HANCOCK COAL PTY LTD

calibre

# Calibre Rail

# Alpha Coal Project - Rail Phase 1B

# Detailed Floodplain Study Suttor River/Eaglefield Creek

## HC-CRL-24100-RPT-0132
## CJVP10007-REP-C-013

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# 1.0 PURPOSE

The purpose of this report is to analyse and assess the impact of the Alpha Coal Project (ACP) railway line as it traverses the Suttor River / Eaglefield Creek floodplain system. The analysis provides recommendations of the cross drainage infrastructure required to minimise impacts to existing flow paths and to meet the conditions set in the Environmental Impact Study (EIS) and the Supplementary Environmental Impact Study (SEIS).

This report provides details of the floodplain analysis undertaken for the Eaglefield Creek and Suttor River systems. It details the pre- and post-development inundation extents for the 5, 50 and 100 year Average Recurrence Interval (ARI) events. The results for flow depths, velocity fields and afflux from the development of the railway have been assessed for the approved design criteria of a 50 year ARI event.

# 2.0 PROJECT BACKGROUND

Hancock Coal Infrastructure Pty LTD (HCIPL) are progressing into the development of a 30 Mtpa open pit thermal coal mine within the Galilee Basin 50 km north of the Alpha township in central Queensland. This project is known as the Alpha Coal Project (ACP). A project overview can be seen in Figure 1.

As part of this project, a 500 km standard gauge rail alignment and its associated infrastructure is required to transport the coal from the mine, at Alpha, to the port at Abbot Point, north of Bowen. Calibre has recently completed the Bankable Feasibility Study (BFS) for the rail alignment and is continuing to progress the identified critical path detail design activities.

Subsequent to this, an EIS has been prepared and a corresponding SEIS compiled to clearly define design parameters to be adhered to in any further investigations, and eventually, designs.

Part of the stakeholder response to the EIS identified specific concerns that were raised in relation to the drainage criteria approved by Hancock Coal in the BFS. The SEIS has taken into account these concerns and the drainage criteria updated to address the issues raised in the EIS. This Detail Floodplain Study takes into account these changes in the drainage criteria developed for the SEIS.


**Figure 1: Proposed Alpha Coal Railway Alignment**

## 3.0 REFERENCES, CODES AND STANDARDS

The following reports and codes were used as part of the floodplain modelling:

- BFS Drainage Engineering Report (CJVP10007-REP-C-001);
- Queensland Government Climate Change Guidelines: *Increasing Queensland's resilience to inland flooding in a changing climate* (2010);
- Australian Rainfall and Runoff (AR&R);
- C&R land holder consultation;
- EIS and SEIS.

The following data sources were used for the hydrologic and hydraulic modelling:

- Department of Environment and Resource management (DERM) blended topographic survey data (Shuttle Radar Topography Mission (SRTM) and combined contour data);
- LiDAR data for current alignment (600 m wide corridor with a vertical accuracy of ±100 mm) provided by HCIPL;
- LiDAR data flown for BFS alignment (1600 m wide corridor with a vertical accuracy of ±500 mm) provided by HCIPL;
- LiDAR Flood Study data provided by HCIPL (vertical accuracy of ±500 mm);
- DERM streamgauge historical data;
- Bureau of Meteorology (BoM) Intensity-Frequency-Duration (IFD) regional data.

## 4.0 ABBREVIATIONS

| | |
|---|---|
| ACP | Alpha Coal Project |
| AEP | Average Exceedance Probability |
| AR&R | Australian Rainfall and Runoff |
| ARI | Average Recurrence Interval |
| BFS | Bankable Feasibility Study |
| BoM | Bureau of Meteorology |
| C&R | C and R Consulting |
| CatchSIM | Hydrologic catchment delineation program |
| CSP | Corrugated Steel Pipe |
| DERM | Department of Environment and Resource Management |
| EIS | Environmental Impact Statement |
| FFA | Flood Frequency Analysis |
| HCPL | Hancock Coal Pty Ltd |
| HCIPL | Hancock Coal Infrastructure Pty Ltd |
| IFD | Intensity-Frequency-Duration |
| LiDAR | Light Detection and Ranging |
| RORB | Rainfall and runoff routing program |
| SEIS | Supplementary Environmental Impact Statement |

| | |
|---|---|
| SRTM | Shuttle Radar Topography Mission |
| TOF | Top of Formation |

# 5.0 INTRODUCTION

The proposed rail alignment for the ACP currently crosses the Suttor-Eaglefield floodplain. The analysis was conducted for this system during the BFS and identified that further detailed hydraulic analysis was required due to the complex floodplain interaction that exists between the two systems. More accurate LiDAR survey along the alignment, Landholder consultation and extended historical stream gauge records were all incorporated into this study.

The primary output of the Detailed Floodplain Study is to provide detailed mapping of the pre- and post-development flood extents, inundation durations, flow velocities and afflux predictions for the Suttor-Eaglefield system. Of particular interest in this study is to assess the impacts that the proposed rail alignment would have on the landscape and surrounding properties.

## 5.1 Flood Plain Location and Description

The combined Suttor-Eaglefield system has a catchment area of 2,845 $km^2$ and forms a significant portion of the Suttor Sub-Basin (18,000 $km^2$) in the Burdekin River Catchment. The terrain is predominantly very flat with significant low-land flood plains and the land-use is dominated by grazing on natural pastures. The landscape is semi-arid with ephemeral streams that typically flow between December and April. The landscape is semi-arid with predominantly ephemeral streams (typically flow during the wet season between December and April).

A locality plan of the affected catchments that interface with the Alpha Coal Railway is illustrated in Figure 2 below.

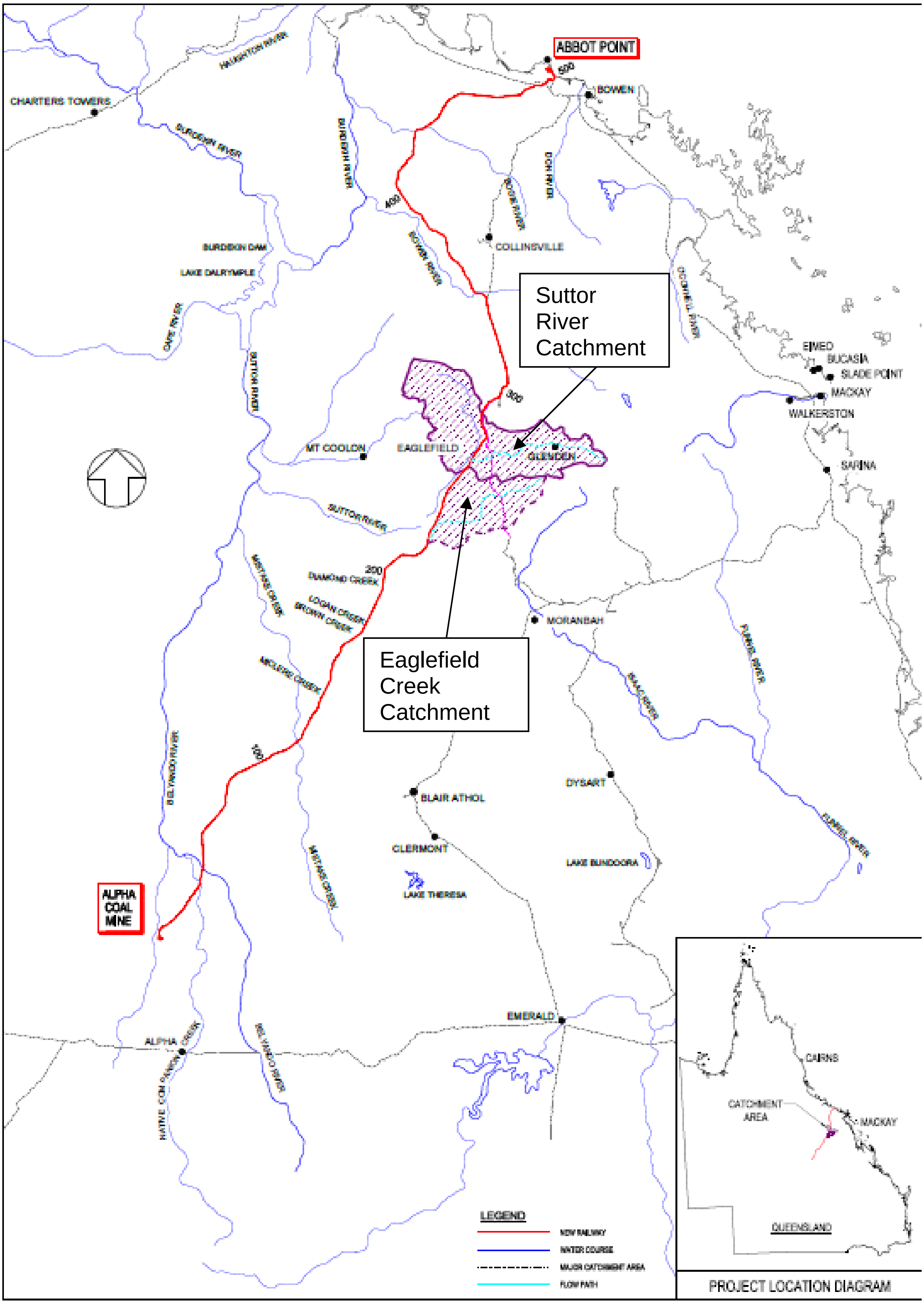



**Figure 2: Eaglefield Creek and Suttor River Catchments**

## 5.2 Suttor River

The Suttor River has a contributing catchment area of approximately 1959 km$^2$ at the start of the Eaglefield Creek and Suttor River floodplain (approximately Rail Chainage 240,000 m). This is also the location of the Suttor River streamgauge (120304A - Suttor River at Eaglefield). The catchment is undeveloped and consists of mostly pastoral land. The main channel is well defined and flows parallel to the proposed alignment for approximately 16 km before turning west and away from the railway. Under large events, the River breaks its banks and flows into the Suttor-Eaglefield floodplain. The confluence with Eaglefield Creek occurs approximately 16 km downstream from where Eaglefield Creek crosses the proposed ACP rail alignment (Rail Chainage 225,943 m).

Anecdotal evidence from landholders suggests that the river breaks out on a bend (located adjacent to Rail Chainage 236,800 m) under major flood events and flows across the floodplain, joining Eaglefield Creek. The hydraulic model developed as part of this detailed floodplain study is also representative of this landholder evidence.

## 5.3 Eaglefield Creek

The catchment area of Eaglefield Creek is 886 km$^2$ at the proposed ACP rail alignment interface (approximately Rail Chainage 226,000 m). The catchment is undeveloped and consists predominantly of pastoral land. The main channel is braided and has many tributaries upstream of the proposed railway. As such, during flood events, there is a significant interaction between the various tributaries and the surrounding Eaglefield floodplain. During major flood events in the Suttor River, a more complex interaction occurs in the Suttor-Eaglefield floodplain, where Eaglefield Creek receives inflows from the Suttor River.

# 6.0 COMMUNITY CONSULTATION

As part of the Detailed Floodplain Study, community consultation was undertaken to correlate the current modelling to the historical knowledge of stakeholders in relation to individual floodplains. The feedback received has been incorporated into the modelling.

# 7.0 BANKABLE FEASIBILITY STUDY (BFS)

Prior to this detailed floodplain analysis, Calibre undertook a BFS level design of all drainage structures on the proposed ACP rail alignment, details of which are summarised in the BFS Drainage Engineering Report (CJVP10007-REP-C-001 / HC-CRL-24100-RPT-0022). The design proposed in the BFS report was used as the basis for the analysis detailed in this study.

## 7.1 Design Criteria

The drainage design criteria approved by HCPL for the BFS are specified in Table 1 and Table 2.

**Table 1: General drainage design criteria**

| Design Aspect | Design Criteria |
|---|---|
| Culvert Classification | Major culverts: culvert locations with a 50 years ARI design flow ≥ 50 $m^3$/sec.<br>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.<br>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 with appropriate scour protection |
| 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)<br>CSP Culverts shall be provided with minimum 600 mm earthwork cover.<br>Min. diameter to be 900mm for engineering culverts. |
| 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 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 2: Bridge hydraulic 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.<br>Min. 300 mm to TOF (embankments and guide banks) for 50.<br>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 | 0.5 m with reduction at sensitive locations. |
| Guide banks | To be designed in accordance with AUSTROADS Waterway Design, 1994. |

## 7.2 Design Process

Hydrologic and hydraulic modelling was completed for all drainage structures along the ACP alignment during the BFS. For major crossings, design flows were estimated using either the rational method, a preliminary hydrologic model (CatchSim and RORB) or a Flood Frequency Analysis (FFA) where streamgauge data were available. Design flows were then selected based on the best information available at the time of the study and what method was considered most appropriate for the level of analysis required for the BFS.

These flows were then hydraulically modelled depending upon the proposed structure type:

- Culverts were analysed using HY-8 (a 1-D modelling program design for culvert analysis) and sizes were determined to ensure afflux was less than 1.5m or the equivalent to the upstream bridge water levels determined from bridge modelling.
- Bridges were assessed using Afflux (a 1-D bridge hydraulic modelling program) to determine span widths that allowed less than 1.5m of afflux (as per the original design criteria). Supplementary culverts for the bridge were sized if the proposed bridge structure was not able to pass flows within the allowable afflux limits.

This level of analysis was sufficient for the purposes of the BFS and were used as a basis for the Detailed Floodplain Study.

# 8.0 FLOOD PLAIN MODELLING DESIGN CRITERIA

The Supplementary Environmental Impact Statement (SEIS) was prepared after the conclusion of the BFS and this resulted in certain design criteria (from Table 1 and Table 2) being modified to meet stakeholder requirements. Table 3 shows the modified drainage design criteria adopted for the Detailed Floodplain Modelling.

**Table 3: SEIS Modified Drainage Design Criteria**

| Design Aspect | Design Criteria |
|---|---|
| Inundation Extent | Acceptable increases in inundation extent (above the existing conditions for a given return period to the 50 year ARI event) will be proposed where such an increase will not alter rural land use and result in significant impacts |
| Inundation Duration | Inundation duration not more than 3 days on valued pasture land that had previously been inundated for 3 days or less for similar rainfall events. |
| Max Velocity | Bridge outlet velocity = maximum of 1.2 x existing velocity at a distance equal to the bridge span downstream of bridge<br>Culverts outlet velocity<br>= 1.5 m/s where erodible soils are present<br>= 2.5 m/s for normal soils (with no erosion control) |
| Maximum afflux | Maximum 0.5 m – normally (unless justifiable)<br>Maximum 0.2m - around critical infrastructure<br>Maximum 0.1 m – around dwellings |

Unless specified in Table 3, the design criteria used for the detailed floodplain analysis are identified in Table 1 and Table 2.

# 9.0 DETAILED FLOODPLAIN ANALYSIS

## 9.1 Introduction

In order to assess the impacts that the proposed ACP rail alignment will have on the Eaglefield Creek-Suttor River floodplain, a detailed floodplain analysis was conducted on the system. This detailed analysis was then used to assess the adequacy of the proposed cross drainage structures determined from the BFS.

A detailed hydrologic analysis was completed for both systems and a combined hydraulic model that covers the area of interest within the floodplain was developed. The modelling results were then used to assess impacts on inundation extents, time of inundation, afflux and velocities as a result of the ACP railway. From the results of the hydraulic modelling, detailed flood mapping has been produced.

The following sections outline the methodology used to derive the required outputs for the Detailed Floodplain Study.

### 9.1.1 Hydrology

#### 9.1.1.1 Previous hydrology

During the BFS, the hydrology for the Suttor River was based off a Flood Frequency Analysis of the Suttor River stream gauge (120304A – Suttor River at Eaglefield). At the time of analysis, the gauge had 37 years of recorded data (daily streamflow readings from 1968 to 2005). The stream gauge location is shown in Figure 1.

Due to the similarities in the catchment characteristics between Eaglefield Creek and the Suttor River, a direct comparison was adopted for Eaglefield Creek from the Suttor River FFA. As the Suttor River has a larger catchment, the estimated 50 year ARI event flows were scaled via a catchment area ratio. This value was used for sizing of the cross drainage structures.

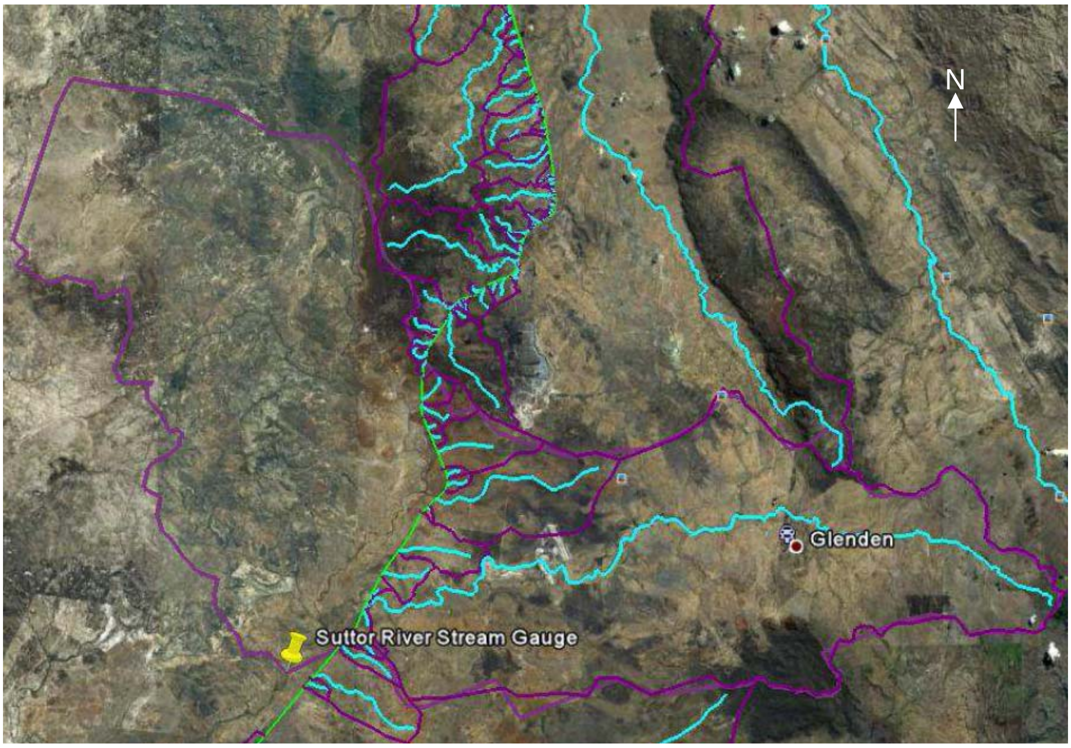



**Figure 1: Suttor River Stream Gauge at Eaglefield**

For full details on the BFS analysis, refer to the BFS Drainage Engineering Report (CJVP10007-REP-C-001 / HC-CRL-24100-RPT-0022).

