HANCOCK COAL PTY LTD

Alpha Coal Project Supplementary EIS • **ADDENDUM**

F Rail Flood Plain Hydrology Reports

F1 Alpha Coal Project – Rail Phase 1B Detailed Floodplain Study Logan Creek/Brown Creek

F2 Alpha Coal Project – Rail Phase 1B Detailed Floodplain Study Suttor River/Eaglefield Creek

F3 Alpha Coal Project – Rail Phase 1B Detailed Floodplain Study Belyando River/Native Companion Creek

F4 Alpha Coal Project – Rail Phase 1B Detailed Floodplain Study Mistake Creek

F5 Alpha Coal Project – Rail Phase 1B Detailed Floodplain Study Miclere Creek/Piebald Creek

F6 Alpha Coal Project – Rail Phase 1B Detailed Floodplain Study Diamond Creek/Myra Creek/Nibbereena

Calibre Rail

Alpha Coal Project - Rail Phase 1B

Detailed Floodplain Study Logan Creek/Brown Creek

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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 Logan Creek / Brown 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 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 the development of a 30Mtpa 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 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 a 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 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 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 (CVJP10007-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 ±100mm) provided by HCIPL;
- LiDAR data flown for BFS alignment (approximate 4000 m wide corridor with a vertical accuracy of ±500 mm) 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
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 Logan Creek and Brown 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 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 Brown and Logan Creek system. A focus of this study is to assess the impacts that the proposed rail alignment would have on the landscape surrounding properties.

5.1 Flood Plain Location and Description

The combined Brown Creek and Logan Creek systems have a catchment area of approximately 2,600 km^2 and form 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 predominantly ephemeral streams (typically flow 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 2 below.

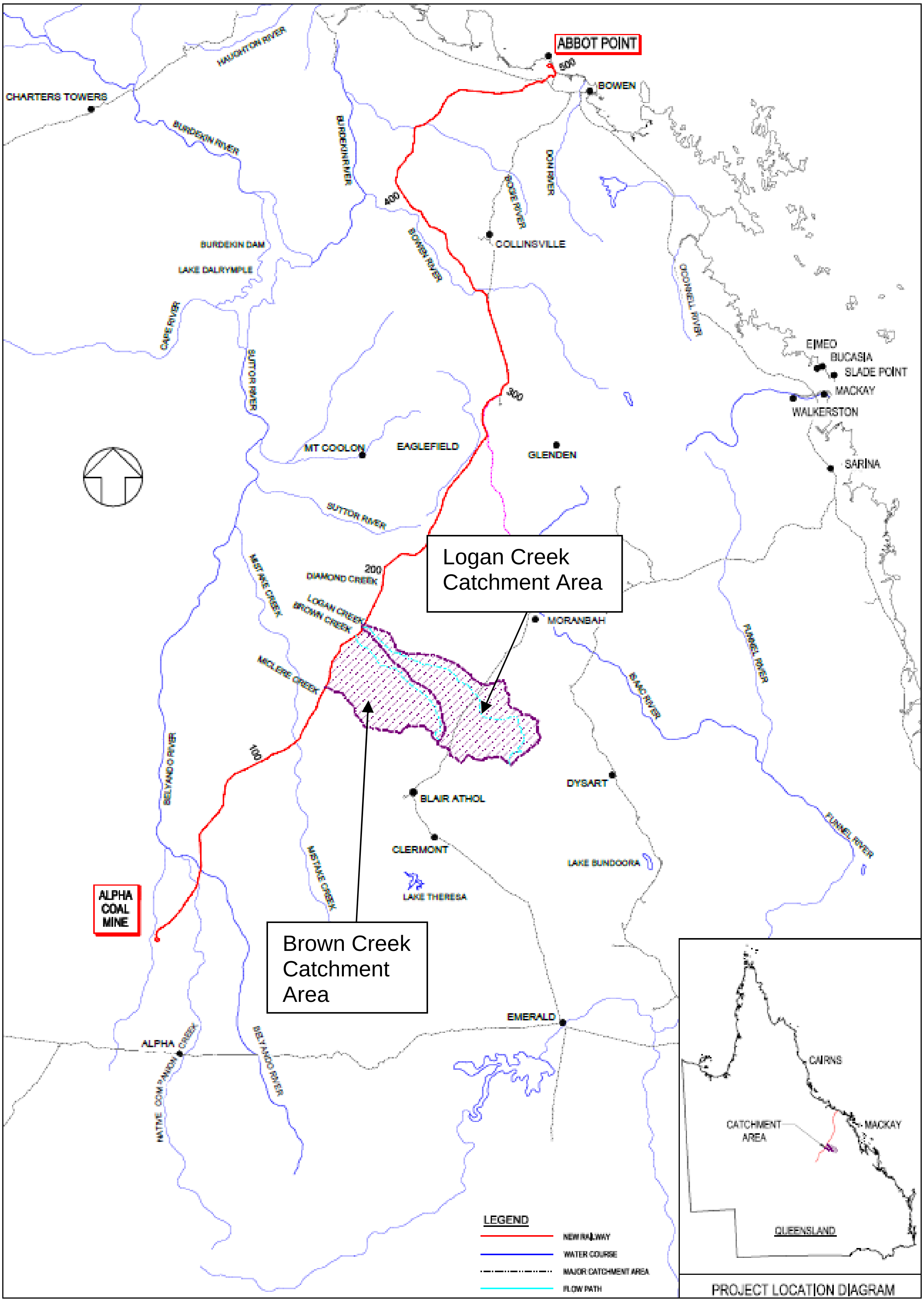


Figure 2: Logan Creek and Brown Creek Catchment boundary and location

5.2 Brown Creek

The catchment area for Brown Creek at the proposed ACP rail alignment (approximately Rail Chainage 170,300 m) is approximately 1,123 km^2. The catchment is undeveloped and consists of predominantly pastoral land. The combined catchment area is divided into two major flows paths: Brown Creek and Mazeppa Creek. The main low flow channels for both Brown and Mazeppa Creeks are predominantly well defined however, during significant flow events, the systems combine and interact with each other upstream of the proposed railway alignment.

5.3 Logan Creek

Logan Creek has a contributing catchment area of approximately 1,477 km^2 at the proposed ACP rail alignment interface (approximately Rail Chainage 175,600 m). The catchment is predominantly undeveloped and consists of mostly agricultural land. The main channel consists of many braids and does not have a major defined flow path. As such, during flood events, a complex interaction between channel and floodplain flows occur.

The confluence of Brown Creek and Logan Creek occurs approximately 4km downstream of the proposed ACP rail alignment.

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. Minor culverts: culvert locations with a 50 year ARI design flow < 50 m^3/sec.

Design Aspect	Design Criteria
Design Flood	Minor culverts shall pass the 20 year ARI design event flow. Major culverts shall pass the 50 year ARI design event flow.
Freeboard	Min. 300 mm to the formation surface for design event.
Headwater	Max. headwater to be 1.5 x culvert diameter.
Max. Outlet Velocity	5.0 m/sec for design event 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 600 mm 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.
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. 500 mm to bridge soffit for 50 Year ARI design flow. Min. 300 mm to TOF (embankments and guide banks) for 50. Year ARI design flow.
Max Velocity	3.8 m/s to enable to adopt a practical limit of 1 tonne rock class protection for economy.
Scour Protection	Provide rock protection to cater for 50 Year ARI design flow velocities. Rock sizing to be designed in accordance with AUSTROADS Waterway Design, 1994.
Maximum backwater	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 1.5 m 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 1.5 m 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 Culverts outlet velocity = 1.5 m/s where erodible soils are present = 2.5 m/s for normal soils (with no erosion control)
Maximum afflux	Maximum 0.5 m – normally (unless justifiable) Maximum 0.2m - around critical infrastructure 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 Brown Creek and Logan 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 Brown and Logan Creeks estimated peak discharges for the 50 year ARI event respectively. No stream gauge data was available for either of the systems and no calibration was undertaken.

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:

Additional Survey

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

9.1.1.3 RORB Analysis

The contributing catchment area for both Brown Creek and Logan Creek were delineated using the GIS based terrain analysis software, CatchSim. A visual check was performed against the BFS delineated catchments 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 Brown Creek and Logan Creek are shown below in Table 4 and Table 5.

Table 4: Brown Creek catchment properties

Item	Value
Catchment area	1,117 km^2
d_{av}	37 km

Table 5: Logan Creek catchment properties

Item	Value
Catchment area	1,486 km^2
d_{av}	71 km

Parameters

RORB model parameters were initially set to those recommended by AR&R for Queensland. As no stream gauge calibration was available for the Brown and Logan systems, if catchment characteristics showed similarities between adjacent calibrated catchments, these calibrated parameters were adopted.

Brown Creek has similar catchment parameters to the neighbouring Suttor River catchment which has a streamgauge that allowed for hydrologic calibration. The Detailed Floodplain Study conducted for the Suttor River and Eaglefield Creek (CJVP10007-REP-C-013 / HC-CRL-24100-RPT-0132) had calibrated RORB parameters as shown in Table 6 and Table 7.

As the Logan Creek catchment characteristics were significantly different to any neighbouring calibrated catchments, no calibrated RORB parameters were used.

Table 6: Suttor River calibrated RORB parameters

Item	Value
k_c (calibrated)	22
M	0.876

Table 7: 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

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 Brown Creek and Logan Creek were calculated and are shown in Table 8 and Table 9.

Table 8: Brown Creek initial RORB parameters

Item	Value
k_c	36.32
m	0.84

Table 9: Logan Creek initial RORB parameters

Item	Value
k_c	42.25
m	0.876

Calibration

No calibration was undertaken for either Brown or Logan Creeks due to the absence of streamgauge data.

Adopted parameters

The calibrated RORB parameters for Suttor River were used for the Brown Creek model due to their conservative estimation of flows when compared to the values suggested by AR&R. For the Logan Creek system, values from AR&R were adopted. Final adopted hydrologic parameters are shown in Table 10 and Table 11.

Table 10: Brown Creek adopted RORB parameters

Item	Value
k_c	22
m	0.876

Table 11: Logan Creek adopted RORB parameters

Item	Value
k_c	42.25
m	0.876

Results

The results extracted from the hydrologic modelling for Brown Creek and Logan Creek systems at the ACP rail interface are shown below in Table 12, Table 13 and Table 14. As Logan Creek was the dominant catchment, peak storm durations have been adopted from Table 13 for both Logan and Brown Creek.

Table 12: Peak storm durations

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

Table 13: Logan Creek predicted peak discharges

Event ARI (years)	Peak predicted discharge (m^3/s)
100	2035
50	1619
5	578

Table 14: Brown Creek predicted peak discharges

Event ARI (years)	Peak predicted discharge (m^3/s)
100	2241
50	1834
5	738

Brown Creek hydrographs have been extracted at 4 locations (including Mazeppa Creek) for the appropriate boundary locations within the hydraulic model. Full hydrographs have been extracted from the RORB model for the 5, 10, 20, 50 and 100 year ARI events are provided in Appendix A. The predicted peak discharges for both systems were then used as inflows into the Brown Creek and Logan Creek floodplain hydraulic model as described in Section 9.1.2.

9.1.2 Hydraulic Modelling

It had been identified during the BFS that the Brown Creek and Logan Creek systems 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 required a significant model domain in order to adequately capture the complex floodplain interaction between the Brown and Logan Creek systems and be sufficiently downstream to reduce the effects of the downstream boundary. This resulted in a bathymetry of 1581 x 664 cells at a grid cell size of 20 m x 20 m (model area of 419 km^2). The final bathymetry used for the pre- and post-development cases is shown below in Figure 3.

A significant portion of the bathymetry has been based off a combination of LiDAR sources (BFS LiDAR and current alignment LiDAR) and covers all of the area downstream of the railway and a minimum of approximately 2km upstream of the rail (varies depending on location as per the "Approximate SRTM/LiDAR interface" shown in Figure 3). At the time of the Detailed Floodplain Study, the only available survey data outside of these extents was the SRTM survey. Due to the significant accuracy reduction of the SRTM in comparison to the LiDAR, it was assessed that some manipulation of the relative levels of the SRTM was needed to ensure boundary levels matched the LiDAR data at stream inverts. For this model, the SRTM tiles were raised by 3.5 m and a variable interpreted transition was generated between the SRTM and LiDAR boundary to provide a smoothed surface between the two data sets. The preference was to ensure that the SRTM surface at stream centrelines was above the LiDAR data to ensure flows were able to pass over the interface. This lead to some large differences, particularly for Brown and Mazeppa Creek area of the model.

This bathymetry manipulation was considered appropriate for the purposes of the assessment of impacts from the proposed ACP rail alignment and utilised the best data available at the time of this Detailed Floodplain Study.

