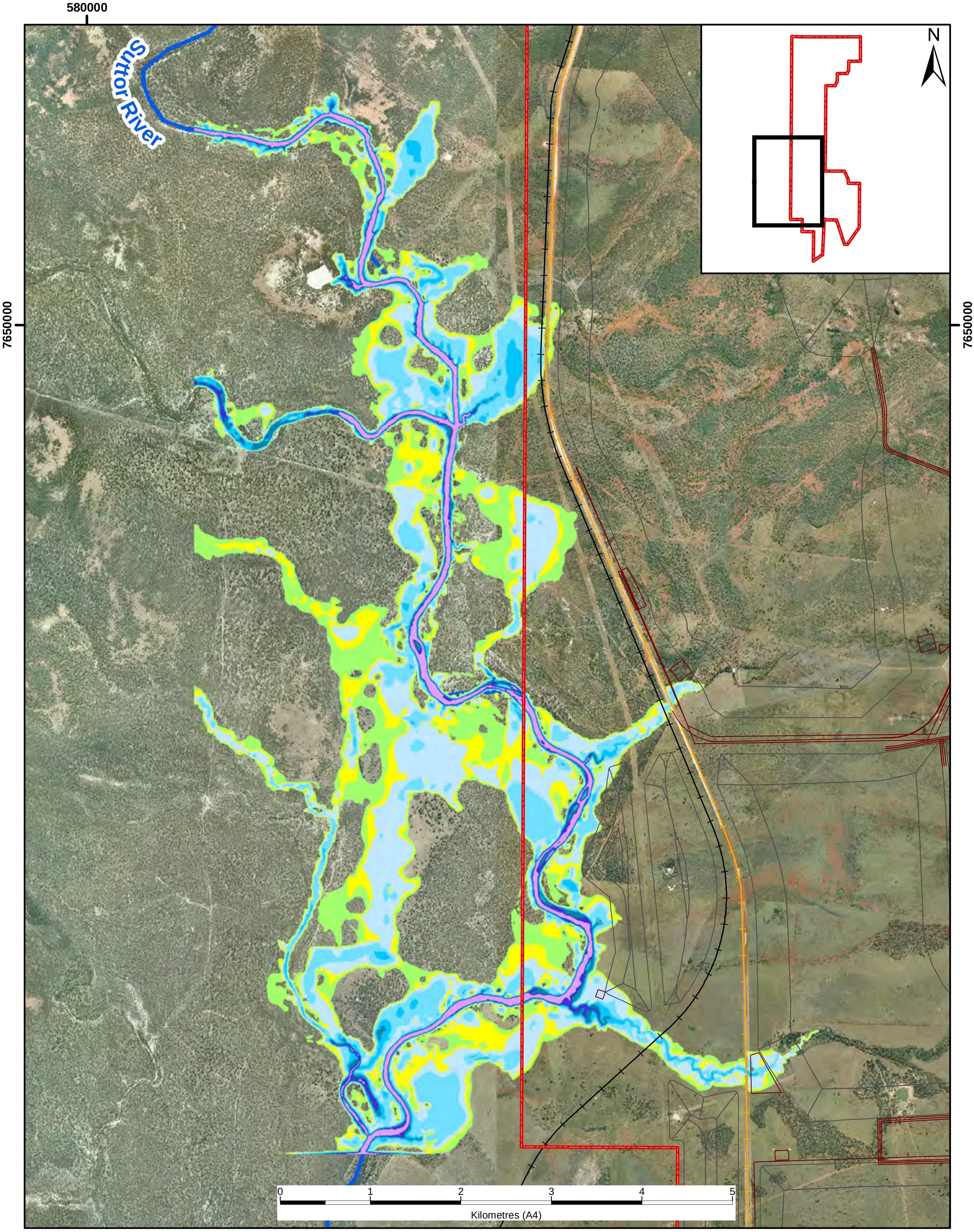
16.5.4 Post-development Flood Modelling

This section discusses changes to flood extents, water levels (afflux) and areas of inundation relative to the location of the project’s mining pits and waste rock dumps.

The post-development flood depths and velocities are shown in:

- **Figure 16-10** and **Figure 16-11** for the 100 year ARI flood event
- **Figure 16-12** and **Figure 16-13** for the 1,000 year ARI flood event
- **Figure 16-14** and **Figure 16-15** for the PMF flood event.

Modelling shows that there is no significant change in the flood extents for the post-development scenario compared to the pre-development scenario, except in the PMF event where the waste rock dumps partially block some of the floodplain flow. In the 1,000 year ARI flood event flood waters reach the waste rock dumps associated with the west pits complex and out of pit waste rock dumps associated with South Pit 1 and South Pit 2. Velocities adjacent to the waste rock dumps are in the order of 0.5 to 2.0 m/s. Modelling results indicate that regional PMF flood events from the Suttor River will not reach the final voids of South Pit 1, West Pit 3, East Pit 2 or North Pit.



Legend

- Project Area
- GAP Rail Line
- Alpha Coal Project Rail Line
- Mine Infrastructure
- Waste Rock Dumps and Pits

Maximum Flood Depth (m)

- < 0.05 Not Shown
- 0.05 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- 3.0 - 4.0
- 4.0 - 5.0
- > 5.0

Pre-development 100 Year ARI Flood Depths

Figure 16-4

Byerwen Coal Project

Date: *4/02/2013*

Author: samuel.ferguson

Map Scale: 1:55,000

Revision: R1

Coordinate System: GDA 1994 MGA Zone 55

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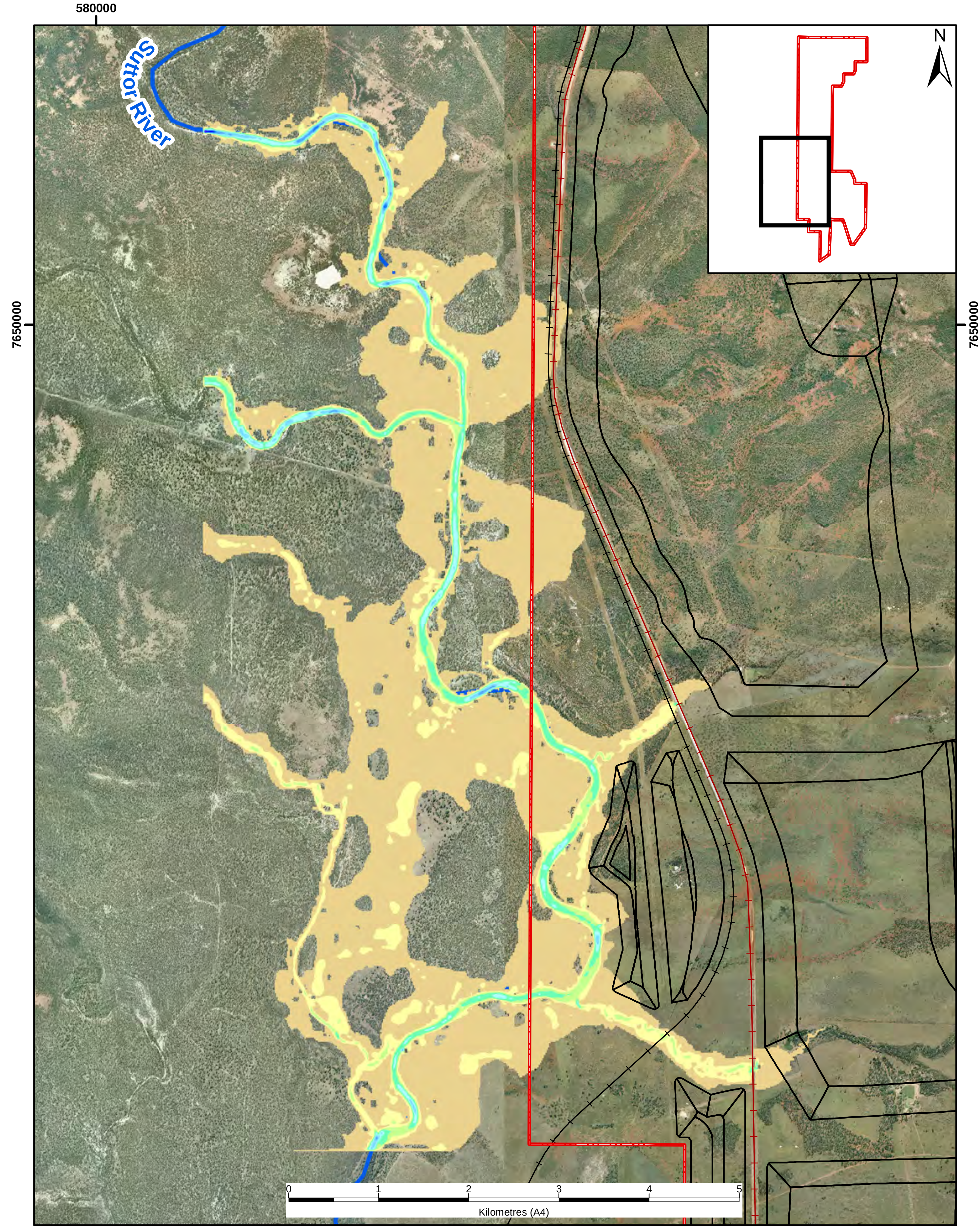

Legend

Project Area	
GAP Rail Line	
Alpha Coal Project Rail Line	
Suttor River	
End of Life Mine Layout	

Flood Velocity (m/s)

0 - 0.5	2.5 - 3
0.5 - 1	3 - 3.5
1.0 - 1.5	3.5 - 4
1.5 - 2	4 - 4.5
2.0 - 2.5	4.5 - 5

Pre-development 100 Year ARI Flood Velocities

Figure 16-5

Byerwen Coal Project

Date: *31/01/2013*

Author: emma.lewis

Map Scale: 1:55,000

Revision: R1

Coordinate System: GDA 1994 MGA Zone 55

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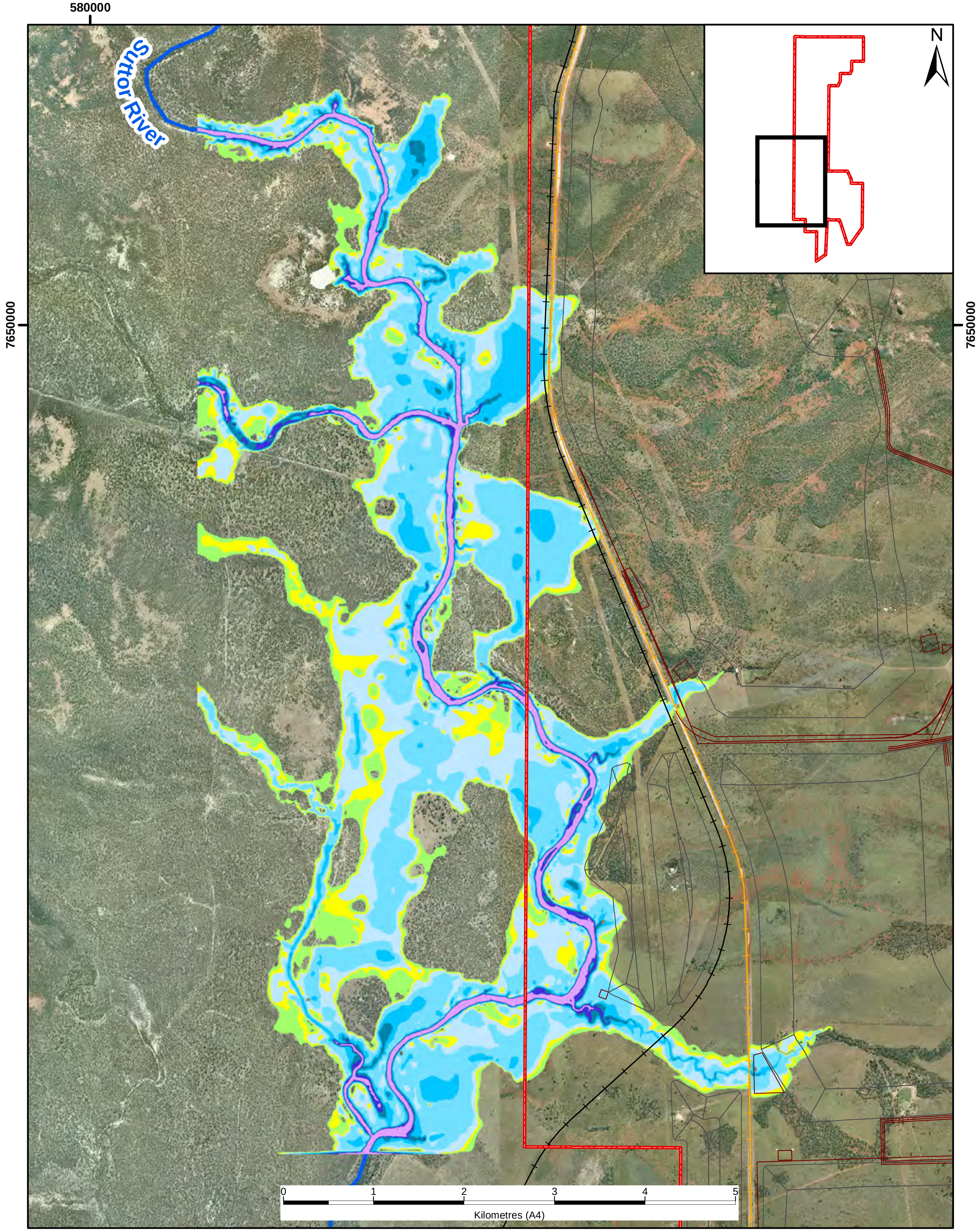

Legend

- Project Area
- Waste Rock Dumps and Pits
- Mine Infrastructure
- Alpha Coal Project Rail Line
- GAP Rail Line

Maximum Flood Depth (m)

- < 0.05 Not Shown
- 0.05 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- 3.0 - 4.0
- 4.0 - 5.0
- > 5.0