#### 9.1.1.2 Additional Information

As a result of the additional flooding information that was obtained from landholder consultation and a floodplain field investigation (undertaken by C&R), a more holistic and representative modelling approach for the floodplain system was able to be generated.

This information contained more accurate details regarding the hydrologic parameters and existing system flooding behaviour. More accurate LiDAR survey along the rail corridor was also obtained for the detailed analysis. These data sets were all incorporated as additional design inputs.

The following additional data sets were made available for the Detailed Floodplain Study:

**Landholder Inputs**

Of key importance in this floodplain study was the identification of the break-out point of Suttor River into the Eaglefield Creek. From discussions with landholders, it was acknowledged that flows in Suttor River at the proposed rail alignment were minimal and could be attributed to local runoff only. From this it was determined that the majority of Suttor River flows into the Eaglefield Creek upstream of the ACP rail alignment.

#### Additional Survey

Additional LiDAR survey was obtained along the proposed rail alignment in a 600m wide corridor with a vertical accuracy of ±100 mm. Supplementary LiDAR survey was provided by HCIPL for the floodplain with a vertical accuracy of ±500 mm.

#### Additional Stream Gauge Data

For the BFS hydrologic analysis, stream gauge data up to 2005 was available for the analysis. At the time of the Detailed Floodplain Study, recorded data up until August 2011 was available. This additional recorded data included 3 of the wettest years on record. The inclusion of this data in the historical stream gauge statistical analysis had a significant effect on the predicted peak discharges.

### 9.1.1.3 Flood Frequency Analysis

A Flood Frequency Analysis was completed for the Suttor River stream gauge at Eaglefield based on the methods prescribed by Australian Rainfall and Runoff (AR&R). A summary of the data set obtained from the Department of Environment and Resource Management (DERM) online database is shown below in Table 4.

**Table 4: Suttor River gauge data**

| Catchment | DERM Stream Gauge | Years of Data | Start - Finish | Q50 ARI ($m^3/s$) |
|---|---|---|---|---|
| Suttor River (P5006A) | 120304A | 44 | 21/08/1967 – 10/03/2011* | 1883.9 |

* This corresponds to > 65,000 data points and includes the last significant rainfall of the season.

The stream gauge has a contributing catchment area of 1915 $km^2$.

An annual series based on water years (1 September to 30 August) was extracted from the daily data and analysed based on a Log-Pearson III probability distribution. The results are shown below in Figure 3.

The results of the FFA are contained in Appendix A.

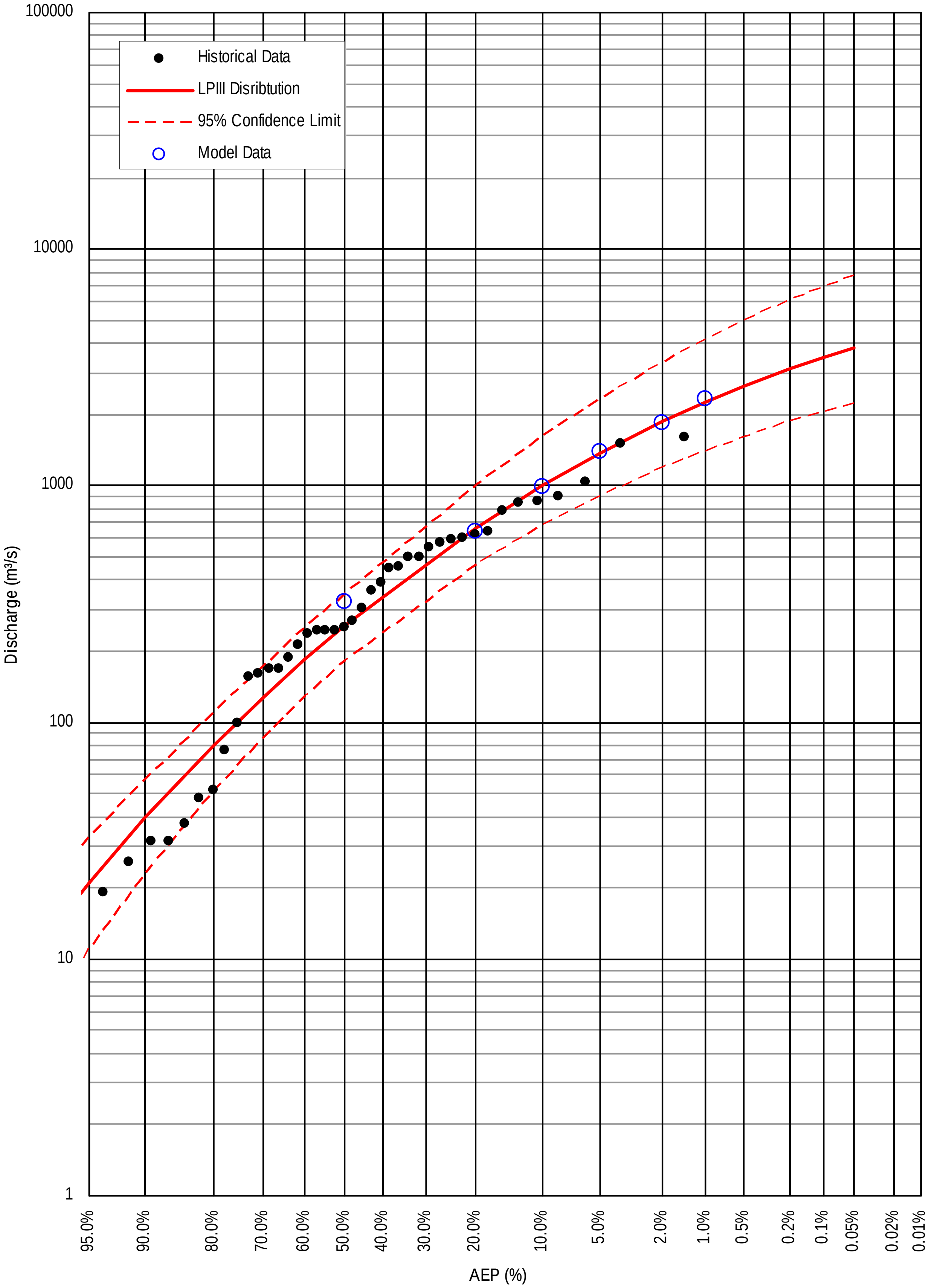



**Figure 3: Suttor River stream gauge FFA**

From the FFA, the design event flows shown in Table 5 have been derived:

**Table 5: Flood Frequency Analysis event analysis results**

| Event ARI (years) | Design discharge ($m^3/s$) | Upper confidence limit discharge ($m^3/s$) | Lower confidence limit discharge ($m^3/s$) |
|---|---|---|---|
| 100 | 2266.2 | 4215.8 | 1422.7 |
| 50 | 1883.9 | 3390.8 | 1207.5 |
| 20 | 1382.0 | 2358.6 | 915.1 |
| 10 | 1013.8 | 1646.0 | 691.1 |
| 5 | 665.2 | 1016.7 | 468.4 |

The contributing catchment area for both Suttor River and Eaglefield Creek were delineated using the GIS based terrain analysis software, CatchSim. A visual check was performed against the BFS delineated catchments, stream gauge catchment areas and SRTM contours to ensure the CatchSim delineation was accurate.

Both systems were delineated in CatchSim using the DERM SRTM survey data as this was deemed to have sufficient accuracy for the purposes of hydrologic analyses. Catchments were generated for both systems and exported into the rainfall-runoff routing program, RORB.

A summary of the catchment analysis for Suttor River and the Eaglefield Creek are shown below in Table 6 and Table 7.

**Table 6: Suttor River catchment properties**

| Item | Value |
|---|---|
| Catchment area | 1959 $km^2$ |
| $d_{av}$ | 57.67 km |

**Table 7: Eaglefield Creek catchment properties**

| Item | Value |
|---|---|
| Catchment area | 851.2 $km^2$ |
| $d_{av}$ | 36.87 km |

### Parameters

RORB model parameters were initially set to those recommended by AR&R for Queensland. These were then varied via a calibration exercise to achieve a best-fit for the particular catchment.

The initial parameters for the RORB model were set using the formulae outlined in AR&R guidelines for Queensland. These are shown below:

$k_c = 0.88\ A^{0.53}$ (Equation 9.1)

where A is the catchment area in square kilometres

$(k_c/d_{ave}) = -13.5\ m^3 + 45.8\ m^2 - 53\ m + 21.2$ (Equation 9.2)

where $d_{ave}$ is the average stream length from sub-catchment centroids to the catchment outlet

The RORB manual suggests that the $k_c$ parameter is better estimated using the following formula:

$k_c = 2.2\ (A^{0/5})\ (Q_p/2)^{(0.8-m)}$ (Equation 9.3)

where $Q_p$ is the predicted peak discharge

Using the above formula as recommended by AR&R, initial catchment parameters for Suttor River and Eaglefield Creek were calculated and are shown in Table 8 and Table 9 with initial and continuing loss estimation shown in Table 10.

**Table 8: Suttor River initial RORB parameters**

| Item | Value |
|---|---|
| $k_c$ | 48.89 |
| m | 0.876 |

**Table 9: Eaglefield Creek initial RORB parameters**

| Item | Value |
|---|---|
| $k_c$ | 22.0 |
| m | 0.876 |

**Table 10: Initial and continuing loss estimation**

| Event ARI (years) | Initial loss (mm) | Continuing loss (mm/hr) |
|---|---|---|
| 100 | 10 | 2.5 |
| 50 | 15 | 2.5 |
| 20 | 15 | 2.5 |
| 10 | 20 | 2.5 |
| 5 | 25 | 2.5 |

### Calibration

As Suttor River has a stream gauge upstream of the proposed ACP alignment, a hydrologic calibration was able to be performed. Using the RORB model generated for the system and the adopted initial parameters as described previous, initial loss and $k_c$ values were adjusted to achieve a best-fit for the 5, 10, 20, 50 and 100 year ARI events at the gauging station node against the stream gauge FFA. These calibrated values are shown below in Table 11 and Table 12.

**Table 11: Suttor River calibrated RORB parameters**

| Item | Value |
|---|---|
| $k_c$ (calibrated) | 22.0 |
| M | 0.876 |

**Table 12: Suttor River calibrated losses**

| Event ARI (years) | Initial loss (mm) | Continuing loss (mm/hr) |
|---|---|---|
| 100 | 10 | 2.5 |
| 50 | 15 | 2.5 |
| 20 | 15 | 2.5 |
| 10 | 20 | 2.5 |
| 5 | 25 | 2.5 |

A good calibration was achieved for the 50 year ARI event (design event) with the FFA predicted a peak flow of 1884 $m^3$ and the RORB model estimating 1849 $m^3/s$. A results comparison between the calibrated RORB model and the FFA estimates are shown below in Table 13.

**Table 13: Calibration results at Suttor stream gauge**

| Event ARI (years) | FFA estimate ($m^3/s$) | RORB estimate ($m^3/s$) |
|---|---|---|
| 100 | 2266.2 | 2316 |
| 50 | 1884 | 1849 |
| 20 | 1382 | 1399 |
| 10 | 1013.8 | 985 |
| 5 | 665.2 | 641 |

The peak discharges extracted from the RORB model have been plotted (blue circles) on the FFA provided in Figure 3.

The calibrated parameters in Table 11 and Table 12 were also used for the Eaglefield Creek system due to their similar catchment characteristics and close proximity.

### Results

The results extracted from the hydrologic modelling for Eaglefield Creek and Suttor River systems at the ACP rail interface are shown below:

**Table 14: Suttor and Eaglefield peak storm durations**

| Event ARI (years) | Peak discharge storm duration (hours) |
|---|---|
| 100 | 12 |
| 50 | 12 |
| 5 | 18 |

**Table 15: Suttor River predicted peak discharges**

| Event ARI (years) | Peak predicted discharge ($m^3/s$) |
|---|---|
| 100 | 2316.1 |
| 50 | 1849.0 |
| 5 | 641.1 |

**Table 16: Eaglefield Creek inflow (1.06) predicted peak discharges**

| Event ARI (years) | Peak predicted discharge ($m^3/s$) |
|---|---|
| 100 | 1438.2 |
| 50 | 1152.0 |
| 5 | 418.8 |

**Table 17: Eaglefield Creek source point (6.01) predicted peak discharges**

| Event ARI (years) | Peak predicted discharge ($m^3/s$) |
|---|---|
| 100 | 479.9 |
| 50 | 387.4 |
| 5 | 150.4 |

**Table 18: Eaglefield Creek tributary (9.01) predicted peak discharges**

| Event ARI (years) | Peak predicted discharge ($m^3/s$) |
|---|---|
| 100 | 133.0 |
| 50 | 107.7 |
| 5 | 29.3 |

Please refer to Figure 4 (Hydraulic Model Extent) for the location of points 1.06, 6.01 and 9.01 referenced in Tables 16, 17 and 18.

Full hydrographs have been extracted from the RORB model for the 5, 10, 20, 50 and 100 year ARI events are provided in Appendix B. The predicted peak discharges for both systems were then used as inflows into the Eaglefield Creek and Suttor River floodplain hydraulic model as described in Section 9.1.2.

### 9.1.2 Hydraulic Modelling

It had been identified during the BFS that the Suttor River and Eaglefield Creek systems had a complex floodplain interaction that occurred along the alignment of the proposed ACP railway. In order to accurately assess this interaction, a full hydrodynamic 2-D model was generated using the software package MIKE Flood. The advantage of using MIKE Flood is the program's 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.

The following section outlines the process used to generate the 2-D model, sensitivity analyses conducted and modelling results.

#### 9.1.2.1 MIKE Flood Model

**Bathymetry**

The hydraulic model required a significant model domain in order to adequately capture the upstream breakout points of Suttor River into the Eaglefield Creek and be sufficiently downstream to reduce the effects of the downstream boundary. This resulted in a bathymetry of 1416 x 805 cells at a grid cell size of 20 m x 20 m (model area of 455 $km^2$). The final bathymetry used for the pre- and post-development cases is shown below in Figure 4.

The bathymetry was generated from a combination of LiDAR sources (Flood study LiDAR, BFS LiDAR and current alignment LiDAR) and covers all of the area of interest around the proposed ACP railway. When combining the LiDAR data sets, the survey with the highest accuracy was used as a priority over the other data sets.

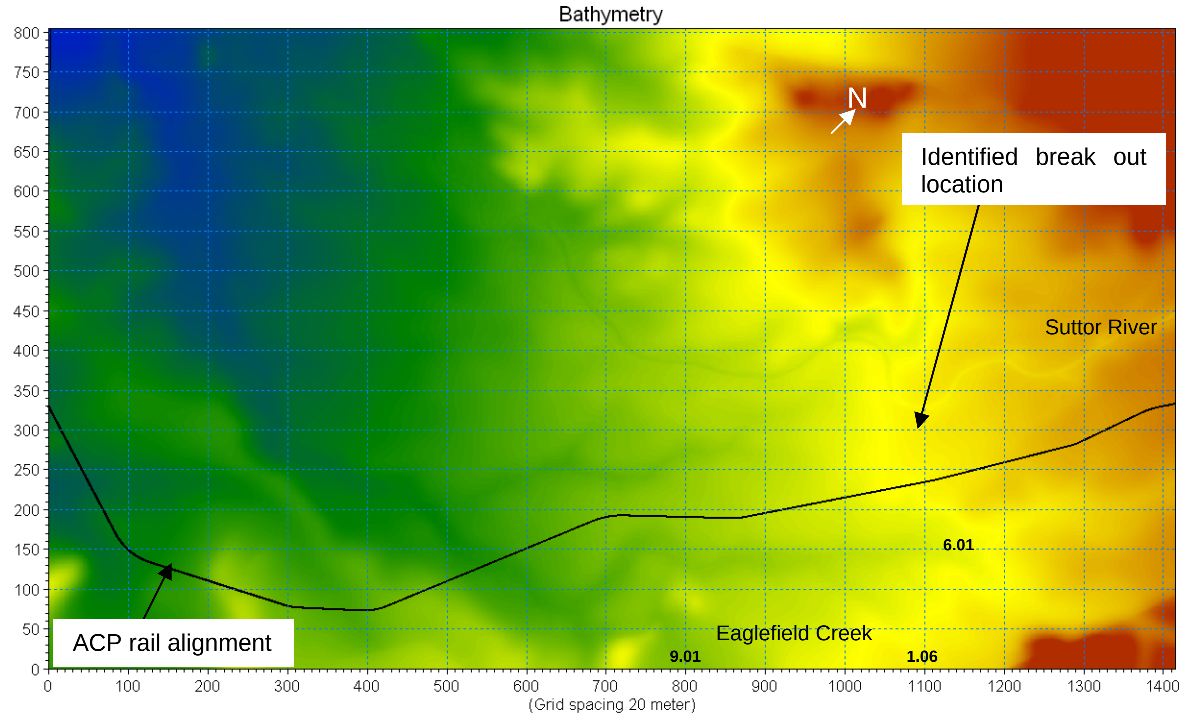



**Figure 4: Hydraulic model extent**

## Boundary conditions

Eaglefield Creek and Suttor River inflow hydrographs were input into the model over an appropriate width to ensure minimal dispersion of flows laterally during peak hydrograph inflows. The downstream boundary condition was set using a combined flow value for the system and a rating curve (discharge-height relationship) generated from the downstream cross section and average stream slope.

Initial water surface levels from the downstream boundary condition were projected back upstream to account for the loss of storage due to tailwater affects. The selection of downstream boundary levels was subject to sensitivity testing as outlined in Section 9.1.3.

## Roughness coefficients

The Eaglefield Creek and Suttor River systems have two distinct types of roughness: a relatively smooth and well defined flow path for the main conveyance channels and a rough, low velocity, low water depth floodplain. As such, two Manning's values were adopted for this Detailed Floodplain Study:

- Channel: n = 0.04
- Floodplain: n = 0.1

In order to easily and accurately define the two separate roughness areas, 5 year ARI event flows were halved and input into the hydraulic model (to simulate a bank-full stream event). Where depths exceeded 0.2 m and velocities above approximately 0.15 m/s, a roughness value attributed to a channel was assigned. The remaining model domain was set to a roughness equivalent to floodplain. The adopted values are shown in Figure 5. . The selection of roughness values was subject to sensitivity testing as outlined in Section 9.1.3.