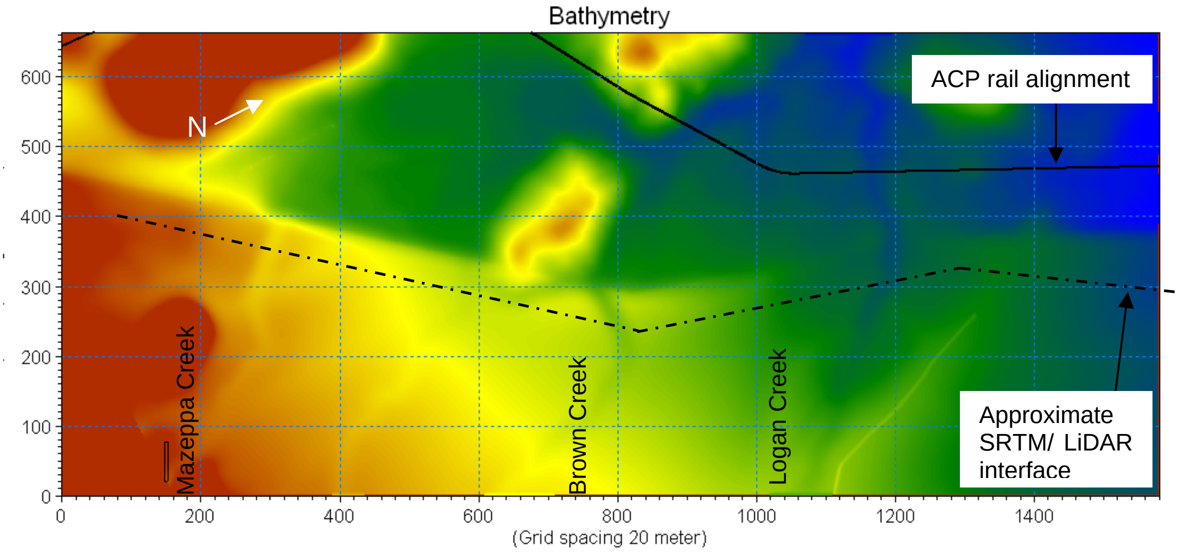


Figure 3: Hydraulic model extent

Boundary conditions

Brown & Mazeppa Creek and Logan Creek 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 Logan Creek and Brown Creek 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 0.2m 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 4. The selection of roughness values was subject to sensitivity testing as outlined in Section 9.1.3.

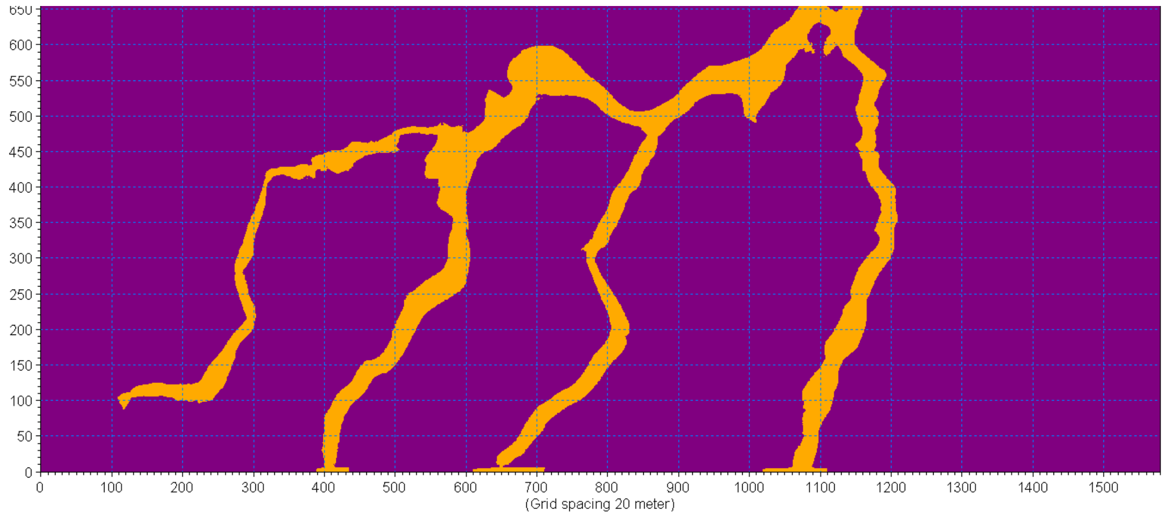


Figure 4: Manning's roughness

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 5.

In order to maintain inundation extents post-rail and as specified in the BFS, floodplain relief culverts are proposed for the Brown Creek and Logan 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 was verified against a 1-D model of a single 900mm diameter CSP using the HY-8 modelling package.

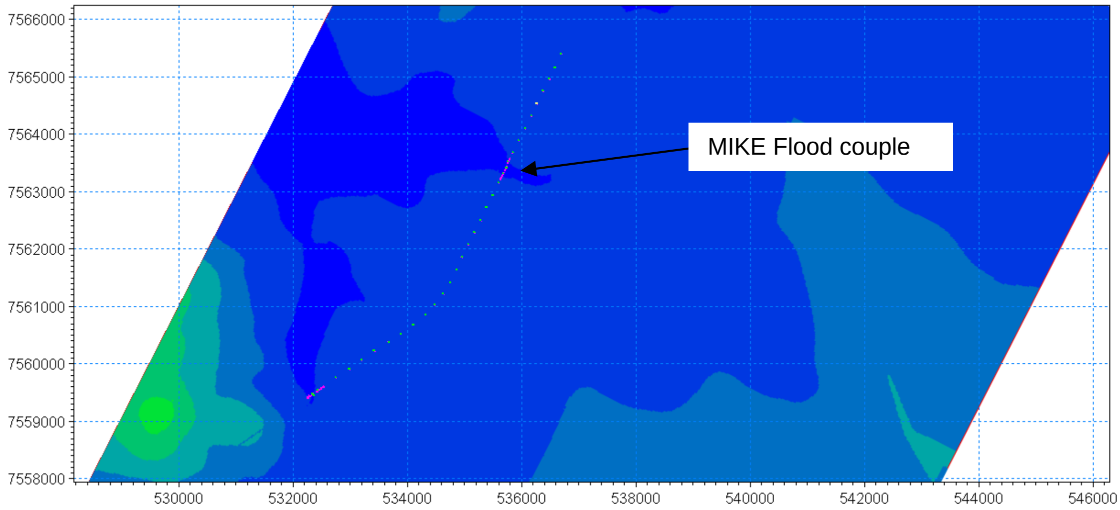


Figure 5: MIKE Flood couple locations

In addition to the floodplain relief culverts, the BFS proposed a single bridge span of 140 m for Brown Creek and a 120 m bridge for Logan Creek. These were also inserted as couples 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 the locations shown in Figure 6.

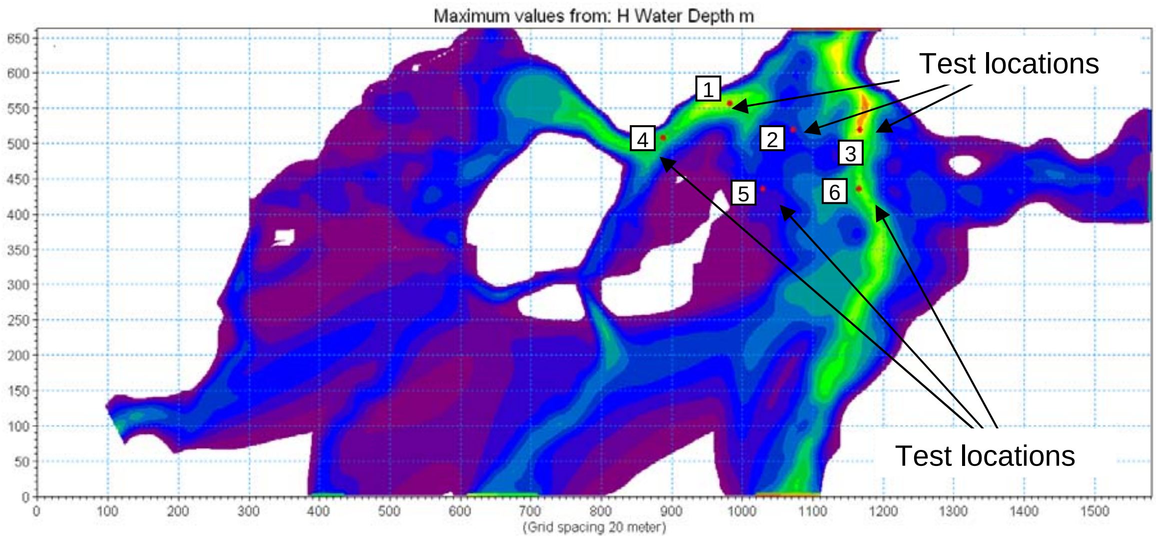


Figure 6: Sensitivity testing locations

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 5.

Table 15: Manning's 'M' value sensitivity (depth)

Location	Adopted value (m)	+30% value	Change (m)	-30% value	Change (m)
1	2.570	2.429	-0.141	2.770	0.2
2	0.748	0.588	-0.16	0.983	0.235
3	3.040	2.833	-0.207	3.328	0.288
4	2.057	1.898	-0.159	2.262	0.205
5	0.563	0.383	-0.18	0.831	0.268
6	2.477	2.311	-0.166	2.723	0.246

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 -4.8% and +5.7%, which is a relatively minor impact on the predicted extents.

At the same testing locations, the peak velocities were also extracted. From Table 16, 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 16: Manning's 'M' value sensitivity (velocity)

Location	Adopted value (m/s)	+30% value	Change (%)	-30% value	Change (%)
1	0.545	0.653	19.8	0.412	-24.4
2	0.198	0.235	18.7	0.154	-22.2
3	0.906	1.219	34.5	0.717	-20.9
4	0.929	1.132	21.9	0.700	-24.7
5	0.147	0.150	2.0	0.138	-6.1
6	1.014	1.219	20.2	0.785	-22.6

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 17.

Table 17: Inflow hydrograph sensitivity

Location	Adopted value (m)	+30% value	Change (m)	-30% value	Change (m)
1	2.570	2.807	0.237	2.303	-0.267
2	0.748	1.006	0.258	0.462	-0.286
3	3.040	3.326	0.286	2.693	-0.347
4	2.057	2.312	0.255	1.752	-0.305
5	0.563	0.819	0.256	0.282	-0.281
6	2.477	2.688	0.211	2.221	-0.256

The inflow values have an impact ranging from -350 mm to +300 mm on the predicted water surface level. This has an equivalent inundation extent impact of -5.2% and +5.2%, 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 18.

Table 18: Downstream boundary sensitivity

Location	Adopted value (m)	+30% value	Change (m)	-30% value	Change (m)
1	2.570	2.604	0.034	2.569	-0.001
2	0.748	0.909	0.161	0.744	-0.004
3	3.040	3.390	0.35	3.024	-0.016
4	2.057	2.073	0.016	2.057	0
5	0.563	0.595	0.032	0.562	-0.001
6	2.477	2.513	0.036	2.476	-0.001

The downstream boundary level has an impact ranging from -20 mm to +200 mm on the predicted water surface level. This has an equivalent inundation extent impact of -0.04% and +0.5%, which has minimal impact on the predicted extents.

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 the results 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 Brown Creek, an additional 80/ 1800 mm diameter supplementary CSPs are recommended in order to minimise the impacts of the railway. Logan Creek required an additional 140 / 1800 mm diameter supplementary CSPs. Floodplain relief culverts are required at 50 m spacing between Brown and Logan Creeks. An additional 60 / 900 mm diameter CSPs are recommended in supplementary banks along at specified locations between the two creeks.

In order to stop inundation of the proposed railway vertical alignment (under a 50 year ARI event) at the time of the study, the alignment had to be lifted approximately 0.5 m across the floodplain.

With the recommended drainage structures, afflux levels adjacent to the proposed railway generally meet the criteria specified within the SEIS.

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 Logan Creek / Brown 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 B.

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 19.

Table 19: 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 Culverts outlet velocity: = 1.5 m/s where erodible soils are present = 2.5 m/s for normal soils (with no erosion control)	Conforms to SEIS requirements. Refer Velocity drawing in Appendix B for details.
Maximum afflux	Maximum 0.5 m – normally (unless justifiable) Maximum 0.2m – around critical infrastructure Maximum 0.1 m – around dwellings	Conforms to SEIS requirements. Refer Afflux drawing in Appendix B 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 20.

Table 20: Change in inundation extents

Event ARI (years)	% change in "wet" cells	Change in area (ha)
5	-0.64	-164.8
50	0.20	62.9

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 A.

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 Brown and Logan Creeks 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 Brown and Logan Creek are shown below. Alternative drainage structures may be utilised providing equivalent hydraulic performance is maintained or improved.