Pre-development 1,000 Year ARI Flood Depths

Figure 16-6 **Byerwen Coal Project**

Date: *4/02/2013*

Author: samuel.ferguson

Map Scale: 1:55,000

Revision: R1

Coordinate System: GDA 1994 MGA Zone 55

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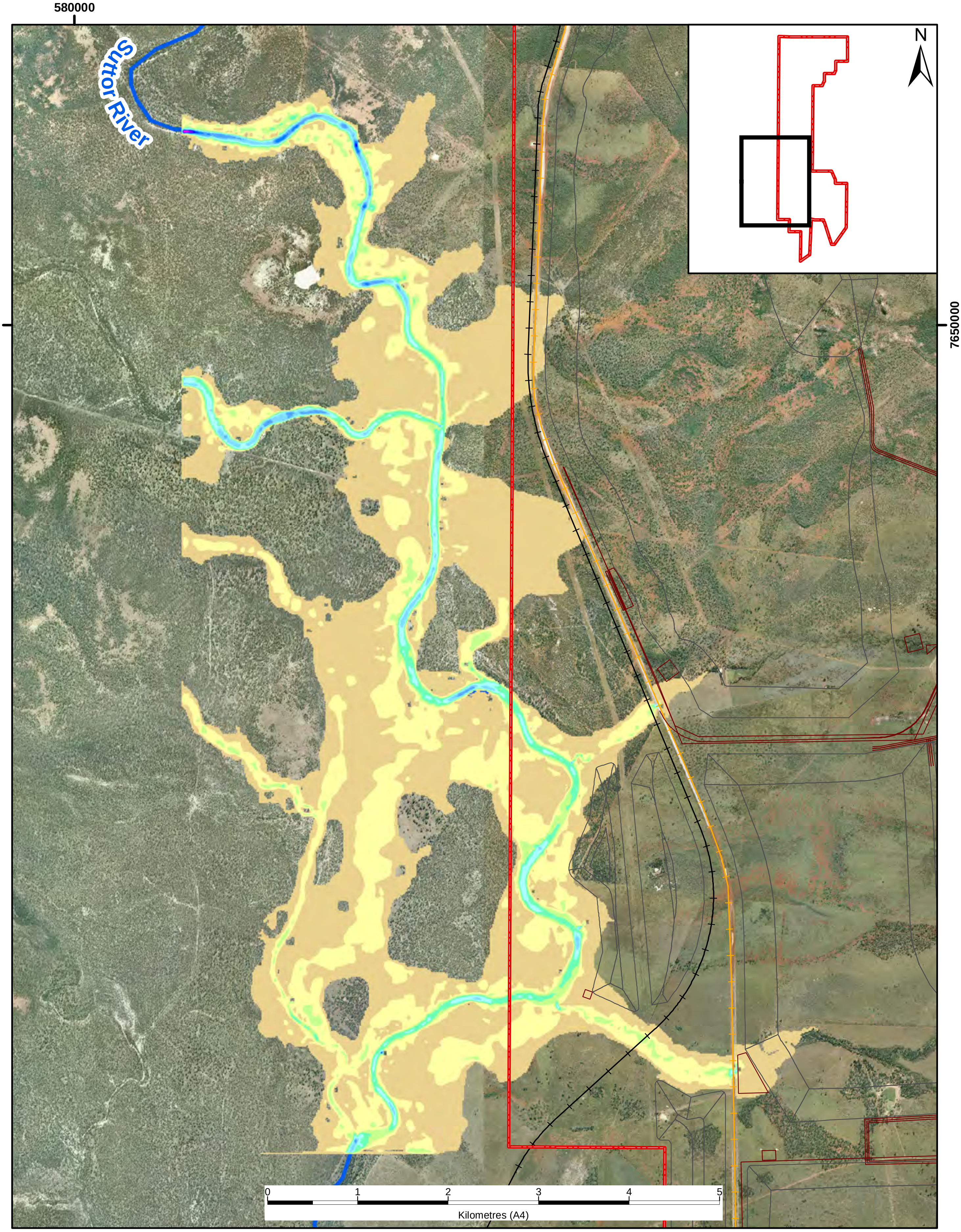

Legend

- Project Area
- Waste Rock Dumps and Pits
- Mine Infrastructure
- Alpha Coal Project Rail Line
- GAP Rail Line

Flood Velocity (m/s)

0 - 0.5	2.0 - 2.5	4 - 4.5
0.5 - 1	2.5 - 3	4.5 - 5
1.0 - 1.5	3 - 3.5	Greater than 5
1.5 - 2	3.5 - 4	

Pre-development 1,000 Year ARI Flood Velocities	QCOAL GROUP
Figure 16-7	Byerwen Coal Project
Date: *4/02/2013*	**Author:** samuel.ferguson
	Map Scale: 1:55,000
Revision: R1	**Coordinate System:** GDA 1994 MGA Zone 55

environmental and licensing professionals pty ltd

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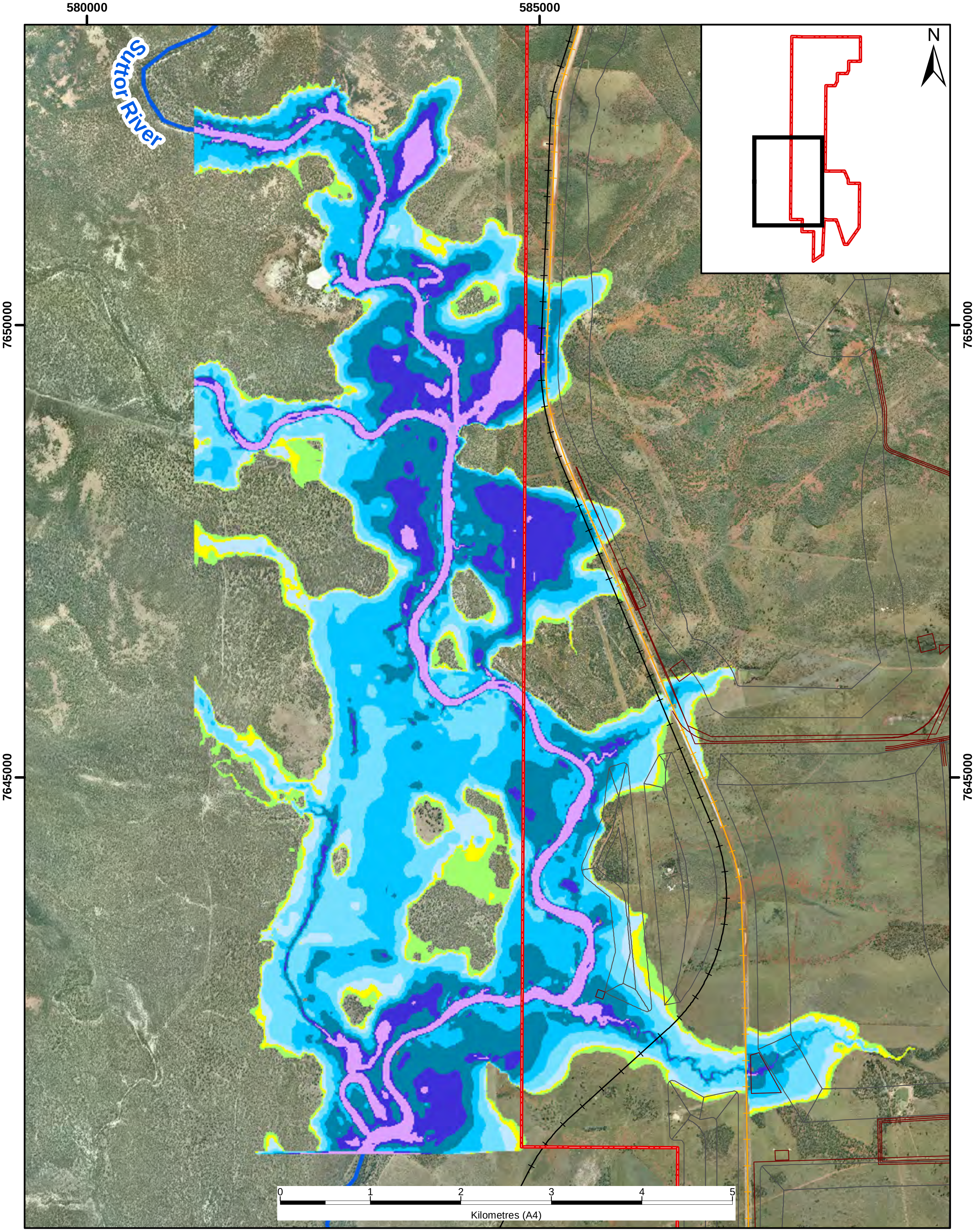

Legend

- Project Area
- Waste Rock Dumps and Pits
- Mine Infrastructure
- Alpha Coal Project Rail Line
- GAP Rail Line

Probable Maximum Flood Depth (m)

- < 0.05 Not Shown
- 0.05 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- 3.0 - 4.0
- 4.0 - 5.0
- > 5.0

Pre-development PMF Flood Depths	QCOAL GROUP
Figure 16-8 / **Byerwen Coal Project**	environmental and licensing professionals pty ltd
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Revision: R1 / **Coordinate System:** GDA 1994 MGA Zone 55	
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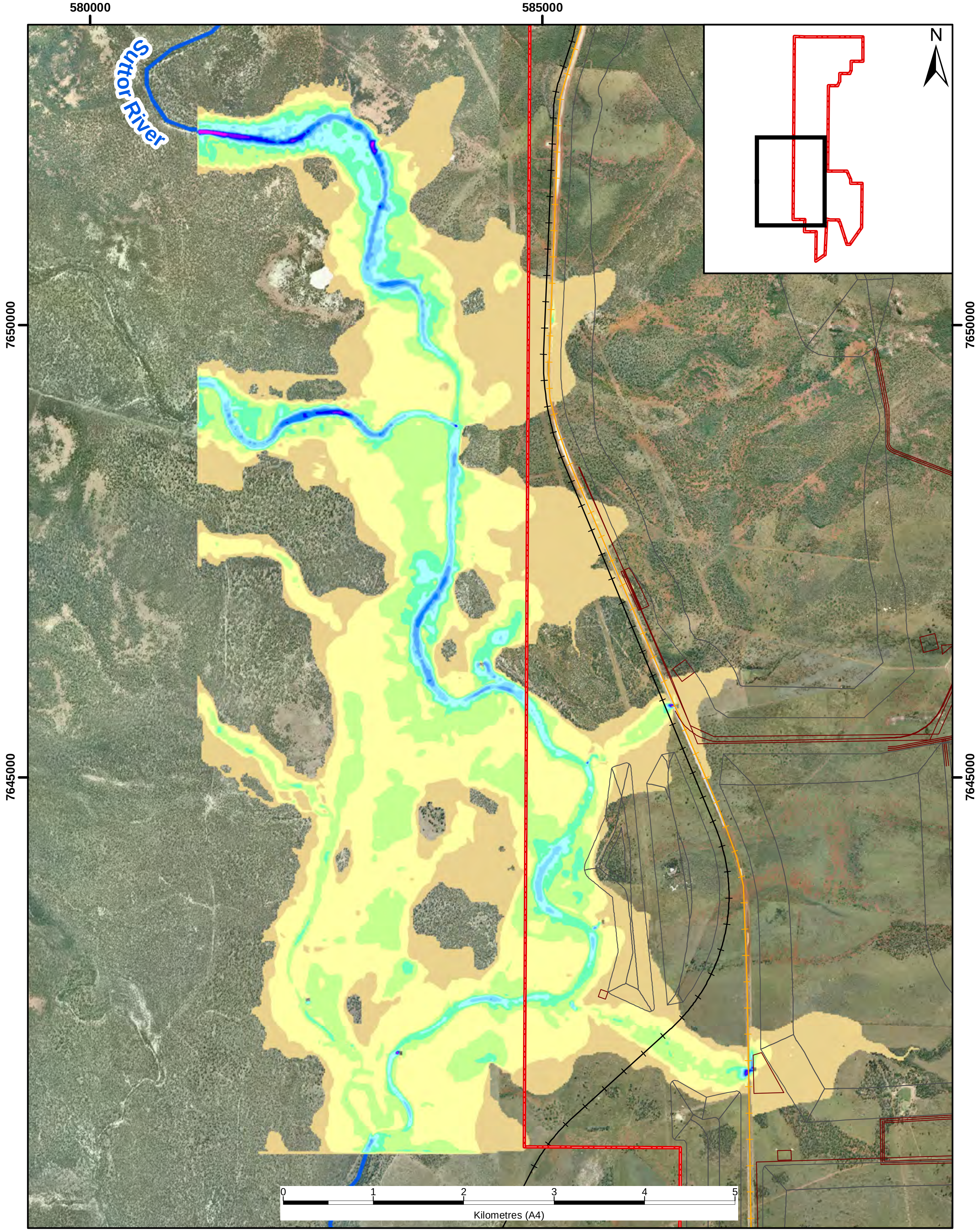

Legend

- Project Area
- Waste Rock Dumps and Pits
- Mine Infrastructure
- Alpha Coal Project Rail Line
- GAP Rail Line

Probable Maximum Flood Velocities (m/s)

0 - 0.5	2.0 - 2.5	4 - 4.5
0.5 - 1	2.5 - 3	4.5 - 5
1.0 - 1.5	3 - 3.5	Greater than 5
1.5 - 2	3.5 - 4	

Pre-development PMF Flood Velocities	QCOAL GROUP
Figure 16-9	**Byerwen Coal Project**
Date: *4/02/2013*	**Author:** samuel.ferguson **Map Scale:** 1:55,000
Revision: R1	**Coordinate System:** GDA 1994 MGA Zone 55