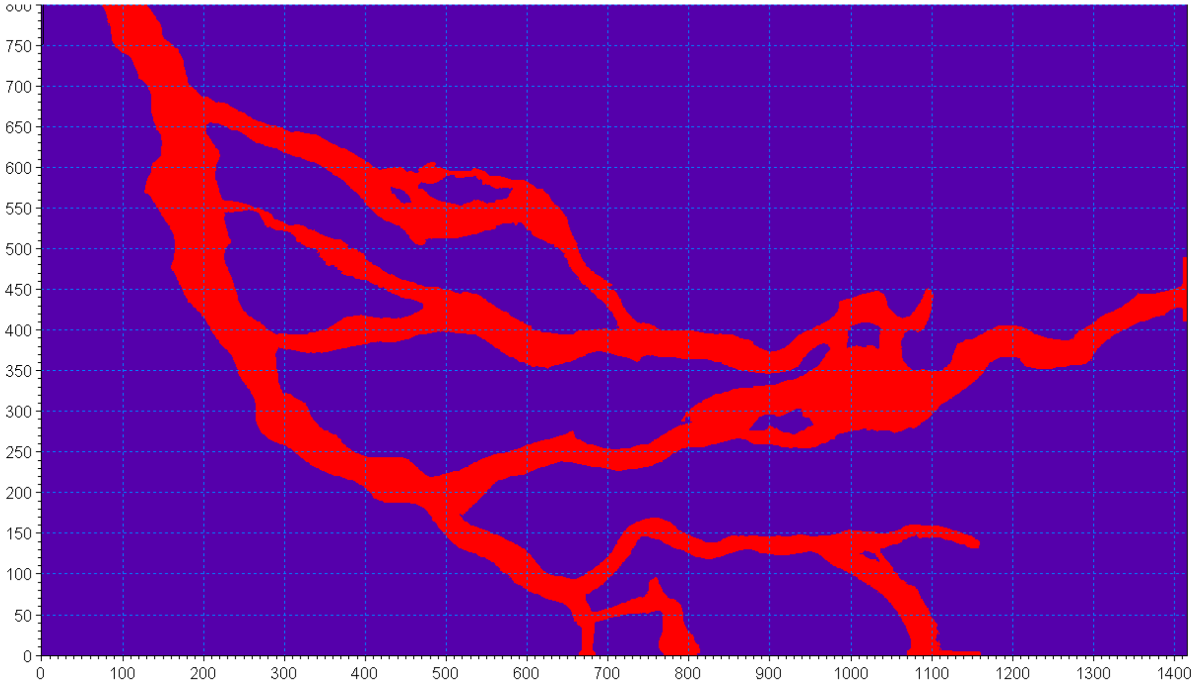



**Figure 5: Manning's roughness**

### MIKE Flood coupling

The MIKE Flood modelling package allows for the input of 1-D modelling elements (MIKE11) within the 2-D model domain (MIKE21). These links are known as 'couples' and are shown in Figure 6. For this Detailed Floodplain Study, bridges and culverts have been input into the model as 1-D elements to accurately assess the headloss through cross drainage structures. All structures have been modelled implicitly with standard MIKE11 variables.

In order to maintain inundation extents post-development and as specified in the BFS, floodplain relief culverts are proposed for the Eaglefield Creek and Suttor River System at 50m spacing. These relief culverts consist of 900mm diameter Corrugated Steel Pipes (CSP). Through sensitivity testing it was determined that in order to minimise geometric grid scale problems and minimising the required number of couples within the model, it was feasible to group 5 floodplain relief culverts from adjacent 2-D grid cells. This resulted in a grouping a 5 / 900 mm CSP every 250m within the model.

Flows through the floodplain relief culverts in MIKE Flood was verified against a 1-D model of a single 900 mm diameter CSP using the HY-8 modelling package.

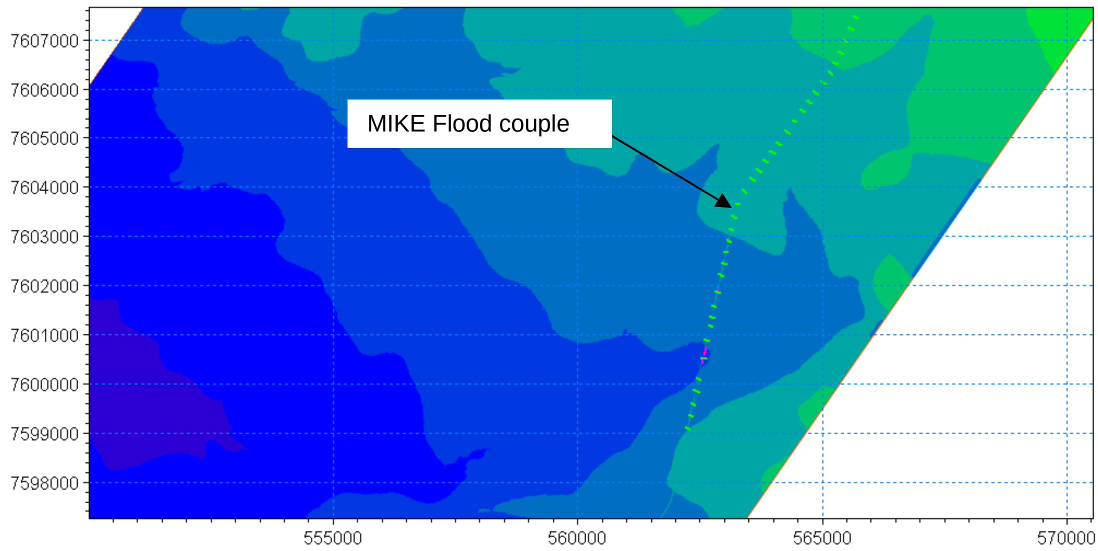



**Figure 6: MIKE Flood couple locations**

In addition to the floodplain relief culverts, the BFS proposed a single bank of 59 / 2700 mm CSPs for the Eaglefield Creek crossing. These were also inserted as a couple into the MIKE Flood model.

### 9.1.3 Sensitivity Testing

Due to the lack of calibration data available for the hydraulic model, a sensitivity range of ± 30% on Roughness values, inflow hydrographs and downstream boundary water levels was tested. Sensitivity testing was undertaken for the 50 year ARI event and for the pre-development case only at locations shown in Figure 7.

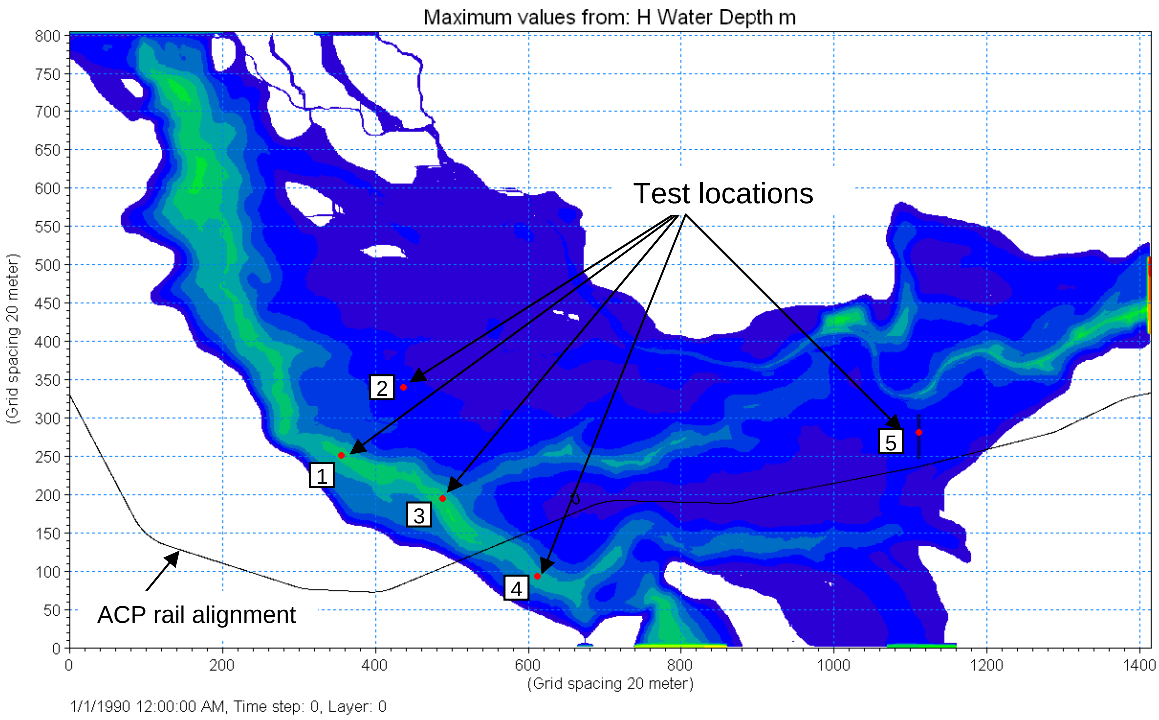



**Figure 7: Sensitivity testing locations**

Five locations were selected both upstream and downstream of the proposed railway alignment and included main channel and floodplain locations in order to assess the sensitivity of certain parameters on the predicted water levels and velocities.

### Manning's values

The value of Manning's' 'M' (M=1/n) was adjusted by ±30% to assess the impacts of this parameter on the predicted maximum inundation depths and velocities at the locations shown in Figure 4.

**Table 19: Manning's 'M' value sensitivity (depth)**

| Location | Adopted value (m) | +30% value | Change (m) | -30% value | Change (m) |
|---|---|---|---|---|---|
| 1 | 2.501 | 2.326 | -0.175 | 2.731 | 0.230 |
| 2 | 0.410 | 0.298 | -0.112 | 0.588 | 0.178 |
| 3 | 2.551 | 2.361 | -0.190 | 2.809 | 0.258 |
| 4 | 2.038 | 1.844 | -0.194 | 2.314 | 0.276 |
| 5 | 0.534 | 0.444 | -0.090 | 0.674 | 0.140 |

The Manning's value has an impact ranging from -200 mm to +300 mm on the predicted water surface level. This has an equivalent inundation extent impact of -2.9% and +3.7%, which is a relatively minor impact on the predicted extents.

At the same testing locations, the peak velocities were also extracted. From Table 20, it can be seen that there is an equivalent change in velocity as per the change in Manning's percentage. However the flow velocity change is small and remains in the same order of magnitude as the adopted existing case.

**Table 20: Manning's 'M' value sensitivity (velocity)**

| Location | Adopted value (m/s) | +30% value | Change (%) | -30% value | Change (%) |
|---|---|---|---|---|---|
| 1 | 1.229 | 1.497 | 21.8 | 0.931 | -24.2 |
| 2 | 0.209 | 0.222 | 6.2 | 0.185 | -11.5 |
| 3 | 1.153 | 1.386 | 20.2 | 0.883 | -23.4 |
| 4 | 1.140 | 1.390 | 21.9 | 0.876 | -23.2 |
| 5 | 0.230 | 0.265 | 15.2 | 0.189 | -17.8 |

### Inflow hydrographs

The inflow values were adjusted by ±30% to assess the impacts of this parameter on the predicted maximum inundation depths at the locations shown in Table 21.

**Table 21: Inflow hydrograph sensitivity**

| Location | Adopted value (m) | +30% value | Change (m) | -30% value | Change (m) |
|---|---|---|---|---|---|
| 1 | 2.501 | 2.771 | 0.270 | 2.189 | -0.312 |
| 2 | 0.410 | 0.622 | 0.212 | 0.223 | -0.187 |
| 3 | 2.551 | 2.855 | 0.304 | 2.202 | -0.349 |
| 4 | 2.038 | 2.325 | 0.287 | 1.727 | -0.311 |
| 5 | 0.534 | 0.644 | 0.110 | 0.404 | -0.130 |

The inflow values have an impact ranging from -350 mm to +310 mm on the predicted water surface level. This has an equivalent inundation extent impact of -5.4% and +4.1%, which is a relatively minor impact on the predicted extents.

### Downstream boundary

The downstream boundary water surface levels were adjusted by ±30% to assess the impacts of this parameter on the predicted maximum inundation depths at the locations shown in Table 22.

**Table 22: Downstream boundary sensitivity**

| Location | Adopted value (m) | +30% value | Change (m) | -30% value | Change (m) |
|---|---|---|---|---|---|
| 1 | 2.501 | 2.501 | 0 | 2.501 | 0 |
| 2 | 0.410 | 0.410 | 0 | 0.410 | 0 |
| 3 | 2.551 | 2.551 | 0 | 2.551 | 0 |
| 4 | 2.038 | 2.038 | 0 | 2.038 | 0 |
| 5 | 0.534 | 0.534 | 0 | 0.534 | 0 |

The downstream boundary level has no impact on the predicted water surface level at the points of interest.

The sensitivity analysis has shown that the magnitude of the hydraulic model inflows has the most significant impact on the predicted water surface levels within the 2-D model. Although the relative change in level is high when compared to the predicted water depth, the change in inundation extent is minimal.

Conservative values for all variables have been adopted as part of this study. It is considered that the outcomes of the study are adequate without hydraulic model calibration and are conservative in nature.

## 9.2 Floodplain Drainage Structure Recommendations

As discussed in previous sections, with the additional data received and incorporated as part of the Detailed Floodplain Study, additional analysis was required on the proposed BFS cross drainage infrastructure in order to demonstrate that the impacts of the proposed ACP rail alignment could be mitigated to levels that comply with the EIS and SEIS.

A preliminary HEC-RAS 1-D model for the rail crossing was generated to assess the additional cross drainage infrastructure requirements. For Eaglefield Creek, an additional 69 / 2700 mm diameter CSPs were required in order to achieve the predicted headloss of 0.5 m. This increased the proposed cross drainage infrastructure to 128 / 2700 mm diameter CSPs at Eaglefield Creek.

## 9.3 Results

Following the collation of information received from landholders during the consultation process, the findings from this Detailed Floodplain Study have been presented to specific landowners who have an interest in and/or are influenced by the proposed Alpha Coal rail alignment and its impact on the Suttor River / Eaglefield Creek floodplain system.

Feedback from landowners though continued consultation has shown the pre-development flood modelling correlates well with what has been observed on site during major flood events. The post-development models utilise the same hydrologic parameters and same hydraulic modelling methods as the pre-development models to ensure consistency. Preliminary drainage structures have been modelled in the post-development case to conform to the SEIS requirements.

Peak floodplain inundation depths, water surface elevations, velocities and inundation extents have all been plotted and are shown in Appendix C.

Drawings include:

- Inundation extents
  - 5, 50 and 100 year ARI events pre- and post-development.
- Inundation depths
  - 50 year ARI event post-development.
- Water surface elevations
  - 50 year ARI event post-development.
- Velocity profiles
  - 50 year ARI event post-development.
- Afflux
  - 50 year ARI event.

A summary of the findings from the Detailed Floodplain Study compared to the SEIS drainage criteria is shown in Table 23.

**Table 23: Results Summary**

| Design Aspect | SEIS Design Criteria | Result Summary |
|---|---|---|
| Inundation Extent | Acceptable increases in inundation extent (above the existing conditions for a given return period to the 50 year ARI event) will be proposed where such an increase will not alter rural land use and result in significant impacts | Conforms to SEIS requirements. There is an overall increase of 0.2% in inundation extent of the modelled area during the design flood event. |
| Inundation Duration | Inundation duration not more than 3 days on valued pasture land that had previously been inundated for 3 days or less for similar rainfall events. | Conforms to SEIS requirements. |
| Max Velocity | Bridge outlet velocity = maximum of 1.2 x existing velocity at a distance equal to the bridge span downstream of bridge<br>Culverts outlet velocity:<br>= 1.5 m/s where erodible soils are present<br>= 2.5 m/s for normal soils (with no erosion control) | Conforms to SEIS requirements.<br>Refer Velocity drawing in Appendix C for details. |
| Maximum afflux | Maximum 0.5 m – normally (unless justifiable)<br>Maximum 0.2m – around critical infrastructure<br>Maximum 0.1 m – around dwellings | Conforms to SEIS requirements.<br>Refer Afflux drawing in Appendix C for details. |

Further to the above table, results show that there is a minimal change in overall inundation extents due to the current alignment and proposed floodplain drainage structures. This is shown below in Table 23.

**Table 23: Change in inundation extents**

| Event ARI (years) | % change in "wet" cells | Change in area (ha) |
|---|---|---|
| 5 | -0.68 | 92.4 |
| 50 | -0.21 | 39.6 |

With the inclusion of additional cross drainage structures, the proposed ACP rail alignment will meet the afflux limits specified in the SEIS with minor localised areas of inundation exceeding 0.5 m; with these areas being small in extent, localised to areas adjacent to the alignment and have no impact upon existing infrastructure, inundation times and velocities. Afflux and velocity results for the nominated design criteria post-development meet the requirements of the SEIS and stakeholder requirements. Results are shown in Appendix B.

One of the primary concerns of landholders from the EIS and during the consultation process is related to the change in duration of inundation due to the development of the Alpha Coal rail alignment.

Detailed 2-D modelling with time-step analysis on areas of interest reports that inundation duration has been maintained across the floodplain to the requirements of the SEIS ie; inundation duration of not more than 3 days on valued pasture land that had previously been inundated for 3 days or less for similar rainfall events.

# 10.0 CONCLUSION

Detailed hydrologic and hydraulic modelling has been completed for Eaglefield Creek and Suttor River floodplain at the proposed ACP rail alignment. It has been shown that the proposed railway can mitigate its hydraulic impacts to the criteria outlined in the SEIS. The recommended cross drainage structures for Suttor River and Eaglefield Creek are shown below. Alternative drainage structures may be utilised providing equivalent hydraulic performance is maintained or improved.

**Table 25: Eaglefield Creek**

| Item | Value |
|---|---|
| Proposed cross drainage infrastructure | 128/ 2700mm diameter CSPs |

**Table 26: Floodplain relief culverts**

| Item | Value |
|---|---|
| Proposed cross drainage infrastructure | 900mm diameter CSP at 50m spacing in the floodplain |

The findings can be further optimised when further hydraulic analysis is undertaken during the Detailed Design phase of the project.