Table 20: Brown Creek

Item	Value
Proposed cross drainage infrastructure	1/ 140m bridge and 80/ 1800mm diameter supplementary CSPs

Table 22: Logan Creek

Item	Value
Proposed cross drainage infrastructure	1/ 120m bridge and 140/ 1800mm diameter supplementary CSPs

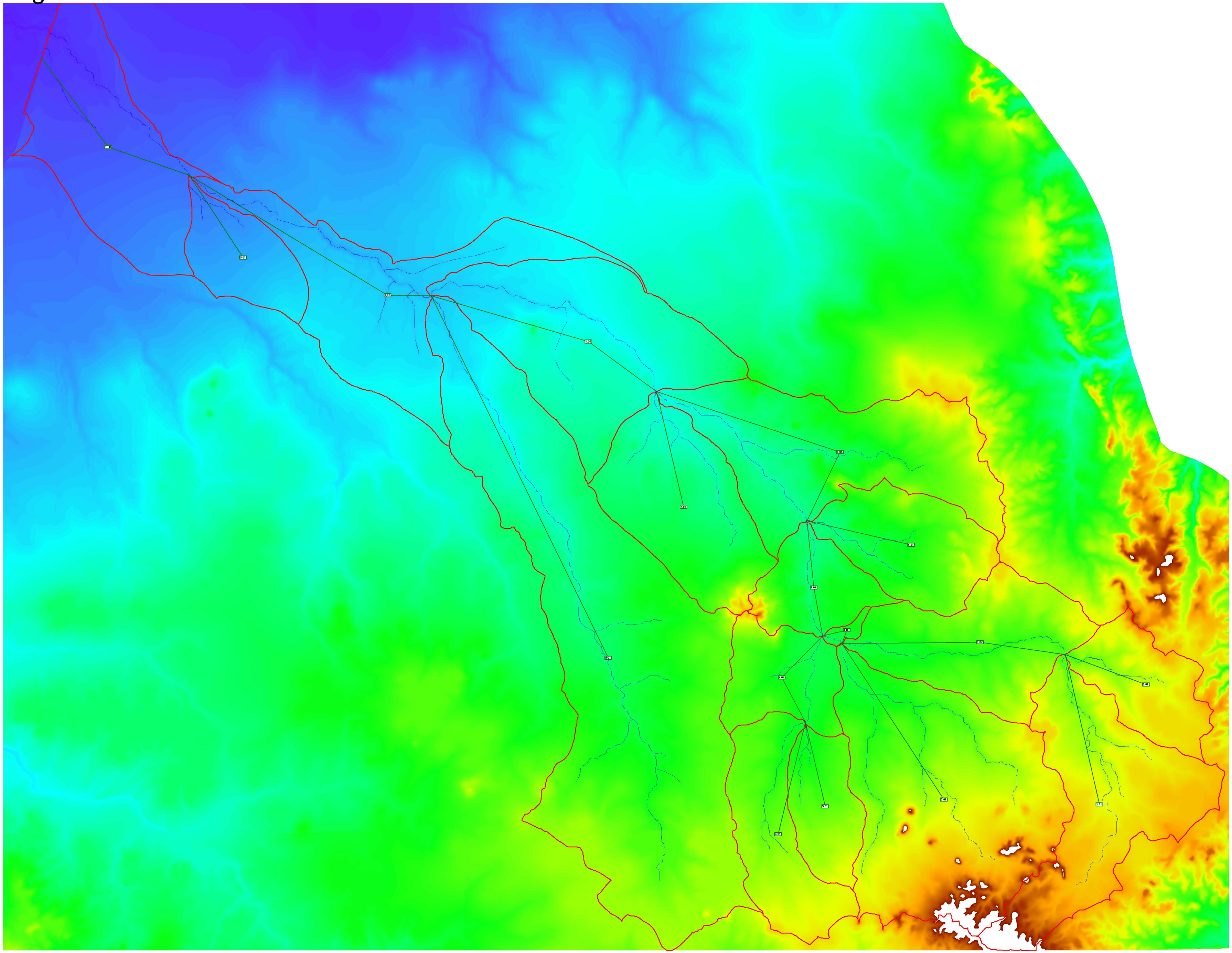
Table 23: Floodplain relief culverts

Item	Value
Proposed cross drainage infrastructure	4 additional banks of 15/ 900mm diameter CSPs and 900mm diameter CSPs at 50m in the floodplain

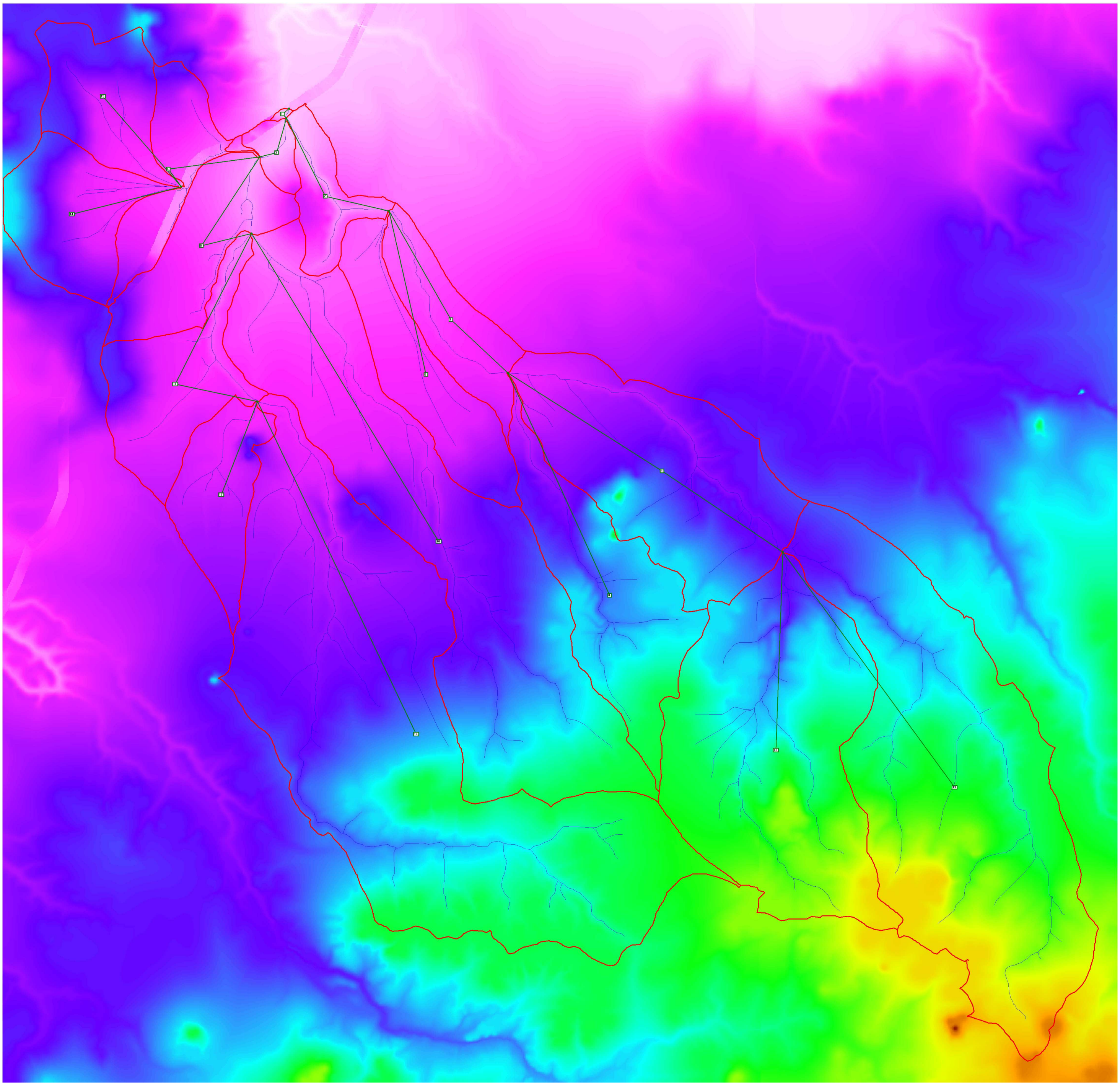
The findings can be further optimised when further hydraulic analysis is undertaken during the Detailed Design phase of the project.

APPENDIX A
RORB RESULTS

Logan Creek Catchment Delineation



Brown Creek Catchment Delineation



Logan Creek RORB Parameters

Logan Creek

ARR Book 5

Catchment area	1486.8	km^2	
d_{av}	71.11	km	(from RORB model)
K_c (Weeks, QLD)	42.25		

adjusted K_c	42.25	
m	0.876	for 0.6<m<1.2

LHS	RHS (goal seek to LHS by changing m)
0.594149909	0.842832

Brown Creek RORB Parameters

Brown Creek

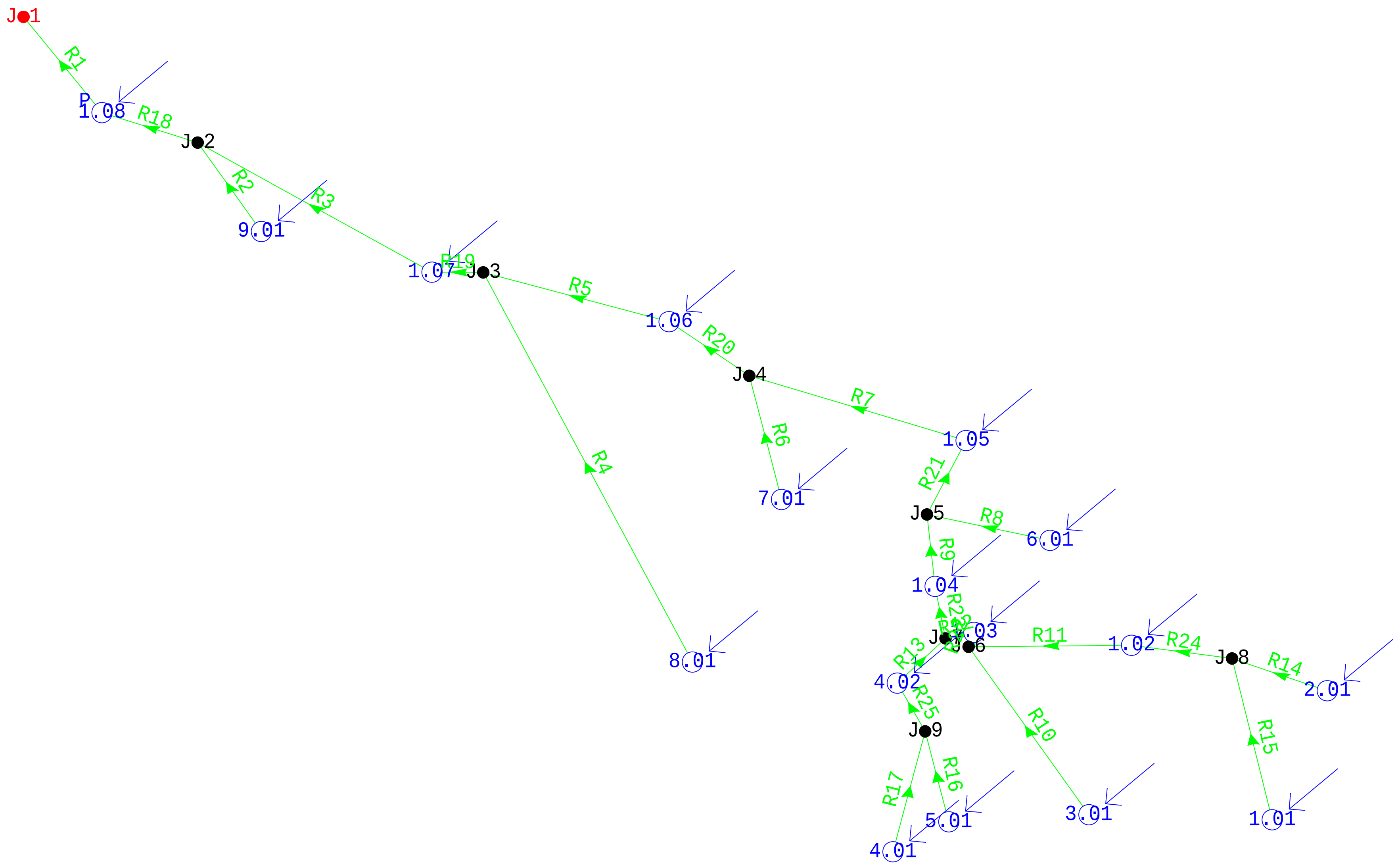
ARR Book 5

Catchment area	1117.8	km^2	
d_{av}	37.09	km	(from RORB model)
K_c (Weeks, QLD)	36.32		

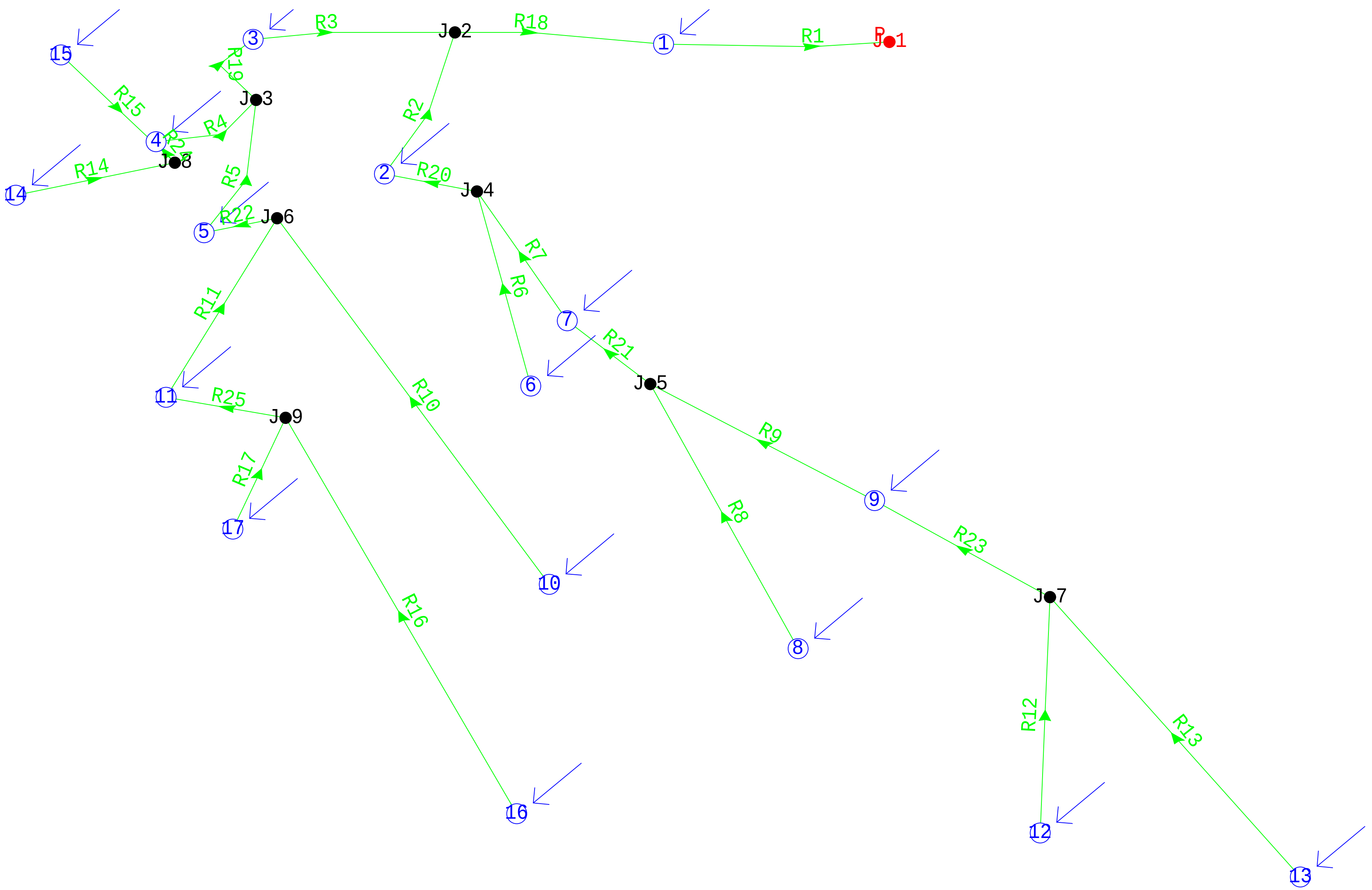
adjusted K_c	36.32	
m	0.843452	for 0.6<m<1.2

