HANCOCK COAL PTY LTD

Calibre Rail
Alpha Coal Project – Rail
Phase 1B

Detailed Floodplain Study
Mistake Creek

HC-CRL-24100-RPT-0137
CJVP10007-REP-C-015

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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 Mistake Creek floodplain system. The analysis provides recommendations of the cross-drainage infrastructure required to minimise impacts to existing flowpaths 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 Mistake Creek system. It details the pre- and post-development inundation extents for the 5, 50 and 100 year Average Recurrence Interval (ARI) events. The results for depths of flow, velocity fields and afflux from the development of the railway have been assessed for the approved design criteria of the 50 year ARI event.

2.0 PROJECT BACKGROUND

Hancock Coal Infrastructure Pty Ltd (HCIPL) are undertaking an investigation into the development of a 30 Mtpa open pit, thermal coal mine within the Galilee Basin 50km 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 500km standard gauge rail alignment and 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 corresponding SEIS compiled to clearly define design parameters to be adhered to in any further investigations, and eventual, design.

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 Project 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 / HC-CRL-24100-RPT-0022);
- 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 (600m wide corridor with a vertical accuracy of ±100mm) provided by HCIPL;
- LiDAR data flown for BFS alignment (approximate 4000m wide corridor with a vertical accuracy of ±500mm) provided by HCIPL;
- 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&R Consulting Pty Ltd
CatchmentSIM	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 Mistake Creek 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 occurs at the proposed railway floodplain crossing. 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 was to provide detailed mapping of the pre- and post-development flood extents, inundation durations, flow velocities and afflux predictions for the Mistake Creek system. A focus of this study is to assess the impacts that the proposed rail alignment would have on the landscape and surrounding properties.

5.1 Floodplain Location and Description

The Mistake Creek system has a catchment area of approximately 2739km^2 and is a significant portion of the Suttor Sub-Basin (18,000km^2) in the Burdekin River Catchment. The terrain is predominantly very flat with significant low-land floodplains with grazing being the main land-use. The landscape is semi-arid with predominantly ephemeral streams (typically flow each year during the wet season between December and April).

A locality plan of the affected catchments that interface with the ACP railway is illustrated in Figure 1.

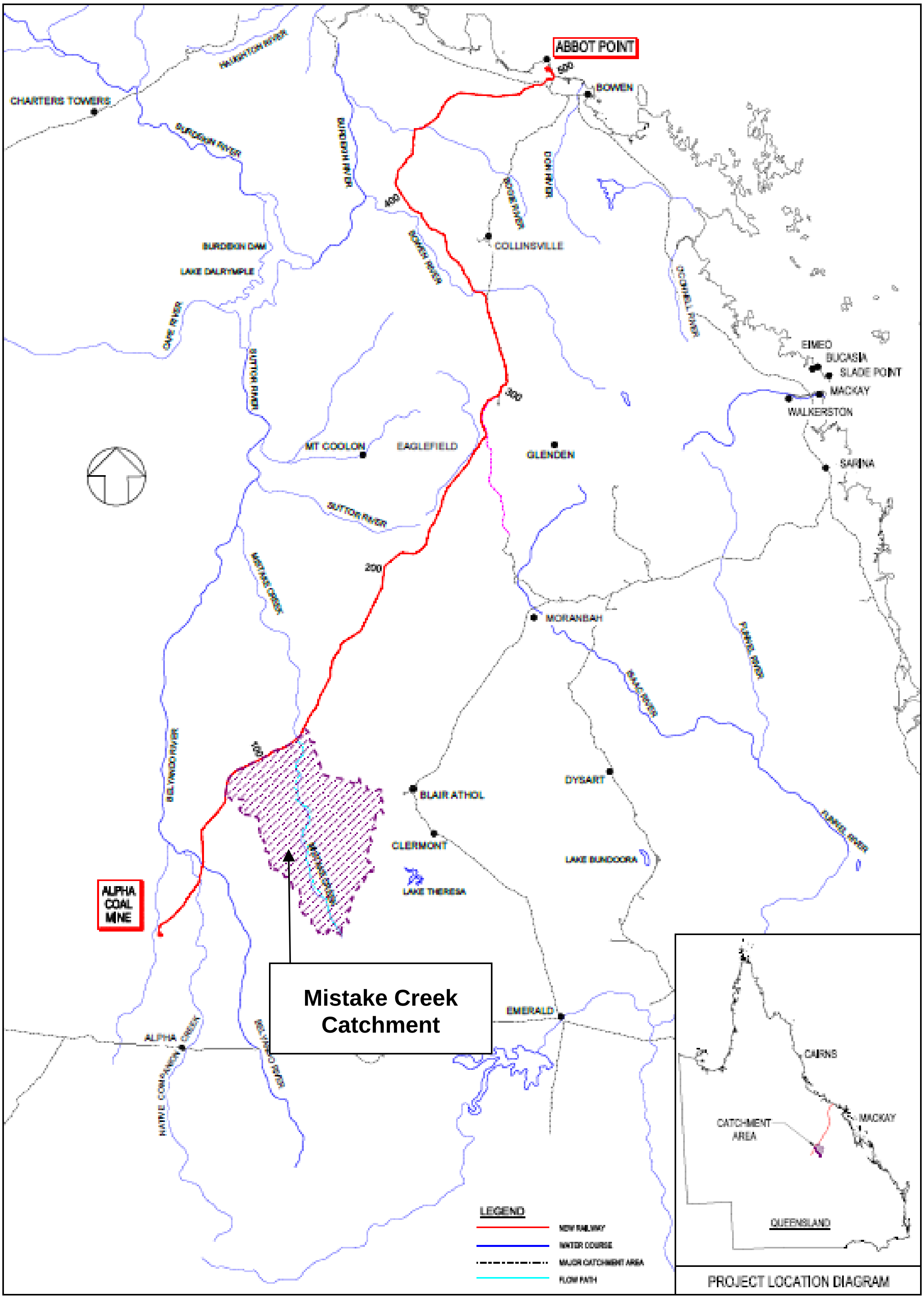


Figure 2: Catchment boundary and location

5.2 Mistake Creek

The catchment area for Mistake Creek at the proposed ACP rail alignment (Rail Chainage 117,855m) is approximately 2739km^2. The main low flow channel is poorly defined and braided. As such, in large flow events there is a complex interaction between channel and floodplain.

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 Tables 1 and 2.

Table 1: General drainage design criteria

Design Aspect	Design Criteria
Culvert Classification	Major culverts: culvert locations with a 50 years ARI design flow ≥ 50m^3/sec. Minor culverts: culvert locations with a 50 year ARI design flow < 50m^3/sec.
Design Flood	Minor culverts shall pass the 20 year ARI design event flow. Major culverts shall pass the 50 year ARI design event flow.
Freeboard	Min. 300mm to the formation surface for design event.
Headwater	Max. headwater to be 1.5 x culvert diameter.
Max. Outlet Velocity	5.0m/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). CSP Culverts shall be provided with minimum 600mm earthwork cover. 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.

Design Aspect	Design Criteria
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 100mm 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. 500mm to bridge soffit for 50 year ARI design flow. Min. 300mm to TOF (embankments and guide banks) for 50 year ARI design flow.
Max Velocity	3.8m/s to enable to adopt a practical limit of 1 tonne rock class protection for economy.
Scour Protection	Provide rock protection to cater for 50 year ARI design flow velocities. Rock sizing to be designed in accordance with AUSTROADS Waterway Design, 1994.
Maximum backwater	1.5m 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 (CatchmentSim and RORB) or a Flood Frequency Analysis (FFA) where stream-gauge 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 was used as a basis for the Detailed Floodplain Study.

8.0 FLOODPLAIN MODELLING DESIGN CRITERIA

A Supplementary Environmental Impact Statement (SEIS) was prepared after the conclusion of the BFS and this resulted in certain design criteria (from Tables 1 and 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. Culverts outlet velocity: = 1.5m/s where erodible soils are present. = 2.5m/s for normal soils (with no erosion control).
Maximum afflux	Maximum 0.5m – normally (unless justifiable). Maximum 0.2m – around critical infrastructure. Maximum 0.1m – around dwellings.

Unless specified in Table 3, the design criteria used for the detailed floodplain analysis are identified in Tables 1 and 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 Mistake Creek systems, a detailed floodplain analysis was conducted. 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 Mistake Creek was based on RORB models and a Flood Frequency Analysis (FFA) of the Mistake Creek stream-gauge (120306A – Mistake Creek at Charlton). At the time of the analysis, the stream-gauge had 24 years of recorded data (daily streamflow readings from 1968 to 1993). The estimated 50 year ARI event flow was used for the sizing of the Mistake Creek cross-drainage structure.

It should be noted that the stream-gauge is located upstream of the ACP railway as shown in Figure 3 below.

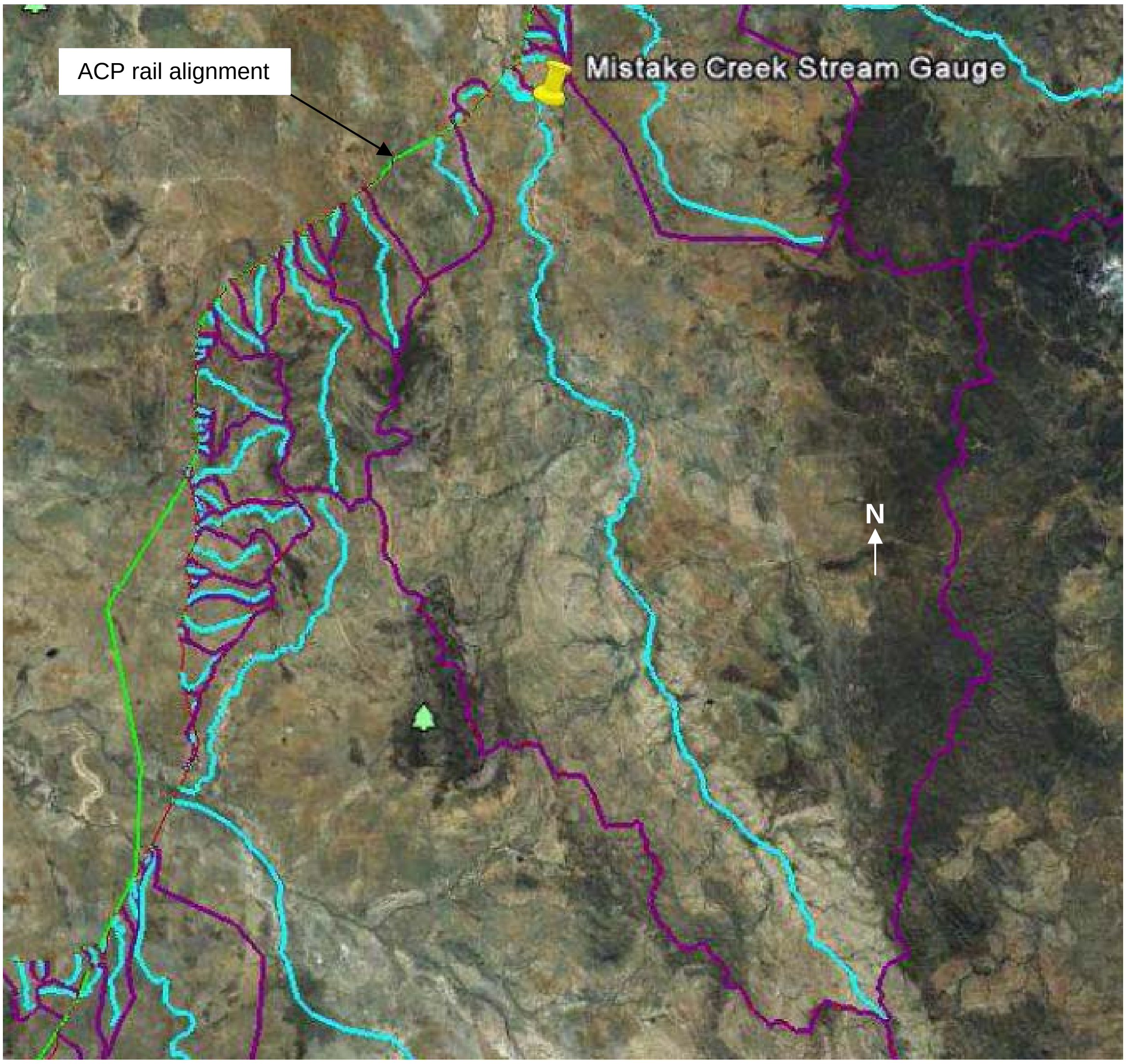


Figure 3: Mistake Creek Stream-gauge

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 consulting), 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:

Additional Survey

Additional LiDAR survey was obtained along the proposed rail alignment in a 600m wide corridor with a vertical accuracy of ±100mm.

9.1.1.3 Flood Frequency Analysis

A Flood Frequency Analysis was completed for the Mistake Creek stream-gauge at Charlton 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: Mistake Creek gauge data

Catchment	DERM stream-gauge	Years of data	Start - finish
Mistake Creek	120306A	24	16/05/1968 – 07/09/1993

The stream-gauge has a contributing catchment area of 2739km^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 4.

The results of the FFA are presented in Appendix A.