# APPENDIX A
# FFA ANALYSIS

# Suttor River Flood Frequency Analysis

| | | | | | |
|---|---|---|---|---|---|
| Client: | Hancock coal | | | Date: | 17/8/2011 |
| Project/Job: | ACP | Job No: | | Sheet No: | |
| Subject: | **FFA Suttor River** | | | By: | ARB |

## *HISTORICAL DATA*

| | | | |
|---|---|---|---|
| Sample Period (Years) | 43 | Adjusted Mean, *M* | 2.343 |
| Number of Samples to Use, *N* | 43 | Adjusted Std Deviation, *S* | 0.560 |
| Plotting Position Parameter, α | 0.4 | Coefficient of Skewness, *g* | -0.698 |

| **Rank** | **Discharge ($m^3/s$)** | $P_N$ **AEP** | $Y_P$ **ARI** | **Plotting Position** | ∑Log(*Q*) | ∑Log(*Q*)² | ∑Log(*Q*)³ |
|---|---|---|---|---|---|---|---|
| 1 | 1596.518 | 1.4% | 72.00 | 2.200 | 3.203 | 10.260 | 32.866 |
| 2 | 1504.865 | 3.7% | 27.00 | 1.786 | 6.381 | 20.357 | 64.947 |
| 3 | 1040.456 | 6.0% | 16.62 | 1.553 | 9.398 | 29.460 | 92.415 |
| 4 | 904.871 | 8.3% | 12.00 | 1.383 | 12.354 | 38.202 | 118.260 |
| 5 | 859.556 | 10.6% | 9.39 | 1.245 | 15.289 | 46.812 | 143.524 |
| 6 | 846.962 | 13.0% | 7.71 | 1.128 | 18.217 | 55.384 | 168.622 |
| 7 | 779.089 | 15.3% | 6.55 | 1.025 | 21.108 | 63.745 | 192.800 |
| 8 | 636.385 | 17.6% | 5.68 | 0.931 | 23.912 | 71.606 | 214.839 |
| 9 | 622.541 | 19.9% | 5.02 | 0.845 | 26.706 | 79.414 | 236.654 |
| 10 | 607.064 | 22.2% | 4.50 | 0.765 | 29.489 | 87.160 | 258.215 |
| 11 | 592.577 | 24.5% | 4.08 | 0.689 | 32.262 | 94.848 | 279.532 |
| 12 | 571.647 | 26.9% | 3.72 | 0.617 | 35.019 | 102.450 | 300.491 |
| 13 | 552.578 | 29.2% | 3.43 | 0.549 | 37.762 | 109.971 | 321.115 |
| 14 | 503.965 | 31.5% | 3.18 | 0.482 | 40.464 | 117.274 | 340.851 |
| 15 | 499.668 | 33.8% | 2.96 | 0.418 | 43.163 | 124.557 | 360.505 |
| 16 | 454.563 | 36.1% | 2.77 | 0.355 | 45.820 | 131.619 | 379.275 |
| 17 | 448.964 | 38.4% | 2.60 | 0.294 | 48.472 | 138.654 | 397.932 |
| 18 | 389.558 | 40.7% | 2.45 | 0.234 | 51.063 | 145.365 | 415.317 |
| 19 | 358.729 | 43.1% | 2.32 | 0.175 | 53.618 | 151.891 | 431.992 |
| 20 | 303.741 | 45.4% | 2.20 | 0.116 | 56.100 | 158.054 | 447.291 |
| 21 | 268.541 | 47.7% | 2.10 | 0.058 | 58.529 | 163.954 | 461.622 |
| 22 | 252.491 | 50.0% | 2.00 | 0.000 | 60.932 | 169.725 | 475.485 |
| 23 | 245.991 | 52.3% | 1.91 | -0.058 | 63.323 | 175.442 | 489.153 |
| 24 | 244.109 | 54.6% | 1.83 | -0.116 | 65.710 | 181.142 | 502.763 |
| 25 | 242.864 | 56.9% | 1.76 | -0.175 | 68.095 | 186.832 | 516.336 |
| 26 | 235.769 | 59.3% | 1.69 | -0.234 | 70.468 | 192.461 | 529.690 |
| 27 | 214.132 | 61.6% | 1.62 | -0.294 | 72.799 | 197.893 | 542.350 |
| 28 | 188.722 | 63.9% | 1.57 | -0.355 | 75.074 | 203.072 | 554.138 |
| 29 | 169.384 | 66.2% | 1.51 | -0.418 | 77.303 | 208.040 | 565.210 |
| 30 | 167.561 | 68.5% | 1.46 | -0.482 | 79.527 | 212.987 | 576.213 |
| 31 | 159.958 | 70.8% | 1.41 | -0.549 | 81.731 | 217.845 | 586.920 |
| 32 | 155.262 | 73.1% | 1.37 | -0.617 | 83.923 | 222.646 | 597.438 |
| 33 | 99.565 | 75.5% | 1.33 | -0.689 | 85.921 | 226.638 | 605.416 |
| 34 | 76.366 | 77.8% | 1.29 | -0.765 | 87.804 | 230.183 | 612.091 |
| 35 | 51.655 | 80.1% | 1.25 | -0.845 | 89.517 | 233.118 | 617.119 |
| 36 | 48.234 | 82.4% | 1.21 | -0.931 | 91.200 | 235.952 | 621.889 |
| 37 | 37.313 | 84.7% | 1.18 | -1.025 | 92.772 | 238.422 | 625.772 |
| 38 | 31.571 | 87.0% | 1.15 | -1.128 | 94.271 | 240.670 | 629.143 |
| 39 | 31.373 | 89.4% | 1.12 | -1.245 | 95.768 | 242.910 | 632.494 |
| 40 | 25.696 | 91.7% | 1.09 | -1.383 | 97.178 | 244.898 | 635.297 |
| 41 | 19.094 | 94.0% | 1.06 | -1.553 | 98.458 | 246.538 | 637.398 |
| 42 | 16.594 | 96.3% | 1.04 | -1.786 | 99.678 | 248.027 | 639.214 |
| 43 | 11.376 | 98.6% | 1.01 | -2.200 | 100.734 | 249.142 | 640.392 |
| 44 | 1.643 | 100.9% | 0.99 | #N/A | 100.950 | 249.188 | 640.402 |

| | | | |
|---|---|---|---|
| Client: Hancock coal | | Date: | 17/8/2011 |
| Project/Job: ACP | Job No: | Sheet No: | |
| Subject: **FFA Suttor River** | | By: | ARB |

## LOG-PEARSON III DISTRIBUTION

| | | |
|---|---|---|
| Mean Override, *M* | 2.343 | 2.343 |
| Std Deviation Override, *S* | 0.56 | 0.560 |
| Skewness Override, *g* | -0.698 | -0.698 |

## Gridline Data

| | Min | Max |
|---|---|---|
| Discharge (r | 1 | 100000 |
| AEP | 0.95 | 0.0001 |
| | -1.645 | 3.719 |

| $Y_P$ ARI | $P_N$ AEP | LPIII Discharge | LPIII Confidence Limit Lower | Upper | Plotting Position | Frequency Factor |
|---|---|---|---|---|---|---|
| 2000 | 0.05% | 3837.1 | 2261.8 | 7873.5 | 3.291 | 2.216 |
| 1000 | 0.1% | 3492.2 | 2082.6 | 7038.7 | 3.090 | 2.143 |
| 500 | 0.2% | 3134.5 | 1894.1 | 6190.2 | 2.878 | 2.059 |
| 200 | 0.5% | 2645.2 | 1631.1 | 5061.6 | 2.576 | 1.928 |
| 100 | 1.0% | 2266.2 | 1422.7 | 4215.8 | 2.326 | 1.808 |
| 50 | 2.0% | 1883.9 | 1207.5 | 3390.8 | 2.054 | 1.664 |
| 20 | 5.0% | 1382.0 | 915.1 | 2358.6 | 1.645 | 1.424 |
| 10 | 10.0% | 1013.8 | 691.1 | 1646.0 | 1.282 | 1.184 |
| 5 | 20.0% | 665.2 | 468.4 | 1016.7 | 0.842 | 0.857 |
| 2 | 50.0% | 255.7 | 184.7 | 357.4 | 0.000 | 0.115 |
| 1.667 | 60.0% | 184.1 | 131.5 | 254.6 | -0.253 | -0.139 |
| 1.429 | 70.0% | 126.7 | 88.2 | 175.6 | -0.524 | -0.429 |
| 1.250 | 80.0% | 79.5 | 52.6 | 112.3 | -0.842 | -0.790 |
| 1.111 | 90.0% | 39.5 | 23.6 | 59.0 | -1.282 | -1.333 |
| 1.053 | 95.0% | 21.1 | 11.3 | 33.7 | -1.645 | -1.818 |
| 1.010 | 99.0% | 5.8 | 2.4 | 10.9 | -2.326 | -2.822 |

## HYDROLOGIC MODEL DATA

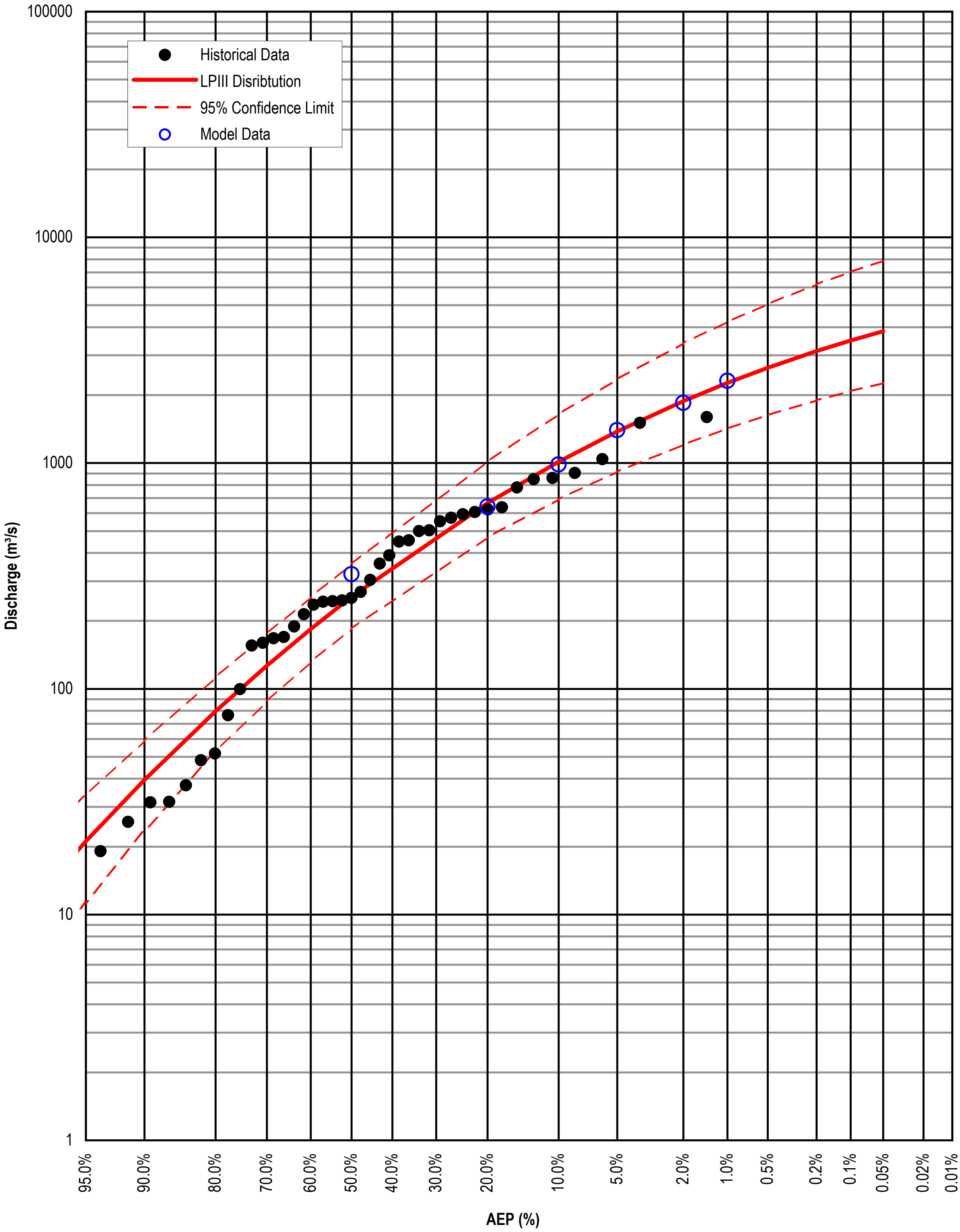
| ARI | AEP | Discharge | Position |
|---|---|---|---|
| 2000 | 0.0005 | | 3.291 |
| 1000 | 0.001 | | 3.090 |
| 500 | 0.002 | | 2.878 |
| 200 | 0.005 | | 2.576 |
| 100 | 0.01 | 2316 | 2.326 |
| 50 | 0.02 | 1849 | 2.054 |
| 20 | 0.05 | 1399 | 1.645 |
| 10 | 0.1 | 985 | 1.282 |
| 5 | 0.2 | 641 | 0.842 |
| 2 | 0.5 | 322 | 0.000 |

| |
|---|
| 2414 |
| 1886 |
| 1384 |
| 727 |
| 548 |
| 264 |

| | | | | | |
|---|---|---|---|---|---|
| Client: | Hancock coal | | | Date: | 17/8/2011 |
| Project/Job: | ACP | Job No: | | Sheet No: | |
| Subject: | **FFA Suttor River** | | | By: | ARB |

| | |
|---|---|
| Sample Period (Years) | 43 |
| Number of Samples Used, *N* | 43 |
| Plotting Position Parameter, α | 0.4 |

| | |
|---|---|
| Adjusted Mean, *M* | 2.343 |
| Adjusted Std Deviation, *S* | 0.560 |
| Coefficient of Skewness, *g* | -0.698 |



1

# 0.( # # # 99.999%
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# 0.: # # # 99.5%
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# 1.( # # # 99.0%
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# 2.( # # # 98.0%
# # #