LHS	RHS (goal seek to LHS by changing m)
0.979239687	0.979124

Logan Creek RORB



Brown Creek RORB



Logan Creek RORB Result File

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

 Program version 6.15 (last updated 30th March 2010)
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 Date run: 07 Oct 2011 11:52

 Vector file       : \\calibre.network\PROJECTS\CEJV\BRI\Projects\PRO-Projects\2011
\CARP11064 HCPL Alpha FEED\06 Engineering\6.4 Hydrology\Logan Creek\RORB\Logan
Cr.catg
 Storm file        : S:\PRO-Projects\2011\CARP11064 HCPL Alpha FEED\06 Engineering
\6.4 Hydrology\Logan Creek\RORB\Logan Cr_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.  41     7.0 Location read as  Subcatchment: 1.08
 Sub-area areas
 Impervious flag
 Initial storm data
 Rainfall burst times
 Pluviograph 1
 Sub-area rainfalls

 Data check completed



 Data:
 ****

 Logan Creek


 Time data, in increments from initial time
 Logan 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:  120



 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	2	Add sub-area 'E' inflow & route thru normal storage 7
12	3	Store hydrograph from step 11; reset hydrograph to zero
13	1	Add sub-area 'F' inflow & route thru normal storage 8
14	3	Store hydrograph from step 13; reset hydrograph to zero
15	1	Add sub-area 'G' inflow & route thru normal storage 9
16	4	Add h-graph ex step 14 to h-graph ex step 15
17	5	Route hydrograph thru normal storage 10
18	2	Add sub-area 'H' inflow & route thru normal storage 11
19	4	Add h-graph ex step 12 to h-graph ex step 18
20	5	Route hydrograph thru normal storage 12
21	2	Add sub-area 'I' inflow & route thru normal storage 13
22	3	Store hydrograph from step 21; reset hydrograph to zero
23	1	Add sub-area 'J' inflow & route thru normal storage 14
24	4	Add h-graph ex step 22 to h-graph ex step 23
25	5	Route hydrograph thru normal storage 15
26	2	Add sub-area 'K' inflow & route thru normal storage 16
27	3	Store hydrograph from step 26; reset hydrograph to zero
28	1	Add sub-area 'L' inflow & route thru normal storage 17
29	4	Add h-graph ex step 27 to h-graph ex step 28
30	5	Route hydrograph thru normal storage 18
31	2	Add sub-area 'M' inflow & route thru normal storage 19
32	3	Store hydrograph from step 31; reset hydrograph to zero
33	1	Add sub-area 'N' inflow & route thru normal storage 20
34	4	Add h-graph ex step 32 to h-graph ex step 33
35	5	Route hydrograph thru normal storage 21
36	2	Add sub-area 'O' inflow & route thru normal storage 22
37	3	Store hydrograph from step 36; reset hydrograph to zero
38	1	Add sub-area 'P' inflow & route thru normal storage 23
39	4	Add h-graph ex step 37 to h-graph ex step 38
40	5	Route hydrograph thru normal storage 24
41	7.0	Print hydrograph, Subcatchment: 1.08
42	2	Add sub-area 'Q' inflow & route thru normal storage 25
43	0	**********End of control vector**********

Sub-area data

Sub-area	Area km²	Dist. km*
A	4.17E+01	1.11E+02
B	1.04E+02	1.20E+02
C	7.87E+01	9.48E+01
D	1.65E+02	1.01E+02
E	2.60E+00	8.51E+01
F	3.40E+01	9.77E+01
G	5.57E+01	1.00E+02
H	3.91E+01	8.77E+01
I	3.49E+01	8.00E+01

J	5.74E+01	8.37E+01
K	1.18E+02	6.75E+01
L	8.25E+01	6.97E+01
M	1.22E+02	4.80E+01
N	3.15E+02	6.54E+01
O	1.01E+02	2.59E+01
P	3.64E+01	2.18E+01
Q	9.84E+01	7.53E+00

Total 1.487E+03

For whole catchment ; Av. Dist., km* = 71.11
For interstation area 1; Av. Dist., km* = 71.11; 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	7.4	0.104	Natural	
2	16.0	0.224	Natural	
3	8.9	0.126	Natural	
4	8.9	0.126	Natural	
5	14.9	0.209	Natural	
6	0.8	0.011	Natural	
7	0.8	0.011	Natural	
8	6.6	0.093	Natural	
9	9.3	0.131	Natural	
10	3.3	0.047	Natural	
11	3.3	0.047	Natural	
12	4.4	0.061	Natural	
13	4.4	0.061	Natural	
14	8.0	0.113	Natural	
15	8.2	0.115	Natural	
16	8.2	0.115	Natural	
17	10.5	0.148	Natural	
18	11.3	0.159	Natural	
19	11.3	0.159	Natural	
20	28.7	0.404	Natural	
21	10.8	0.152	Natural	
22	10.8	0.152	Natural	
23	6.7	0.095	Natural	
24	7.5	0.106	Natural	
25	7.5	0.106	Natural	

* or other function of reach properties related to travel time

Input of parameters:
****

Logan Creek
DESIGN Run
Logan 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	Catch ment	Sub-Area A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
0	5.7	6	6	6	6	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	36	36	36	36
2	6.5	7	7	7	7	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	4	4	4

4	7.5	8	8	8	8	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	19	19	19	19
6	3.2	3	3	3	3	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	2	2	2	2
8	14.7	15	15	15	15	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	12	12	12	12
10	3.7	4	4	4	4	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	3	3	3	3
12	8.7	9	9	9	9	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	25	25	25	25
14	10.2	10	10	10	10	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	5	5	5	5
16	1.3	1	1	1	1	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	1	1	1	1
Tot.	167.4	167	167	167	167	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	1	1	1	1

Time Incs	Catchment	Sub-Area Q
0	5.7	6
1	36.0	36
2	6.5	7
3	4.4	4
4	7.5	8
5	18.6	19
6	3.2	3
7	2.0	2
8	14.7	15
9	11.9	12
10	3.7	4
11	2.5	3
12	8.7	9
13	24.8	25
14	10.2	10
15	5.0	5
16	1.3	1
17	0.7	1
Tot.	167.4	167
Pluvi. ref. no.		1

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

Time Incs	Catchment	Sub-Area A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	24.2	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
2	4.0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
3	1.9	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
4	5.0	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
5	16.1	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
6	0.7	1	1	1	1	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	0	0	0	0
8	12.2	12	12	12	12	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	9	9	9	9
10	1.2	1	1	1	1	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	0	0	0	0
12	6.2	6	6	6	6	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	22	22	22	22
14	7.7	8	8	8	8	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	3	3	3	3
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.	113.4	113	113	113	113	113	113	113	113	113	113	113	113	113	113	113	113

Logan Creek RORB Result File

Time Incs	Catch ment	Sub-Area Q
0	0.0	0
1	24.2	24
2	4.0	4
3	1.9	2
4	5.0	5
5	16.1	16
6	0.7	1
7	0.0	0
8	12.2	12
9	9.4	9
10	1.2	1
11	0.0	0
12	6.2	6
13	22.3	22
14	7.7	8
15	2.5	3
16	0.0	0
17	0.0	0
Tot.	113.4	113

```
Routing results:
****************
Logan Creek
Logan Creek: 18 hour 50 year Design Storm
DESIGN run no.  1


Parameters:  kc =    59.90    m = 0.88

Loss parameters     Initial loss (mm)   Cont. loss (mm/h)
                          15.00              2.50



*** Calculated hydrograph,   Subcatchment: 1.08
```

	Hydrograph Calc.
Peak discharge,m³/s	1147.
Time to peak,h	29.0
Volume,m³	1.58E+08
Time to centroid,h	35.5
Lag (c.m. to c.m.),h	27.5
Lag to peak,h	21.0

```
Hydrograph summary
*****************

Site  Description
  01  Calculated hydrograph,   Subcatchment: 1.08
```

Inc	Time	Hyd0001
1	1.00	0.00
2	2.00	0.00
3	3.00	7.90
4	4.00	37.93
5	5.00	76.61
6	6.00	108.22
7	7.00	145.94
8	8.00	195.41
9	9.00	239.62
10	10.00	279.15
11	11.00	332.85

12	12.00	394.93
13	13.00	447.30
14	14.00	492.07
15	15.00	555.83
16	16.00	650.58
17	17.00	747.62
18	18.00	822.82
19	19.00	879.70
20	20.00	926.23
21	21.00	967.53
22	22.00	1005.14
23	23.00	1039.09
24	24.00	1068.97
25	25.00	1094.34
26	26.00	1114.87
27	27.00	1130.41
28	28.00	1140.91
29	29.00	1146.40
30	30.00	1146.99
31	31.00	1142.79
32	32.00	1133.94
33	33.00	1120.65
34	34.00	1103.13
35	35.00	1081.66
36	36.00	1056.55
37	37.00	1028.17
38	38.00	996.92
39	39.00	963.24
40	40.00	927.58
41	41.00	890.39
42	42.00	852.11
43	43.00	813.18
44	44.00	773.97
45	45.00	734.87
46	46.00	696.17
47	47.00	658.15
48	48.00	621.04
49	49.00	585.03
50	50.00	550.26
51	51.00	516.85
52	52.00	484.87
53	53.00	454.37
54	54.00	425.38
55	55.00	397.92
56	56.00	371.95
57	57.00	347.47
58	58.00	324.43
59	59.00	302.78
60	60.00	282.48
61	61.00	263.48
62	62.00	245.70
63	63.00	229.09
64	64.00	213.58
65	65.00	199.12
66	66.00	185.64
67	67.00	173.09
68	68.00	161.40
69	69.00	150.53
70	70.00	140.41
71	71.00	131.00
72	72.00	122.25
73	73.00	114.11
74	74.00	106.54
75	75.00	99.51
76	76.00	92.97
77	77.00	86.89
78	78.00	81.23
79	79.00	75.97
80	80.00	71.08
81	81.00	66.52
82	82.00	62.29
83	83.00	58.34

84	84.00	54.67
85	85.00	51.25
86	86.00	48.06
87	87.00	45.09
88	88.00	42.32
89	89.00	39.74
90	90.00	37.33
91	91.00	35.08
92	92.00	32.98
93	93.00	31.02
94	94.00	29.19
95	95.00	27.47
96	96.00	25.87
97	97.00	24.37
98	98.00	22.97
99	99.00	21.66
100	100.00	20.43
101	101.00	19.28
102	102.00	18.20
103	103.00	17.19
104	104.00	16.24
105	105.00	15.35
106	106.00	14.51
107	107.00	13.73
108	108.00	12.99
109	109.00	12.29
110	110.00	11.64
111	111.00	11.03
112	112.00	10.45
113	113.00	9.91
114	114.00	9.39
115	115.00	8.91
116	116.00	8.46
117	117.00	8.03
118	118.00	7.62
119	119.00	7.24
120	120.00	6.88
121	121.00	6.54

Brown Creek RORB Result File

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

 Program version 6.15 (last updated 30th March 2010)
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 Date run: 13 Sep 2011 13:42

 Vector file       : \\calibre.network\PROJECTS\CEJV\BRI\Projects\PRO-Projects\2011
\CARP11064 HCPL Alpha FEED\06 Engineering\6.4 Hydrology\Brown Creek\Rorb\brown
creek.catg
 Storm file        : S:\PRO-Projects\2011\CARP11064 HCPL Alpha FEED\06 Engineering
\6.4 Hydrology\Brown Creek\Rorb\brown creek_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.  42     7.0 Location read as out
 Sub-area areas
 Impervious flag
 Initial storm data
 Rainfall burst times
 Pluviograph 1
 Sub-area rainfalls

 Data check completed



 Data:
 ****

 brown creek


 Time data, in increments from initial time
 brown 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:  120