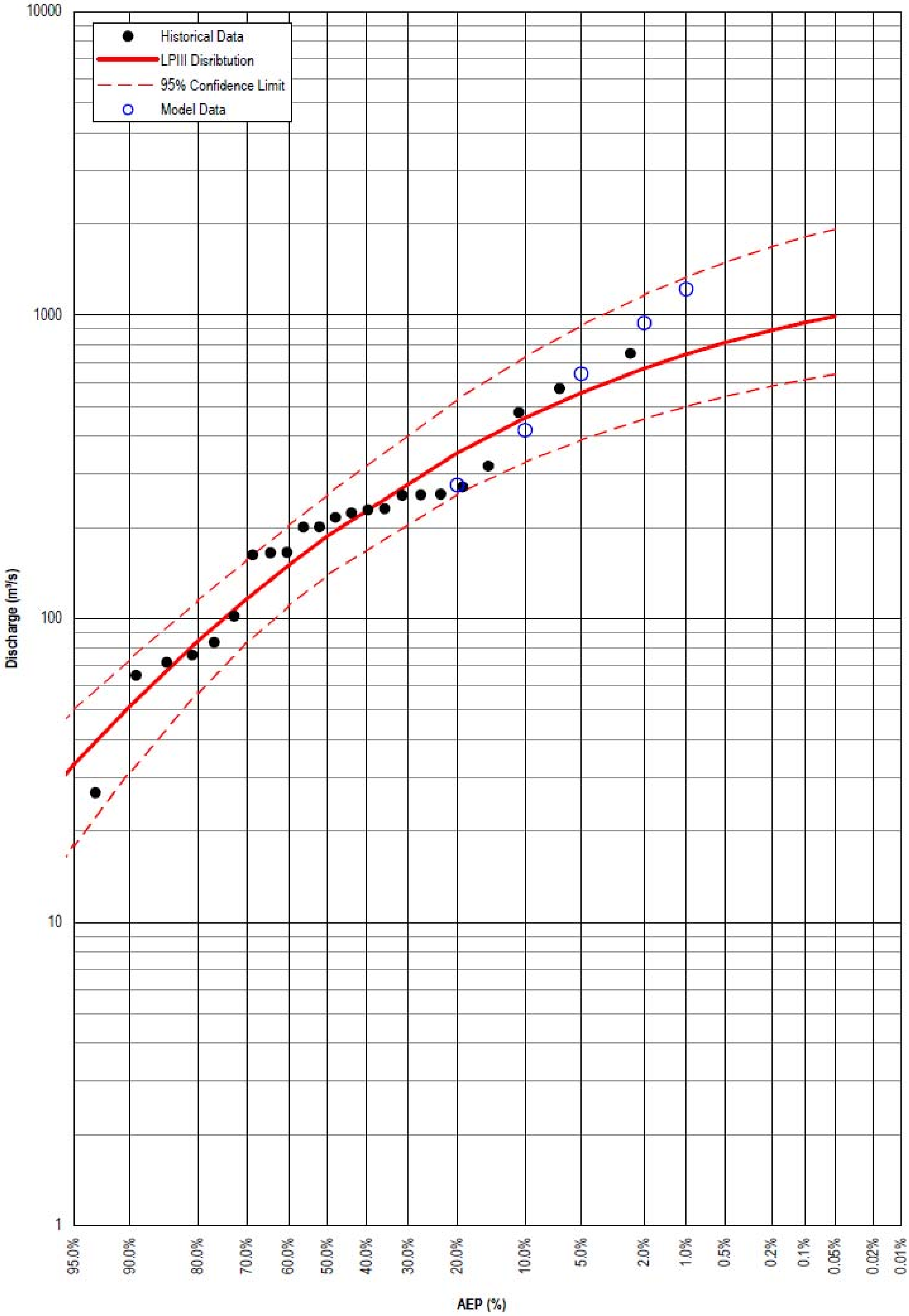


Figure 4: Mistake Creek stream-gauge FFA

From the FFA, the following design event flows have been derived and are shown below.

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	744.6	1335.9	500.6
50	669.0	1167.0	456.4
20	555.9	925.3	388.4
10	459.3	730.3	328.0
5	351.7	527.7	257.4

9.1.1.4 RORB Analysis

The contributing catchment area for Mistake Creek was delineated using the GIS based terrain analysis software, CatchmentSim. A visual check was performed against the BFS delineated catchment, stream-gauge catchment areas and SRTM contours to ensure the CatchmentSim delineation was accurate.

The system was delineated in CatchmentSim using the DERM SRTM survey data as this was deemed to have sufficient accuracy for the purposes of hydrologic analyses. The catchment was generated for the system and exported into the rainfall-runoff routing program, RORB.

A sub-catchment node was specifically placed at the location of the Mistake Creek stream-gauge in order to calibrate the model.

A summary of the catchment analysis for Mistake Creek is shown below in Table 6.

Table 6: Mistake Creek catchment properties

Item	Value
Catchment area	$2739km^2$
d_{av}	60.62km

The RORB analysis results are contained in Appendix B.

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 (equation 9.2) as recommended by AR&R, initial catchment parameters for Mistake Creek were calculated and are shown in Table 7 along with an estimate of the initial and continuing loss in Table 8.

Table 7: Mistake Creek initial RORB parameters

Item	Value
k_c	58.4
m	0.847

Table 8: Initial and continuing loss estimation

Event ARI (years)	Initial loss (mm)	Continuing loss (mm/hr)
100	25	2.5
50	25	2.5
20	30	2.5
10	30	2.5
5	35	2.5

Calibration

As Mistake Creek 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 Tables 9 and 10.

Table 9: Mistake Creek calibrated RORB parameters

Item	Value
k_c (calibrated)	150
m	0.847

Table 10: Mistake Creek calibrated losses

Event ARI (years)	Initial loss (mm)	Continuing loss (mm/hr)
100	25	2.5
50	25	2.5
20	30	2.5
10	30	2.5
5	35	2.5

An order-of-magnitude calibration was achieved for the 50 year ARI event (design event) with the FFA predicted a peak flow of 669m^3 and the RORB model estimating 942m^3/s.

Although not achieving an ideal calibration, the design storm peak discharge was overestimating the historical flow data which would in turn lead to a conservative design. A results comparison between the calibrated RORB model and the FFA estimates are shown below in Table 11.

Table 11: Calibration results at Mistake Creek stream-gauge

Event ARI (years)	FFA estimate (m^3/s)	RORB estimate (m^3/s)
100	744.6	1219
50	669.0	942
20	555.9	642
10	459.3	418
5	351.7	276

The peak discharges extracted from the RORB model have been plotted (blue circles) on the FFA provided in Figure 4.

Results

The results extracted from the hydrologic modelling for Mistake Creek system at the ACP rail interface are shown below in Tables 12 and 13:

Table 12: Mistake Creek peak storm durations

Event ARI (years)	Peak discharge storm duration (hours)
100	72
50	72
5	36

Table 13: Mistake Creek predicted peak discharges

Event ARI (years)	Peak predicted discharge (m^3/s)
100	1219
50	942
5	276

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 the system was then used as inflows into the Mistake Creek floodplain hydraulic model as described in Section 9.1.2.

9.1.2 Hydraulic Modelling

It was identified that the Mistake Creek system had a complex floodplain interaction that occurred upstream of the proposed ACP rail alignment. 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 had a bathymetry of 459 x 605 cells at a grid cell size of 10m x 10m (model area of 28km^2). The final bathymetry used for the pre- and post-development rail cases is shown below in Figure 5.

The bathymetry was generated from a combination of LiDAR sources (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.

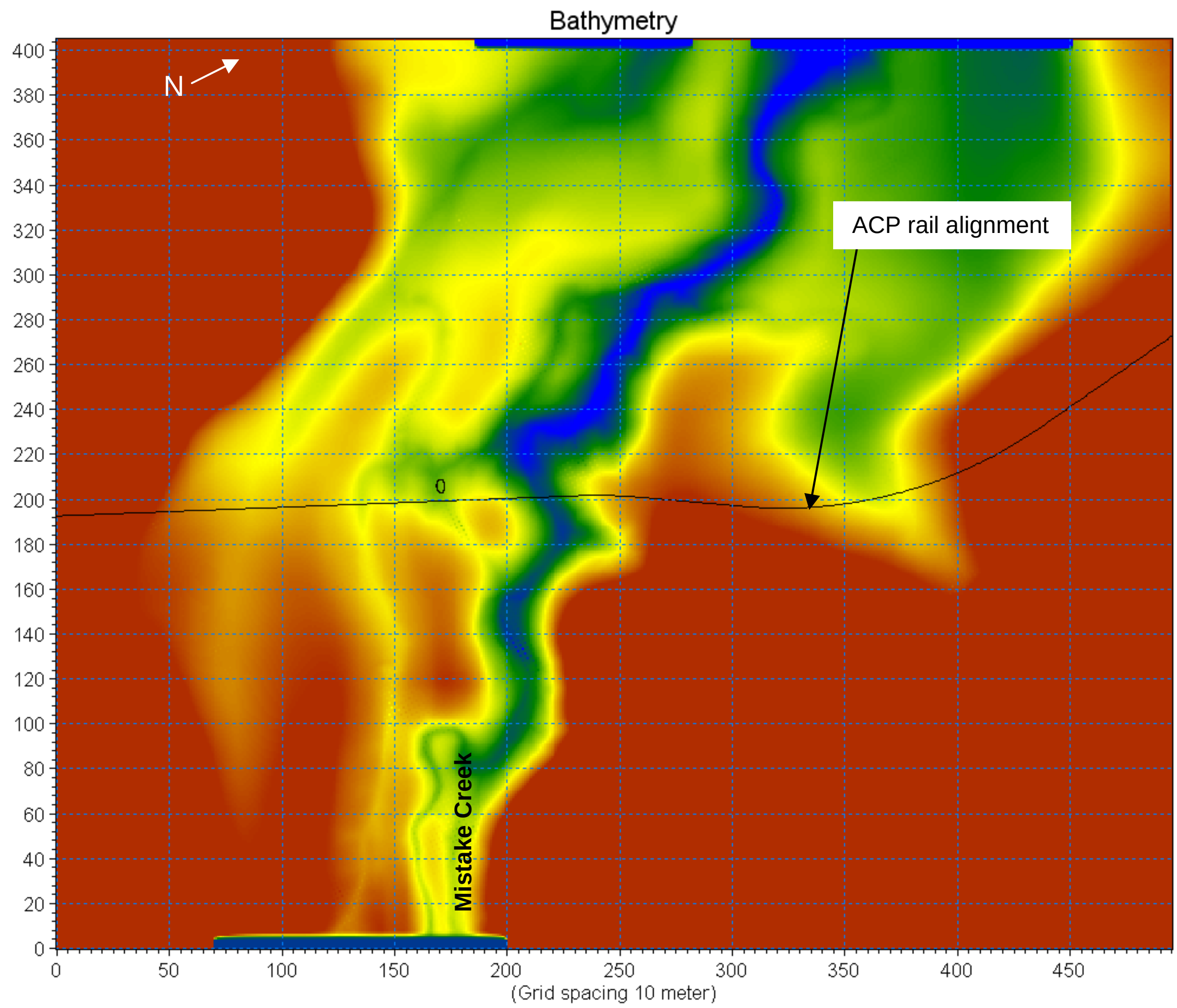


Figure 5: Hydraulic model extent

Boundary conditions

A Mistake Creek inflow hydrograph was 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 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 Mistake Creek system has two distinct types of roughness: a relatively smooth and well defined flowpath 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 an initial approach 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 0.2m and velocities above approximately 0.15m/s, a roughness value attributed to a channel was assigned. The remaining model domain was set to a roughness equivalent to floodplain.

After Landholder feedback was received on several neighbouring floodplain systems it was identified that a more accurate representation of the two separate roughness areas was to assign a channel roughness to the main stream flowpath only (delineated by contour maps) and set a roughness value equivalent to a floodplan for the remaining model domain. The adopted values are shown in Figure 6. The selection of roughness values was subject to sensitivity testing as outlined in Section 9.1.3.

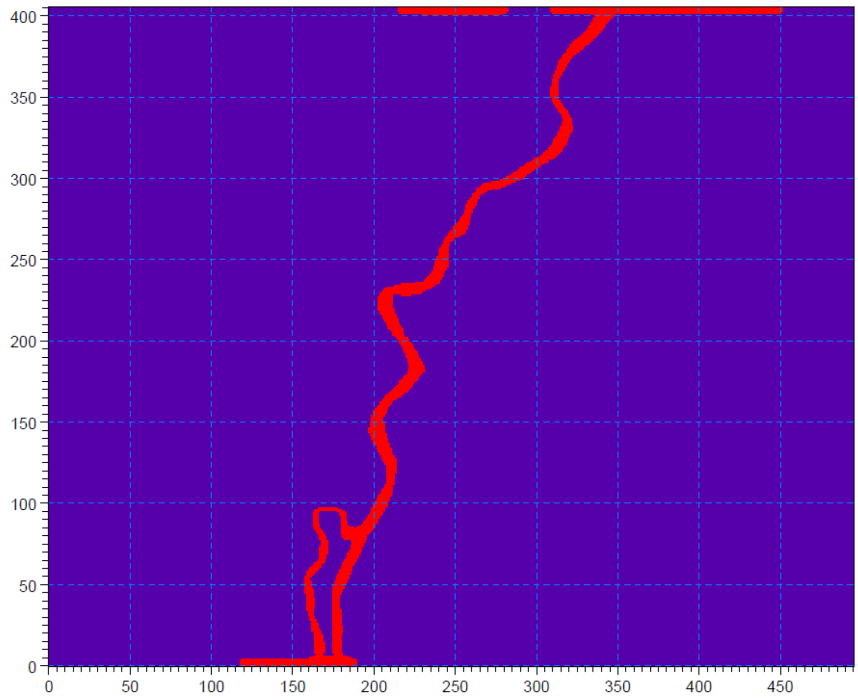


Figure 6: Manning's roughness

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'. 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. Coupled locations are shown in Figure 7.

In order to maintain inundation extents post-development and as specified in the SEIS, floodplain relief culverts are proposed for the Mistake Creek 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 5/900mm CSP every 250m within the model.