# 5.( # # # 95.0%
# # #

# 1( # # # 90.0%
# # #

# 2( # # # 80.0%
# # #

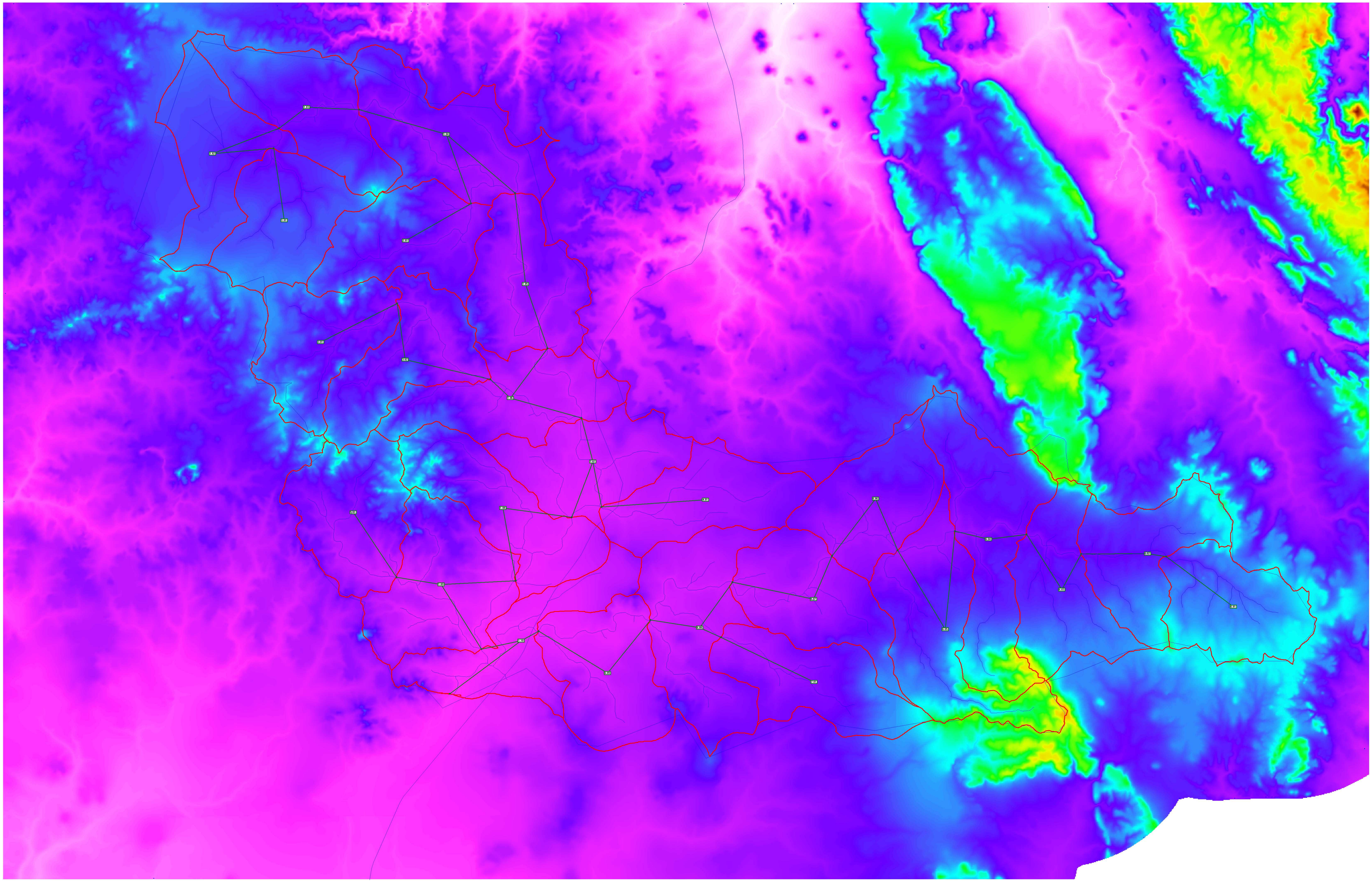
# 3( # # # 70.0%
# # #

# 4( # # # 60.0%
# # #

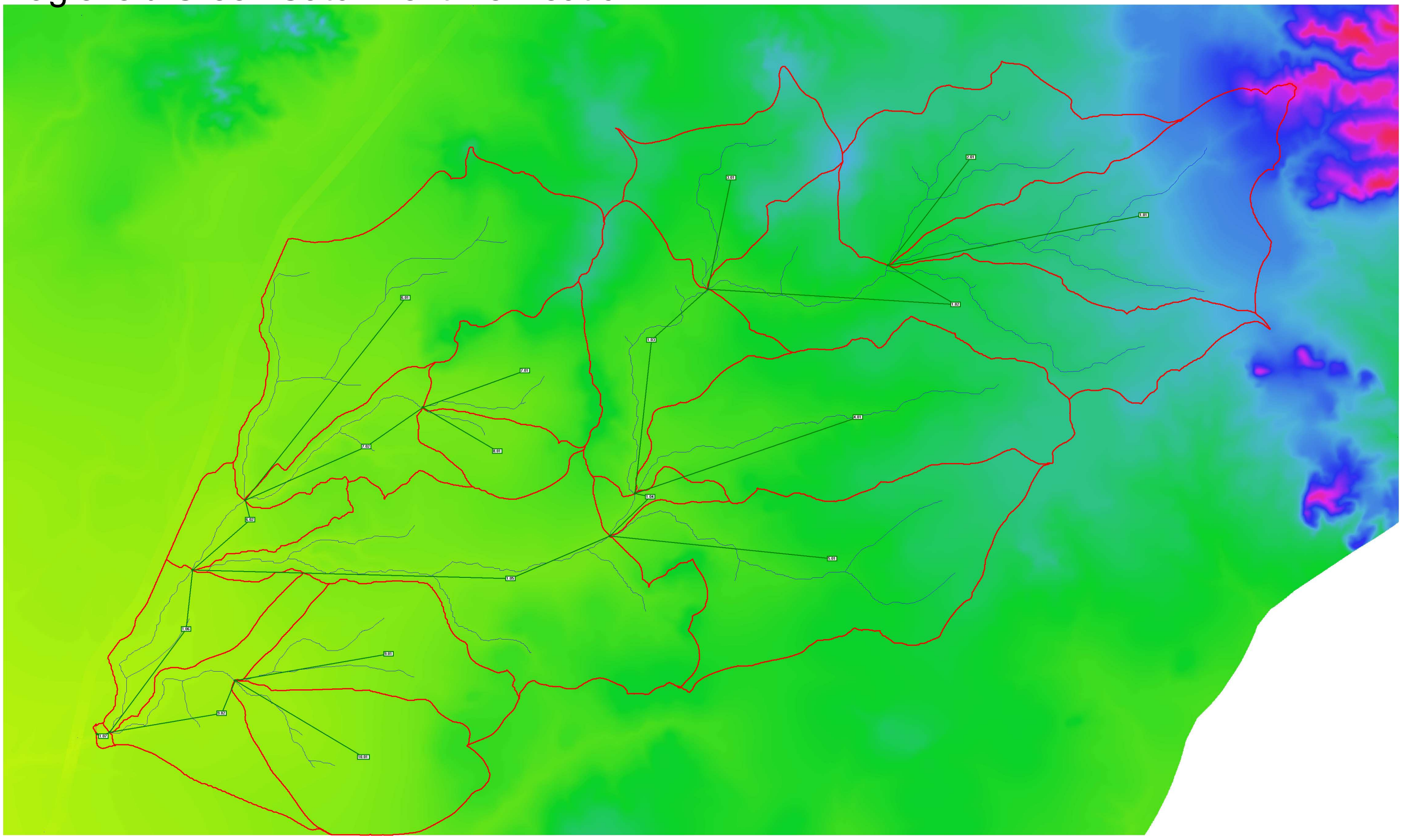
# 5( # #
# #

# APPENDIX B
# RORB RESULTS

Suttor River Catchment Delineation



# Eaglefield Creek Catchment Delineation



# Suttor River RORB Parameters

**Suttor River**

**ARR Book 5**

| | | | |
|---|---|---|---|
| Catchment area | 1959 | $km^2$ | |
| $d_{av}$ | 57.67 | km | (from RORB model) |
| $K_c$ (Weeks, QLD) | 48.89 | | |

| | | |
|---|---|---|
| adjusted $K_c$ | 48.89 | |
| m | 0.874736 | for 0.6<m<1.2 |

| LHS | RHS (goal seek to LHS by changing m) |
|---|---|
| 0.847754465 | 0.847698 |

| **RORB manual** | **Iteration1** | |
|---|---|---|
| $K_c$ | 25.41137 | |
| $Q_p$ | 1200 | $m^3/s$ |
| $m_1$ | 1.01 | |

# Eaglefield Creek RORB Parameters

**Eaglefield Creek**

**ARR Book 5**

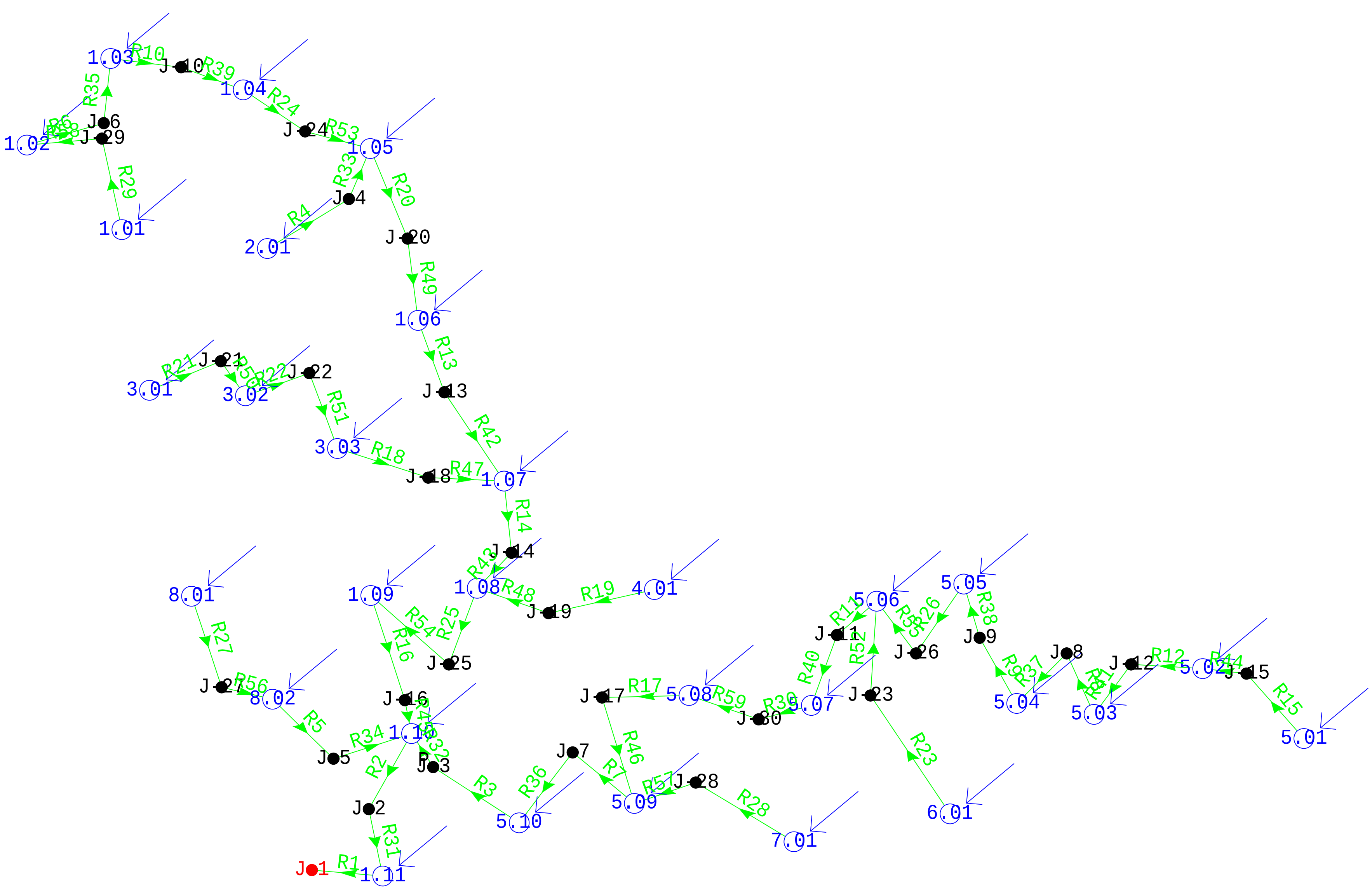
| | | | |
|---|---|---|---|
| Catchment area | 1959 | $km^2$ | |
| $d_{av}$ | 58.1 | km | (from RORB model) |
| $K_c$ (Weeks, QLD) | 48.89 | | |

| | | |
|---|---|---|
| adjusted $K_c$ | 48.89 | |
| m | 0.876347 | for 0.6<m<1.2 |

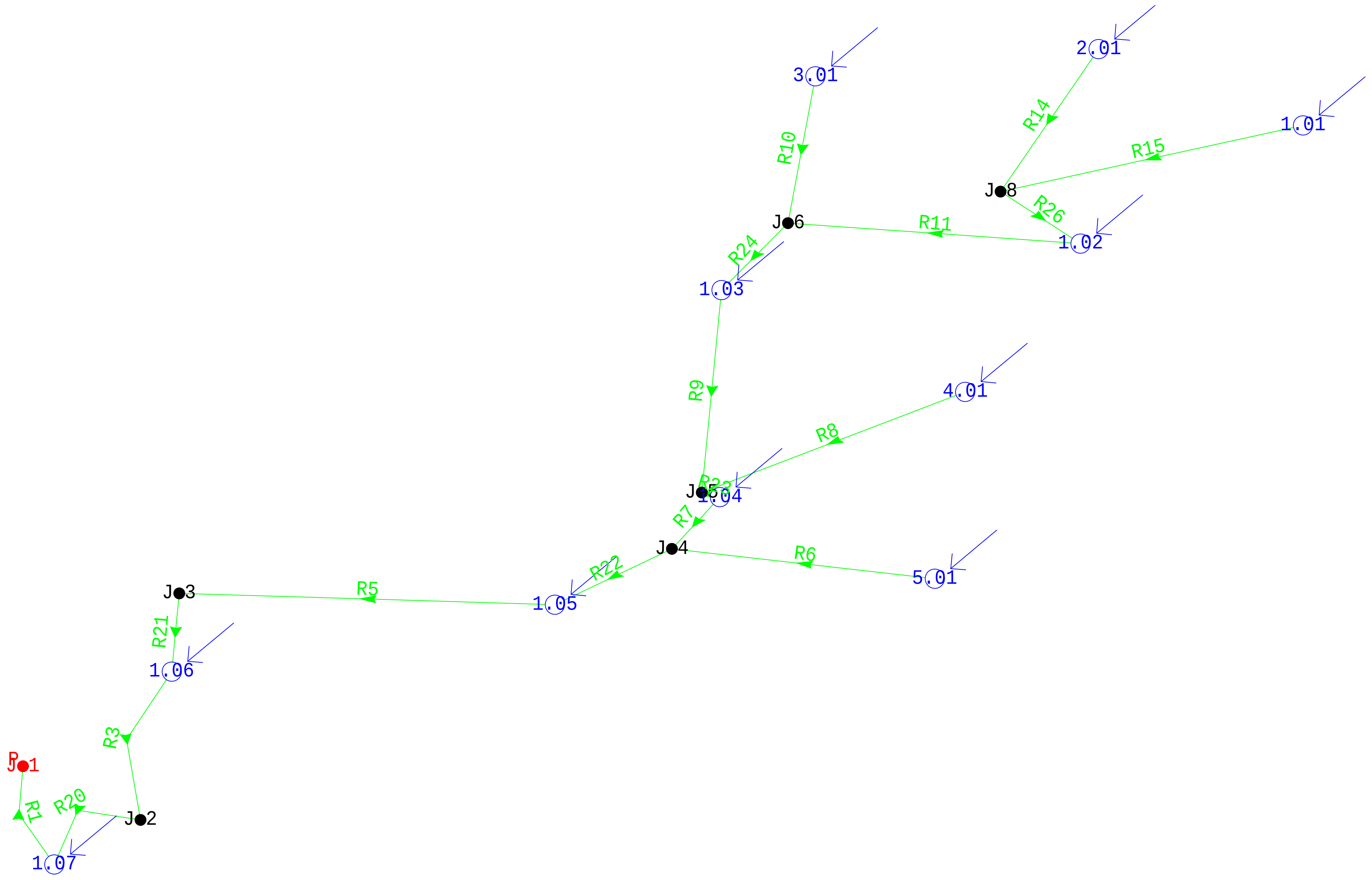
| LHS | RHS (goal seek to LHS by changing m) |
|---|---|
| 0.841480207 | 0.841502 |

| **RORB manual** | **Iteration1** | |
|---|---|---|
| $K_c$ | 23.33721 | |
| $Q_p$ | 1800 | $m^3/s$ |
| $m_1$ | 1.01 | |

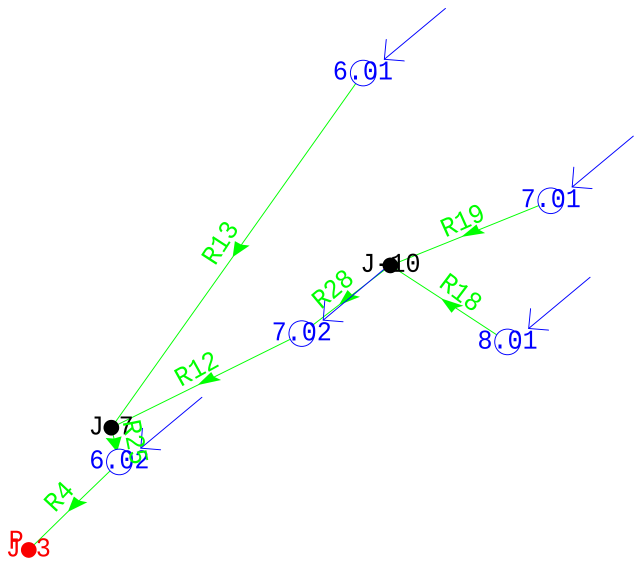
# Suttor Creek RORB



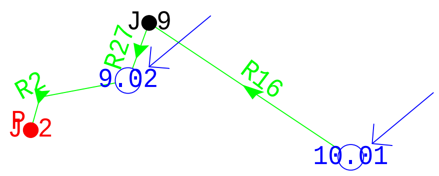
Eaglefield Creek RORB 1.06



Eaglefield Creek RORB 6.01



# Eaglefield Creek RORB 9



# Suttor River RORB Results File

```
 RORBWin Output File
 *******************

 Program version 6.15 (last updated 30th March 2010)
 Copyright Monash University and Sinclair Knight Merz

 Date run: 05 Oct 2011 15:47

 Vector file       : S:\PRO-Projects\2010\CJVP10007 Alpha Coal – BFS\06 Engineering
\6.3 Drainage\Design Iteration 2 Data\Major catchment analysis\Major culvert
locations\Miclere creek\Rorb\Rorb.catg
 Storm file        : \\calibre.network\PROJECTS\CEJV\BRI\Projects\PRO-Projects\2011
\CARP11064 HCPL Alpha FEED\06 Engineering\6.4 Hydrology\Suttor Creek\RORB model
\Rorb_18h50y.stm
 Output information: Flows & all input data


 Data checks:
 ************
 Next data to be read & checked:

 Catchment name & reach type flag
 Control vector & storage data
 Code no.  32     7.0 Location read as outlet
 Sub-area areas
 Impervious flag
 Initial storm data
 Rainfall burst times
 Pluviograph 1
 Sub-area rainfalls

 Data check completed



 Data:
 ****

 Miclere creek


 Time data, in increments from initial time
 Miclere creek: 18 hour 50 year Design Storm
 Time increment (hours)=  1.00

                   Start   Finish
 Rainfall times:     0       18


 End of hyeto/hydrographs:   18
 Duration of calculations:   70



 Pluviograph data (time in incs, rainfall in mm, in
                   increment following time shown)

         1:Temporal pattern (% of depth
   Time     1
     0     3.4
     1    21.5
     2     3.9
     3     2.6
     4     4.5
     5    11.1
     6     1.9
     7     1.2
     8     8.8
     9     7.1
    10     2.2
    11     1.5
    12     5.2
```

| | |
|---|---|
| 13 | 14.8 |
| 14 | 6.1 |
| 15 | 3.0 |
| 16 | 0.8 |
| 17 | 0.4 |
| Total | 100.0 |

DESIGN run control vector

| Step | Code | Description |
|---|---|---|
| 1 | 1 | Add sub-area 'A' inflow & route thru normal storage 1 |
| 2 | 3 | Store hydrograph from step 1; reset hydrograph to zero |
| 3 | 1 | Add sub-area 'B' inflow & route thru normal storage 2 |
| 4 | 4 | Add h-graph ex step 2 to h-graph ex step 3 |
| 5 | 5 | Route hydrograph thru normal storage 3 |
| 6 | 2 | Add sub-area 'C' inflow & route thru normal storage 4 |
| 7 | 3 | Store hydrograph from step 6; reset hydrograph to zero |
| 8 | 1 | Add sub-area 'D' inflow & route thru normal storage 5 |
| 9 | 4 | Add h-graph ex step 7 to h-graph ex step 8 |
| 10 | 5 | Route hydrograph thru normal storage 6 |
| 11 | 3 | Store hydrograph from step 10; reset hydrograph to zero |
| 12 | 1 | Add sub-area 'E' inflow & route thru normal storage 7 |
| 13 | 3 | Store hydrograph from step 12; reset hydrograph to zero |
| 14 | 1 | Add sub-area 'F' inflow & route thru normal storage 8 |
| 15 | 4 | Add h-graph ex step 13 to h-graph ex step 14 |
| 16 | 3 | Store hydrograph from step 15; reset hydrograph to zero |
| 17 | 1 | Add sub-area 'G' inflow & route thru normal storage 9 |
| 18 | 4 | Add h-graph ex step 16 to h-graph ex step 17 |
| 19 | 5 | Route hydrograph thru normal storage 10 |
| 20 | 4 | Add h-graph ex step 11 to h-graph ex step 19 |
| 21 | 2 | Add sub-area 'H' inflow & route thru normal storage 11 |
| 22 | 3 | Store hydrograph from step 21; reset hydrograph to zero |
| 23 | 1 | Add sub-area 'I' inflow & route thru normal storage 12 |
| 24 | 4 | Add h-graph ex step 22 to h-graph ex step 23 |
| 25 | 5 | Route hydrograph thru normal storage 13 |
| 26 | 2 | Add sub-area 'J' inflow & route thru normal storage 14 |
| 27 | 3 | Store hydrograph from step 26; reset hydrograph to zero |
| 28 | 1 | Add sub-area 'K' inflow & route thru normal storage 15 |
| 29 | 4 | Add h-graph ex step 27 to h-graph ex step 28 |
| 30 | 5 | Route hydrograph thru normal storage 16 |
| 31 | 2 | Add sub-area 'L' inflow & route thru normal storage 17 |
| 32 | 7.0 | Print hydrograph, outlet |
| 33 | 0 | **********End of control vector********** |