 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	2	Add sub-area 'E' inflow & route thru normal storage 7
12	3	Store hydrograph from step 11; reset hydrograph to zero
13	1	Add sub-area 'F' inflow & route thru normal storage 8
14	4	Add h-graph ex step 12 to h-graph ex step 13
15	5	Route hydrograph thru normal storage 9
16	2	Add sub-area 'G' inflow & route thru normal storage 10
17	3	Store hydrograph from step 16; reset hydrograph to zero
18	1	Add sub-area 'H' inflow & route thru normal storage 11
19	3	Store hydrograph from step 18; reset hydrograph to zero
20	1	Add sub-area 'I' inflow & route thru normal storage 12
21	4	Add h-graph ex step 19 to h-graph ex step 20
22	5	Route hydrograph thru normal storage 13
23	2	Add sub-area 'J' inflow & route thru normal storage 14
24	3	Store hydrograph from step 23; reset hydrograph to zero
25	1	Add sub-area 'K' inflow & route thru normal storage 15
26	4	Add h-graph ex step 24 to h-graph ex step 25
27	5	Route hydrograph thru normal storage 16
28	2	Add sub-area 'L' inflow & route thru normal storage 17
29	3	Store hydrograph from step 28; reset hydrograph to zero
30	1	Add sub-area 'M' inflow & route thru normal storage 18
31	3	Store hydrograph from step 30; reset hydrograph to zero
32	1	Add sub-area 'N' inflow & route thru normal storage 19
33	4	Add h-graph ex step 31 to h-graph ex step 32
34	5	Route hydrograph thru normal storage 20
35	2	Add sub-area 'O' inflow & route thru normal storage 21
36	4	Add h-graph ex step 29 to h-graph ex step 35
37	5	Route hydrograph thru normal storage 22
38	2	Add sub-area 'P' inflow & route thru normal storage 23
39	4	Add h-graph ex step 17 to h-graph ex step 38
40	5	Route hydrograph thru normal storage 24
41	2	Add sub-area 'Q' inflow & route thru normal storage 25
42	7.0	Print hydrograph, out
43	0	**********End of control vector**********

Sub-area data

Sub-area	Area km^2	Dist. km*
A	1.26E+02	5.57E+01
B	1.73E+02	6.18E+01
C	8.80E+01	3.21E+01
D	5.83E+01	3.41E+01
E	2.58E+01	1.54E+01
F	3.67E+01	1.74E+01
G	1.58E+01	4.90E+00
H	2.38E+02	4.51E+01
I	2.78E+01	2.68E+01

J	3.91E+01	1.37E+01
K	1.62E+02	2.82E+01
L	3.42E+01	5.69E+00
M	3.45E+01	1.40E+01
N	3.03E+01	1.49E+01
O	2.30E+01	6.32E+00
P	5.78E+00	2.05E+00
Q	3.40E-01	2.88E-01

Total 1.118E+03

For whole catchment ; Av. Dist., km* = 37.09
For interstation area 1; Av. Dist., km* = 37.09; 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	13.1	0.353	Natural	
2	19.2	0.518	Natural	
3	10.5	0.283	Natural	
4	10.5	0.283	Natural	
5	12.5	0.337	Natural	
6	6.2	0.167	Natural	
7	6.2	0.167	Natural	
8	8.2	0.220	Natural	
9	4.3	0.117	Natural	
10	4.3	0.117	Natural	
11	25.5	0.689	Natural	
12	7.2	0.194	Natural	
13	5.9	0.158	Natural	
14	5.9	0.158	Natural	
15	20.4	0.549	Natural	
16	2.2	0.058	Natural	
17	2.2	0.058	Natural	
18	4.9	0.131	Natural	
19	5.8	0.156	Natural	
20	2.8	0.075	Natural	
21	2.8	0.075	Natural	
22	1.5	0.040	Natural	
23	1.5	0.040	Natural	
24	0.3	0.008	Natural	
25	0.3	0.008	Natural	

* or other function of reach properties related to travel time

Input of parameters:
****

brown creek
DESIGN Run
brown 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	Catch ment	Sub-Area A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
0	5.7	6	6	6	6	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	36	36	36	36
2	6.5	7	7	7	7	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	4	4	4

4	7.5	8	8	8	8	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	19	19	19	19
6	3.2	3	3	3	3	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	2	2	2	2
8	14.7	15	15	15	15	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	12	12	12	12
10	3.7	4	4	4	4	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	3	3	3	3
12	8.7	9	9	9	9	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	25	25	25	25
14	10.2	10	10	10	10	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	5	5	5	5
16	1.3	1	1	1	1	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	1	1	1	1
Tot.	167.4	167	167	167	167	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	1	1	1	1

Time Incs	Catchment	Sub-Area Q
0	5.7	6
1	36.0	36
2	6.5	7
3	4.4	4
4	7.5	8
5	18.6	19
6	3.2	3
7	2.0	2
8	14.7	15
9	11.9	12
10	3.7	4
11	2.5	3
12	8.7	9
13	24.8	25
14	10.2	10
15	5.0	5
16	1.3	1
17	0.7	1
Tot.	167.4	167
Pluvi. ref. no.		1

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

Time Incs	Catchment	Sub-Area A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	24.2	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
2	4.0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
3	1.9	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
4	5.0	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
5	16.1	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
6	0.7	1	1	1	1	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	0	0	0	0
8	12.2	12	12	12	12	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	9	9	9	9
10	1.2	1	1	1	1	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	0	0	0	0
12	6.2	6	6	6	6	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	22	22	22	22
14	7.7	8	8	8	8	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	3	3	3	3
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.	113.4	113	113	113	113	113	113	113	113	113	113	113	113	113	113	113	113

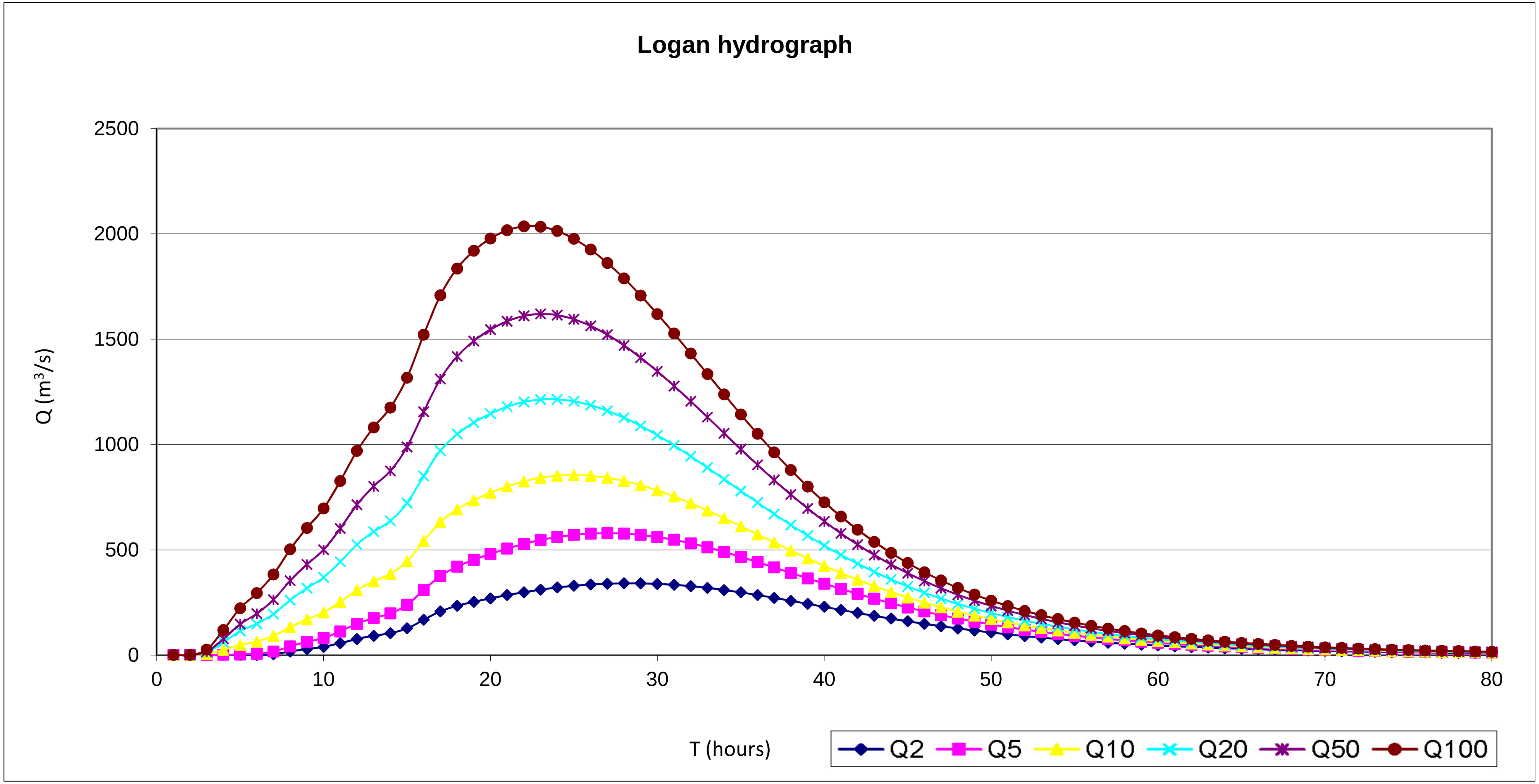
Brown Creek RORB Result File

```
Time                Sub-
     Catch          Area
Incs ment           Q

  0   0.0           0
  1  24.2          24
  2   4.0           4
  3   1.9           2
  4   5.0           5
  5  16.1          16
  6   0.7           1
  7   0.0           0
  8  12.2          12
  9   9.4           9
 10   1.2           1
 11   0.0           0
 12   6.2           6
 13  22.3          22
 14   7.7           8
 15   2.5           3
 16   0.0           0
 17   0.0           0

Tot.113.4         113


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


Parameters:  kc =    22.00    m = 0.88

Loss parameters     Initial loss (mm)   Cont. loss (mm/h)
                          15.00              2.50



*** Calculated hydrograph,  out

                          Hydrograph
                         Calc.
Peak discharge,m³/s     1835.
Time to peak,h           17.0
Volume,m³            1.27E+08
Time to centroid,h       19.5
Lag (c.m. to c.m.),h     11.6
Lag to peak,h            9.03


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

Site  Description
  01  Calculated hydrograph,  out

Inc    Time   Hyd0001
  1    1.00      0.00
  2    2.00      0.00
  3    3.00     62.15
  4    4.00    256.12
  5    5.00    434.90
  6    6.00    535.46
  7    7.00    682.55
  8    8.00    866.50
  9    9.00    958.35
 10   10.00   1023.86
 11   11.00   1171.73
```

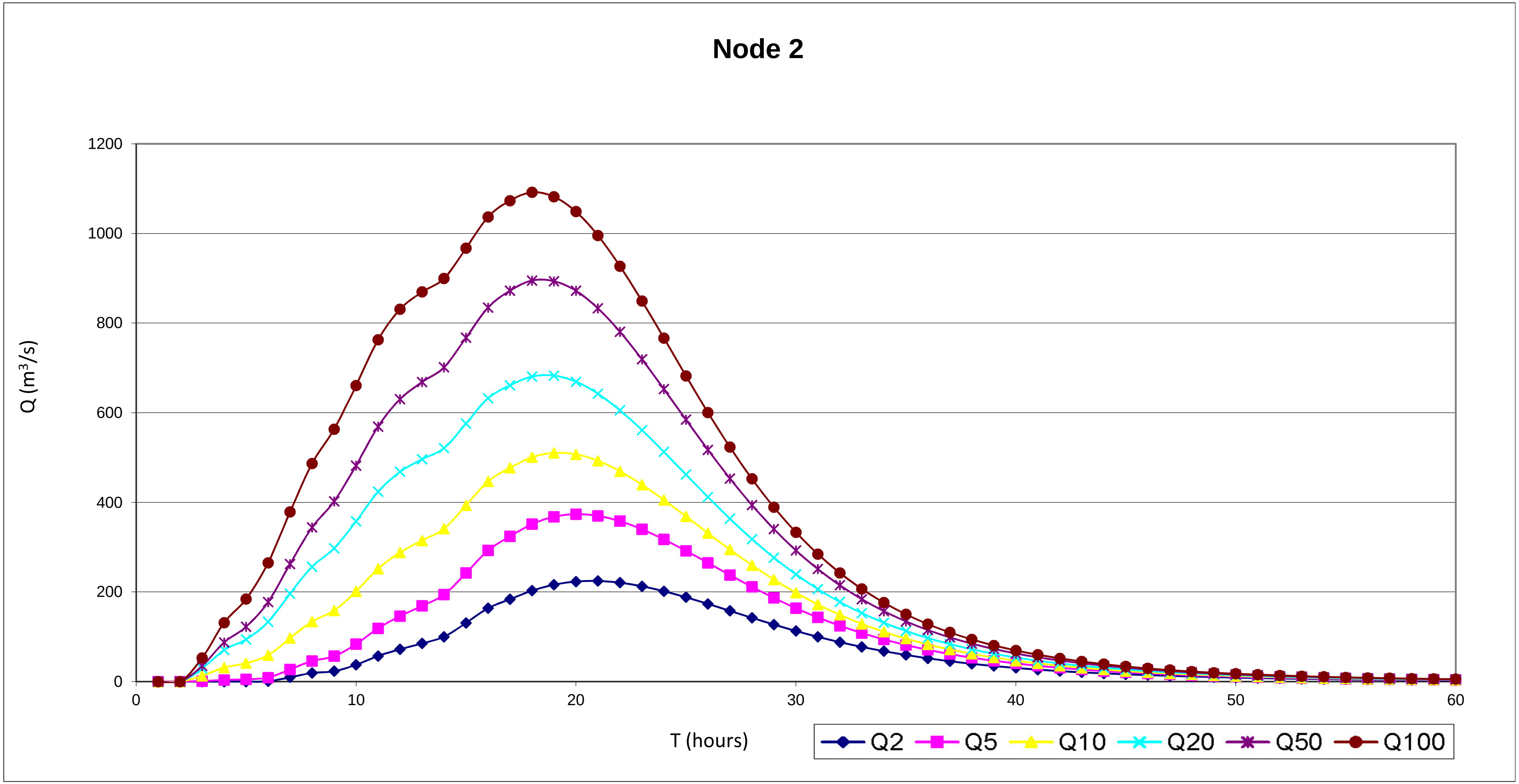
12	12.00	1303.02
13	13.00	1335.98
14	14.00	1335.03
15	15.00	1450.69
16	16.00	1673.78
17	17.00	1821.35
18	18.00	1834.79
19	19.00	1770.49
20	20.00	1667.55
21	21.00	1547.43
22	22.00	1424.06
23	23.00	1301.08
24	24.00	1179.83
25	25.00	1064.39
26	26.00	955.14
27	27.00	853.68
28	28.00	760.19
29	29.00	674.78
30	30.00	597.57
31	31.00	528.01
32	32.00	466.07
33	33.00	410.91
34	34.00	362.27
35	35.00	319.24
36	36.00	281.51
37	37.00	248.29
38	38.00	219.25
39	39.00	193.75
40	40.00	171.47
41	41.00	151.91
42	42.00	134.80
43	43.00	119.76
44	44.00	106.58
45	45.00	94.96
46	46.00	84.76
47	47.00	75.75
48	48.00	67.80
49	49.00	60.78
50	50.00	54.56
51	51.00	49.05
52	52.00	44.16
53	53.00	39.81
54	54.00	35.94
55	55.00	32.48
56	56.00	29.40
57	57.00	26.64
58	58.00	24.18
59	59.00	21.96
60	60.00	19.98
61	61.00	18.19
62	62.00	16.59
63	63.00	15.14
64	64.00	13.83
65	65.00	12.65
66	66.00	11.58
67	67.00	10.62
68	68.00	9.74
69	69.00	8.95
70	70.00	8.22
71	71.00	7.57
72	72.00	6.97
73	73.00	6.42
74	74.00	5.92
75	75.00	5.47
76	76.00	5.05
77	77.00	4.67
78	78.00	4.33
79	79.00	4.01
80	80.00	3.71
81	81.00	3.45
82	82.00	3.20
83	83.00	2.97