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

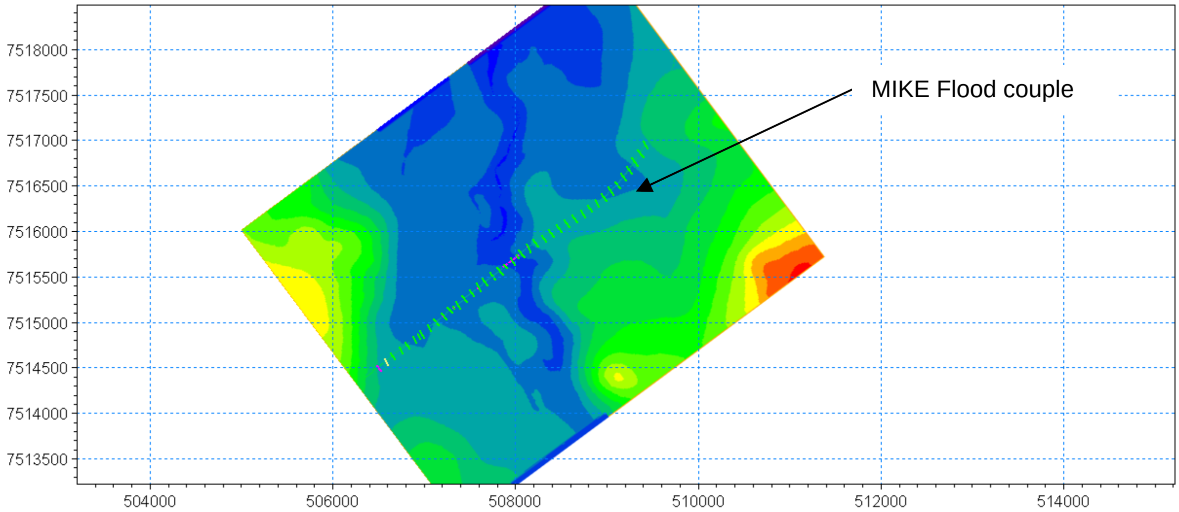


Figure 7: MIKE Flood couple locations

In addition to the floodplain relief culverts, the BFS proposed a single bridge span of 100m for Mistake Creek. This was also inserted as a couple into the MIKE Flood model.

9.1.3 Sensitivity Testing

Due to the lack of anecdotal evidence available to calibrate 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 8.

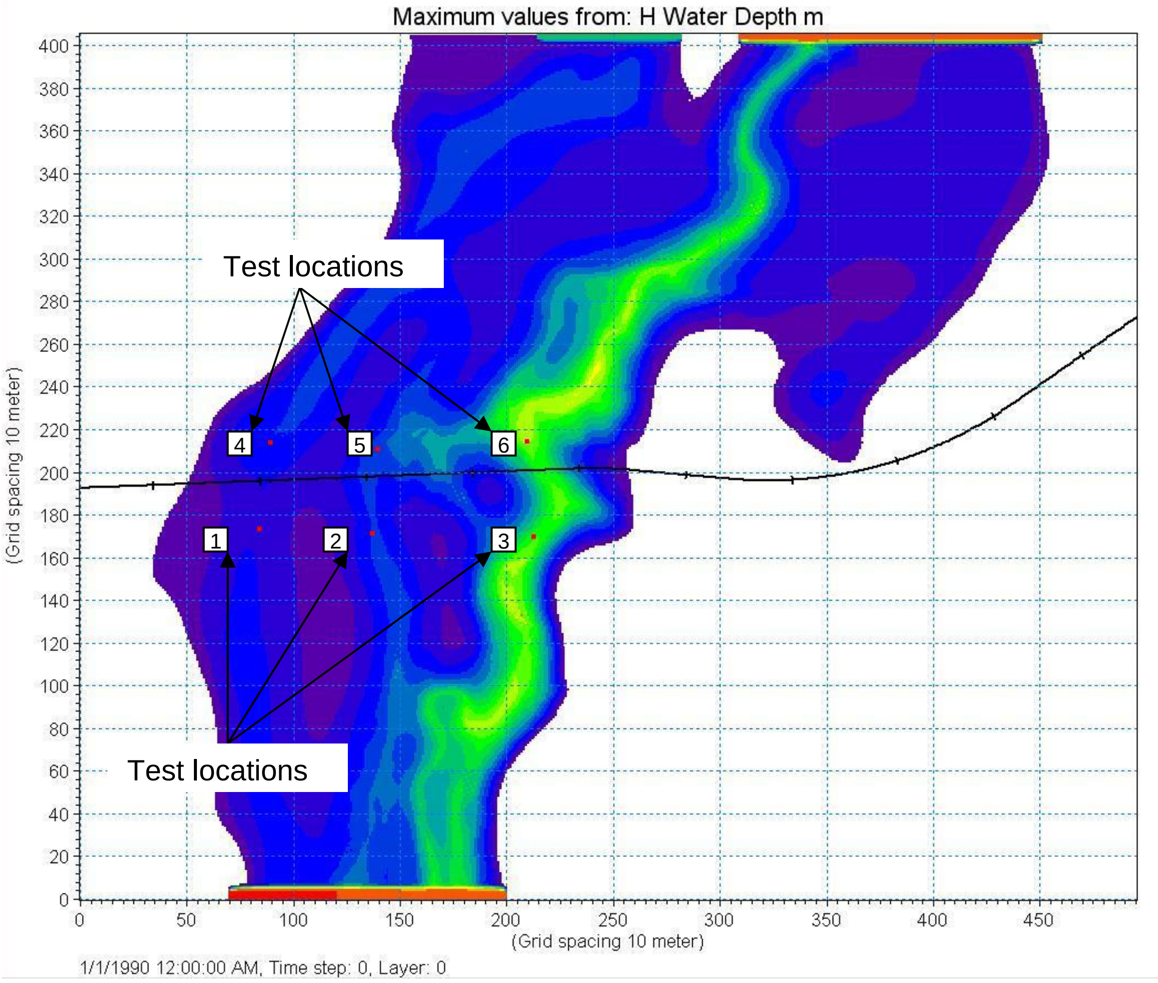


Figure 8: Sensitivity testing locations

Six 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 8. The sensitivity of the Manning's 'M' value is shown in Table 14.

Table 14: Manning's 'M' value sensitivity (depth)

Location	Adopted value (m)	+30% value	Change (m)	-30% value	Change (m)
1	0.695	1.016	0.321	0.545	-0.150
2	1.242	1.598	0.356	1.034	-0.208
3	3.344	3.690	0.346	3.124	-0.220
4	1.170	1.573	0.403	0.922	-0.248
5	1.483	1.864	0.381	1.246	-0.237
6	4.162	4.503	0.341	3.949	-0.213

The Manning's value has an impact ranging from -250mm to +410mm on the predicted water surface level. This has an equivalent inundation extent impact of -5.0% and +4.6%, which is a relatively minor impact on the predicted extents.

At the same testing locations, the peak velocities were also extracted. From Table 15, 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 15: Manning's 'M' value sensitivity (velocity)

Location	Adopted value (m/s)	+30% value	Change (%)	-30% value	Change (%)
1	0.288	0.225	-21.9	0.331	14.9
2	0.384	0.297	-22.7	0.458	19.3
3	1.385	1.071	-22.7	1.633	17.9
4	0.164	0.145	-11.6	0.181	10.4
5	0.208	0.191	-8.2	0.223	7.2
6	0.805	0.669	-16.9	0.915	13.7

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 16.

Table 16: Inflow hydrograph sensitivity

Location	Adopted value (m)	+30% value	Change (m)	-30% value	Change (m)
1	0.695	0.943	0.248	0.469	-0.226
2	1.242	1.520	0.278	0.936	-0.306
3	3.344	3.610	0.266	3.019	-0.325
4	1.170	1.491	0.321	0.786	-0.384
5	1.483	1.785	0.302	1.123	-0.360
6	4.162	4.433	0.271	3.839	-0.323

The inflow values have an impact ranging from -330mm to +390mm on the predicted water surface level. This has an equivalent inundation extent impact of -8.5% and +3.6%, 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 17.

Table 17: Downstream boundary sensitivity

Location	Adopted value (m)	+30% value	Change (m)	-30% value	Change (m)
1	0.695	0.695	0.000	0.695	-0.000
2	1.242	1.242	0.000	1.242	-0.000
3	3.344	3.345	0.001	3.344	-0.000
4	1.170	1.171	0.001	1.170	-0.000
5	1.483	1.483	0.000	1.482	-0.001
6	4.162	4.163	0.001	4.162	-0.000

The downstream boundary level has a negligible impact on the predicted water surface level.

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.

At the time of completion of this Detailed Floodplain Study, a significant increase in cross-drainage infrastructure was required in order to minimise the impact of the proposed ACP rail alignment on the floodplain system.

The following additional cross-drainage structures are proposed to meet the EIS, SEIS and stakeholder requirements for the system. For Mistake Creek, the following additional cross-drainage infrastructure is recommended in order to minimise the impacts of the railway:

- 23/ 1200mm diameter CSPs on the southern side of the floodplain;
- 40/ 1200mm diameter CSPs on the central branch of the floodplain;
- 20/1800mm and 10/1200mm diameter CSPs on the northern side of the floodplain;
- 41/ 2700mm diameter supplementary CSPs on the main branch of Mistake Creek.

The approximate locations for the proposed cross-drainage infrastructure are shown below in Figure 9.

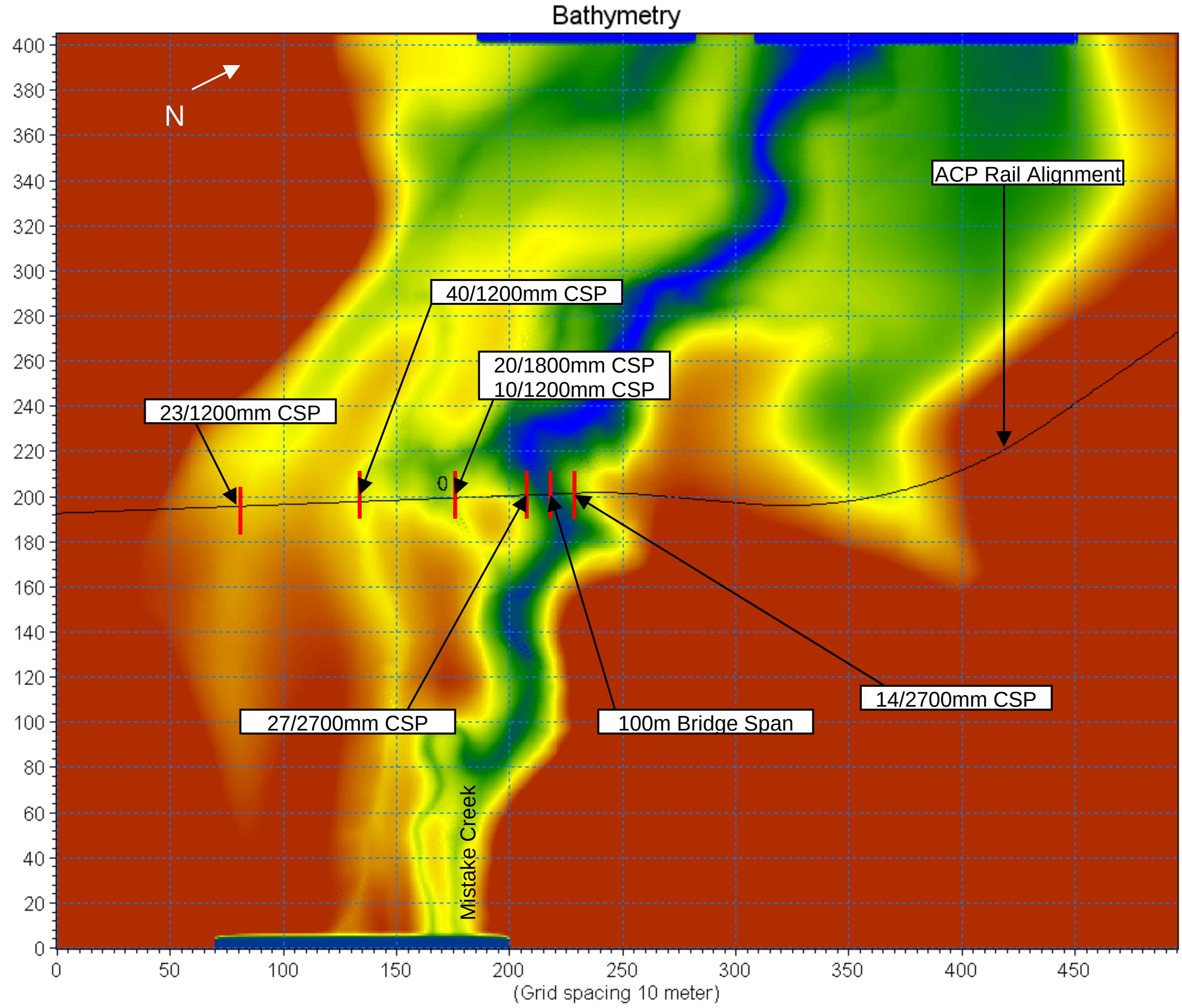


Figure 9: Drainage structure locations and total quantities

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 Mistake Creek system.

Feedback from Landholders through 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 18.

Table 18: 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 0.01% 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. Culverts outlet velocity: = 1.5m/s where erodible soils are present. = 2.5m/s for normal soils (with no erosion control).	Conforms to SEIS requirements. Refer Velocity drawing in Appendix C for details.
Maximum afflux	Maximum 0.5m – normally (unless justifiable). Maximum 0.2m – around critical infrastructure. Maximum 0.1m – around dwellings.	Conforms to SEIS requirements. 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 19.