Sub-area data

| Sub-area | Area km² | Dist. km* |
|---|---|---|
| A | 1.09E+02 | 8.62E+01 |
| B | 1.40E+02 | 8.89E+01 |
| C | 5.58E+01 | 6.88E+01 |
| D | 7.69E+01 | 7.60E+01 |
| E | 6.69E+01 | 7.69E+01 |
| F | 2.00E+01 | 7.29E+01 |
| G | 5.00E+01 | 6.88E+01 |
| H | 6.41E+01 | 5.87E+01 |
| I | 1.45E+02 | 7.19E+01 |
| J | 1.87E+02 | 3.52E+01 |
| K | 3.38E+01 | 2.61E+01 |
| L | 8.00E+01 | 8.15E+00 |

Total 1.029E+03

For whole catchment ; Av. Dist., km* = 62.10
For interstation area 1; Av. Dist., km* = 62.10; ISA Factor = 1.000

* or other function of reach properties related to travel time

Normal storage data

| Storage no. | Length km* | Rel. delay time | Type | Slope percent |
|---|---|---|---|---|
| 1 | 12.0 | 0.193 | Natural | |
| 2 | 14.6 | 0.235 | Natural | |
| 3 | 5.4 | 0.088 | Natural | |
| 4 | 5.4 | 0.088 | Natural | |
| 5 | 12.6 | 0.203 | Natural | |
| 6 | 4.7 | 0.075 | Natural | |
| 7 | 10.0 | 0.161 | Natural | |
| 8 | 6.0 | 0.097 | Natural | |
| 9 | 2.0 | 0.032 | Natural | |
| 10 | 8.1 | 0.131 | Natural | |
| 11 | 4.7 | 0.075 | Natural | |
| 12 | 17.8 | 0.287 | Natural | |
| 13 | 18.9 | 0.304 | Natural | |
| 14 | 18.9 | 0.304 | Natural | |
| 15 | 9.8 | 0.157 | Natural | |
| 16 | 8.1 | 0.131 | Natural | |
| 17 | 8.1 | 0.131 | Natural | |

* or other function of reach properties related to travel time

Input of parameters:
********************

Miclere creek
DESIGN Run
Miclere creek: 18 hour 50 year Design Storm
Time increment = 1.00 hours

Constant loss model selected

Rainfall, mm, in time inc. following time shown

| Time Incs | Catchment | Sub-Area A | B | C | D | E | F | G | H | I | J | K | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 5.7 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| 1 | 36.0 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 |
| 2 | 6.5 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| 3 | 4.4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| 4 | 7.5 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| 5 | 18.6 | 19 | 19 | 19 | 19 | 19 | 19 | 19 | 19 | 19 | 19 | 19 | 19 |
| 6 | 3.2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 7 | 2.0 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 8 | 14.7 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| 9 | 11.9 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| 10 | 3.7 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| 11 | 2.5 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 12 | 8.7 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| 13 | 24.8 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| 14 | 10.2 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 15 | 5.0 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 16 | 1.3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 17 | 0.7 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Tot. | 167.4 | 167 | 167 | 167 | 167 | 167 | 167 | 167 | 167 | 167 | 167 | 167 | 167 |
| Pluvi. ref. no. | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

Rainfall-excess, mm, in time inc. following time shown

# Suttor River RORB Results File

| Time Incs | Catchment | Sub-Area A | B | C | D | E | F | G | H | I | J | K | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 | 6.2 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| 6 | 0.7 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 7 | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 | 12.2 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| 9 | 9.4 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| 10 | 1.2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 11 | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 12 | 6.2 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| 13 | 22.3 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 |
| 14 | 7.7 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| 15 | 2.5 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 16 | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17 | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tot. | 68.4 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 |

Routing results:
****************
Miclere creek
Miclere creek: 18 hour 50 year Design Storm
DESIGN run no. 1

Parameters: kc = 450.00 m = 0.86

| Loss parameters | Initial loss (mm) | Cont. loss (mm/h) |
|---|---|---|
| | 70.00 | 2.50 |

*** Calculated hydrograph, outlet

| | Hydrograph Calc. |
|---|---|
| Peak discharge,m³/s | 38.04 |
| Time to peak,h | 16.0 |
| Volume,m³ | 6.27E+06 |
| Time to centroid,h | 39.7 |
| Lag (c.m. to c.m.),h | 28.4 |
| Lag to peak,h | 4.69 |

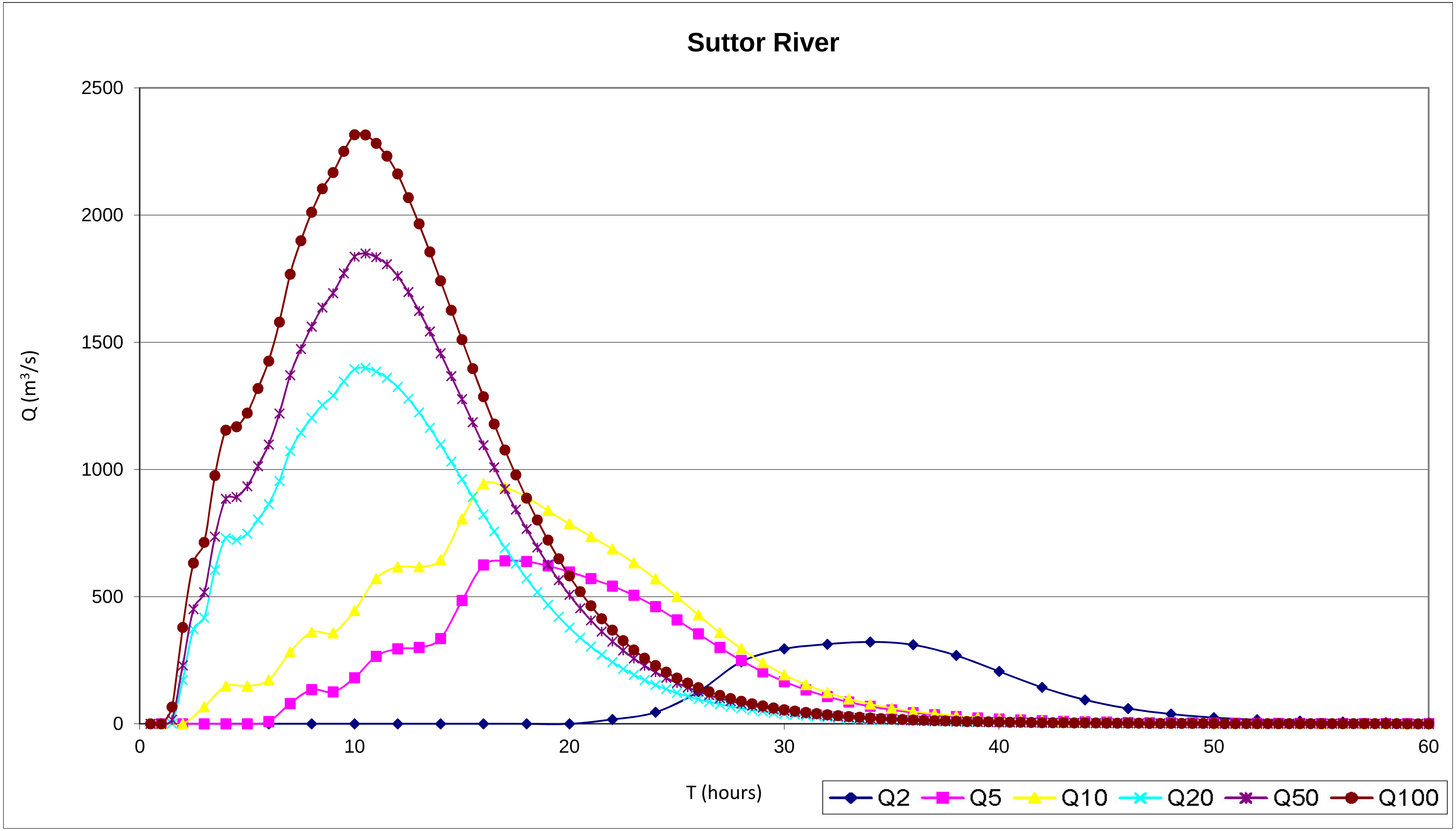
Hydrograph summary
*****************

| Site | Description |
|---|---|
| 01 | Calculated hydrograph, outlet |

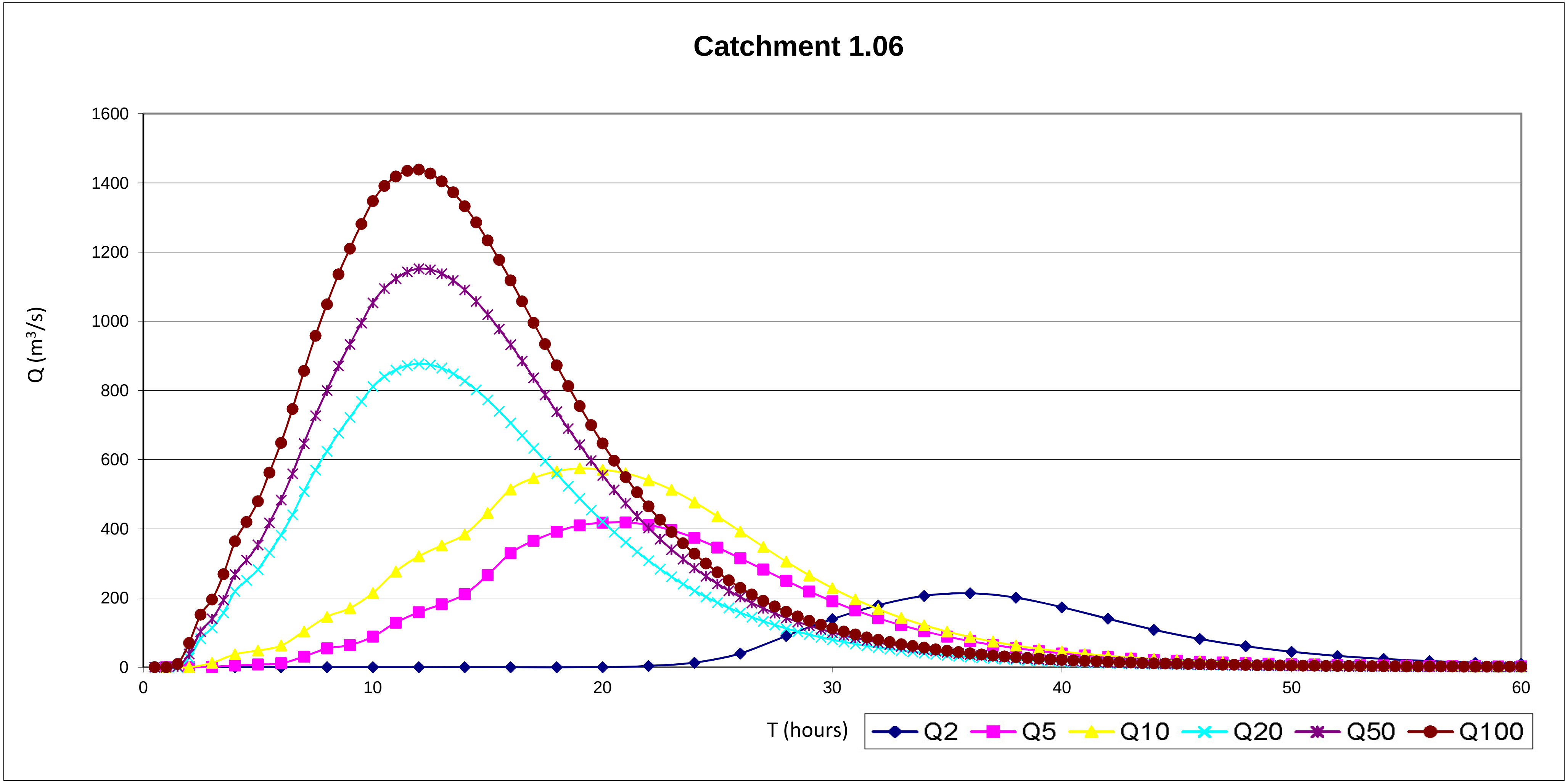
| Inc | Time | Hyd0001 |
|---|---|---|
| 1 | 1.00 | 0.0000 |
| 2 | 2.00 | 0.0000 |
| 3 | 3.00 | 0.0000 |
| 4 | 4.00 | 0.0000 |
| 5 | 5.00 | 0.0000 |
| 6 | 6.00 | 0.0000 |
| 7 | 7.00 | 1.1761 |
| 8 | 8.00 | 2.7742 |
| 9 | 9.00 | 2.8786 |
| 10 | 10.00 | 6.0624 |
| 11 | 11.00 | 12.2537 |
| 12 | 12.00 | 15.2148 |

| | | |
|---|---|---|
| 13 | 13.00 | 15.1850 |
| 14 | 14.00 | 16.7629 |
| 15 | 15.00 | 25.7241 |
| 16 | 16.00 | 35.4180 |
| 17 | 17.00 | 38.0425 |
| 18 | 18.00 | 37.8745 |
| 19 | 19.00 | 36.8425 |
| 20 | 20.00 | 35.8848 |
| 21 | 21.00 | 34.9976 |
| 22 | 22.00 | 34.1772 |
| 23 | 23.00 | 33.4200 |
| 24 | 24.00 | 32.7223 |
| 25 | 25.00 | 32.0949 |
| 26 | 26.00 | 31.5180 |
| 27 | 27.00 | 30.9886 |
| 28 | 28.00 | 30.5042 |
| 29 | 29.00 | 30.0622 |
| 30 | 30.00 | 29.6600 |
| 31 | 31.00 | 29.2955 |
| 32 | 32.00 | 28.9663 |
| 33 | 33.00 | 28.6703 |
| 34 | 34.00 | 28.4054 |
| 35 | 35.00 | 28.1698 |
| 36 | 36.00 | 27.9615 |
| 37 | 37.00 | 27.7789 |
| 38 | 38.00 | 27.6203 |
| 39 | 39.00 | 27.4841 |
| 40 | 40.00 | 27.3688 |
| 41 | 41.00 | 27.2730 |
| 42 | 42.00 | 27.1954 |
| 43 | 43.00 | 27.1348 |
| 44 | 44.00 | 27.0899 |
| 45 | 45.00 | 27.0596 |
| 46 | 46.00 | 27.0428 |
| 47 | 47.00 | 27.0387 |
| 48 | 48.00 | 27.0461 |
| 49 | 49.00 | 27.0643 |
| 50 | 50.00 | 27.0924 |
| 51 | 51.00 | 27.1297 |
| 52 | 52.00 | 27.1754 |
| 53 | 53.00 | 27.2288 |
| 54 | 54.00 | 27.2893 |
| 55 | 55.00 | 27.3563 |
| 56 | 56.00 | 27.4293 |
| 57 | 57.00 | 27.5077 |
| 58 | 58.00 | 27.5910 |
| 59 | 59.00 | 27.6789 |
| 60 | 60.00 | 27.7710 |
| 61 | 61.00 | 27.8668 |
| 62 | 62.00 | 27.9660 |
| 63 | 63.00 | 28.0683 |
| 64 | 64.00 | 28.1734 |
| 65 | 65.00 | 28.2810 |
| 66 | 66.00 | 28.3909 |
| 67 | 67.00 | 28.5028 |
| 68 | 68.00 | 28.6165 |
| 69 | 69.00 | 28.7318 |
| 70 | 70.00 | 28.8486 |
| 71 | 71.00 | 28.9667 |