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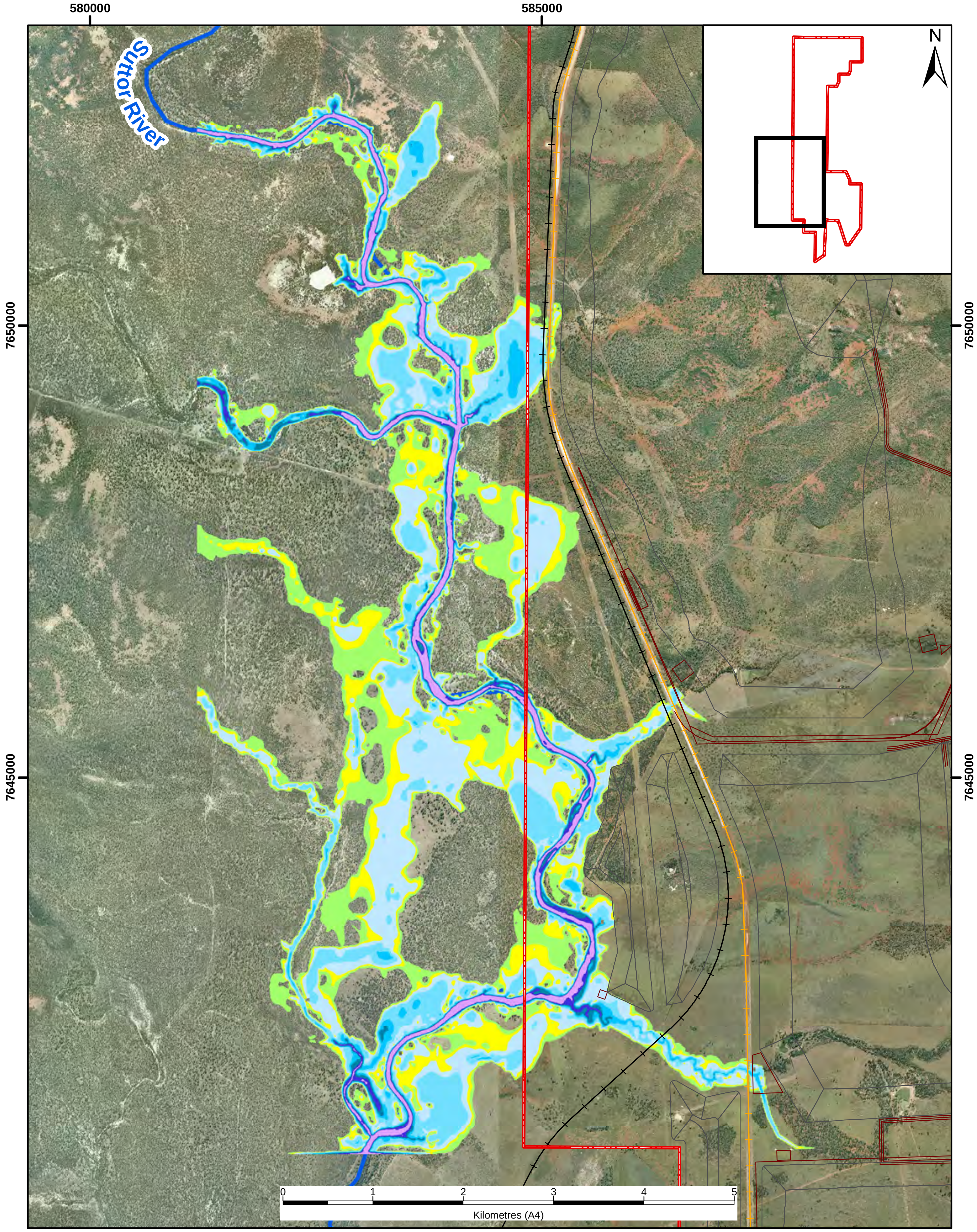

Legend

- Project Area
- Waste Rock Dumps and Pits
- Mine Infrastructure
- Alpha Coal Project Rail Line
- GAP Rail Line

Maximum Flood Depth (m)

- < 0.05 Not Shown
- 0.05 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- 3.0 - 4.0
- 4.0 - 5.0
- > 5.0

Post-development 100 Year ARI Flood Depths		QCOAL GROUP
Figure 16-10	Byerwen Coal Project	environmental and licensing professionals pty ltd
Date: 4/02/2013	Author: samuel.ferguson	
	Map Scale: 1:55,000	
Revision: R1	Coordinate System: GDA 1994 MGA Zone 55	

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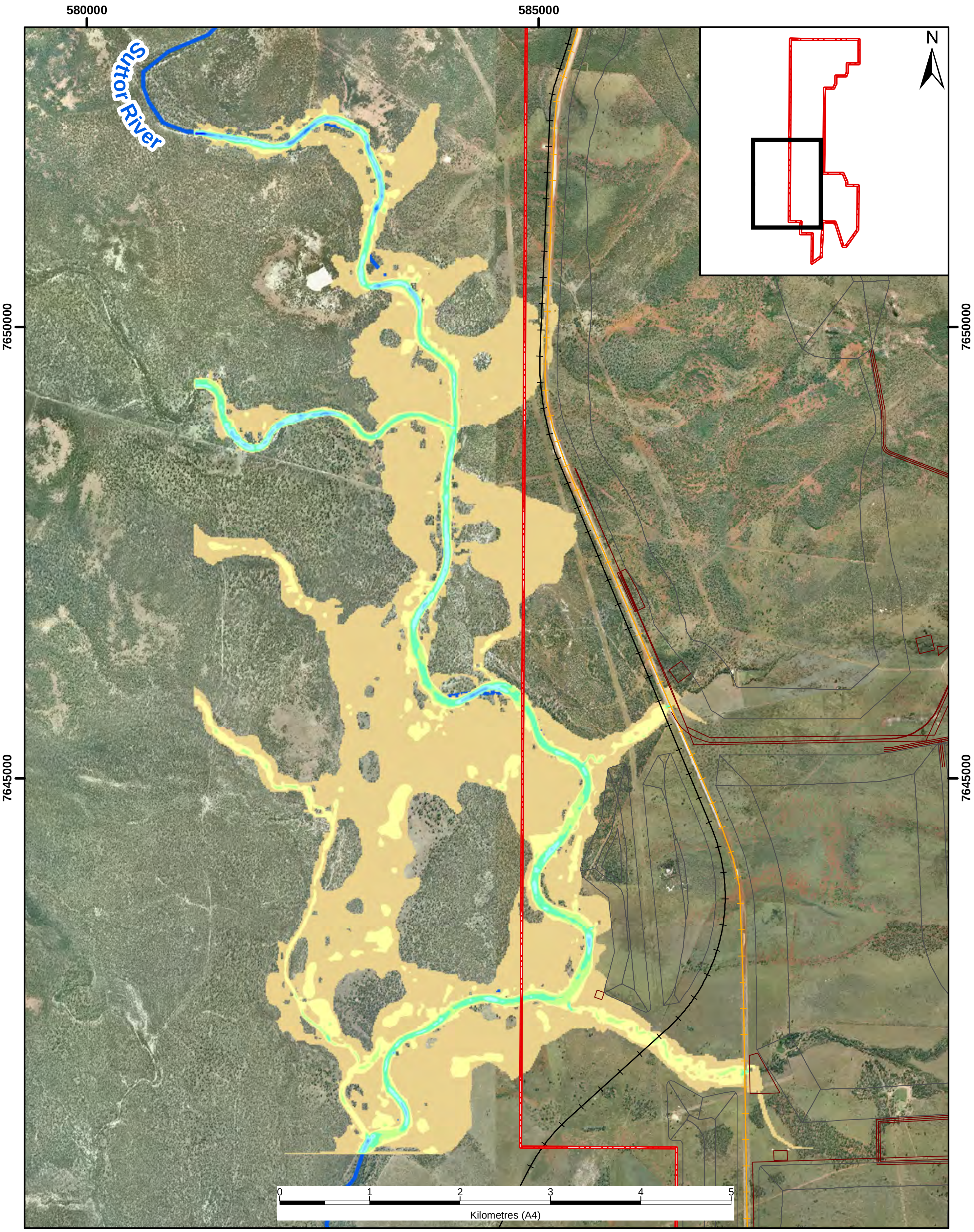

Legend

- Project Area
- Waste Rock Dumps and Pits
- Mine Infrastructure
- Alpha Coal Project Rail Line
- GAP Rail Line

Flood Velocity (m/s)

- 0 - 0.5
- 0.5 - 1
- 1.0 - 1.5
- 1.5 - 2
- 2.0 - 2.5
- 2.5 - 3
- 3 - 3.5
- 3.5 - 4
- 4 - 4.5
- 4.5 - 5

Post-development 100 Year ARI Flood Velocities

Figure 16-11

Byerwen Coal Project

Date: *4/02/2013*

Author: samuel.ferguson

Map Scale: 1:55,000

Revision: R1

Coordinate System: GDA 1994 MGA Zone 55

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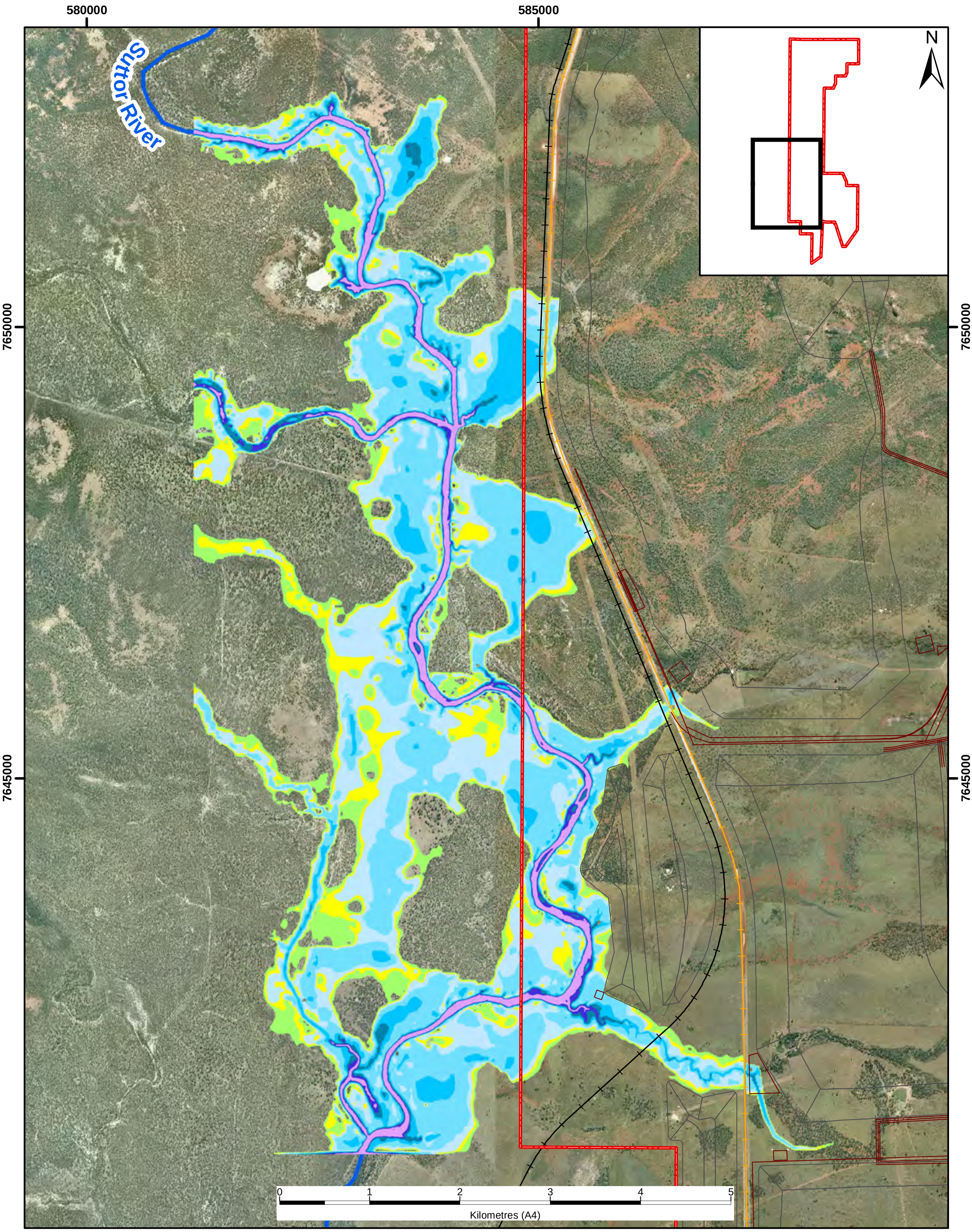

Legend

- Project Area
- Waste Rock Dumps and Pits
- Mine Infrastructure
- Alpha Coal Project Rail Line
- GAP Rail Line

Maximum Flood Depth (m)

- < 0.05 Not Shown
- 0.05 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- 3.0 - 4.0
- 4.0 - 5.0
- > 5.0