Table 19: Change in inundation extents

Event ARI (years)	% change in "wet" cells	Change in area (ha)
5	1.88	4.37
50	0.01	0.26

With the inclusion of additional cross-drainage structures, the proposed ACP rail alignment will meet the afflux limits specified in the SEIS. 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 C.

Inundation Duration

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 i.e; 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.

It should be noted that the predicted impacts from the proposed railway extend up to the upstream model boundary and as such, the current model cannot be used to demonstrate the entire impacted area. An attempt was made to match the SRTM surface to the LiDAR however large irregularities between adjacent SRTM tiles meant that the area around Mistake Creek was unusable. In order to undertake further modelling, additional detailed survey data would be required further upstream from the proposed railway alignment. However, the maximum relative impact is 20mm at the upstream boundary during the design event. As this level is below the threshold for impacts under the SEIS conditions, the model extent is considered adequate for the purposes of this Detailed Floodplain Study.

10.0 CONCLUSION

Detailed hydrologic and hydraulic modelling has been completed for Mistake Creek at the proposed ACP rail alignment. It has been shown that the proposed railway can mitigate its hydraulic impacts to meet the limits placed on the project by the SEIS. The recommended cross-drainage structures for Mistake Creek are shown in Tables 20 and 21. Alternative drainage structures may be utilised providing equivalent hydraulic performance is maintained or improved.

Table 20: Mistake Creek

Item	Value
Proposed cross-drainage infrastructure	1/ 100m bridge span. 73/ 1200mm diameter supplementary CSPs. 20/ 1800mm diameter supplementary CSPs. 41/ 2700mm diameter supplementary CSPs.

Table 21: Floodplain relief culverts

Item	Value
Proposed cross-drainage infrastructure	900mm diameter CSPs at 50m 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

Client:	Hancock coal			Date:	17/8/2011
Project/Job:	ACP	Job No:		Sheet No:	
Subject:	**FFA Mistake Creek**			By:	ARB

HISTORICAL DATA

Sample Period (Years)	24	Adjusted Mean, *M*	2.221
Number of Samples to Use, *N*	24	Adjusted Std Deviation, *S*	0.380
Plotting Position Parameter, α	0.4	Coefficient of Skewness, *g*	-0.827

Rank	Discharge (m³/s)	P_N AEP	Y_P ARI	Plotting Position	$\sum Log(Q)$	$\sum Log(Q)^2$	$\sum Log(Q)^3$
1	748.09	2.5%	40.33	1.964	2.874	8.260	23.738
2	573.52	6.6%	15.13	1.505	5.633	15.869	44.729
3	478.68	10.7%	9.31	1.240	8.313	23.052	63.979
4	318.69	14.9%	6.72	1.042	10.816	29.319	79.667
5	272.07	19.0%	5.26	0.878	13.251	35.246	94.099
6	257.41	23.1%	4.32	0.734	15.661	41.057	108.108
7	256.3	27.3%	3.67	0.605	18.070	46.860	122.083
8	255.19	31.4%	3.18	0.484	20.477	52.653	136.026
9	230.43	35.5%	2.81	0.371	22.839	58.234	149.213
10	228.48	39.7%	2.52	0.262	25.198	63.798	162.338
11	222.85	43.8%	2.28	0.156	27.546	69.311	175.283
12	215.52	47.9%	2.09	0.052	29.880	74.757	187.989
13	200.61	52.1%	1.92	-0.052	32.182	80.057	200.194
14	200.22	56.2%	1.78	-0.156	34.484	85.354	212.385
15	165.43	60.3%	1.66	-0.262	36.702	90.277	223.305
16	164.78	64.5%	1.55	-0.371	38.919	95.191	234.200
17	162.23	68.6%	1.46	-0.484	41.129	100.076	244.996
18	101.95	72.7%	1.38	-0.605	43.138	104.110	253.097
19	83.65	76.9%	1.30	-0.734	45.060	107.805	260.203
20	75.86	81.0%	1.23	-0.878	46.940	111.340	266.847
21	71.83	85.1%	1.17	-1.042	48.796	114.786	273.244
22	65.09	89.3%	1.12	-1.240	50.610	118.075	279.208
23	26.74	93.4%	1.07	-1.505	52.037	120.111	282.115
24	18.72	97.5%	1.03	-1.964	53.309	121.730	284.175

Client:	Hancock coal		Date:	17/8/2011
Project/Job:	ACP	Job No:	Sheet No:	
Subject:	**FFA Mistake Creek**		By:	ARB

LOG-PEARSON III DISTRIBUTION

Mean Override, *M*	2.221	2.221
Std Deviation Override, *S*	0.38	0.380
Skewness Override, *g*	-0.827	-0.827

Gridline Data

	Min	Max
Discharge (r	1	10000
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%	991.9	639.3	1923.9	3.291	2.041
1000	0.1%	944.7	613.4	1807.6	3.090	1.985
500	0.2%	891.9	584.1	1679.8	2.878	1.919
200	0.5%	812.6	539.5	1492.3	2.576	1.813
100	1.0%	744.6	500.6	1335.9	2.326	1.713
50	2.0%	669.0	456.4	1167.0	2.054	1.591
20	5.0%	555.9	388.4	925.3	1.645	1.379
10	10.0%	459.3	328.0	730.3	1.282	1.161
5	20.0%	351.7	257.4	527.7	0.842	0.856
2	50.0%	187.4	139.3	256.0	0.000	0.136
1.667	60.0%	150.1	110.0	202.1	-0.253	-0.117
1.429	70.0%	116.3	82.9	156.1	-0.524	-0.409
1.250	80.0%	84.3	56.9	114.6	-0.842	-0.777
1.111	90.0%	51.6	31.3	73.6	-1.282	-1.337
1.053	95.0%	33.1	17.9	50.1	-1.645	-1.845
1.010	99.0%	13.0	5.4	22.9	-2.326	-2.909

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	1219	2.326
50	0.02	942	2.054
20	0.05	642	1.645
10	0.1	418	1.282
5	0.2	276	0.842
2	0.5		0.000

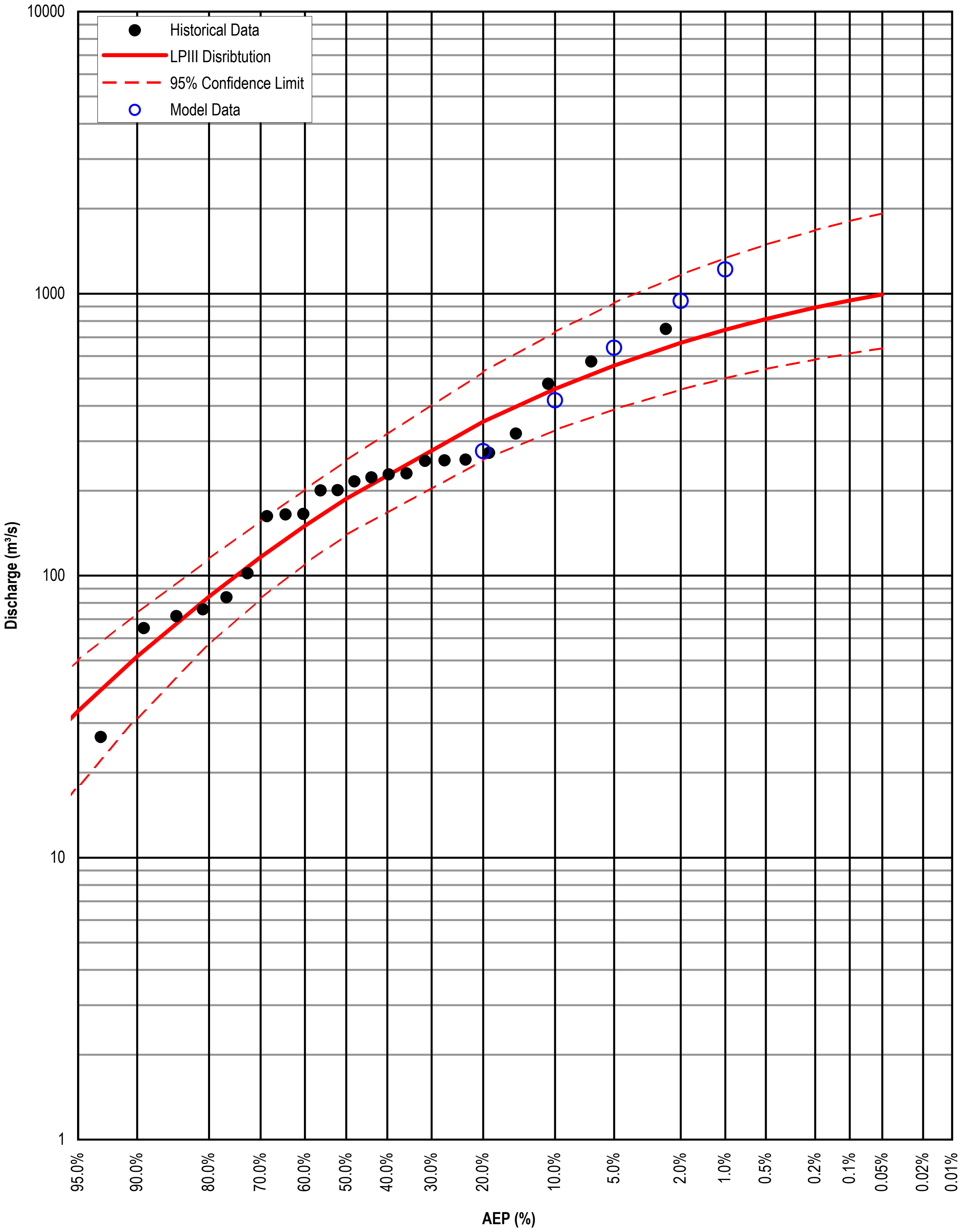
m=1.1, IL=10, CL=2

1437
1224
975
771
618
382

Client:	Hancock coal			Date:	17/8/2011
Project/Job:	ACP	Job No:		Sheet No:	
Subject:	**FFA Mistake Creek**			By:	ARB

Sample Period (Years)	24
Number of Samples Used, *N*	24
Plotting Position Parameter, α	0.4

Adjusted Mean, *M*	2.221
Adjusted Std Deviation, *S*	0.380
Coefficient of Skewness, *g*	-0.827