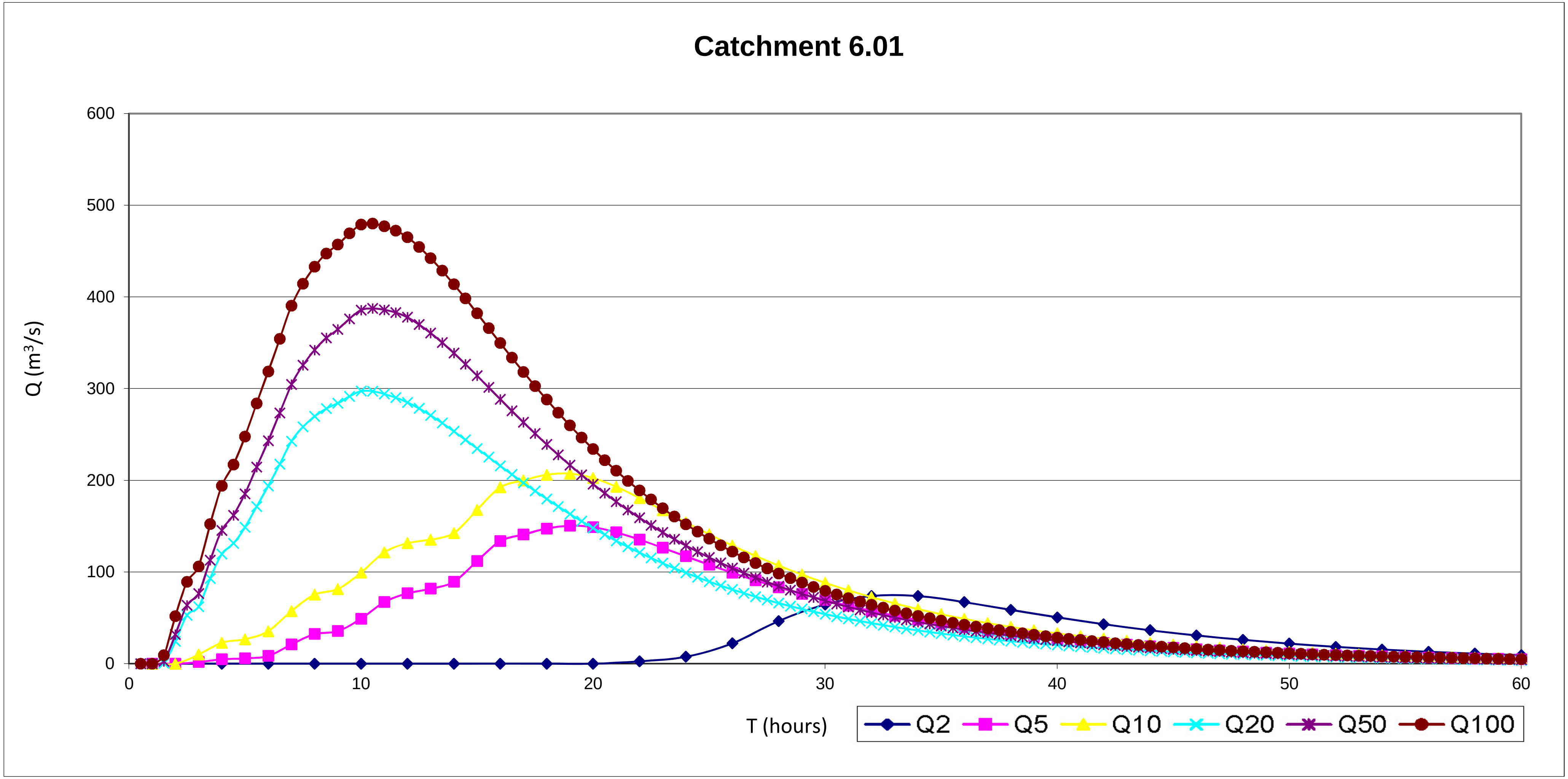
Suttor Hydrograph



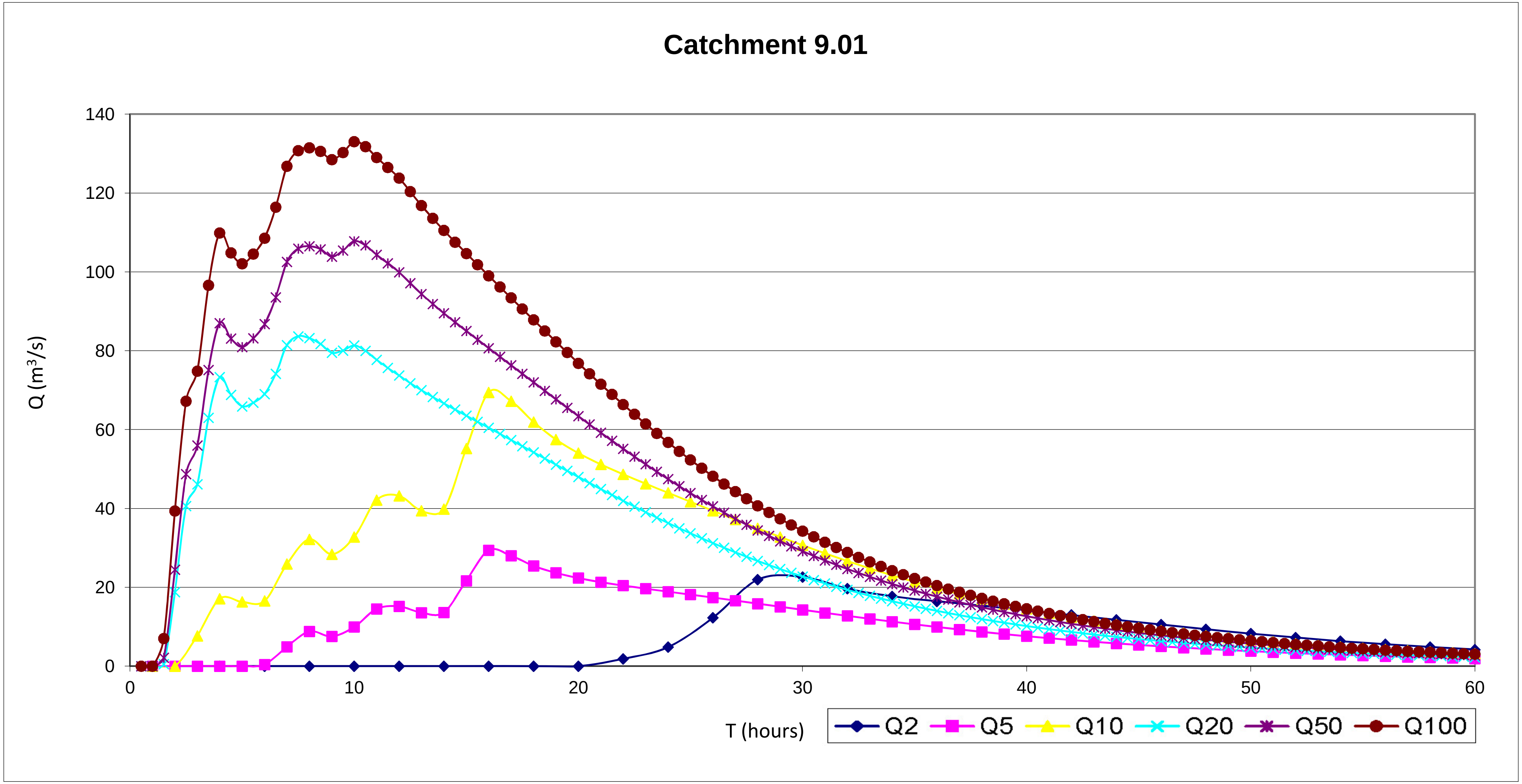
Eaglefield Hydrograph - 1



Eaglefield Hydrograph 6



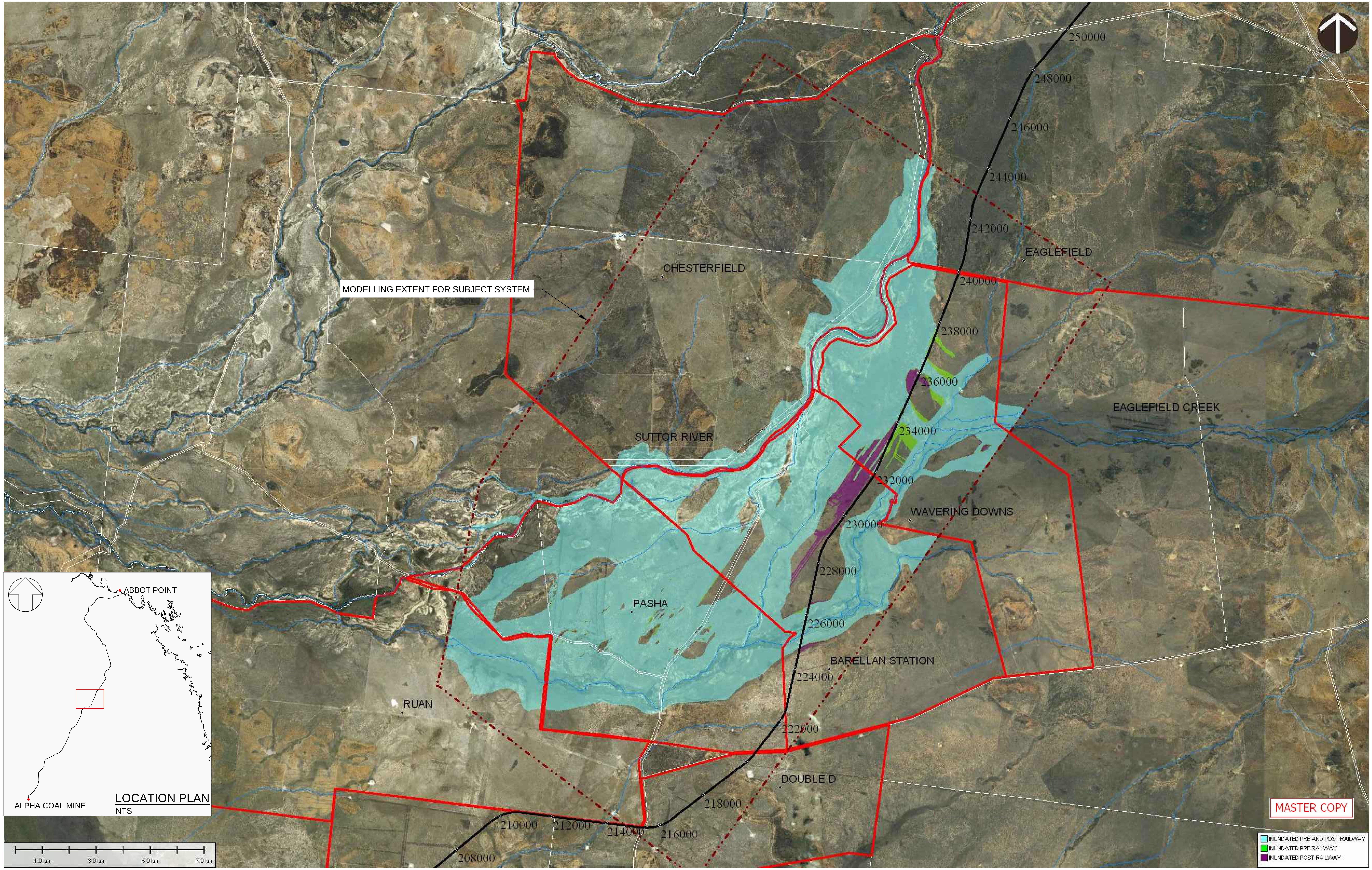
Eaglefield Hydrograph 9



# APPENDIX C
# FLOOD MAPS

NOT TO BE SCALED

NOT TO BE SCALED



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| DRAWN | D. SMITH | 30.09.11 |
| DRAFTING CHECK | | |
| DESIGNER | | |
| ENG. APPROVED | | |
| ENG. MANAGER | | |
| PROJECT MANAGER | | |
| CLIENT APPROVED | | |

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HANCOCK COAL PTY LTD

ALPHA COAL PROJECT
RAIL ALIGNMENT - MINE TO ABBOT POINT
FLOOD INUNDATION
EAGLEFIELD CREEK / SUTTOR RIVER - Q5

SHEET SIZE: A1

PN No: CJVP10007

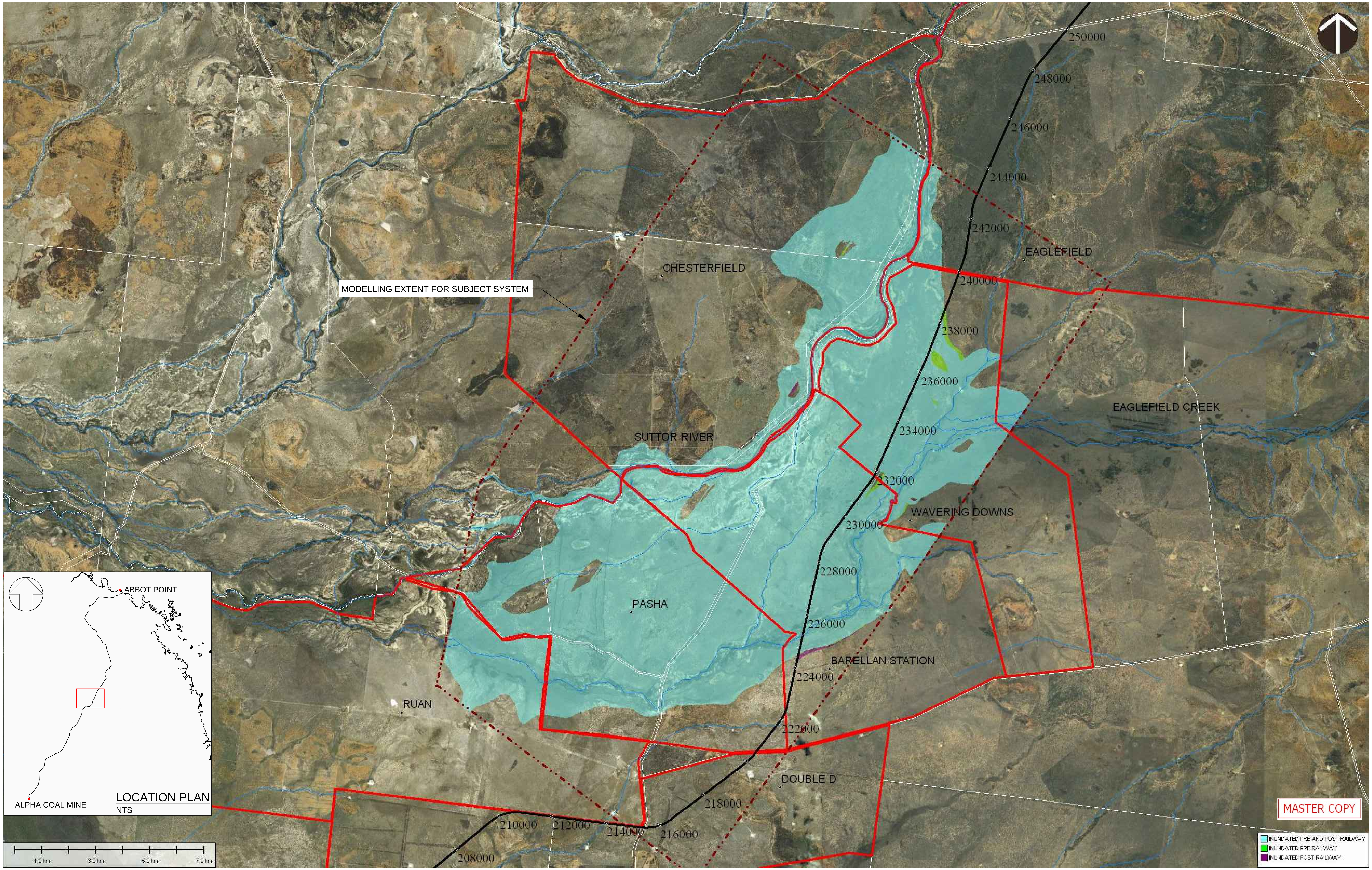
SCALE: NTS

CALIBRE DRAWING No.: CJVP10007-DWG-G-614

HANCOCK COAL REFERENCE No.: HC-CRL-24100-DRG-0546

REV: B

NOT TO BE SCALED NOT TO BE SCALED

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| A | DES | 30.09.11 | ISSUED FOR INFORMATION | TLB | |

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| DRAWN | D. SMITH | 30.09.11 |
| DRAFTING CHECK | | |
| DESIGNER | | |
| ENG. APPROVED | | |
| ENG. MANAGER | | |
| PROJECT MANAGER | | |
| CLIENT APPROVED | | |

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HANCOCK COAL PTY LTD

ALPHA COAL PROJECT
RAIL ALIGNMENT - MINE TO ABBOT POINT
FLOOD INUNDATION
EAGLEFIELD CREEK / SUTTOR RIVER - Q50

SHEET SIZE A1
PN No CJVP10007
SCALE NTS

CALIBRE DRAWING No. CJVP10007-DWG-G-615
HANCOCK COAL REFERENCE No. HC-CRL-24100-DRG-0547
REV B

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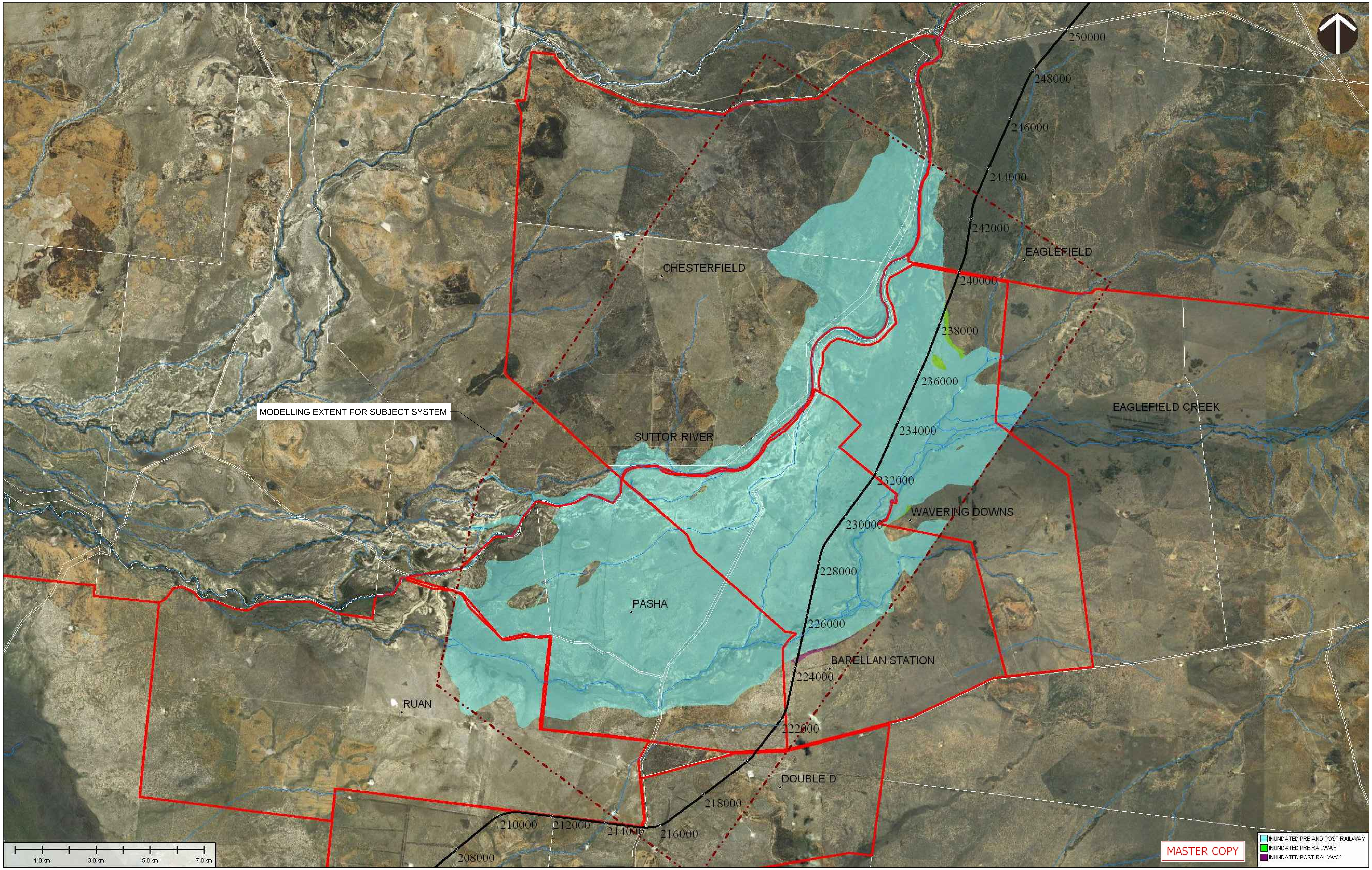


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| DESIGNER | | |
| ENG. APPROVED | | |
| ENG. MANAGER | | |
| PROJECT MANAGER | | |
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HANCOCK COAL PTY LTD