Post-development 1,000 Year ARI Flood Depths

Figure 16-12

Byerwen Coal Project

Date: *4/02/2013*

Author: samuel.ferguson

Map Scale: 1:55,000

Revision: R1

Coordinate System: GDA 1994 MGA Zone 55

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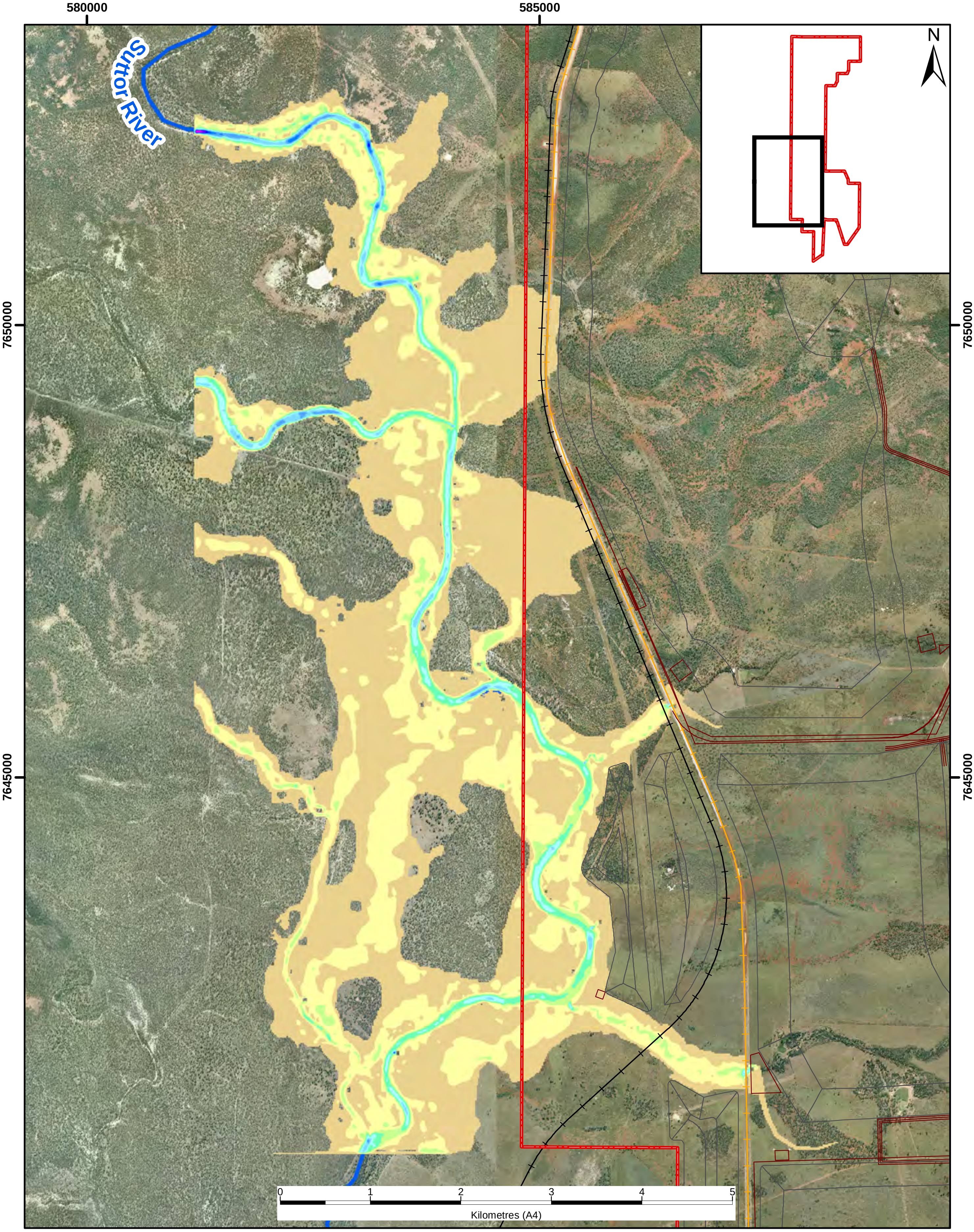

Legend

- Project Area
- Waste Rock Dumps and Pits
- Mine Infrastructure
- Alpha Coal Project Rail Line
- GAP Rail Line

Flood Velocity (m/s)

- 0 - 0.5
- 0.5 - 1
- 1.0 - 1.5
- 1.5 - 2
- 2.0 - 2.5
- 2.5 - 3
- 3 - 3.5
- 3.5 - 4
- 4 - 4.5
- 4.5 - 5
- Greater than 5

Post-development 1,000 Year ARI Flood Velocities

Figure 16-13

Byerwen Coal Project

Date: *4/02/2013*

Author: samuel.ferguson

Map Scale: 1:55,000

Revision: R1

Coordinate System: GDA 1994 MGA Zone 55

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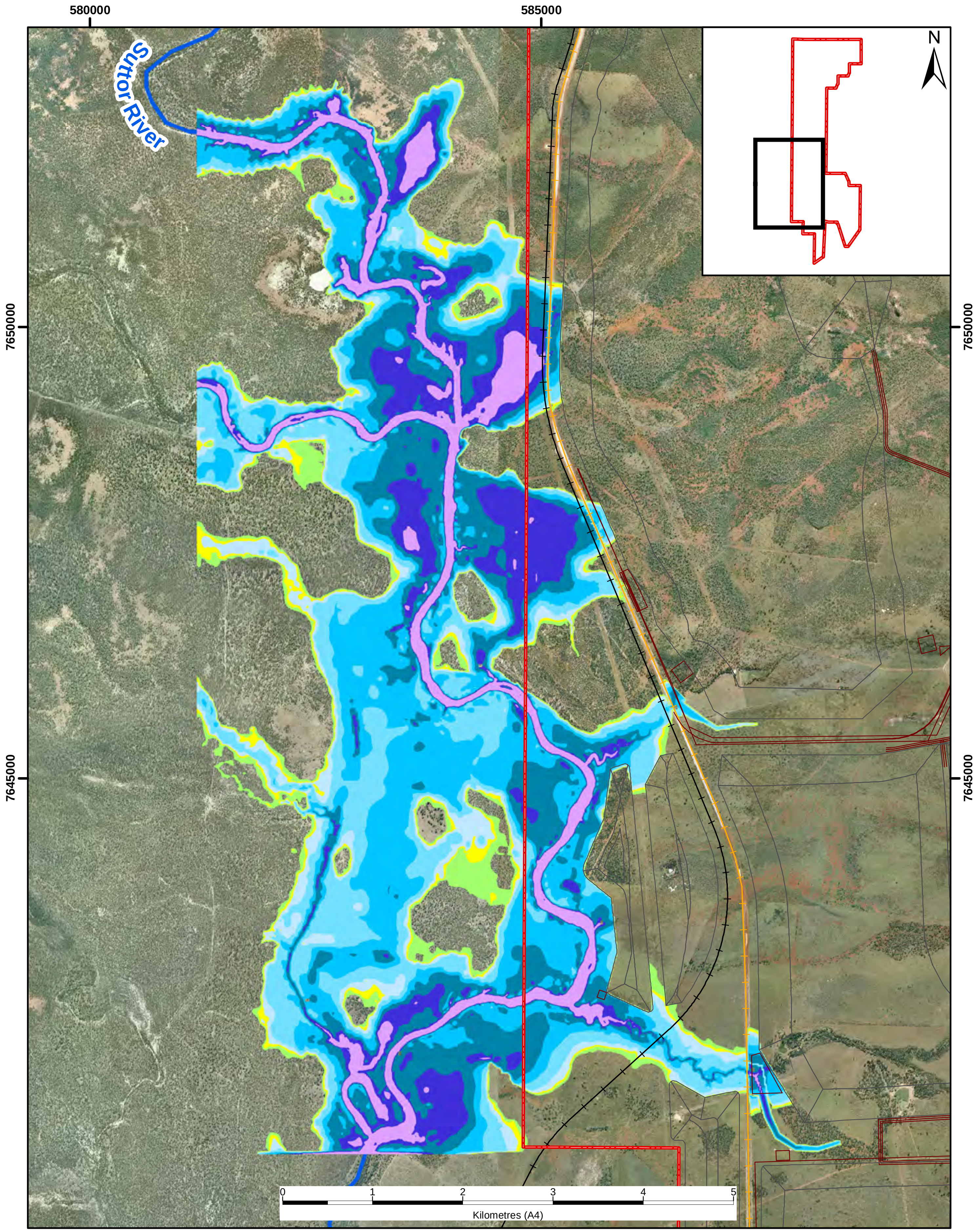

Legend

- Project Area
- Waste Rock Dumps and Pits
- Mine Infrastructure
- Alpha Coal Project Rail Line
- GAP Rail Line

Probable Maximum Flood Depth (m)

- < 0.05 Not Shown
- 0.05 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- 3.0 - 4.0
- 4.0 - 5.0
- > 5.0

Post-development PMF Flood Depths		QCOAL GROUP
Figure 16-14	Byerwen Coal Project	environmental and licensing professionals pty ltd
Date: 4/02/2013	**Author:** samuel.ferguson **Map Scale:** 1:55,000	
Revision: R1	**Coordinate System:** GDA 1994 MGA Zone 55	
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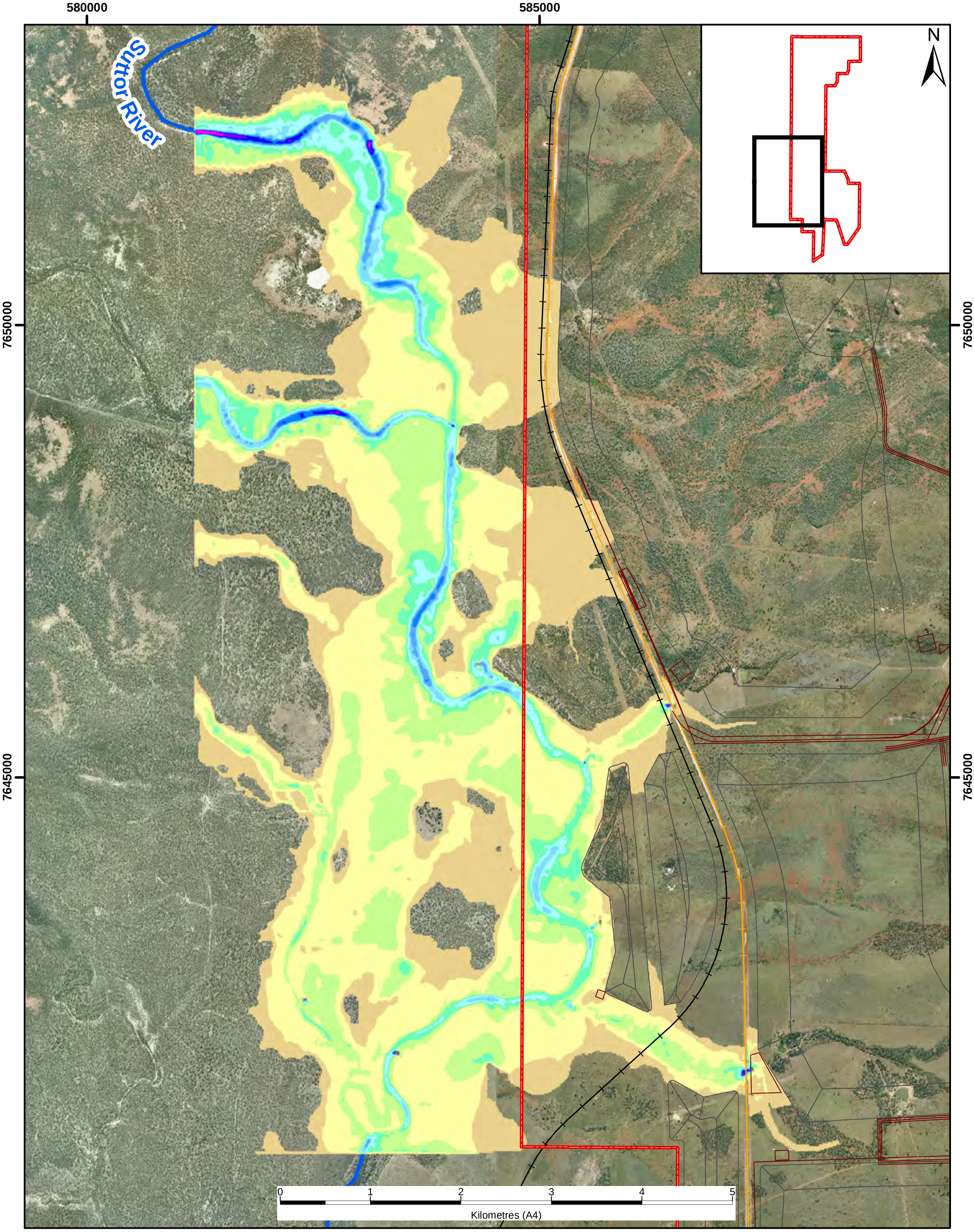

Legend

- Project Area
- Waste Rock Dumps and Pits
- Mine Infrastructure
- Alpha Coal Project Rail Line
- GAP Rail Line

Probable Maximum Flood Velocity (m/s)

- 0 - 0.5
- 0.5 - 1
- 1.0 - 1.5
- 1.5 - 2
- 2.0 - 2.5
- 2.5 - 3
- 3 - 3.5
- 3.5 - 4
- 4 - 4.5
- 4.5 - 5
- Greater than 5

Post-development PMF Flood Velocities	
Figure 16-15	**Byerwen Coal Project**
Date: *4/02/2013*	**Author:** samuel.ferguson **Map Scale:** 1:55,000
Revision: R1	**Coordinate System:** GDA 1994 MGA Zone 55