84	84.00	2.76
85	85.00	2.57
86	86.00	2.39
87	87.00	2.23
88	88.00	2.08
89	89.00	1.94
90	90.00	1.81
91	91.00	1.69
92	92.00	1.58
93	93.00	1.48
94	94.00	1.38
95	95.00	1.29
96	96.00	1.21
97	97.00	1.13
98	98.00	1.06
99	99.00	1.00
100	100.00	0.94
101	101.00	0.88
102	102.00	0.83
103	103.00	0.78
104	104.00	0.73
105	105.00	0.69
106	106.00	0.65
107	107.00	0.61
108	108.00	0.57
109	109.00	0.54
110	110.00	0.51
111	111.00	0.48
112	112.00	0.45
113	113.00	0.43
114	114.00	0.41
115	115.00	0.38
116	116.00	0.36
117	117.00	0.34
118	118.00	0.32
119	119.00	0.31
120	120.00	0.29
121	121.00	0.28

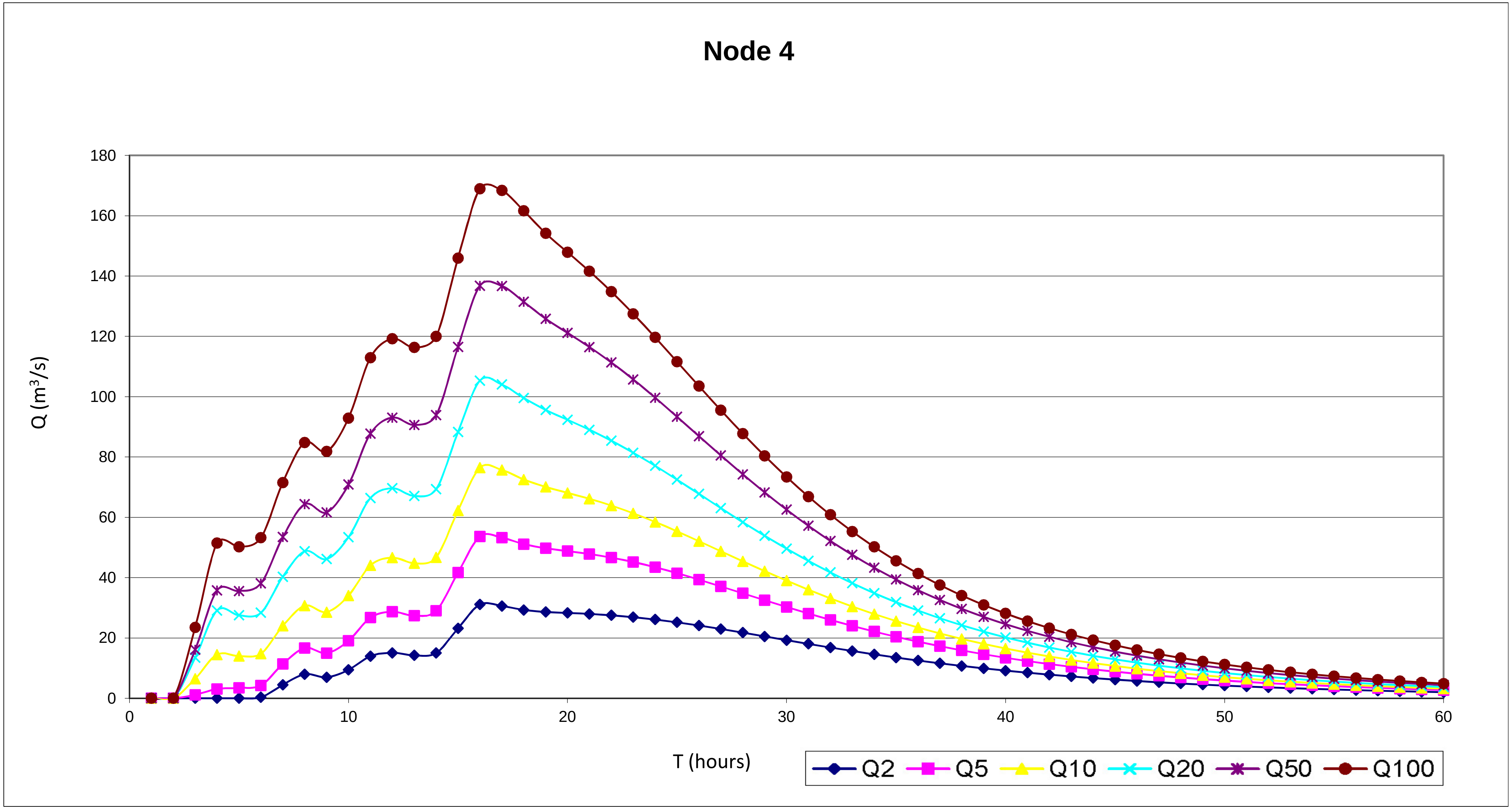
Logan Hydrograph



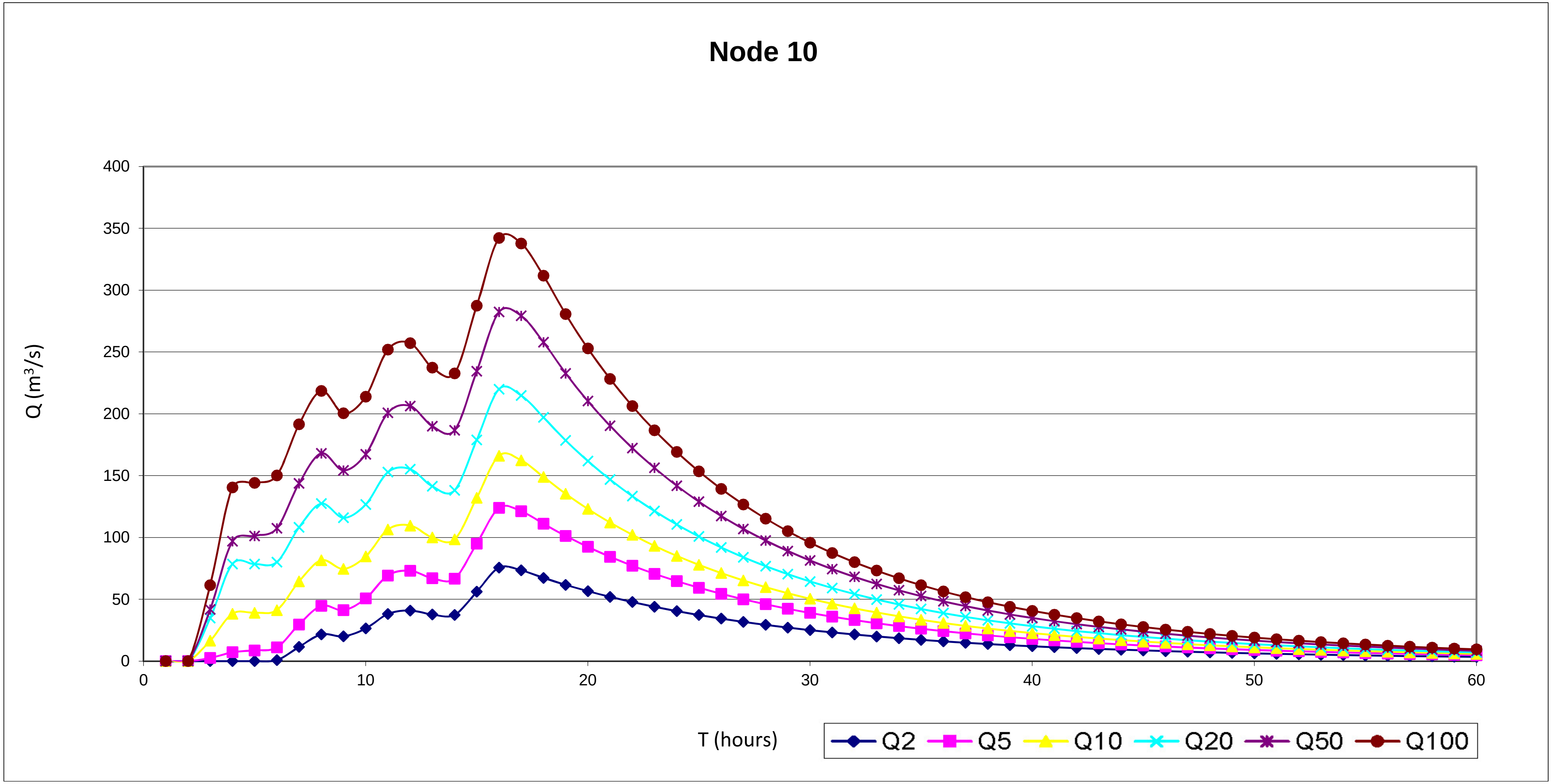
Brown Hydrograph - Node 2



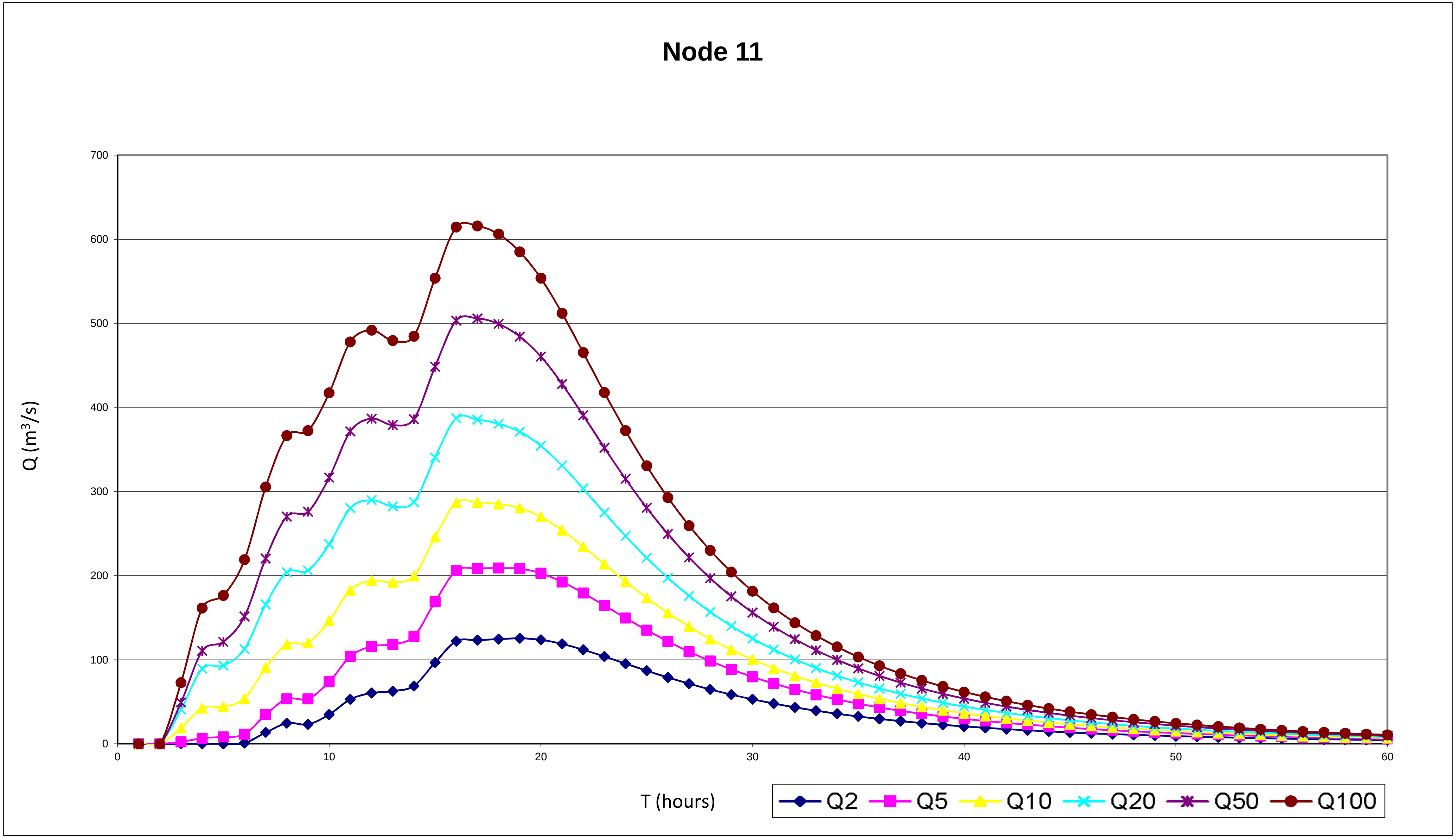
Brown Hydrograph - Node 4



Brown Hydrograph - Node 10



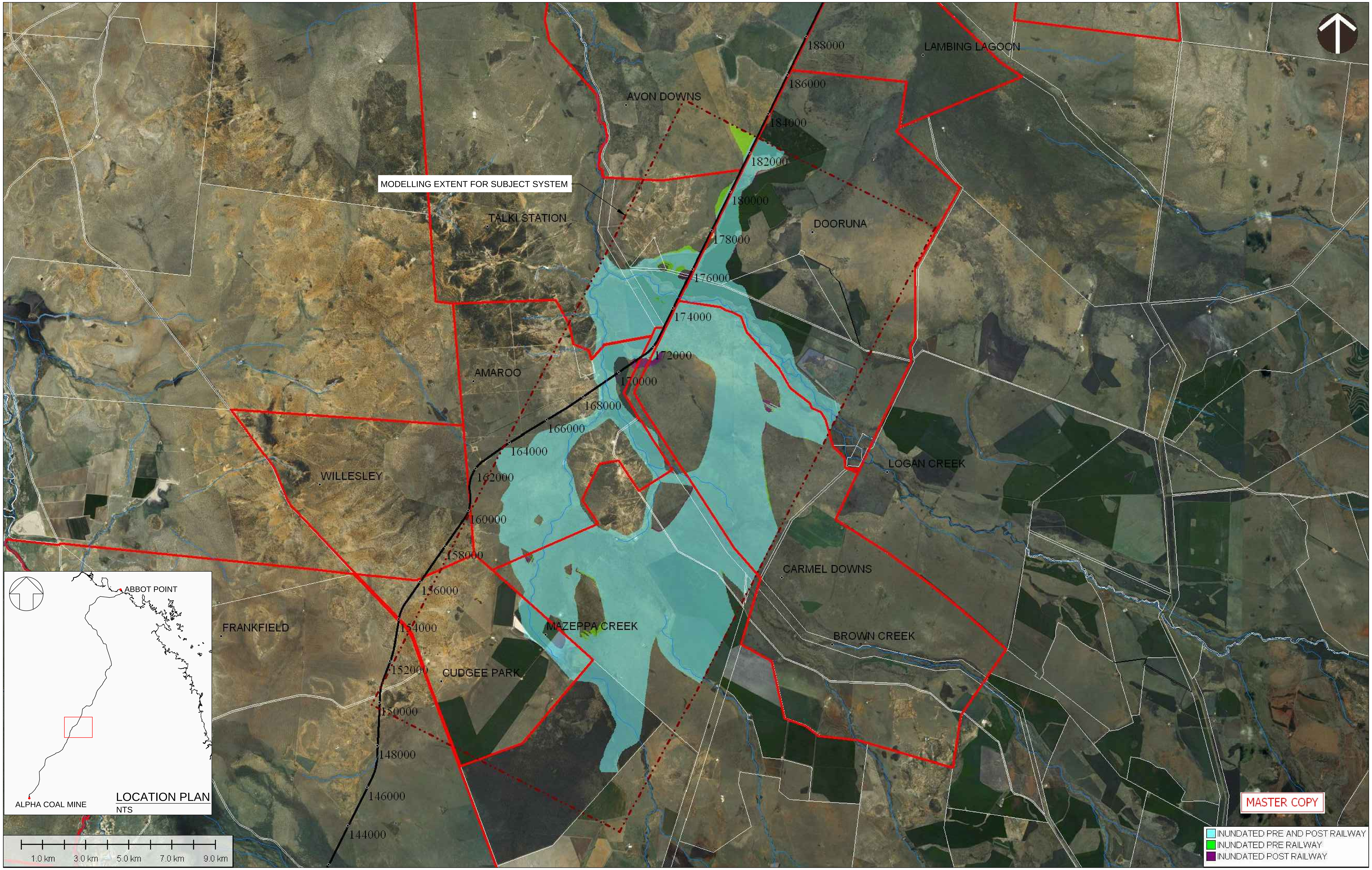
Brown Hydrograph - Node 11



APPENDIX B
FLOOD MAPS

NOT TO BE SCALED

NOT TO BE SCALED



REFERENCES

REVISIONS

REV	BY	DATE	DESCRIPTION	CKD	APP