1

0.(# # # 99.999%
# # #

0.(# # # 99.995%
# # #

0.(# # # 99.99%
# # #

0.(# # # 99.98%
# # #

0.(# # # 99.95%
# # #

0. # # # 99.9%
# # #

0.: # # # 99.8%
# # #

0.: # # # 99.5%
# # #

1.(# # # 99.0%
# # #

2.(# # # 98.0%
# # #

5.(# # # 95.0%
# # #

1(# # # 90.0%
# # #

2(# # # 80.0%
# # #

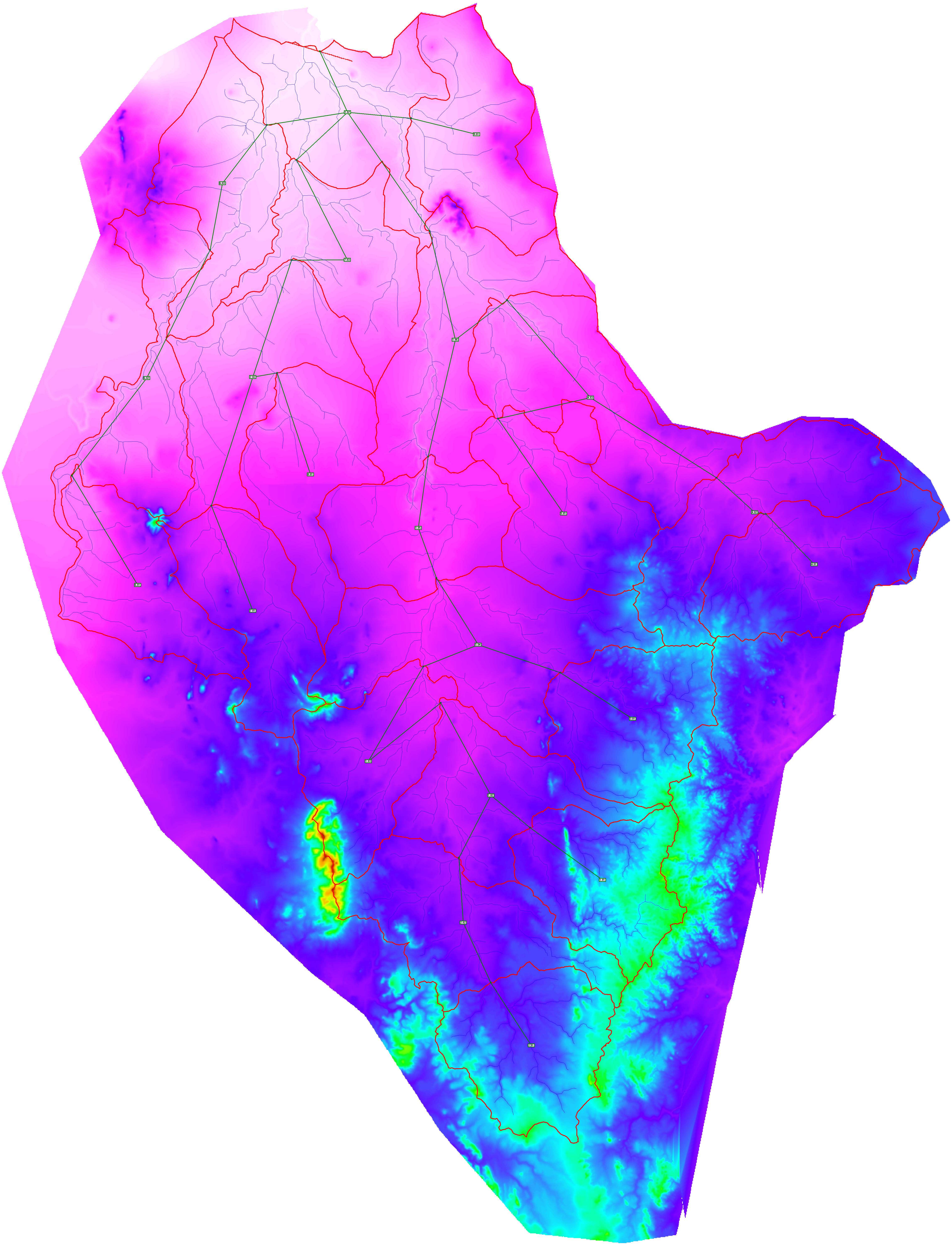
3(# # # 70.0%
# # #

4(# # # 60.0%
# # #

5(#
# #

APPENDIX B
RORB RESULTS

Mistake Creek Catchment Deliniation



Kc and m parameters - Mistake Creek Stream Gauge

Mistake Creek

ARR Book 5

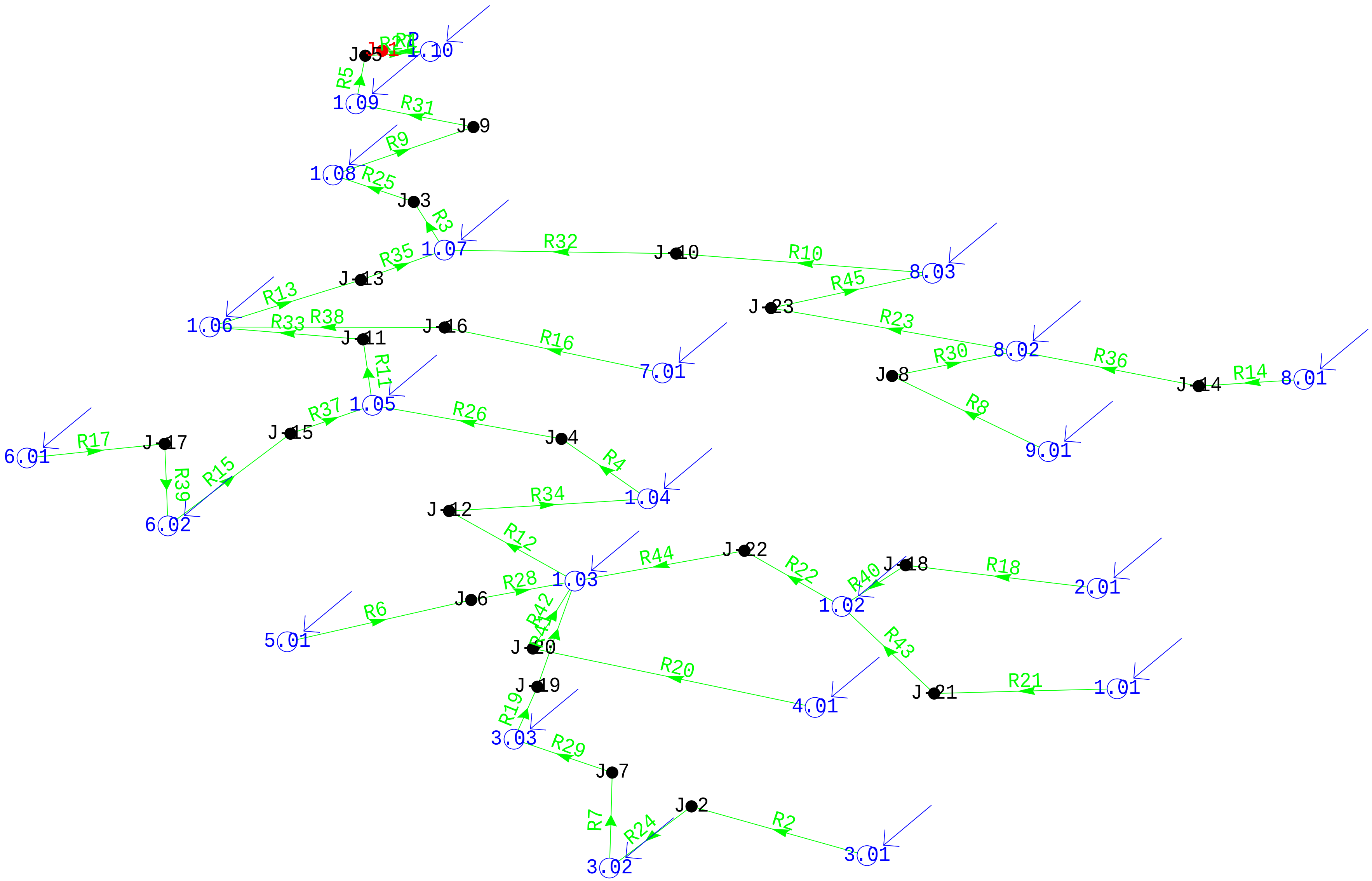
Catchment area	2739	km^2	
d_{av}	60.62	km	(from RORB model)
K_c (Weeks, QLD)	58.40		

adjusted K_c	58.4	
m	0.846986	for 0.6<m<1.2

LHS	RHS (goal seek to LHS by changing m)
0.963378423	0.963181

RORB manual	**Iteration1**	
K_c	83.43187	
Q_p	1000	m^3/s
m_1	0.85183	

Mistake Creek RORB



mistake creek_72h50y

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

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

 Date run: 08 Oct 2011 14:23

 Vector file       : S:\PRO-Projects\2011\CARP11064 HCPL Alpha FEED\06
Engineering\6.4 Hydrology\Mistake Creek\RORB\Mistake Creek.catg
 Storm file        : S:\PRO-Projects\2011\CARP11064 HCPL Alpha FEED\06
Engineering\6.4 Hydrology\Mistake Creek\RORB\Mistake Creek_72h50y.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.  61     7.0 Location read as  Subcatchment: 1.10
 Sub-area areas
 Impervious flag
 Initial storm data
 Rainfall burst times
 Pluviograph 1
 Sub-area rainfalls

 Data check completed



 Data:
 ****

 Mistake  Creek


 Time data, in increments from initial time
 Mistake  Creek: 72 hour 50 year Design Storm
 Time increment (hours)=  4.00

                  Start   Finish
 Rainfall times:     0       18


 End of hyeto/hydrographs:   18
 Duration of calculations:  100



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

         1:Temporal pattern (% of depth
   Time     1
     0    25.8
     1     4.7
     2     1.7
     3     0.7
     4     1.3
     5     2.6
     6    12.0
     7    17.0
     8     6.0
     9     3.1
    10     1.0
```

11	2.1
12	7.5
13	9.4
14	3.8
15	0.5
16	0.5
17	0.3
Total	100.0

DESIGN run control vector

Step	Code	Description
1	1	Add sub-area 'A' inflow & route thru normal storage 1
2	5	Route hydrograph thru normal storage 2
3	2	Add sub-area 'B' inflow & route thru normal storage 3
4	5	Route hydrograph thru normal storage 4
5	2	Add sub-area 'C' inflow & route thru normal storage 5
6	5	Route hydrograph thru normal storage 6
7	3	Store hydrograph from step 6; reset hydrograph to zero
8	1	Add sub-area 'D' inflow & route thru normal storage 7
9	5	Route hydrograph thru normal storage 8
10	3	Store hydrograph from step 9; reset hydrograph to zero
11	1	Add sub-area 'E' inflow & route thru normal storage 9
12	5	Route hydrograph thru normal storage 10
13	4	Add h-graph ex step 10 to h-graph ex step 12
14	2	Add sub-area 'F' inflow & route thru normal storage 11
15	5	Route hydrograph thru normal storage 12
16	4	Add h-graph ex step 7 to h-graph ex step 15
17	3	Store hydrograph from step 16; reset hydrograph to zero
18	1	Add sub-area 'G' inflow & route thru normal storage 13
19	5	Route hydrograph thru normal storage 14
20	4	Add h-graph ex step 17 to h-graph ex step 19
21	3	Store hydrograph from step 20; reset hydrograph to zero
22	1	Add sub-area 'H' inflow & route thru normal storage 15
23	5	Route hydrograph thru normal storage 16
24	4	Add h-graph ex step 21 to h-graph ex step 23
25	2	Add sub-area 'I' inflow & route thru normal storage 17
26	5	Route hydrograph thru normal storage 18
27	2	Add sub-area 'J' inflow & route thru normal storage 19
28	5	Route hydrograph thru normal storage 20
29	3	Store hydrograph from step 28; reset hydrograph to zero
30	1	Add sub-area 'K' inflow & route thru normal storage 21
31	5	Route hydrograph thru normal storage 22
32	2	Add sub-area 'L' inflow & route thru normal storage 23
33	5	Route hydrograph thru normal storage 24
34	4	Add h-graph ex step 29 to h-graph ex step 33
35	2	Add sub-area 'M' inflow & route thru normal storage 25
36	5	Route hydrograph thru normal storage 26
37	3	Store hydrograph from step 36; reset hydrograph to zero
38	1	Add sub-area 'N' inflow & route thru normal storage 27
39	5	Route hydrograph thru normal storage 28
40	4	Add h-graph ex step 37 to h-graph ex step 39
41	2	Add sub-area 'O' inflow & route thru normal storage 29
42	5	Route hydrograph thru normal storage 30
43	3	Store hydrograph from step 42; reset hydrograph to zero
44	1	Add sub-area 'P' inflow & route thru normal storage 31
45	5	Route hydrograph thru normal storage 32
46	3	Store hydrograph from step 45; reset hydrograph to zero
47	1	Add sub-area 'Q' inflow & route thru normal storage 33
48	5	Route hydrograph thru normal storage 34
49	4	Add h-graph ex step 46 to h-graph ex step 48
50	2	Add sub-area 'R' inflow & route thru normal storage 35
51	5	Route hydrograph thru normal storage 36
52	2	Add sub-area 'S' inflow & route thru normal storage 37

mistake creek_72h50y

```
 53    5     Route hydrograph thru normal storage   38
 54    4     Add h-graph ex step   43 to h-graph ex step   53
 55    2     Add sub-area 'T' inflow & route thru normal storage   39
 56    5     Route hydrograph thru normal storage   40
 57    2     Add sub-area 'U' inflow & route thru normal storage   41
 58    5     Route hydrograph thru normal storage   42
 59    2     Add sub-area 'V' inflow & route thru normal storage   43
 60    5     Route hydrograph thru normal storage   44
 61    7.0   Print hydrograph,  Subcatchment: 1.10
 62    2     Add sub-area 'W' inflow & route thru normal storage   45
 63    0     **********End of control vector**********
```

Sub-area data

Sub-area	Area km²	Dist. km*
A	1.91E+02	1.09E+02
B	1.36E+02	9.39E+01
C	1.02E+02	8.60E+01
D	1.02E+02	9.86E+01
E	1.00E+02	1.03E+02
F	1.00E+02	8.51E+01
G	1.37E+02	9.28E+01
H	1.01E+02	9.76E+01
I	1.18E+02	7.11E+01
J	1.71E+02	5.58E+01
K	1.02E+02	6.38E+01
L	1.06E+02	5.31E+01
M	1.18E+02	4.24E+01
N	1.05E+02	4.58E+01
O	1.13E+02	3.12E+01
P	1.28E+02	6.06E+01
Q	1.07E+02	5.48E+01
R	1.00E+02	4.12E+01
S	1.24E+02	3.19E+01
T	1.74E+02	2.39E+01
U	1.25E+02	1.57E+01
V	1.66E+02	6.00E+00
W	1.22E+01	2.44E-01

Total 2.740E+03

```
For whole catchment     ; Av. Dist., km* =      60.62
For interstation area  1; Av. Dist., km* =      60.62; 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	12.4	0.204	Natural	
2	2.9	0.047	Natural	
3	2.9	0.047	Natural	
4	5.0	0.082	Natural	
5	5.0	0.082	Natural	
6	10.0	0.165	Natural	
7	9.5	0.156	Natural	
8	4.0	0.067	Natural	
9	13.4	0.220	Natural	
10	4.0	0.067	Natural	
11	4.0	0.067	Natural	
12	10.0	0.165	Natural	
13	11.8	0.194	Natural	

14	10.0	0.165	Natural
15	16.5	0.272	Natural
16	10.0	0.165	Natural
17	10.0	0.165	Natural
18	5.3	0.087	Natural
19	5.3	0.087	Natural
20	8.1	0.133	Natural
21	8.1	0.133	Natural
22	2.6	0.043	Natural
23	2.6	0.043	Natural
24	8.1	0.133	Natural
25	8.1	0.133	Natural
26	3.2	0.053	Natural
27	11.4	0.188	Natural
28	3.2	0.053	Natural
29	3.2	0.053	Natural
30	4.1	0.067	Natural
31	14.0	0.230	Natural
32	5.4	0.089	Natural
33	8.2	0.136	Natural
34	5.4	0.089	Natural
35	5.4	0.089	Natural
36	3.9	0.064	Natural
37	3.9	0.064	Natural
38	4.1	0.067	Natural
39	4.1	0.067	Natural
40	4.2	0.069	Natural
41	4.2	0.069	Natural
42	5.5	0.091	Natural
43	5.5	0.091	Natural
44	0.2	0.004	Natural
45	0.2	0.004	Natural

* or other function of reach properties related to travel time

Input of parameters:
****

Mistake Creek
DESIGN Run
Mistake Creek: 72 hour 50 year Design Storm
Time increment = 4.00 hours