ALPHA COAL PROJECT
RAIL ALIGNMENT - MINE TO ABBOT POINT
FLOOD INUNDATION
EAGLEFIELD CREEK / SUTTOR RIVER - Q100

SHEET SIZE A1

PN No CJVP10007

SCALE NTS

CALIBRE DRAWING No. CJVP10007-DWG-G-642

HANCOCK COAL REFERENCE No. HC-CRL-24100-DRG-0574

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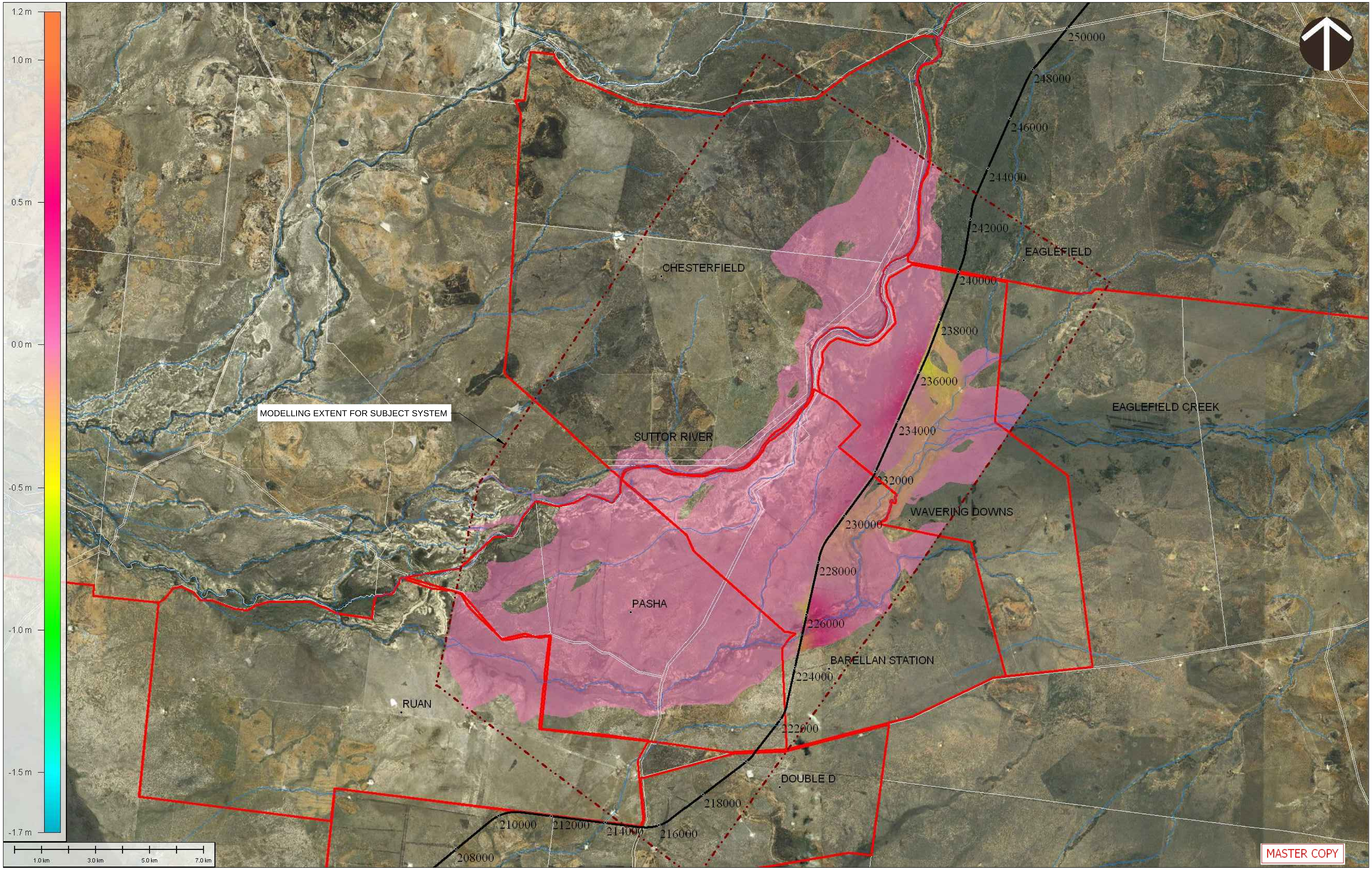
NOT TO BE SCALED



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| DESIGNER | | |
| ENG. APPROVED | | |
| ENG. MANAGER | | |
| PROJECT MANAGER | | |
| CLIENT APPROVED | | |

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HANCOCK COAL PTY LTD

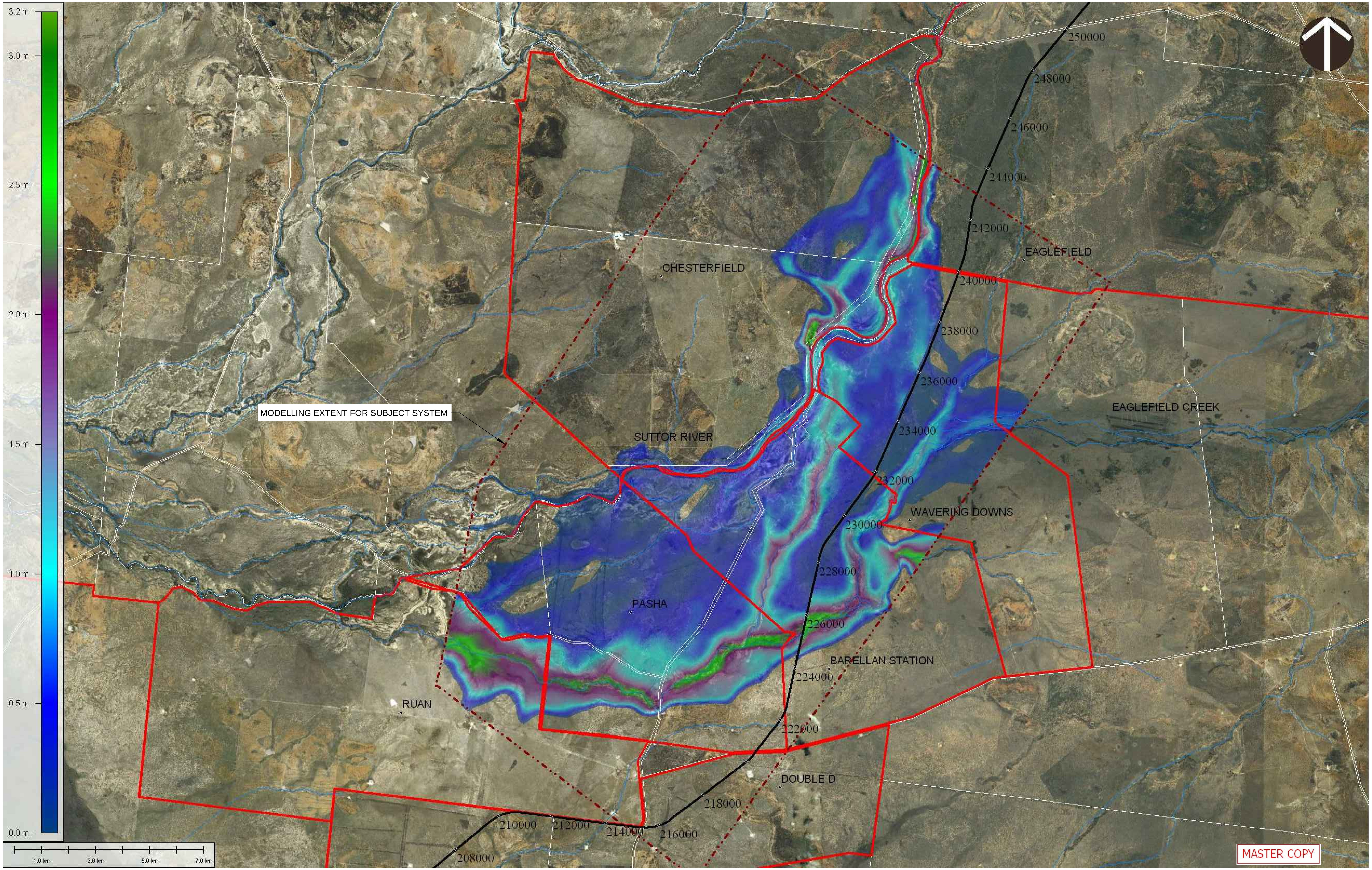
ALPHA COAL PROJECT
RAIL ALIGNMENT - MINE TO ABBOT POINT
AFFLUX
EAGLEFIELD CREEK / SUTTOR RIVER - Q50

SHEET SIZE: A1
PN No: CJVP10007
SCALE: NTS

CALIBRE DRAWING No.: CJVP10007-DWG-G-712
HANCOCK COAL REFERENCE No.: HC-CRL-24100-DRG-0644
REV: A

NOT TO BE SCALED

NOT TO BE SCALED



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| DRAFTING CHECK | | |
| DESIGNER | | |
| ENG. APPROVED | | |
| ENG. MANAGER | | |
| PROJECT MANAGER | | |
| CLIENT APPROVED | | |

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HANCOCK COAL PTY LTD

ALPHA COAL PROJECT
RAIL ALIGNMENT - MINE TO ABBOT POINT
DEPTH
EAGLEFIELD CREEK / SUTTOR RIVER - Q50

SHEET SIZE A1

PN No CJVP10007

SCALE NTS

CALIBRE DRAWING No. CJVP10007-DWG-G-713

HANCOCK COAL REFERENCE No. HC-CRL-24100-DRG-0645

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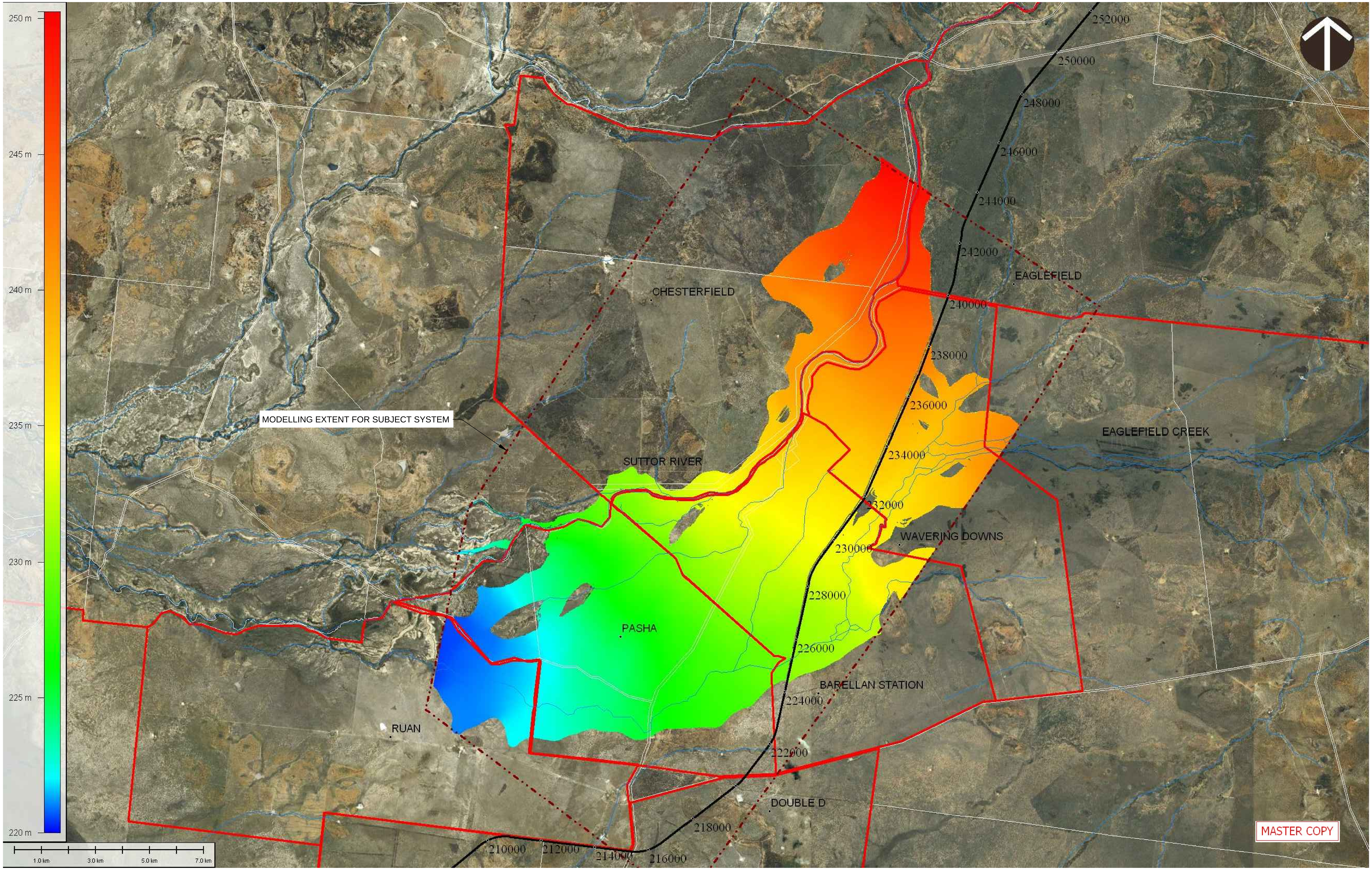


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REFERENCES

REVISIONS

| | | |
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| DRAFTING CHECK | | |
| DESIGNER | | |
| ENG. APPROVED | | |
| ENG. MANAGER | | |
| PROJECT MANAGER | | |
| CLIENT APPROVED | | |

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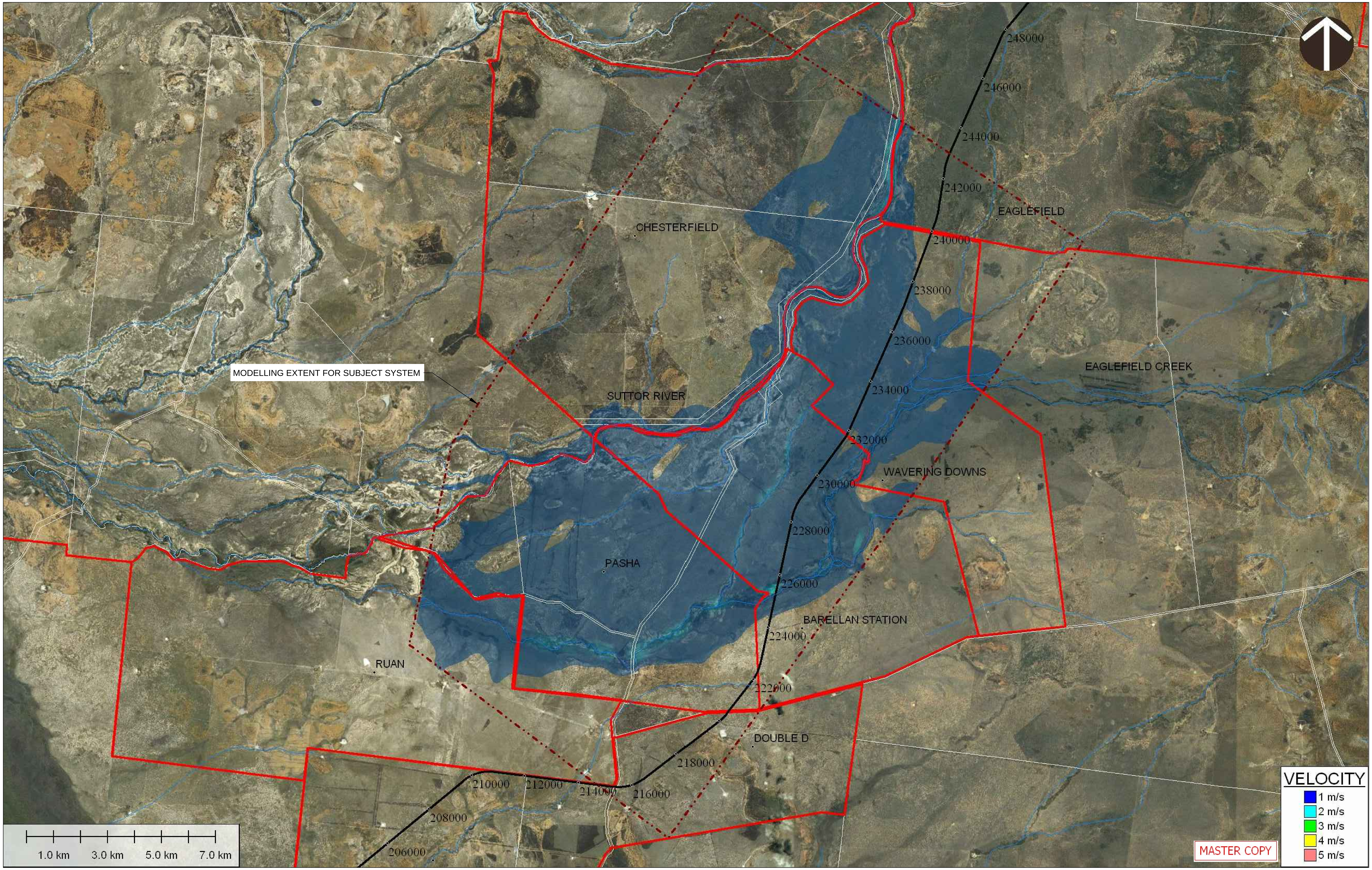
HANCOCK COAL PTY LTD

ALPHA COAL PROJECT
RAIL ALIGNMENT - MINE TO ABBOT POINT
SURFACE EVLEVATION
EAGLEFIELD CREEK / SUTTOR RIVER - Q50

SHEET SIZE A1
PN No CJVP10007
SCALE NTS

CALIBRE DRAWING No. CJVP10007-DWG-G-714
HANCOCK COAL REFERENCE No. HC-CRL-24100-DRG-0646
REV A



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| DRAFTING CHECK | | |
| DESIGNER | | |
| ENG. APPROVED | | |
| ENG. MANAGER | | |
| PROJECT MANAGER | | |
| CLIENT APPROVED | | |

calibre

HANCOCK COAL PTY LTD

ALPHA COAL PROJECT
RAIL ALIGNMENT - MINE TO ABBOT POINT
VELOCITY
EAGLEFIELD CREEK / SUTTOR RIVER - Q50

SHEET SIZE A1
PN No CJVP10007
SCALE NTS
CALIBRE DRAWING No. CJVP10007-DWG-G-715
HANCOCK COAL REFERENCE No. HC-CRL-24100-DRG-0647
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