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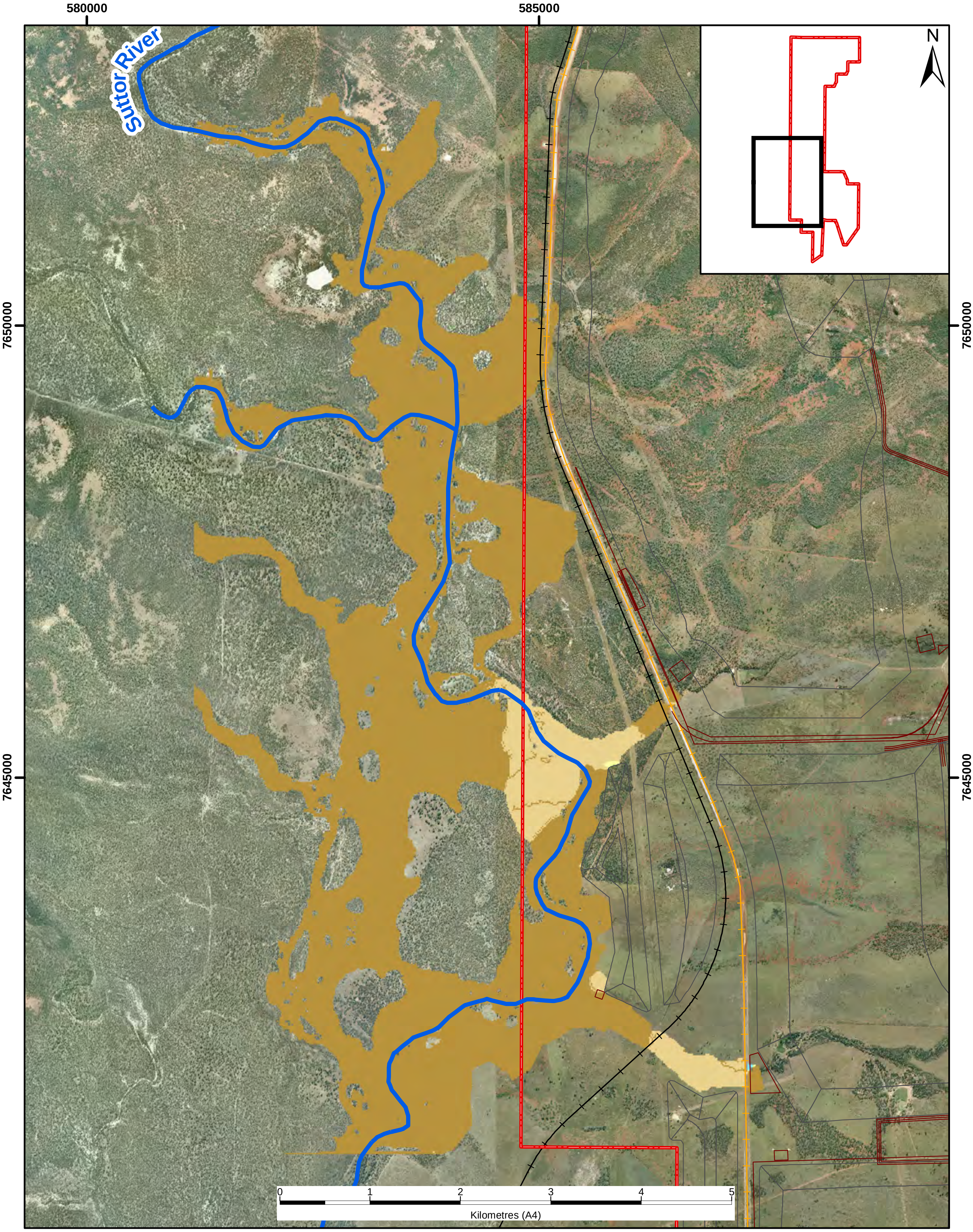
16.5.5 Changes in Flood Level and Velocity

Figure 16-16 and **Figure 16-17** present the change in the modelled peak flood level (afflux) between the pre and post-development scenarios for the 100 year and 1,000 year ARI flood events respectively. The results indicate negligible change in peak flood levels, generally less than 0.02 m, with a localised maximum of no more than 0.2 m.

The GAP rail line is not overtopped in the pre-development Suttor River 100 year ARI flood event and this flood immunity is not affected by the project. There are minor impacts at the GAP rail line (maximum 0.15 m for the 100 year ARI flood event) and negligible impacts on the proposed Alpha Coal Project rail line.

The minor changes that are predicted are attributable to available floodplain storage and flow paths in the pre-development scenario being modified by the waste rock dumps and diversion channels.

Figure 16-18 and **Figure 16-19** present the change in average velocity between the pre and post-development scenario for the 100 year and 1,000 year ARI flood events respectively. Generally the velocity change is negligible, with a few localised areas where velocities increase by about 0.1 m/s. This occurs near the South Pit 1 waste rock dump and at the downstream end of diversions.



Legend

- Project Area
- Waste Rock Dumps and Pits
- Mine Infrastructure
- Alpha Coal Project Rail Line
- GAP Rail Line

Flood Afflux (m)

- 0.00
- 0.00 - 0.02
- 0.02 - 0.04
- 0.04 - 0.06
- 0.06 - 0.08
- 0.08 - 0.1
- 0.1 - 0.2

Suttor River 100 Year ARI Flood Afflux

Figure 16-16

Byerwen Coal Project

Date: *4/02/2013*

Author: samuel.ferguson

Map Scale: 1:55,000

Revision: R1

Coordinate System: GDA 1994 MGA Zone 55

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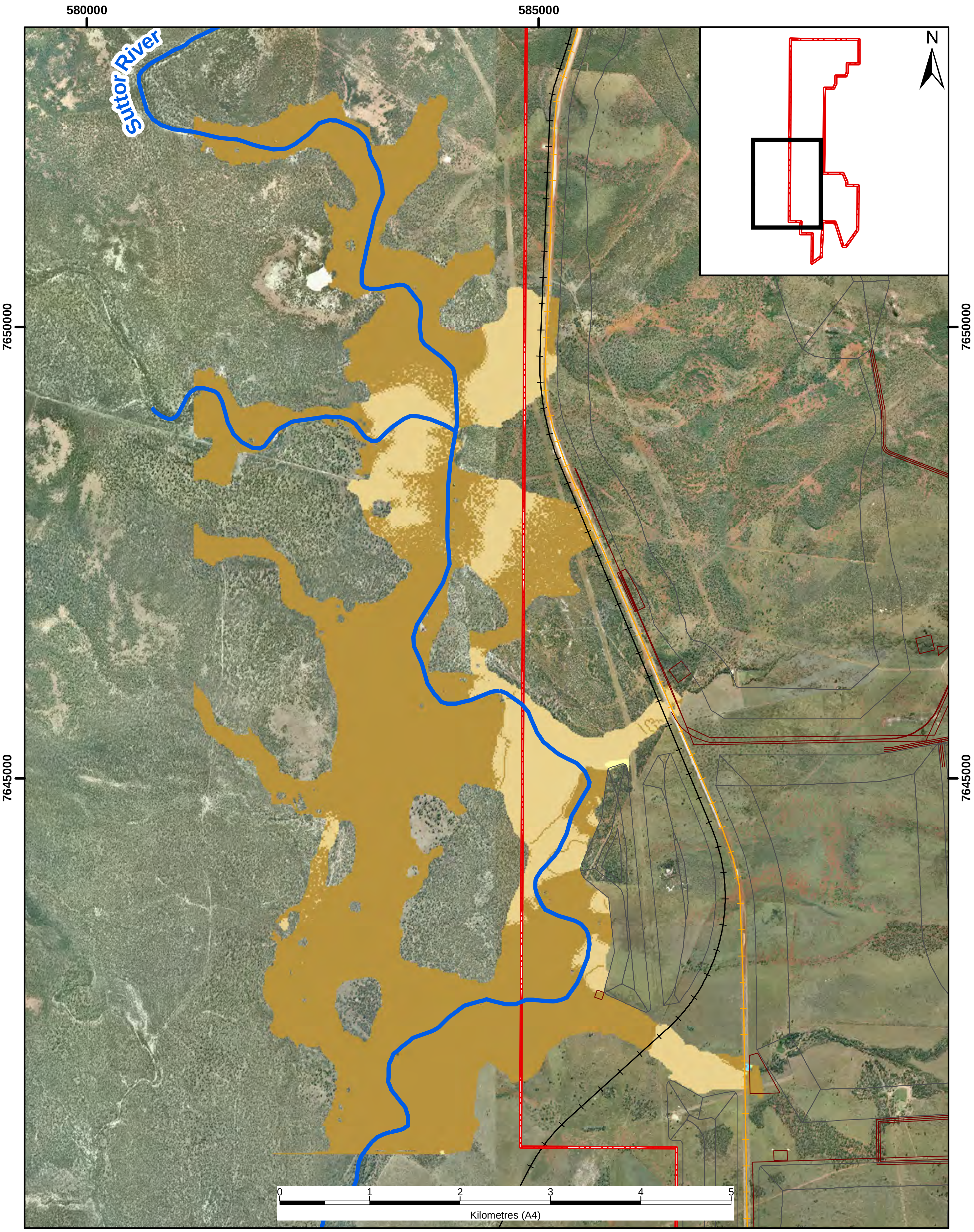

Legend

- Project Area
- Waste Rock Dumps and Pits
- Mine Infrastructure
- Alpha Coal Project Rail Line
- GAP Rail Line

Flood Afflux (m)

- Less 0.00
- 0.00 - 0.02
- 0.02 - 0.04
- 0.04 - 0.06
- 0.06 - 0.08
- 0.08 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3

Suttor River 1,000 Year ARI Flood Afflux

Figure 16-17

Byerwen Coal Project

Date: *4/02/2013*

Author: samuel.ferguson

Map Scale: 1:55,000

Revision: R1

Coordinate System: GDA 1994 MGA Zone 55

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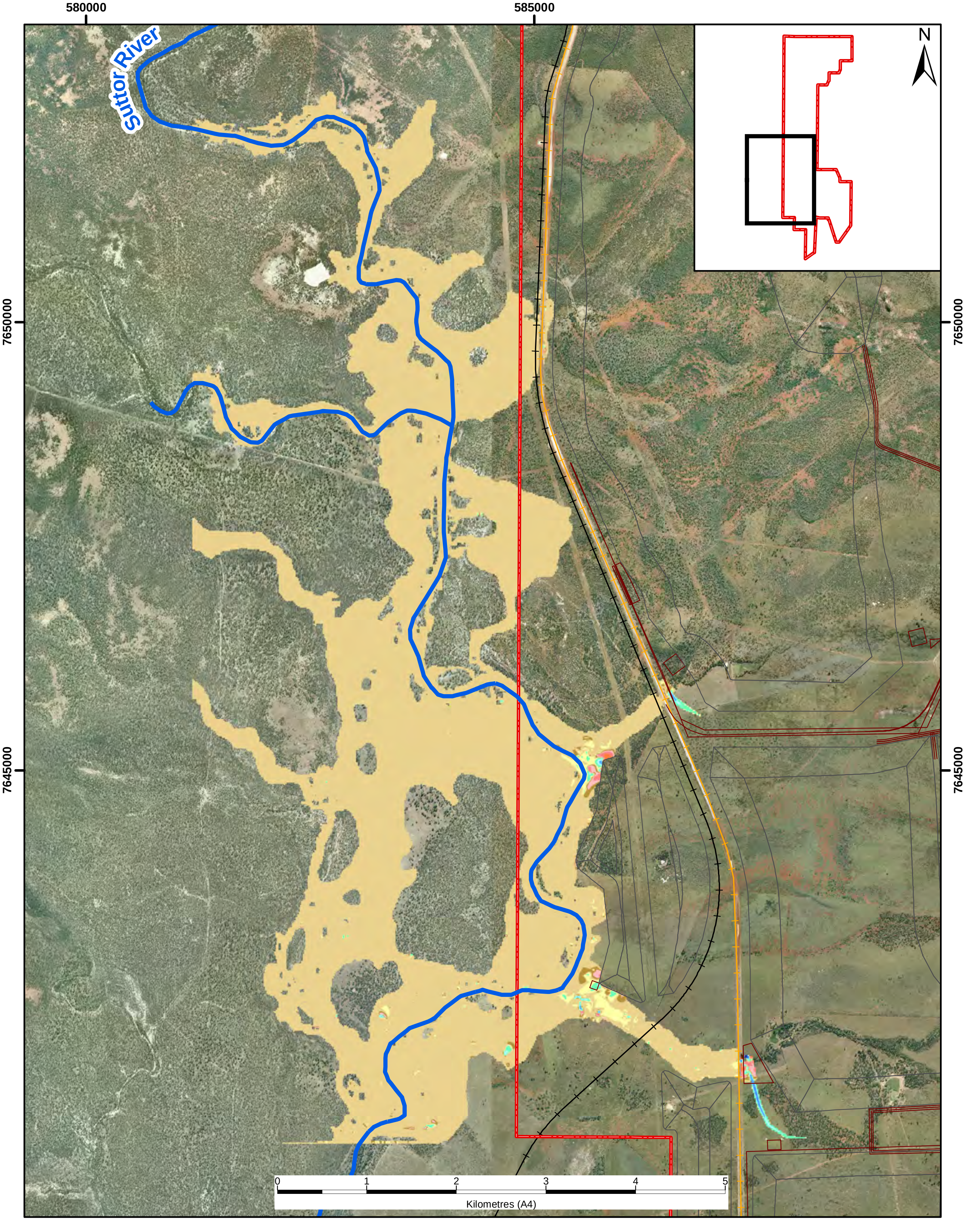

Legend

- Project Area
- Waste Rock Dumps and Pits
- Mine Infrastructure
- Alpha Coal Project Rail Line
- GAP Rail Line

Flood Velocity Change (m/s)

< -0.5	-0.05 - -0.02	0.1 - 0.2
-0.5 - -0.4	-0.02 - -0.005	0.2 - 0.3
-0.4 - -0.3	-0.005 - 0.005	0.3 - 0.4
-0.3 - -0.2	0.005 - 0.02	> 0.4
-0.2 - -0.1	0.02 - 0.05	
-0.1 - -0.05	0.05 - 0.1	