B	DES	07.10.11	RE-ISSUED FOR INFORMATION	TLB	
A	DES	30.09.11	ISSUED FOR INFORMATION	TLB	

REVISIONS

REV	BY	DATE	DESCRIPTION	CKD	APP

DRAWN	D. SMITH	30.09.11
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
FLOOD INUNDATION
LOGAN CREEK / BROWN CREEK - Q5

SHEET SIZE A1

PN No CJVP10007

SCALE NTS

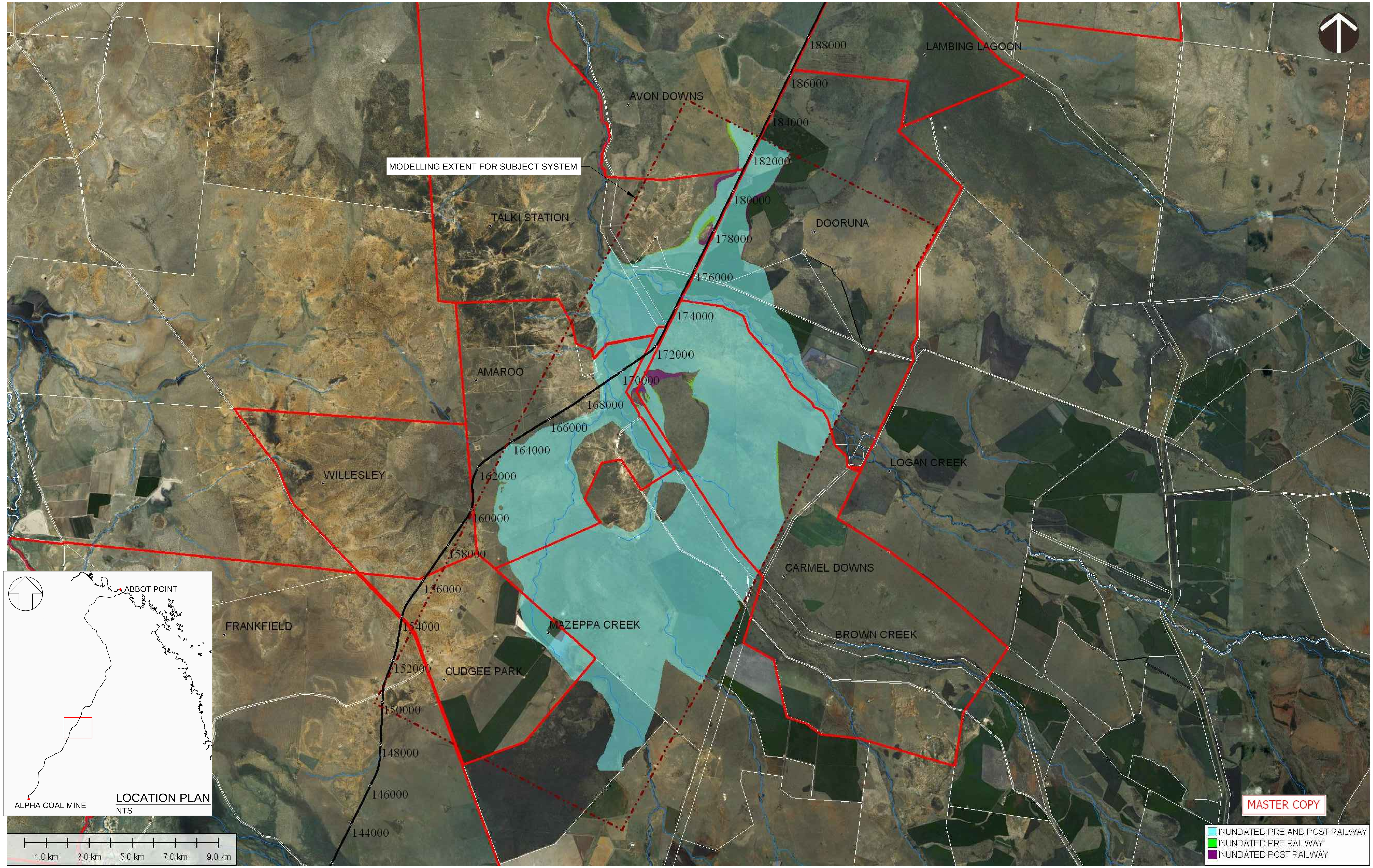
CALIBRE DRAWING No. CJVP10007-DWG-G-612

HANCOCK COAL REFERENCE No. HC-CRL-24100-DRG-0544

REV B

NOT TO BE SCALED

NOT TO BE SCALED



REV	BY	DATE	DESCRIPTION	CKD	APP
B	DES	07.10.11	RE-ISSUED FOR INFORMATION	TLB	
A	DES	30.09.11	ISSUED FOR INFORMATION	TLB	

DRAWN	D. SMITH	30.09.11
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
FLOOD INUNDATION
LOGAN CREEK / BROWN CREEK - Q50

SHEET SIZE A1

PN No CJVP10007

SCALE NTS

CALIBRE DRAWING No. CJVP10007-DWG-G-613

HANCOCK COAL REFERENCE No. HC-CRL-24100-DRG-0545

REV B

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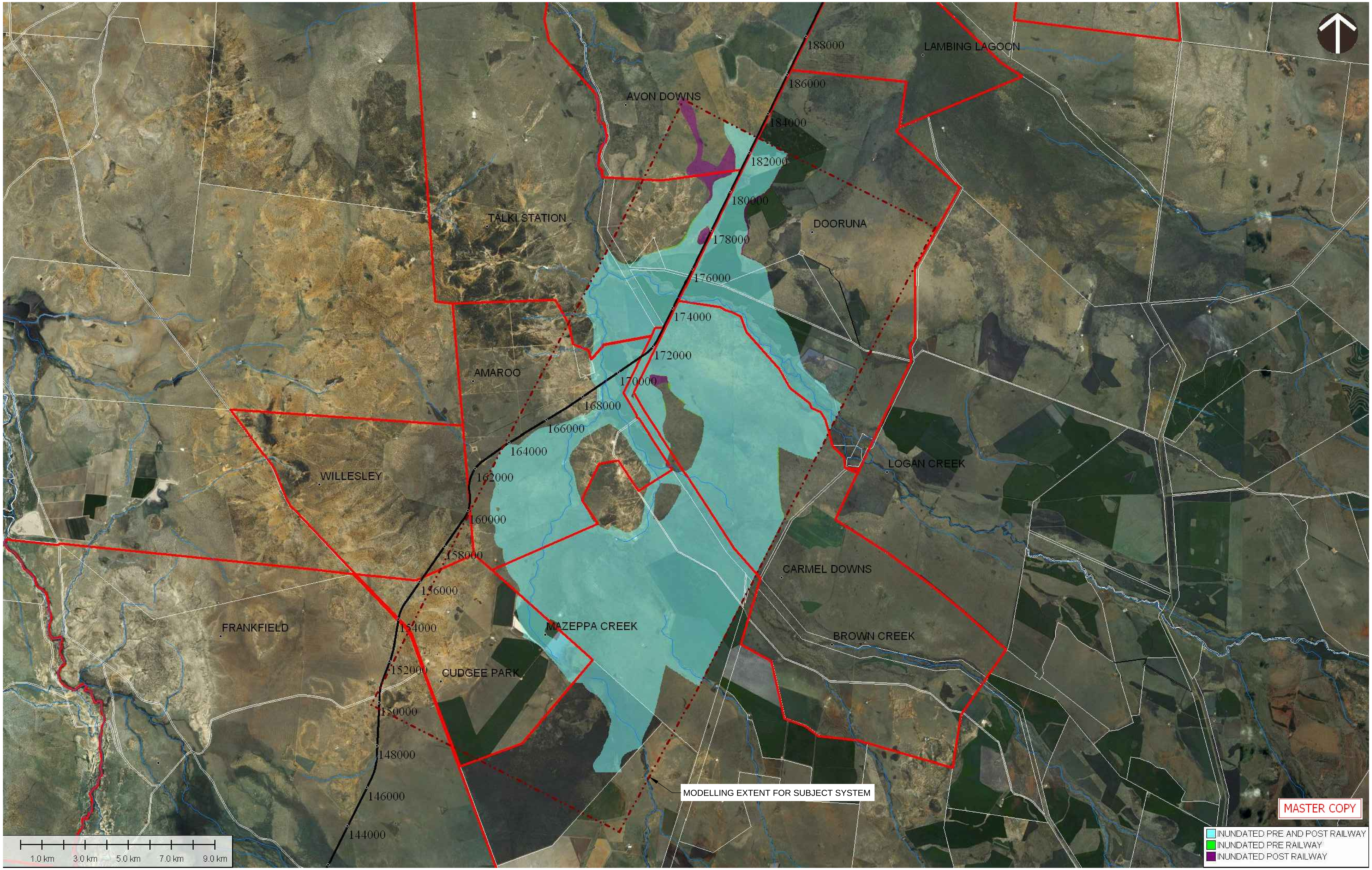