Constant loss model selected

Rainfall, mm, in time inc. following time shown

Time Incs	Catch ment	Sub-Area A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
0	69.9	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
1	12.7	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
2	4.6	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
3	1.9	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
4	3.5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
5	7.0	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
6	32.5	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33

```
                                  mistake creek_72h50y
    7   46.1          46   46   46   46   46   46   46   46   46   46   46   46   46   46   46
46
    8   16.3          16   16   16   16   16   16   16   16   16   16   16   16   16   16   16
16
    9    8.4           8    8    8    8    8    8    8    8    8    8    8    8    8    8    8
8
   10    2.7           3    3    3    3    3    3    3    3    3    3    3    3    3    3    3
3
   11    5.7           6    6    6    6    6    6    6    6    6    6    6    6    6    6    6
6
   12   20.3          20   20   20   20   20   20   20   20   20   20   20   20   20   20   20
20
   13   25.5          25   25   25   25   25   25   25   25   25   25   25   25   25   25   25
25
   14   10.3          10   10   10   10   10   10   10   10   10   10   10   10   10   10   10
10
   15    1.4           1    1    1    1    1    1    1    1    1    1    1    1    1    1    1
1
   16    1.4           1    1    1    1    1    1    1    1    1    1    1    1    1    1    1
1
   17    0.8           1    1    1    1    1    1    1    1    1    1    1    1    1    1    1
1

 Tot.271.0           271  271  271  271  271  271  271  271  271  271  271  271  271  271  271
271
 Pluvi. ref. no.       1    1    1    1    1    1    1    1    1    1    1    1    1    1    1
1

 Time                 Sub-
      Catch           Area
 Incs ment             Q    R    S    T    U    V    W

    0   69.9          70   70   70   70   70   70   70
    1   12.7          13   13   13   13   13   13   13
    2    4.6           5    5    5    5    5    5    5
    3    1.9           2    2    2    2    2    2    2
    4    3.5           4    4    4    4    4    4    4
    5    7.0           7    7    7    7    7    7    7
    6   32.5          33   33   33   33   33   33   33
    7   46.1          46   46   46   46   46   46   46
    8   16.3          16   16   16   16   16   16   16
    9    8.4           8    8    8    8    8    8    8
   10    2.7           3    3    3    3    3    3    3
   11    5.7           6    6    6    6    6    6    6
   12   20.3          20   20   20   20   20   20   20
   13   25.5          25   25   25   25   25   25   25
   14   10.3          10   10   10   10   10   10   10
   15    1.4           1    1    1    1    1    1    1
   16    1.4           1    1    1    1    1    1    1
   17    0.8           1    1    1    1    1    1    1

 Tot.271.0           271  271  271  271  271  271  271
 Pluvi. ref. no.       1    1    1    1    1    1    1



 Rainfall-excess, mm, in time inc. following time shown
 Time                 Sub-
      Catch           Area
 Incs ment             A    B    C    D    E    F    G    H    I    J    K    L    M    N    O
P

    0   34.9          35   35   35   35   35   35   35   35   35   35   35   35   35   35   35
35
    1    2.7           3    3    3    3    3    3    3    3    3    3    3    3    3    3    3
3
    2    0.0           0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
```

```
                              mistake creek_72h50y
0
   3   0.0         0   0   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   0   0   0
0
   5   0.0         0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
0
   6  22.5        23  23  23  23  23  23  23  23  23  23  23  23  23  23  23
23
   7  36.1        36  36  36  36  36  36  36  36  36  36  36  36  36  36  36
36
   8   6.3         6   6   6   6   6   6   6   6   6   6   6   6   6   6   6
6
   9   0.0         0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
0
  10   0.0         0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
0
  11   0.0         0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
0
  12  10.3        10  10  10  10  10  10  10  10  10  10  10  10  10  10  10
10
  13  15.5        15  15  15  15  15  15  15  15  15  15  15  15  15  15  15
15
  14   0.3         0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
0
  15   0.0         0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
0
  16   0.0         0   0   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   0   0   0
0

 Tot.128.6       129 129 129 129 129 129 129 129 129 129 129 129 129 129 129
129

 Time              Sub-
     Catch         Area
 Incs ment         Q   R   S   T   U   V   W

   0  34.9        35  35  35  35  35  35  35
   1   2.7         3   3   3   3   3   3   3
   2   0.0         0   0   0   0   0   0   0
   3   0.0         0   0   0   0   0   0   0
   4   0.0         0   0   0   0   0   0   0
   5   0.0         0   0   0   0   0   0   0
   6  22.5        23  23  23  23  23  23  23
   7  36.1        36  36  36  36  36  36  36
   8   6.3         6   6   6   6   6   6   6
   9   0.0         0   0   0   0   0   0   0
  10   0.0         0   0   0   0   0   0   0
  11   0.0         0   0   0   0   0   0   0
  12  10.3        10  10  10  10  10  10  10
  13  15.5        15  15  15  15  15  15  15
  14   0.3         0   0   0   0   0   0   0
  15   0.0         0   0   0   0   0   0   0
  16   0.0         0   0   0   0   0   0   0
  17   0.0         0   0   0   0   0   0   0

 Tot.128.6       129 129 129 129 129 129 129


 Routing results:
 ****************
 Mistake  Creek
 Mistake  Creek: 72 hour 50 year Design Storm
 DESIGN run no.  1
```

mistake creek_72h50y

Parameters: kc = 150.00 m = 0.85

Loss parameters	Initial loss (mm)	Cont. loss (mm/h)
	25.00	2.50

*** Calculated hydrograph, Subcatchment: 1.10

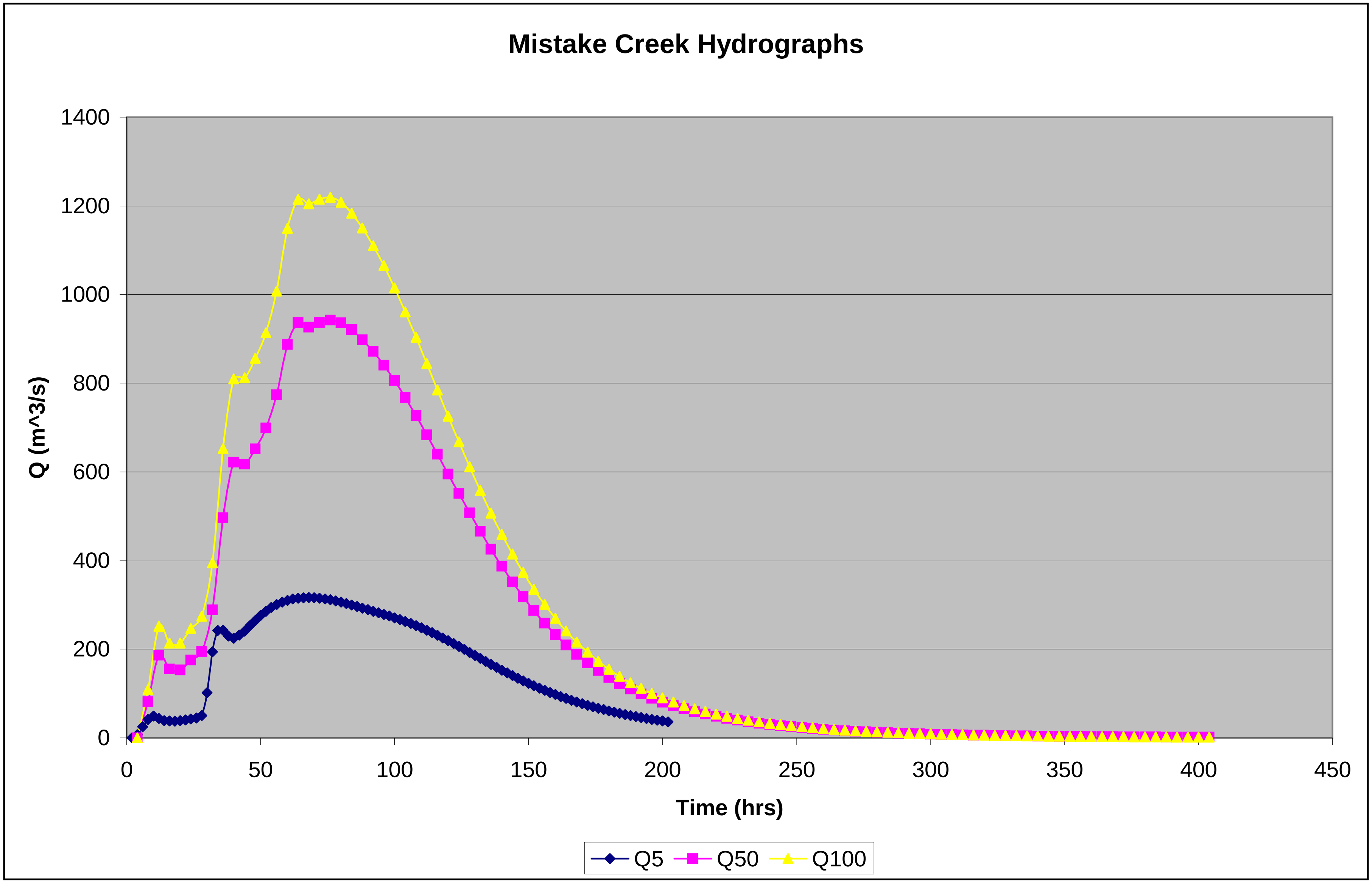
	Hydrograph Calc.
Peak discharge,m³/s	942.3
Time to peak,h	72.0
Volume,m³	3.51E+08
Time to centroid,h	92.3
Lag (c.m. to c.m.),h	66.3
Lag to peak,h	46.1

Hydrograph summary
****

Site	Description
01	Calculated hydrograph, Subcatchment: 1.10

Inc	Time	Hyd0001
1	4.00	0.000
2	8.00	81.321
3	12.00	186.507
4	16.00	155.557
5	20.00	152.981
6	24.00	175.390
7	28.00	194.661
8	32.00	288.922
9	36.00	496.296
10	40.00	621.957
11	44.00	617.683
12	48.00	651.934
13	52.00	699.134
14	56.00	773.802
15	60.00	887.439
16	64.00	936.833
17	68.00	926.294
18	72.00	936.532
19	76.00	942.316
20	80.00	936.015
21	84.00	920.840
22	88.00	898.123
23	92.00	871.464
24	96.00	840.327
25	100.00	805.900
26	104.00	767.602
27	108.00	726.791
28	112.00	683.699
29	116.00	639.688
30	120.00	595.117
31	124.00	550.999
32	128.00	507.616
33	132.00	465.686
34	136.00	425.419
35	140.00	387.292
36	144.00	351.411
37	148.00	318.033
38	152.00	287.144
39	156.00	258.814
40	160.00	232.934
41	164.00	209.449

42	168.00	188.193
43	172.00	169.045
44	176.00	151.823
45	180.00	136.381
46	184.00	122.545
47	188.00	110.172
48	192.00	99.107
49	196.00	89.224
50	200.00	80.392
51	204.00	72.502
52	208.00	65.450
53	212.00	59.145
54	216.00	53.504
55	220.00	48.454
56	224.00	43.930
57	228.00	39.873
58	232.00	36.231
59	236.00	32.960
60	240.00	30.018
61	244.00	27.369
62	248.00	24.982
63	252.00	22.828
64	256.00	20.883
65	260.00	19.125
66	264.00	17.533
67	268.00	16.091
68	272.00	14.783
69	276.00	13.595
70	280.00	12.515
71	284.00	11.532
72	288.00	10.636
73	292.00	9.820
74	296.00	9.075
75	300.00	8.394
76	304.00	7.771
77	308.00	7.200
78	312.00	6.677
79	316.00	6.198
80	320.00	5.757
81	324.00	5.353
82	328.00	4.980
83	332.00	4.638
84	336.00	4.322
85	340.00	4.030
86	344.00	3.762
87	348.00	3.513
88	352.00	3.283
89	356.00	3.071
90	360.00	2.874
91	364.00	2.692
92	368.00	2.522
93	372.00	2.365
94	376.00	2.220
95	380.00	2.084
96	384.00	1.958
97	388.00	1.841
98	392.00	1.731
99	396.00	1.629
100	400.00	1.534
101	404.00	1.446