Suttor River 100 Year ARI Flood Velocity Change	
Figure 16-18	Byerwen Coal Project
Date: *4/02/2013*	**Author:** samuel.ferguson
	Map Scale: 1:55,000
Revision: R1	**Coordinate System:** GDA 1994 MGA Zone 55
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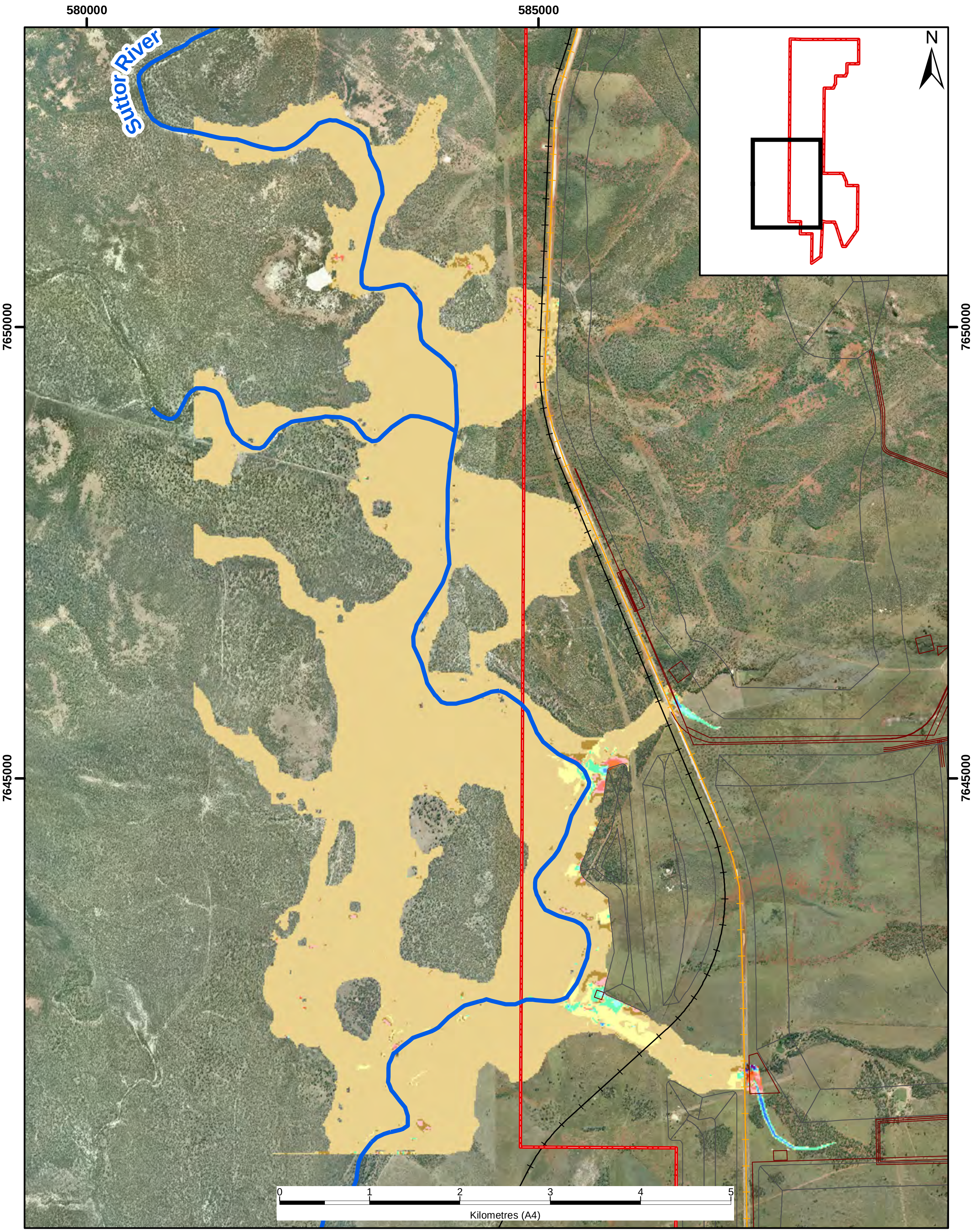

Legend

- Project Area
- Waste Rock Dumps and Pits
- Mine Infrastructure
- Alpha Coal Project Rail Line
- GAP Rail Line

Flood Velocity Change (m/s)

< -0.5	-0.2 - -0.1	-0.005 - 0.005	0.1 - 0.2
-0.5 - -0.4	-0.1 - -0.05	0.005 - 0.02	0.2 - 0.3
-0.4 - -0.3	-0.05 - -0.02	0.02 - 0.05	0.3 - 0.4
-0.3 - -0.2	-0.02 - -0.005	0.05 - 0.1	> 0.4

Suttor River 1,000 Year ARI Flood Velocity Change

Figure 16-19

Byerwen Coal Project

Date: *4/02/2013*

Author: samuel.ferguson

Map Scale: 1:55,000

Revision: R1

Coordinate System: GDA 1994 MGA Zone 55

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16.6 Diversions

16.6.1 Description of Diversions

The project will involve five diversions where existing watercourses or drainage lines are located within the footprint of open pits and / or waste rock dumps. The diversions are:

- Diversion 1 – a drainage line that intersects West Pit 1 will be diverted between West Pit1 and South Pit 1
- Diversion 2 – a drainage line / watercourse that intersects South Pit 1 will be diverted between South Pit 1 and South Pit 2
- Diversion 3 – connected to, and upstream of, diversion 2, which will divert a drainage line upstream of South Pit 1 into Diversion 2
- Diversion 4 – a drainage line that flows through East Pit 2 will be diverted north until it reaches another existing drainage line
- Diversion 5 – a drainage line that intersects North Pit will be diverted between North Pit and the out of pit waste rock dump

These diversions are shown in **Figure 16-20**.

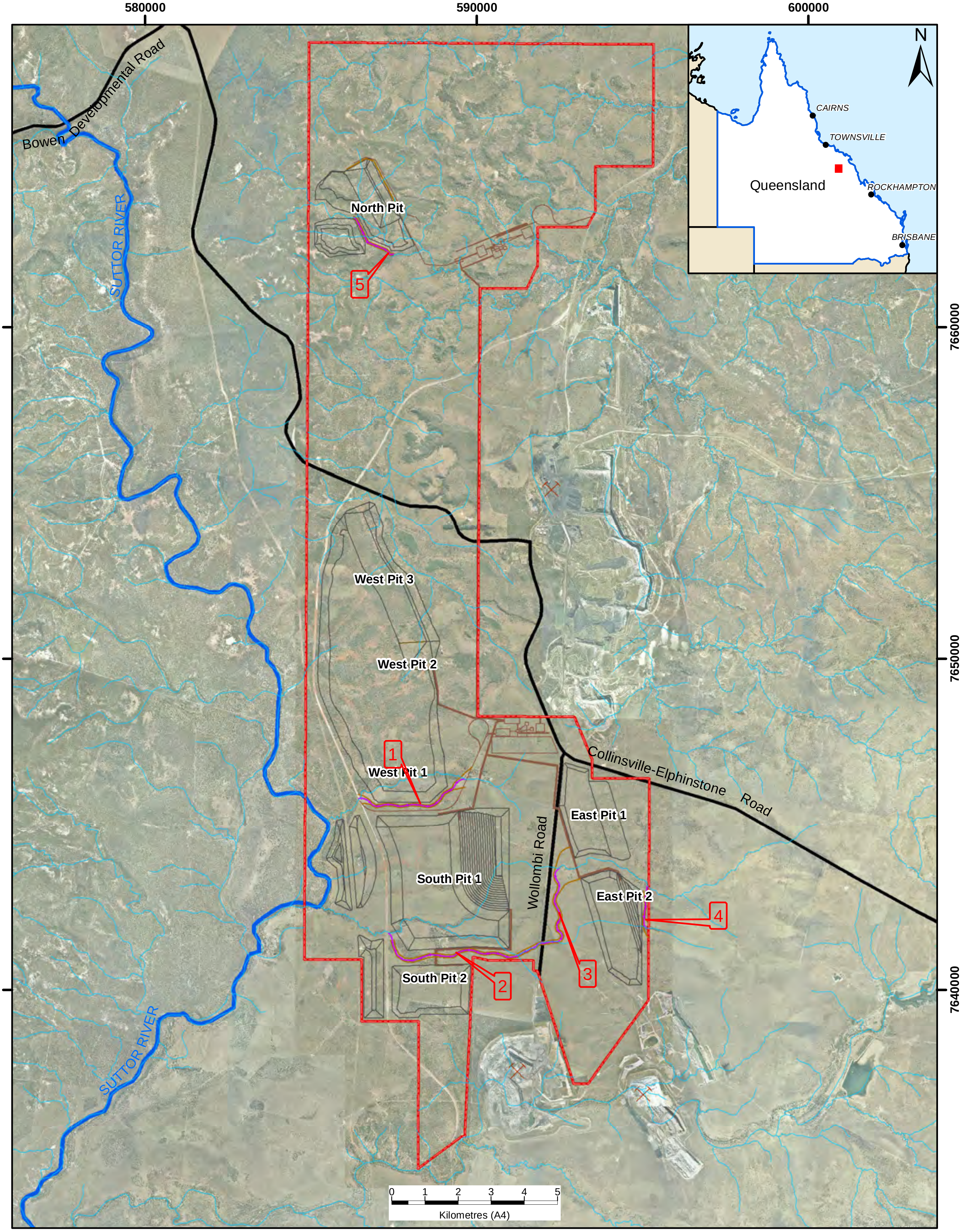
16.6.1.1 Diversion 1

The tributary of the Suttor River that flows through West Pit 1 is not a defined watercourse. The natural topography for the initial 1,200 m of the proposed route of the diversion channel rises approximately 4 m to 300 mAHD before falling 14.5 m to 285.5 mAHD over the remaining 2,500 m. Where necessary, levee banks have been included in the diversion channel feasibility design to contain the 0.1% AEP design discharge.

16.6.1.2 Diversion 2

The tributary which intersects South Pit 1 is a defined watercourse for part of its length, as shown in **Chapter 15, Figure 15-5**. The natural topography along the route of the diversion starts at chainage 5,750 m with a gradual fall in elevation of 6.1 m from 301.6 to 295.5 mAHD for the initial 1,330 m (CH 5,750 to CH 4,420). The surface topography between CH 4,420 and CH 1,100 undulates between 294 and 297 mAHD before falling 11 m over the remaining 1,100 m to an elevation of 283 mAHD at the diversion channel outlet at the GAP rail crossing.

Levee banks have been included in the diversion channel feasibility design to encompass this varying topography where flood flows would spill from the design channel without them.



Legend

Project Area	Existing Mine Site
Waste Rock Dumps and Pits	Drainage Line
Mine Infrastructure	Drainage Bund
Formed Roads	Drainage Diversion

Drainage Diversions	
Figure 16-20	**Byerwen Coal Project**
Date: *4/02/2013*	**Author:** samuel.ferguson
	Map Scale: 1:150,000
Revision: R1	**Coordinate System:** GDA 1994 MGA Zone 55

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16.6.1.3 Diversion 3

Flows from the tributary that runs between East Pit 1 and East Pit 2 are prevented from entering South Pit 1 by Diversion 3 which redirects the flow into Diversion 2.

Diversion 3 is approximately 2,630 m in length and runs in a southerly direction, diverting the drainage line upstream of South Pit 1 into Diversion 2 (refer **Figure 16-20**). It has an upstream elevation of 302 mAHD and remains at a reasonably flat level of 302 to 303 mAHD for the first 1,600 m of channel length (CH 6,750 to CH 8,500), climbing to a maximum elevation of 305 mAHD at CH6 250. From this location, the terrain begins a gradual decline in elevation from 305 to 301.6 mAHD at CH 5,750, where is joins Diversion 2.

As described in **Chapter 8**, the portions of the catchment of this drainage line which remains after the drainage realignment and will flow towards South Pit 1, will be dammed to prevent surface runoff from entering the mining areas of South Pit 1.

16.6.1.4 Diversion 4

The tributary that intersects East Pit 2 is not a defined watercourse. The diversion is located between East Pit 2 and the mine lease boundary and conveys a small drainage line in a northerly direction to a natural tributary which flows through a corridor between East Pit 1 and East Pit 2.

The natural topography along the route of the diversion has an upstream elevation of 312 mAHD for the first 200 m before gradually increasing in elevation to 317 mAHD over the next 600 m (CH 1,200 to CH 600). From CH 600 the topography gradually falls over the remaining 600 m of the diversion channel to an elevation of 310 mAHD at CH 0.

16.6.1.5 Diversion 5

A small drainage line diversion is planned to allow water to bypass the North Pit and flow to Kangaroo Creek. This drainage diversion will be in place before mining operations commence at the North Pit. The drainage diversion put in place will remain as a permanent structure to divert water around the North Pit and its final void. The flood modelling in this report does not include the north pit, north pit diversions and northern MIA, CHPP and co-disposal. This infrastructure is not required until later in the mine life (approximately Year 15) and will be assessed later once further detailed surveys have been completed.

16.6.2 Guidelines for Design of Diversions

The Department of Environment and Heritage Protection (EHP) guideline on Watercourse Diversions – Central Queensland Mining Industry (DERM, 2011[2]) provides advice on an established range of stream powers, velocities and shear stresses that are considered to be the upper range for natural Bowen Basin watercourses which are shown in **Table 16-6**. These guidelines were derived based on research conducted by Australia's Coal Industry Research Program (ACARP) projects C8030 and C9068.

Stream power represents the energy that is available to do work in and on the channel and is a function of the discharge, slope and width of a channel. Higher stream powers can indicate an elevated erosion potential.

High flow velocities have the potential to damage the channel through erosion and additional bank protection is required where estimated velocities exceed the criteria. This can be achieved by lining the channel with more dense vegetation or rock armouring.

[2] Department of Environment and Resource Management (2011), Watercourse Diversions – Central Queensland Mining Industry, Central West Region, Queensland

Shear stress is another indicator of erosion potential and measures the force exerted on the channel surface. It determines the threshold of motion for bed material.

Table 16-6 EHP Guideline Values for Hydraulic Parameters in Natural Bowen Basin Watercourses

Scenario	Stream power (Watts/m^2)	Velocity (m/s)	Shear stress (N/m^2)
50% AEP	<35	<1.0	<40
2% AEP	<220	<2.5	<80

Additionally, the Manual for Assessing Hazard Categories and Hydraulic Performance of Dams (DERM, 2012) (the Manual) outlines the hydrological design criteria for a number of regulated structures, including levees, and specifies the required crest level for levee embankments must contain the 0.1% AEP with an additional 0.5 m freeboard.

16.6.3 Modelling of Diversion Flows

Appendix 17 describes the:

- data obtained and / or models and methodology used to estimate design event peak discharges for the diversions
- parameters used in hydraulic modelling of diversion channels, including elevation data, roughness coefficients, rainfall intensity, frequency and duration and critical storm duration for the 0.1% and 0.05% AEP
- hydraulic effect of GAP rail line bridge structures included the bridge height, span, pier dimensions and abutments.

Table 16-7 provides the modelled design event peak discharges for Diversion 1, 2, 3 and 4. This table includes the 0.1% AEP event which has been adopted as the design basis of the diversion channels.

Table 16-7 Design Events Peak Discharges

	Annual exceedance probability (AEP)[1]								
Peak Discharge (m^3/s)	100%	50%	20%	10%	5%	2%	1%	0.1%2	0.05%
Diversion 1	12.2	23.1	46	59.6	80.4	108.2	133.8	228	267.7
Diversion 2	11.4	23.2	51.7	68.3	92	125.6	157.7	271.5	319.7
Diversion 3	18.7	33	55.4	69.5	94.9	127.3	149	279.8	321.7
Diversion 4	4.3	7.6	11.4	13.9	19.1	25.4	30.2	56.1	64.2

Note1: AEP is equivalent to the reciprocal of the ARI values that have been used previously. AEP is being used to describe design storm frequency in this report.

Note 2: the 0.1% AEP peak design discharge has been interpolated for Diversion 1 and 2 from Gap 50 Design Report undertaken by CoalConnect for the Northern Missing Link Project (NML) in November 2009 (CoalConnect, 2009[3]).

16.6.4 Diversion Channel Design

The conceptual design of diversion channels was based on the following key principles:

[3] CoalConnect (2009), Gap50 Design Report, Brisbane, Queensland

- The diversion channels were designed to have a channel slope similar to the natural watercourse conditions.
- The maximum required width to construct the channels includes an allowance for 10 m wide levees and an additional allowance of 30 m either side of the construction width to allow for design modifications and future possible erosion.
- The proposed channels were designed to meander to match the diverted channel length to the natural creek.
- The diversion channels were designed with a 1:5 bank slope, however this slope is dependent on soil characteristics and a geotechnical study of the area is required to confirm the design parameters and stability of the banks.
- The diversion channels were designed to meet the EHP guidelines on an established range of stream powers, velocities and shear stresses that are considered to be the upper range for natural Bowen Basin watercourses.
- The trapezoidal cross sections do not include channel features such as terraces, benches, riffles, etc. These features will need to be considered in the detailed design and may increase the top width of the channel.
- The diversion channels will be stable, self sustaining and require no ongoing monitoring or management.

Table 16-8 provides a summary of the diversion design parameters, based on the design principles and hydrological models. **Appendix 17** contains cross sections, long sections and velocity profiles for all diversions assessed.

Table 16-8 Summary Details of Diversions

Detail	Diversion 1	Diversion 2	Diversion 3	Diversion 4
Minimum depth (m)	3.6	4.2	4.4	2.4
Minimum top width (m)	56	62	64	40
Bottom width (m)	20	20	20	20
Corridor length (m)	3,700	5,750	2,580	1,700
Corridor width (m)1	215	325	355	130
Deepest cut (m)	7	9	7.5	6.5
Highest levee bank (m)	1.5	2	2	2
Grade (%)	0.30	0.22	0.23	0.20
Bank slope	1:5	1:5	1:5	1:5

Note 1: Includes allowance for any meanders and levees

16.6.4.1 Diversion 1

The diversion channel was designed to be a minimum depth of 3.6 m and minimum top width of 56 m with a 1:5 bank slope, to give a bottom width of 20 m. This caters for flows up to and including the 0.1% AEP event with a minimum freeboard of 0.5 m.

The diversion channel was designed to have a channel slope of approximately 0.3% grade (0.27 m fall every 100 m along the channel), similar to the natural watercourse conditions. This grade resulted in an increased cutting depth for the first 1,200 m (CH 3,600 to CH 2,400) of the diversion channel where the natural topography was rising. In this case a cutting depth of up to 7 m was required, with the greatest depth between CH 2,400 and CH 2,550 to allow for the 0.1% AEP design event discharges.

In the downstream section of the diversion channel (CH 0 to CH 1,350) the terrain is naturally declining and consequently levee banks will be needed to adequately provide for large event discharges. Levee banks will also be required in the first 400 m of the diversion channel (CH 3,200 to CH 3,600).

The Manual specifies the hydrological design criteria for levees. The Manual outlines the required crest level for levee embankments must be for a 0.1% AEP with an additional 0.5 m freeboard.

16.6.4.2 Diversion 2

The diversion channel is approximately 5,750 m in length and was designed to be a minimum depth of 4.2 m and minimum top width of 62 m with a 1:5 bank slope, to give a bottom width of 20 m. This caters for flows up to and including the 0.1% AEP event with a minimum freeboard of 0.5 m.

The proposed channel was designed to meander to match the diverted channel length to the natural creek. The maximum required width of the channel construction is approximately 113 m where the required cut is the deepest at CH 1,250. The meanders will increase the total required channel easement to approximately 325 m width.

In this upper section of the channel (CH 5,400 to CH 4,200) the terrain is naturally declining and consequently levee banks will be needed to adequately provide for the 0.1% AEP design event discharge. Levee banks will also be required from CH 400 downstream to the channel outlet at the GAP rail line. From CH 4,200 to CH 400, the natural terrain is such that the diversion channel does not require levees.

The diversion channel was designed to have a channel slope of approximately 0.22% grade (0.224 m fall every 100 m along the channel), similar to the natural watercourse conditions.

16.6.4.3 Diversion 3

Diversion 3 is approximately 2,630 m in length. With diversion 3 reporting into diversion 2, the combined diversions 2 and 3 have a length of approximately 8,380 m and replace the natural watercourse that crosses South Pit 1. The Diversion 3 channel was designed to be a minimum depth of 4.4 m, with a minimum top width of 64 m and a 1:5 bank slope, to give a bottom width of 20 m.

The proposed channel was designed to meander to reduce stream velocities and better represent natural flow conditions, similar to the existing drainage line. The maximum easement width required is approximately 355 m at CH 6,250 where the deepest cut is required.

The upstream 1,600 m of the diversion channel requires levee banks to cater for flows up to and including the 1,000 year ARI event. In the areas of higher terrain between CH 6,800 and CH 5,750, a large cut will be required.

The diversion channel was designed to have a channel slope of approximately 0.23% grade (0.23 m fall every 100 m along the channel), similar to the natural drainage line conditions.

16.6.4.4 Diversion 4

The diversion channel replaces a length of 1,724 m of natural drainage line across East Pit 2. By diverting the channel north to an alternative drainage line with a longer stream length, the diversion channel does not need to provide compensatory channel length with wide meanders, however the channel was designed to meander within the available space to mimic as much as possible the natural drainage line.

The diversion channel was designed to be a minimum depth of 2.4 m, with a top width ranging between 40 m to 69 m and a 1:5 bank slope, to give a bottom width of 20 m. This caters for flows up to and including the 0.1% AEP event with a minimum freeboard of 0.5 m.

The maximum required depth of the channel construction is approximately 6.6 m at CH 600 where the required cut is the deepest. The total required channel easement is approximately 130 m wide at this location.

Levee banks are required to convey the design event discharges between CH 1,385 and CH 1,000. Levee banks will also be required from CH 200 downstream to the diversion channel outlet at the junction with the existing drainage line flowing between East Pit 1 and East Pit 2. From CH 1,000 to CH 200, the natural terrain is such that the diversion channel does not require levees and the channel will be in cut.

The fall in elevation over the route of the diversion channel was 2.8 m, which gives a channel slope of approximately 0.2% grade (0.2 m fall every 100 m along the channel), similar to the natural watercourse conditions.

The results of modelling of the existing drainage line between East Pit 1 and East Pit 2 have indicated that the 0.1% AEP flood levels will encroach into the area allocated for the waste rock dump of East Pit 1 and may clip the south-western corner of East Pit 1. The toe of the waste rock dump will either be relocated outside the flood extent, or constructed in a manner such that it is non-erodible when in contact with flood waters.

16.6.5 Hydraulic Characteristics of Diversions

The hydraulic characteristics of the diversion channels, represented by the maximum stream power, velocity and shear stress in the diversion channels were assessed against the EHP guidelines. The results are shown in **Table 16-9**. The hydraulic parameters in the diversion channel are all within the guideline values for natural watercourses in the Bowen Basin.

Table 16-9 Maximum Values of Hydraulic Parameters in the Diversion Channels

Scenario	Max. stream power (Watts/m^2)	Max. velocity (m/s)	Max. shear stress (N/m^2)
EHP guideline on natural watercourses in the Bowen Basin			
50% AEP	<35	<1.0	<40
2% AEP	<220	<2.5	<80
Diversion 1			
50% AEP	21	1.0	21
2% AEP	71	1.6	44
0.1% AEP	148	2.2	68
Diversion 2			
50% AEP	17	0.9	18
2% AEP	68	1.6	42
0.1% AEP	144	2.2	66
Diversion 3			
50% AEP	22	1.0	21.5
2% AEP	66	1.6	41
0.1% AEP	59	2.0	118

Scenario	Max. stream power (Watts/m^2)	Max. velocity (m/s)	Max. shear stress (N/m^2)
Diversion 4			
50% AEP	7.0	0.7	11
2% AEP	19	1.0	19
0.1% AEP	37	1.3	29

16.6.6 Receiving Waterway Stability

16.6.6.1 Diversions 1, 2 and 3

The drainage diversion channels 1, 2 and 3 will move the flow of water around the mining area, but still enter their receiving waterways at the same location. Therefore negligible change in flow or velocity is expected to occur in the receiving waterways.

16.6.6.2 Diversion 4

Diversion channel 4 redirects a small part of the catchment upstream of East Pit 2 into the natural drainage line between East Pit 1 and East Pit 2. This increases the contributing catchment of the drainage line by less than 10%, however, this is not expected to significantly alter the flow or velocity of the drainage line.

16.7 Potential Impacts and Mitigation Measures

16.7.1 Hydrology and Flooding

The location of waste rock dumps may alter Suttor River flood depths and velocities, with potential for corresponding impacts on surrounding properties and infrastructure. As described in **Section 16.5.4**, flood waters from the 100 Year and 1,000 Year ARI events reach sections of the waste rock dump associated with the west pits complex and out of pit waste rock dumps associated with South Pit 1 and South Pit 2. However, modelling shows that this results in negligible changes to flood depths and velocities.

In the 1,000 year ARI event flood waters reach some sections of the western waste rock dumps with depths up to 2.0 m and velocities in the order of 1.0 m/s. This will require armouring up to the 1,000 year ARI flood level such that it is non-erodible when in contact with flood waters, resulting in negligible impacts. Alternately the toe of the dump can be relocated outside the flood extent. It should be noted that the peak depth and velocities at the face of the WRD do not occur together and where the velocity is highest adjacent the waste rock dump the depth is 0.8 m.

The PMF flood event reaches the aforementioned waste rock dumps and the south western corner of South Pit 1. The levee of Diversion 2 is overtopped by the Suttor River PMF event, but not the 1,000 year ARI event. However the final void in South Pit 1 will not be affected by the PMF flood event.

Impacts to the mine operations of all open pits in the Suttor River catchment were assessed against the 1,000 year ARI event, which do not overtop the levee. **Figure 16-12** shows that there are no open pits or final voids that will be subject to flooding from the 1,000 year ARI flood event from regional flooding of the Suttor River.

The GAP rail line is not overtopped in the pre-development Suttor River 100 year ARI flood event and this flood immunity is not affected by the project development. There are minor impacts at the GAP rail line (maximum 0.15 m for the 100 year ARI flood event) and negligible impacts at the proposed Alpha Coal Project rail line.

Mine life scenarios at different intervals (e.g. Year 10, Year 25) have not been assessed however diversion channels will be constructed prior to commencement of works at open pits from which they divert water. Therefore impacts from inflows from unnamed tributaries to the Suttor River should be negligible. Additionally, the levees that form part of the drainage diversions works will be extended to protect South Pit 1 and West Pit 1 from 1,000 year ARI regional flooding in the Suttor River at all intervals of the mine life.

North Pit and associated waste rock dump are situated in the upper catchment of Kangaroo Creek at an elevation above any floodplain and the small gullies in these areas are not of sufficient size to warrant flood modelling. South Pit 2 and associated waste rock dump were determined to be beyond the extent of any flood flows from Suttor Creek.

The flood modelling does not include North Pit, North Pit diversions and northern MIA, CHPP and co-disposal dam, which relates to the Kangaroo Creek catchment which has no bearing on flooding in the Suttor River. A small drainage diversion is planned to allow water to bypass the North Pit and flow to Kangaroo Creek. This drainage diversion will be in place before mining operations commence at the North Pit. The northern MIA is located across a tributary of Kangaroo Creek and may require culverts or a bridge to provide access and protect the area. However this infrastructure is not required until approximately Year 15 in the mine life and localised water management measures will be determined during future detailed design work.

The northern part of west pits complex and the Southern MIA and CHPP follows the catchment divide between the Suttor River and Bowen River catchments. The terrain is above the Suttor River floodplain and the small gullies in these areas are not of sufficient size to warrant flood modelling. Drainage issues in these areas are addressed in **Chapter 8**.

The project will obstruct flow paths for local stormwater runoff. The potential impacts on local runoff and the management measures are addressed in **Chapter 8**.

16.7.2 Mine Water Management

The mine water management system is described in **Chapter 8**. This section considers the impacts on the hydrology of the Suttor River, Kangaroo Creek and local tributaries in the project area from the planned operation of the mine water management system (i.e. the system operating in accordance with the release strategy and release rules described in **Chapter 8**).

The project has the potential to alter the hydrology of surface water systems by capturing water in dams, loosing water in the form of dust suppression or pond evaporation, and releasing water during flow events.

16.7.2.1 Suttor River

The potential changes to hydrology were assessed using the water balance model described in **Chapter 8**. Daily runoff over a 46 year period (equivalent to the mine life) was calculated for two scenarios: without the project and with the project. The flow duration curve for both scenarios is presented in **Figure 16-21**, which shows that the mine has a negligible impact on Suttor River hydrology. This is because the Suttor River catchment is much larger than the catchment affected by mining, so any influence is significantly dampened. In addition, the release rules developed for the project are structured to release most water during high flow periods. The relative flow contribution from mine discharges when there is high flow in the Suttor River is therefore small.