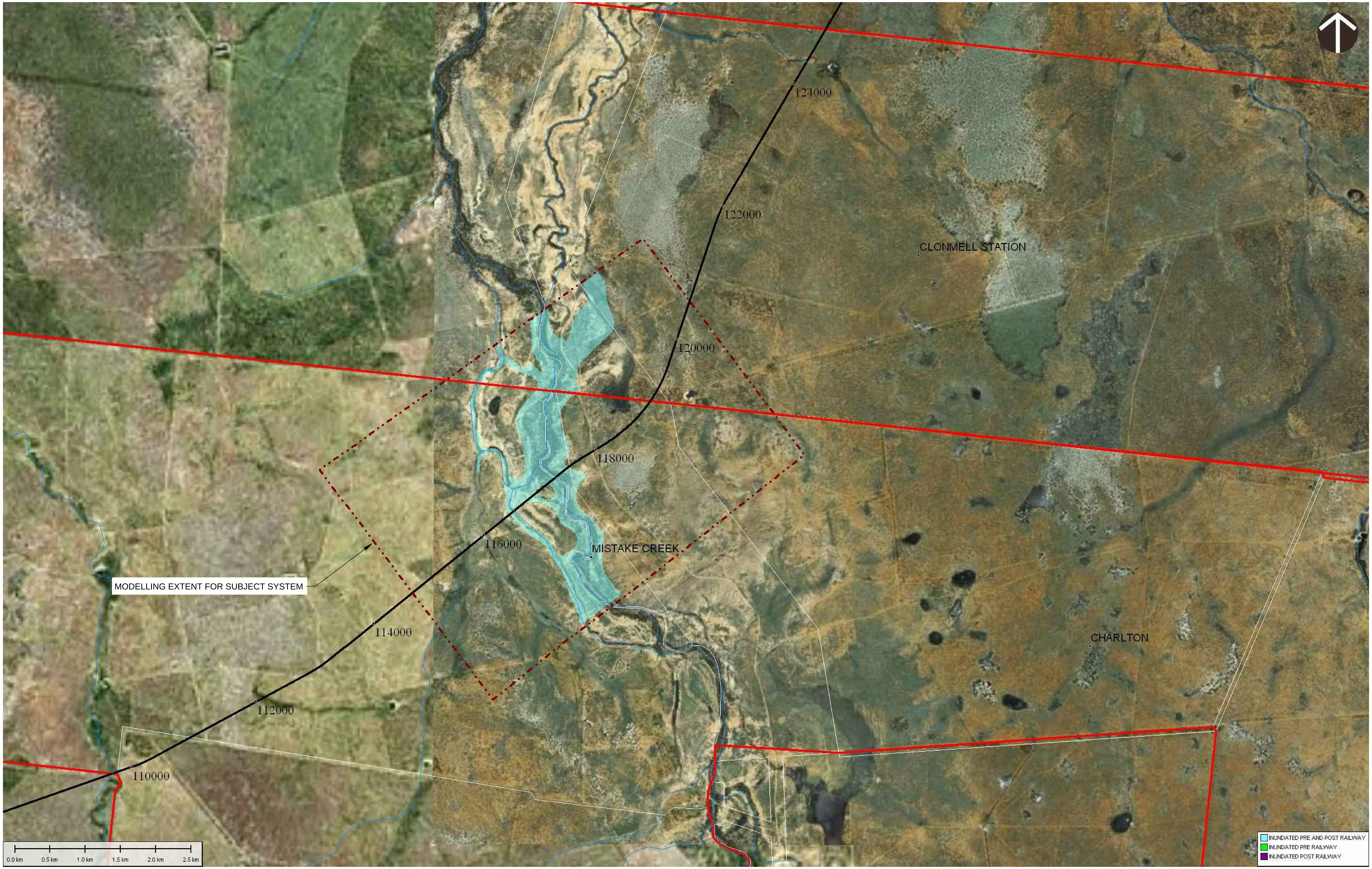


Mistake Creek Hydrographs
Q (m^3/s)
1400
1200
1000
800
600
400
200
0
0
50
100
150
200
250
300
350
400
450
Time (hrs)
Q5
Q50
Q100

APPENDIX C
FLOOD MAPS

NOT TO BE SCALED

NOT TO BE SCALED



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ALPHA COAL PROJECT
RAIL ALIGNMENT - MINE TO ABBOT POINT
FLOOD INUNDATION
MISTAKE CREEK - Q5

SHEET SIZE A1

PN No CJVP10007

SCALE NTS

CALIBRE DRAWING No. CJVP10007-DWG-G-741

HANCOCK COAL REFERENCE No. HC-CRL-24100-DRG-0673

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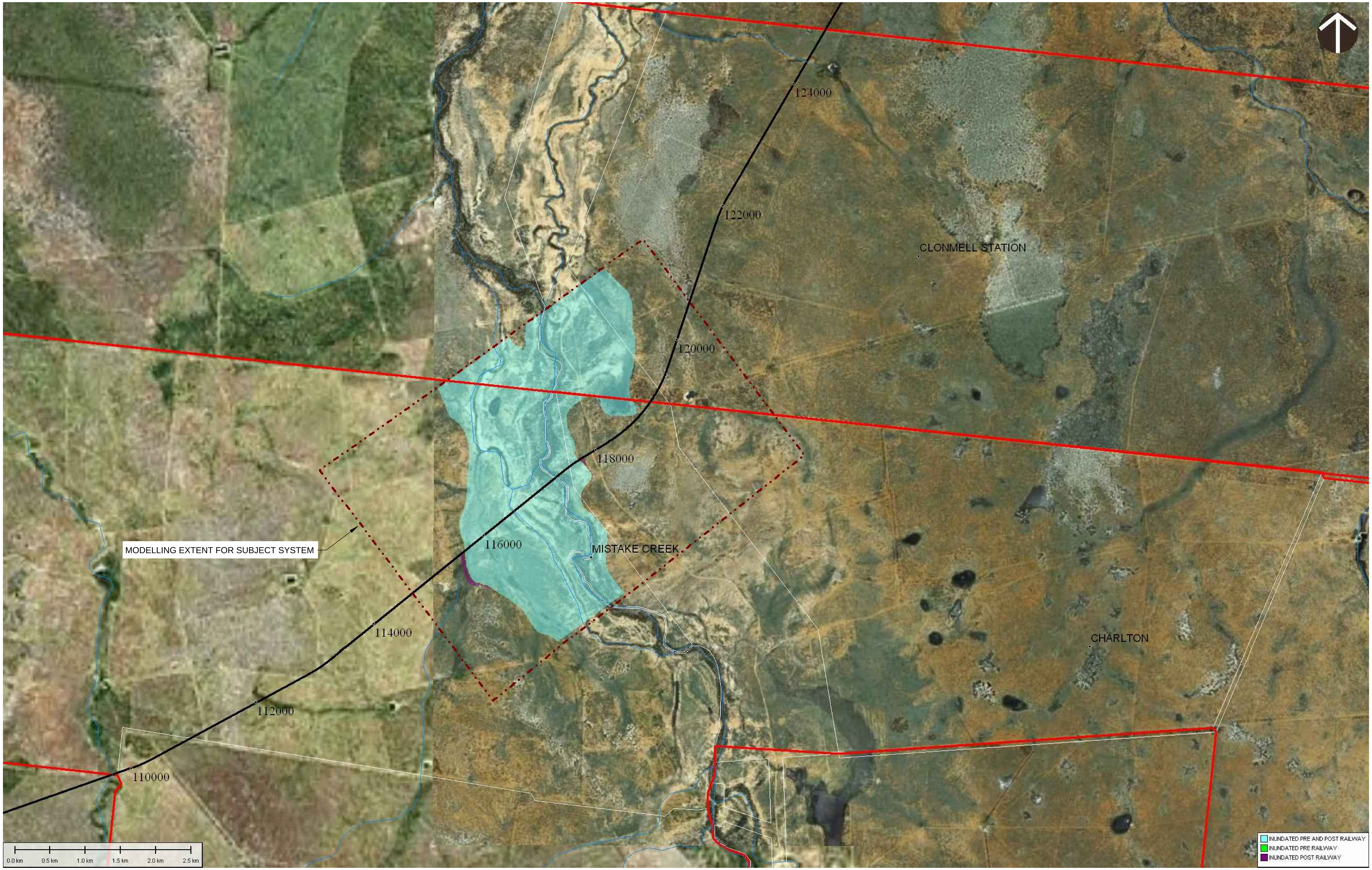

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FLOOD INUNDATION
MISTAKE CREEK - Q50

SHEET SIZE: A1
PN No: CJVP10007
SCALE: NTS

CALIBRE DRAWING No. CJVP10007-DWG-G-742
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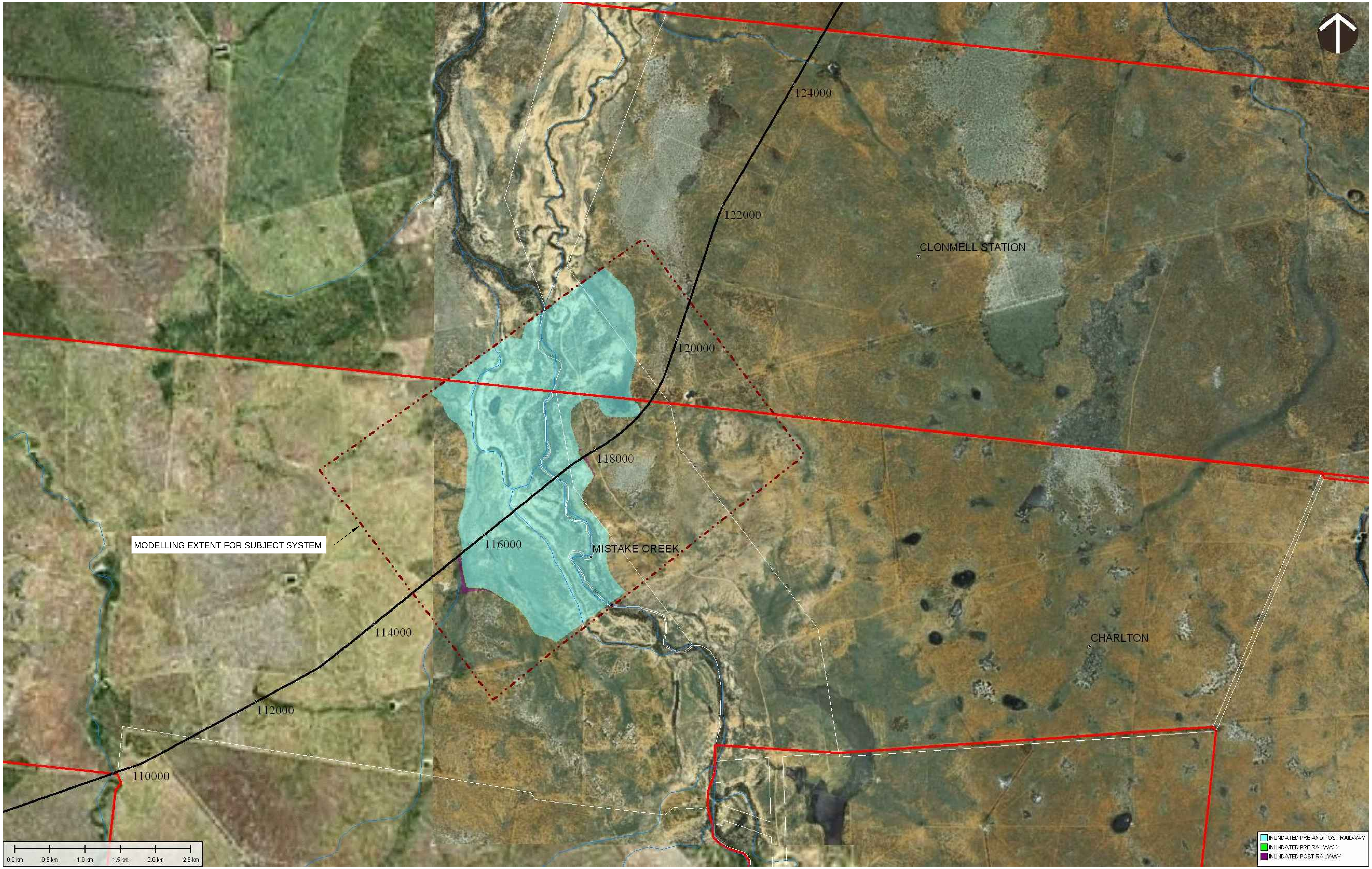

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RAIL ALIGNMENT - MINE TO ABBOT POINT
FLOOD INUNDATION
MISTAKE CREEK - Q100

SHEET SIZE A1

PN No CJVP10007

SCALE NTS

CALIBRE DRAWING No. CJVP10007-DWG-G-743

HANCOCK COAL REFERENCE No. HC-CRL-24100-DRG-0675

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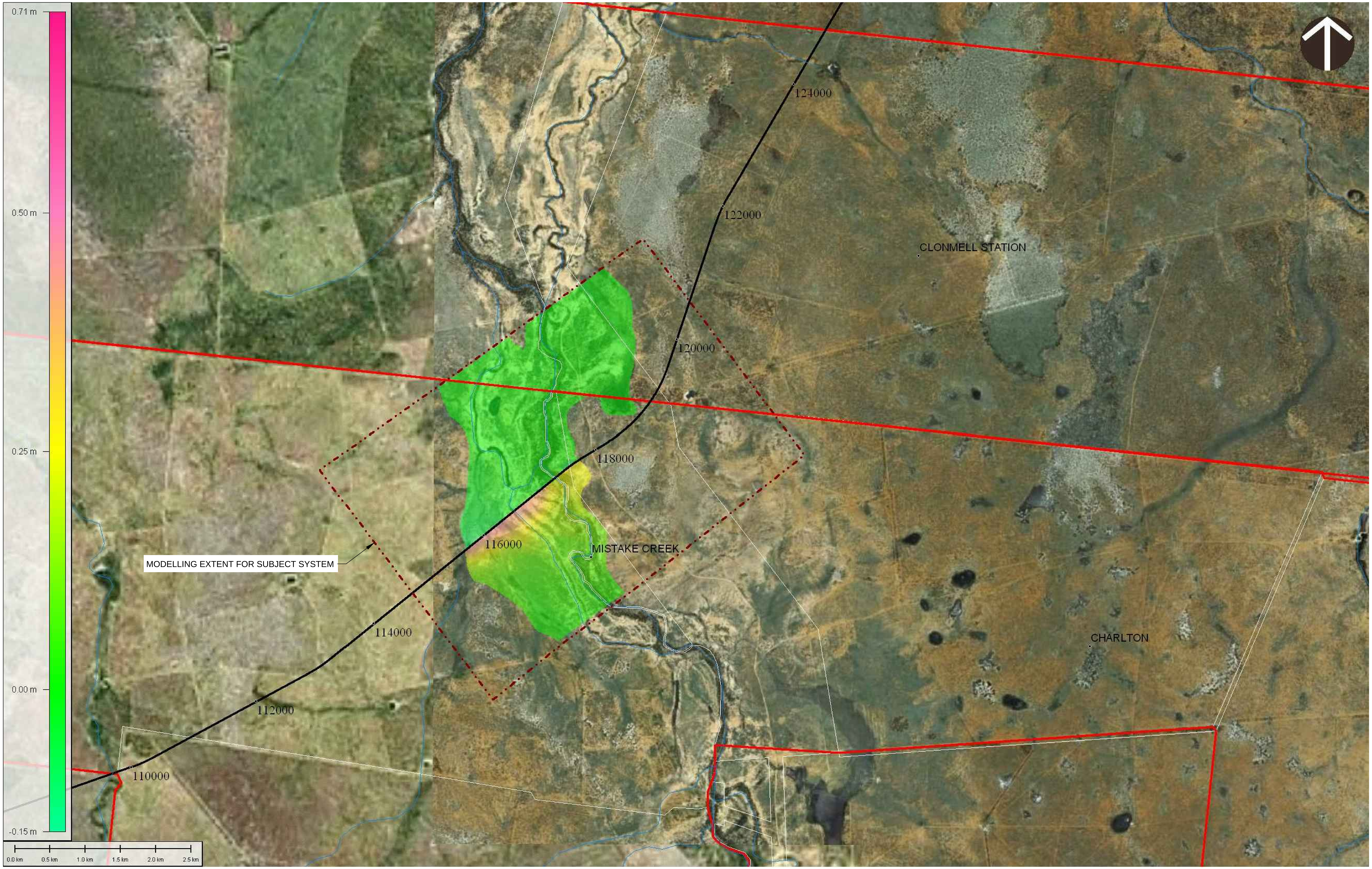