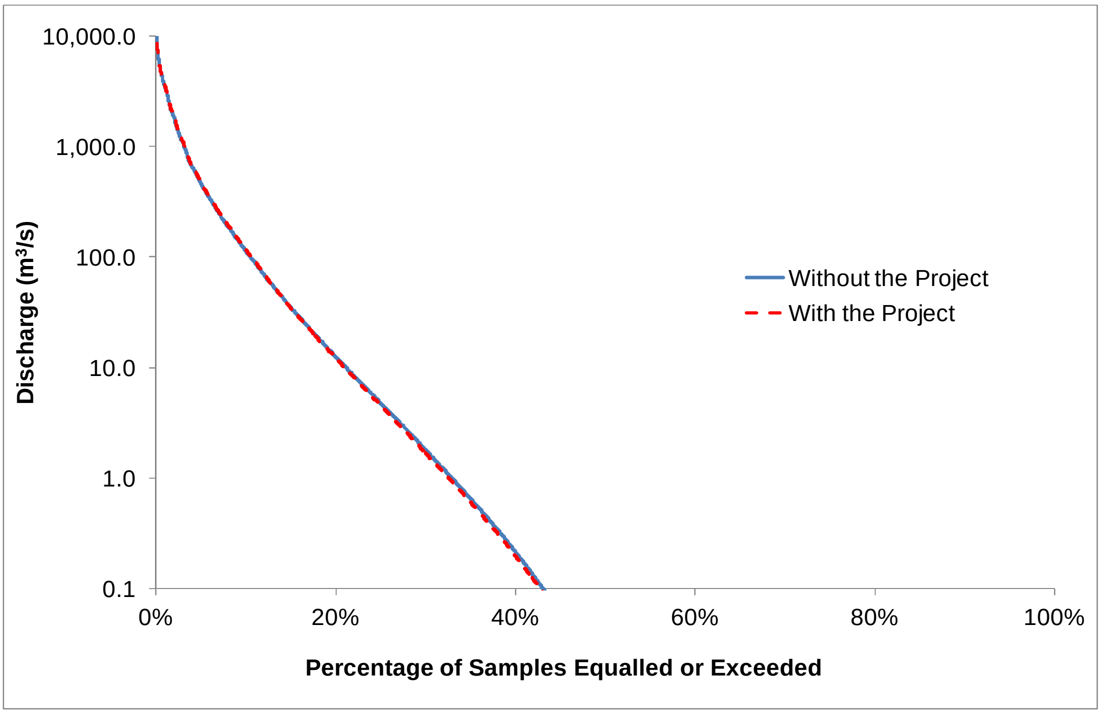

Figure 16-21 Flow Duration Curve – Suttor River at Compliance Point

16.7.2.2 Kangaroo Creek

The flow duration curve with and without the Project was derived for Kangaroo Creek is presented in **Figure 16-22**, which shows that mine has a negligible impact on Kangaroo Creek hydrology.

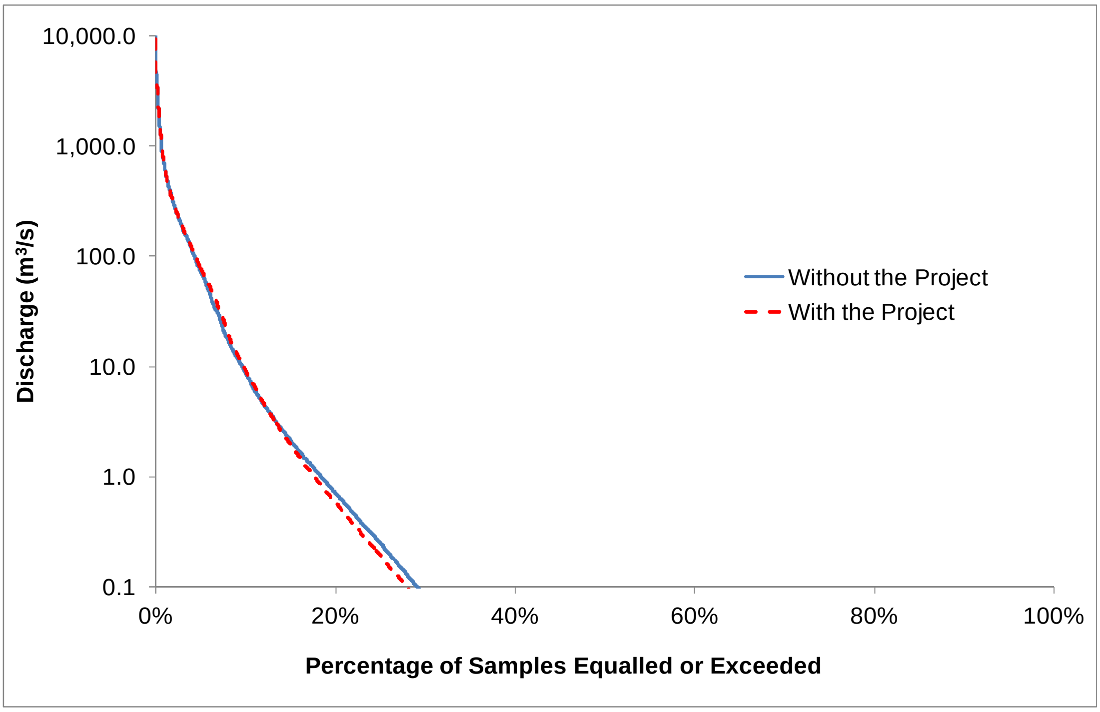

Figure 16-22 Flow Duration Curve – Kangaroo Creek at Compliance Point

16.7.2.3 Local Tributaries

The impact of mine discharge on hydrology in local tributaries will be more pronounced than in the larger river systems (such as the Suttor) because the flow changes will constitute a larger proportion of the usual flow. However, the maximum discharges from the mine water system have been capped at 864 ML/d (or 10 m^3/s), which is a relatively frequent flow event in these systems. For example a 10 m^3/s flow in diversion 1 relates to a design storm event with an average recurrence interval (ARI) of 3–4 months (i.e. a relatively frequent flow event). This compares with the design flow rate (1,000 year ARI) of 228 m^3/s for Diversion 1 and 272 m^3/s for Diversion 2. The design flow rates for the diversions in the southern area have been conservatively calculated based on the existing catchment upstream of the railway crossing (i.e. the downstream end of the diversion). During mining substantial parts of the catchment will be captured within the mine water system, reducing flows reporting to the diversion. This reduction is expected to more than compensate for the additional mine discharges that could be released into a diversion if they happened to coincide with a flood peak. Therefore impacts of mine discharge on hydrology in local tributaries will be minor.

16.7.3 Interaction between Dams and Floodwaters

The concept design of mine water dams is based on turkey's nest design. The crest of these dams will be designed at or above the flood immunity requirements for its hazard rating, as stipulated in **Chapter 8**.

Sediment dams would typically be constructed as an excavated dam in order to collect waste rock dump toe runoff. These would be located outside the 100 year ARI flood level in the nearby waterway.

Clean water dams may be sited within the flood extent of local tributaries, since there is no water quality implication of floodwaters interacting with the impounded water. In these situations the dam would be designed such that there is no scour or damage to the dam as a result of flooding.

Water infrastructure such as pumps and pipes will be designed such that they remain operational during flood events.

Any interaction between dams and floodwaters is expected to result in negligible impacts.

16.7.4 Palustrine Wetland

During mining, the upstream catchment of the wetland will be disrupted by construction of a waste rock dump associated with West Pit complex. In the first year of mining the catchment will reduce from 4.2 km^2 to 2.9 km^2, and then there will be a further reduction from 2.9 km^2 to 2.4 km^2 around year 5. However, the wetland catchment will be rehabilitated to a similar pre-development hydrological profile around year 16, allowing the pre-development hydrological processes currently in the catchment to be reinstated. The disruption to the wetland is therefore temporary. The catchment of the wetland will be reduced for a period of around 16 years. In a median rainfall year the surface water flowing to the wetland would reduce from approximately 170 ML to 95 ML as a result of the catchment reduction, resulting in a shortfall of some 75 ML per annum over the 16 year disturbance period. The impacts on the hydrology of the wetland in the 16 years of reduced catchment will be moderate, however once the catchment is rehabilitated to a similar pre-development hydrological profile, impacts on the hydrology of the wetland will be negligible. The impacts of this change in hydrology on the wetland ecology are discussed in **Chapter 19**.

16.7.5 Diversions

Drainage diversions are a mitigation against flooding of open pits and final voids from drainage lines and watercourses that intersect proposed open pits.

Drainage diversions can introduce a wide range of issues such as changes to catchment hydrology, localised flooding, geomorphology and ecological integrity. Realignment of drainage lines requires detailed hydrological and hydraulic assessment to enable management of downstream impacts. Conceptual diversions have been determined (refer **Section 16.6**) with lengths similar to the natural condition (where possible) to limit erosion potential, with a typical natural drainage line cross-section and appropriate roughness parameters (based on vegetation to be established along the diversions) applied for modelling purposes. The hydraulic parameters in the diversion channel are all within the guideline values for natural watercourses in the Bowen Basin.

The preliminary design of the diversion channels will need to be reviewed during detailed design, and will rely on geotechnical advice to confirm the design parameters and stability of the banks to control erosion and scour. They will be designed as stable systems and maintained over the life of the mine, with refinements made if needed, resulting in diversions and levees that are self sustaining, stable and which require no maintenance post closure.

Rehabilitation of drainage diversions to achieve a self sustaining system that promotes nutrient processing, ecological connectivity and sediment storage and transport is described in **Chapter 10**.

The diversion channels have been designed to cater for local catchment discharges up to and including the 0.1% AEP event discharge plus a 0.5 m freeboard to the top of the bank or levee in accordance with the Manual.

The diversion channel design includes levees to contain the 1,000 year ARI local catchment flows from the unnamed tributaries of the Suttor River. These levees have been included in the hydraulic modelling and extended to high ground at their downstream extent to completely protect the mine pits from backwater flooding in the Suttor River 1,000 year ARI event.

The proposed diversion channel will require part of the Wollombi Road to be removed. The existing road crossing of the tributary has limited flood immunity. A causeway can be constructed to reconnect the road with flood immunity similar to the existing crossing, or it may be increased as required by raising the road above the bottom of the diversion channel using culverts for cross drainage.

With appropriate design and construction, impacts to catchment hydrology, localised flooding, geomorphology and ecological integrity from diversions are expected to be negligible to minor.

16.8 Conclusion

Flood modelling for the Suttor River and statewide floodplain modelling demonstrate that the only project activities that will reached by a 1,000 Year ARI or PMF event are sections of the West Pit complex waste rock dump, the out of pit waste rock dumps associated South Pit 1 and South Pit 2 and the south western corner of South Pit 1.

In the 1,000 year ARI event flood waters reach some sections of the western waste rock dumps with depths up to 2.0 m and velocities in the order of 1.0 m/s. This will require armouring up to the 1,000 year ARI flood level such that it is non-erodible when in contact with flood waters, resulting in negligible impacts. Alternately the toe of the dump can be relocated outside the flood extent.

The levee of Diversion 2 (which protects the south western corner of South Pit 1), is overtopped by the Suttor River PMF event, but not the 1,000 year ARI flood. There are no scenarios where the regional PMF flood event reaches the final voids of South Pit 1, West Pit 3, East Pit 2 or North Pit.

Impacts from inflows from unnamed tributaries to the Suttor River should be negligible. Additionally, the levees that form part of the drainage diversions works will be extended to protect South Pit 1 and West Pit 1 from 1,000 year ARI regional flooding in the Suttor River at all intervals of the mine life.

The change in the modelled peak flood level (afflux) between the pre and post-development scenarios for the 100 year and 1,000 year ARI flood events is generally less than 0.02 m, with a localised maximum of no more than 0.2 m, which is considered negligible. The change in average velocity between the pre and post-development scenario for the 100 year and 1,000 year ARI flood events is generally negligible with a few localised areas where velocities increase by about 0.1 m/s. The minor changes that are predicted are attributable to available floodplain storage and flow paths in the pre-development scenario being modified by the waste rock dumps and diversion channels.

The southern MIA is not a risk from flooding as it is located at the top of a catchment. The northern MIA is located across a tributary of Kangaroo Creek and may require culverts or a bridge to provide access and protect the area.

The GAP rail line is not overtopped in the pre-development Suttor River 100 year ARI flood event and this flood immunity is not affected by the project.

Five diversion channels are proposed to divert local watercourses and drainage lines around open pits and waste rock dumps. The hydraulic parameters in the diversion channels are all within the guideline values for natural watercourses in the Bowen Basin and diversion channels have been designed to meander to match the diverted channel length to the natural creek. Negligible change in flow or velocity is expected to occur in the waterways receiving water from diversions. The diversion channel design includes levees to contain the 1,000 year ARI local catchment flows from the unnamed tributaries of the Suttor River. These levees have been included in the hydraulic modelling and extended to high ground at their downstream extent to completely protect the mine pits from backwater flooding in the Suttor River 1,000 year ARI event. With appropriate design and construction, impacts to catchment hydrology, localised flooding, geomorphology and ecological integrity from diversions are expected to be negligible to minor.

The operation of the water management system in accordance with the planned release strategy will have negligible impact on the hydrology of the Suttor River and Kangaroo Creek. Impacts will be minor in local tributaries in the project area as maximum release rates are well within the design capacities of diversion channels.

The catchment of a palustrine wetland adjacent to the Suttor River would be temporarily affected during a 16 year period as a result of mining. The remediation strategy for the area will include returning the land to a similar hydrological profile after that period, creating a similar hydrological profile within the catchment for the wetland. The impacts on the hydrology of the wetland in the 16 years of reduced catchment will be moderate, however once the catchment is rehabilitated to a similar pre-development hydrological profile, impacts on the hydrology of the wetland will be negligible.