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AFFLUX
MISTAKE CREEK - Q50

SHEET SIZE A1

PN No CJVP10007

SCALE NTS

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HANCOCK COAL REFERENCE No. HC-CRL-24100-DRG-0676

REV A

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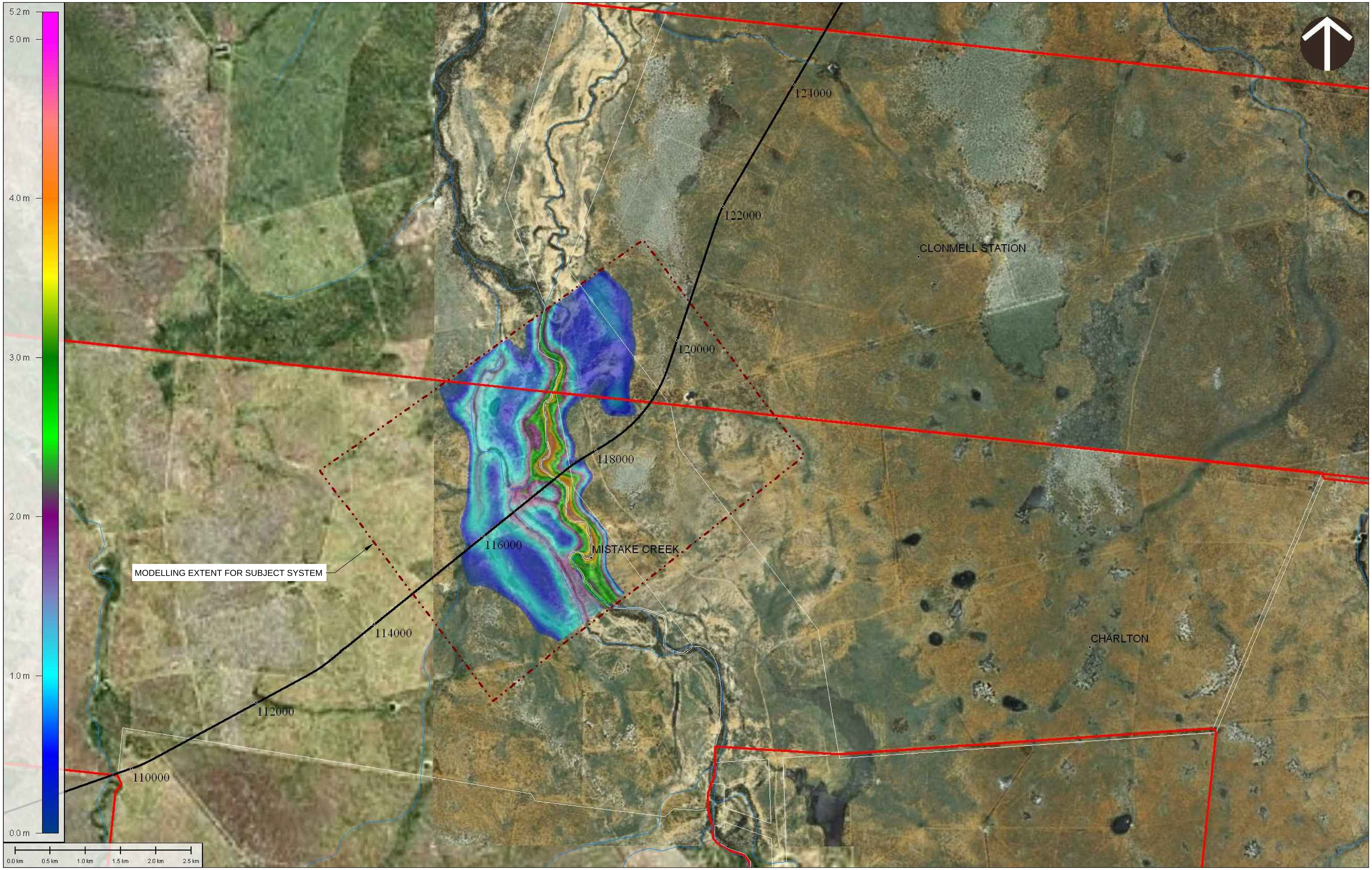

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RAIL ALIGNMENT - MINE TO ABBOT POINT
DEPTH
MISTAKE CREEK - Q50

SHEET SIZE A1

PN No CJVP10007

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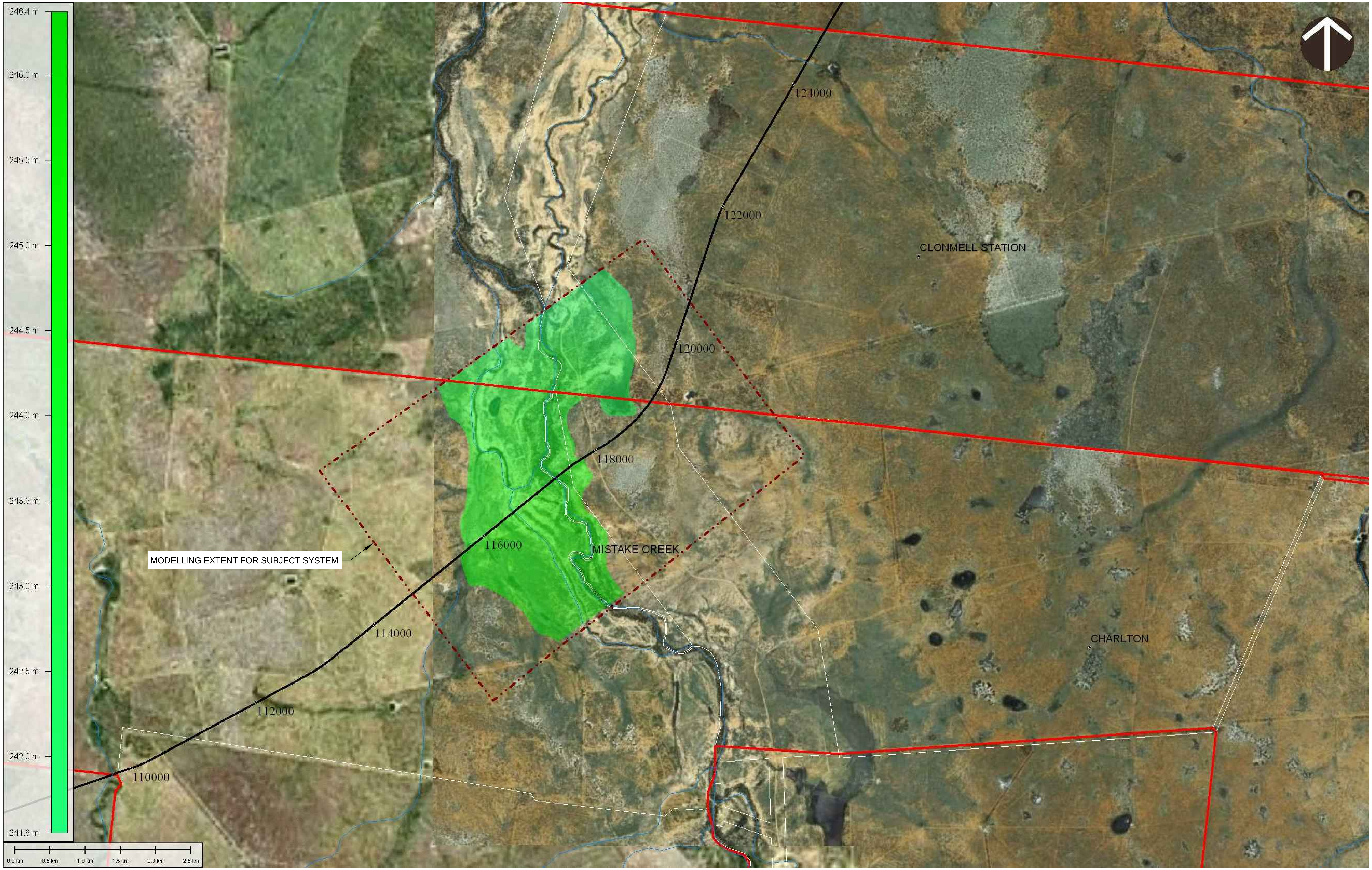

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RAIL ALIGNMENT - MINE TO ABBOT POINT
SURFACE ELEVATION
MISTAKE CREEK - Q50

SHEET SIZE A1
PN No CJVP10007
SCALE NTS

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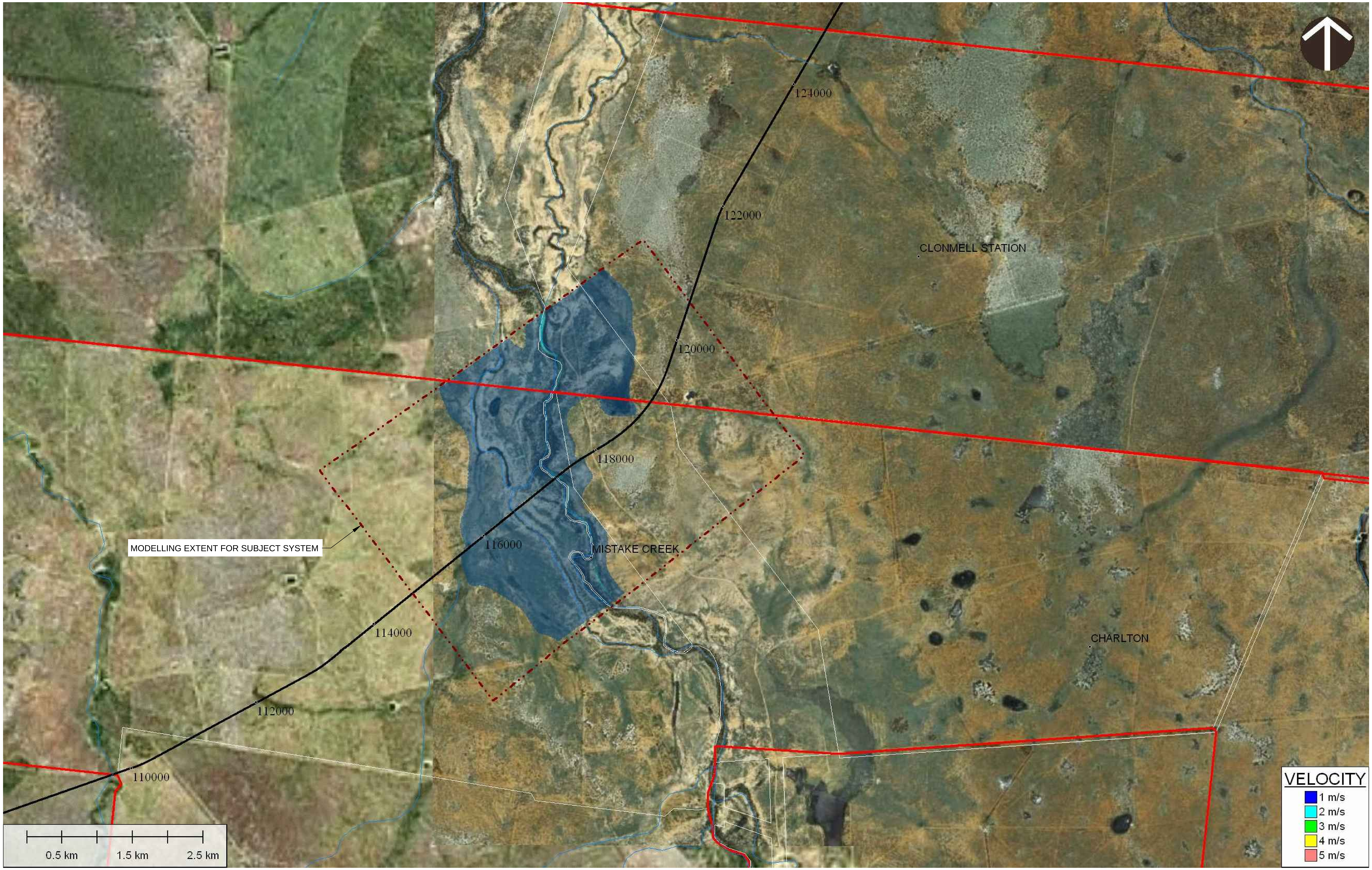

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ALPHA COAL PROJECT
RAIL ALIGNMENT - MINE TO ABBOT POINT
VELOCITY
MISTAKE CREEK - Q50

SHEET SIZE A1
PN No CJVP10007
SCALE NTS

CALIBRE DRAWING No. CJVP10007-DWG-G-747
HANCOCK COAL REFERENCE No. HC-CRL-24100-DRG-0679
REV A