REV	BY	DATE	DESCRIPTION	CKD	APP
A	DES	07.10.11	ISSUED FOR INFORMATION	TLB	

DRAWN	D. SMITH	07.10.11
DRAFTING CHECK		
DESIGNER		
ENG. APPROVED		
ENG. MANAGER		
PROJECT MANAGER		
CLIENT APPROVED		

calibre

HANCOCK COAL PTY LTD

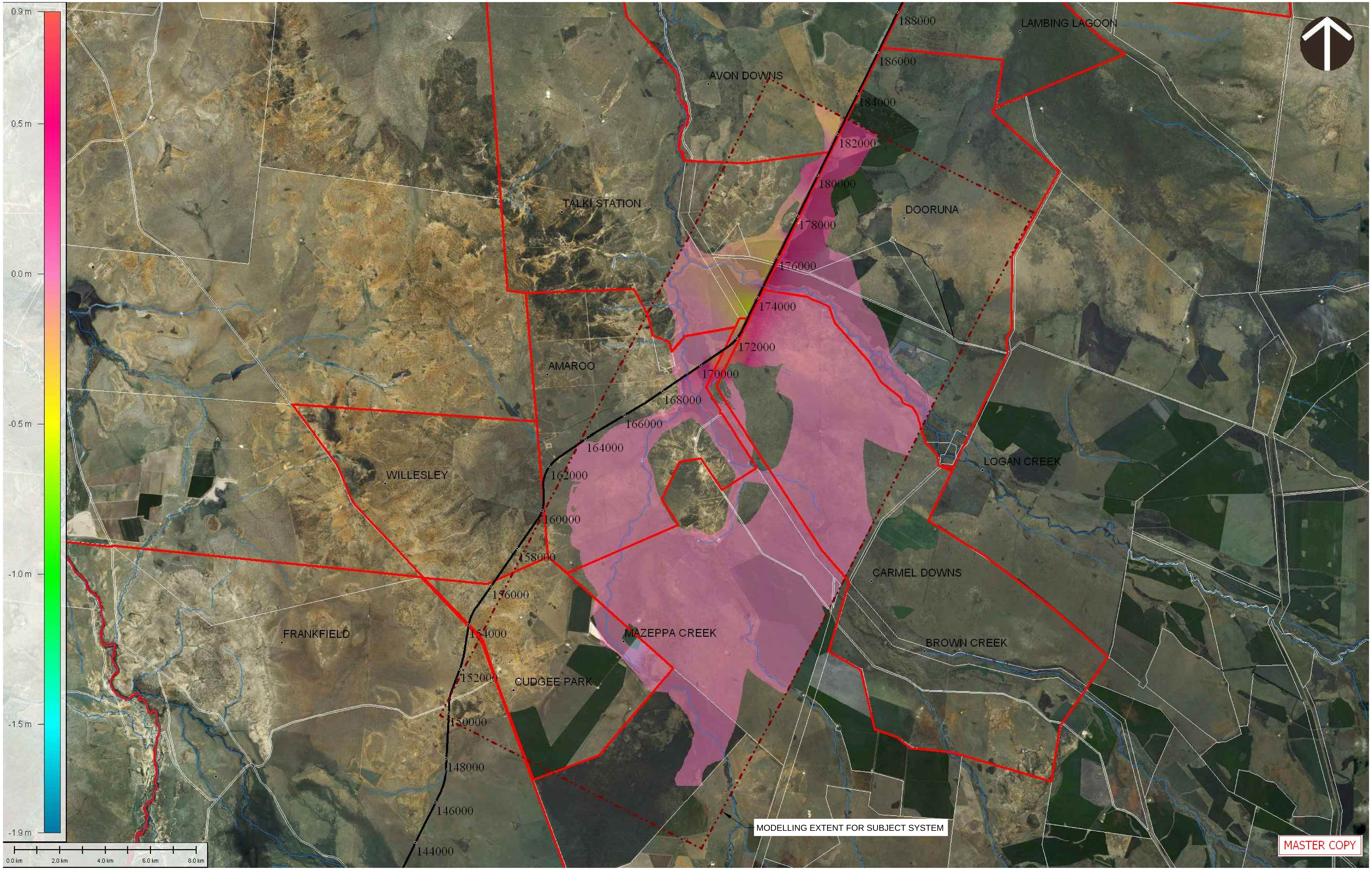
ALPHA COAL PROJECT
RAIL ALIGNMENT - MINE TO ABBOT POINT
FLOOD INUNDATION
LOGAN CREEK / BROWN CREEK - Q100

SHEET SIZE A1
PN No CJVP10007
SCALE NTS

CALIBRE DRAWING No. CJVP10007-DWG-G-641
HANCOCK COAL REFERENCE No. HC-CRL-24100-DRG-0573
REV A

NOT TO BE SCALED

NOT TO BE SCALED



REFERENCES

REVISIONS

REV	BY	DATE	DESCRIPTION	CKD	APP
A	DES	07.10.11	ISSUED FOR INFORMATION	TLB	

REVISIONS

REV	BY	DATE	DESCRIPTION	CKD	APP

DRAWN	D. SMITH	07.10.11
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
AFFLUX
LOGAN CREEK / BROWN CREEK - Q50

SHEET SIZE A1

PN No CJVP10007

SCALE NTS

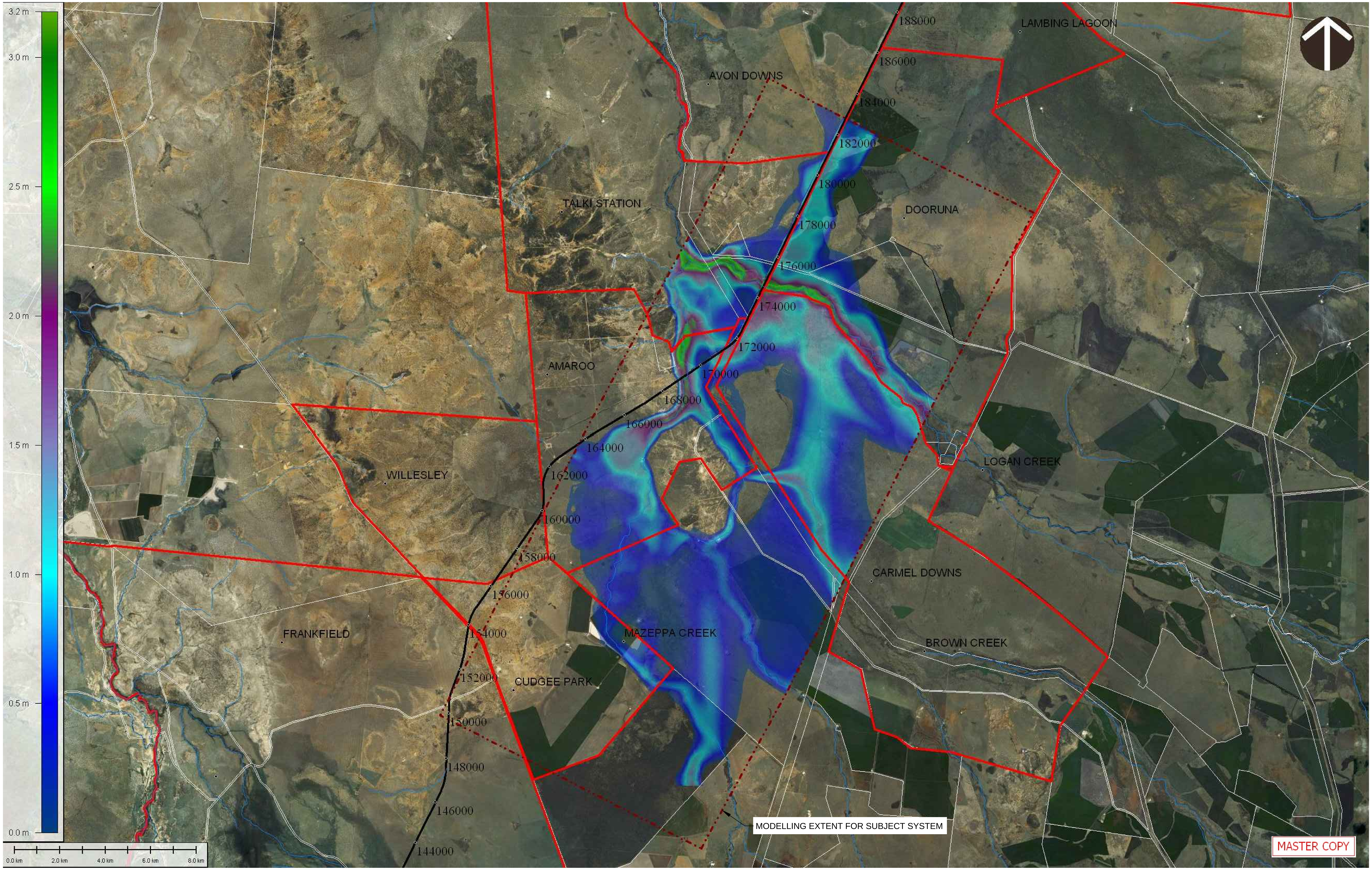
CALIBRE DRAWING No. CJVP10007-DWG-G-716

HANCOCK COAL REFERENCE No. HC-CRL-24100-DRG-0648

REV A

NOT TO BE SCALED

NOT TO BE SCALED



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	A	DES	07.10.11	ISSUED FOR INFORMATION	TLB	
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REVISIONS					
REV	BY	DATE	DESCRIPTION	CKD	APP

DRAWN	D. SMITH	07.10.11
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
DEPTH
LOGAN CREEK / BROWN CREEK - Q50

SHEET SIZE A1

PN No CJVP10007

SCALE NTS

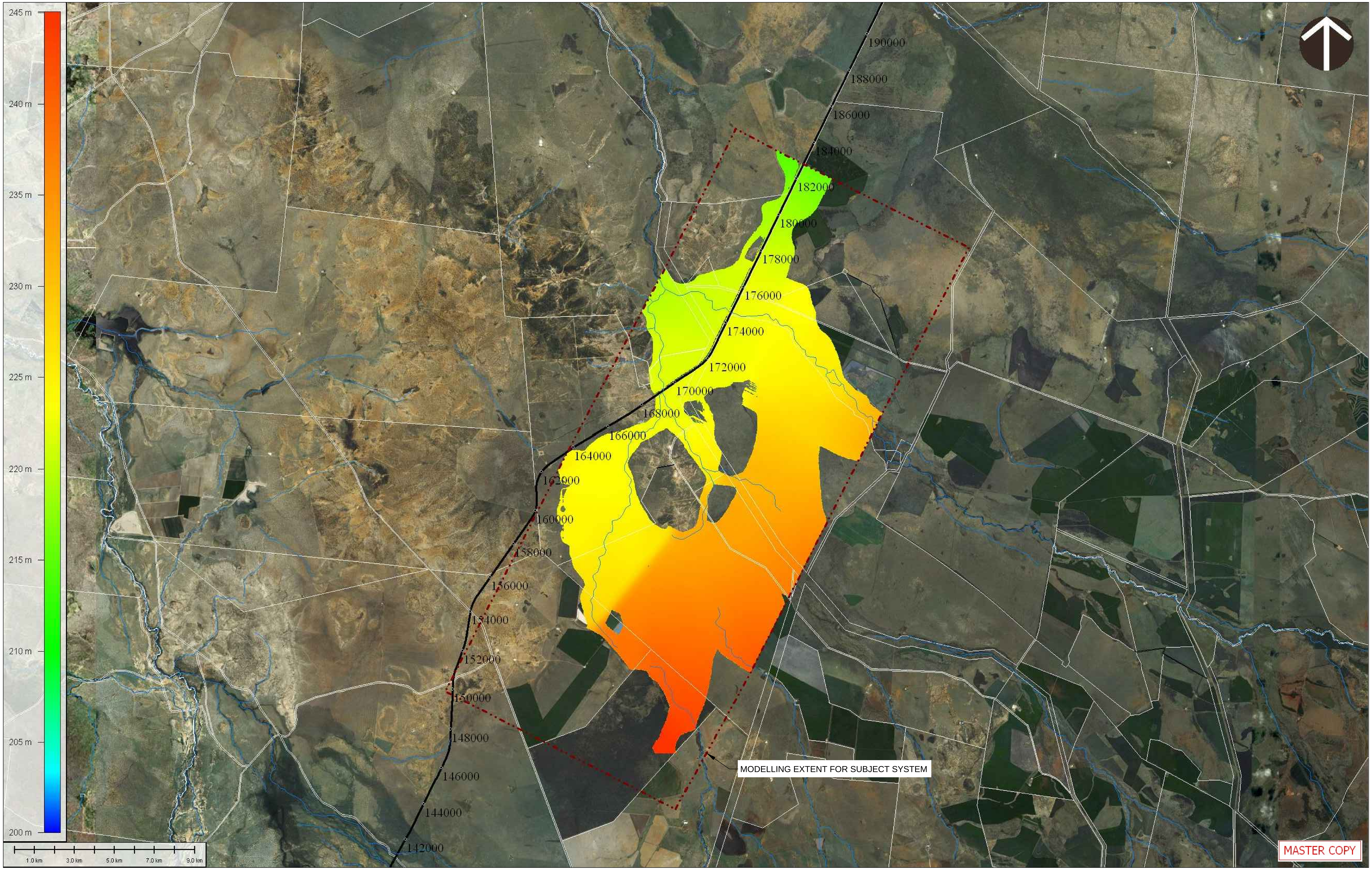
CALIBRE DRAWING No. CJVP10007-DWG-G-717

HANCOCK COAL REFERENCE No. HC-CRL-24100-DRG-0649

REV A

NOT TO BE SCALED

NOT TO BE SCALED



A	DES	07.10.11	ISSUED FOR INFORMATION	TLB	
REV	BY	DATE	DESCRIPTION	CKD	APP

REFERENCES

REVISIONS

DRAWN	D. SMITH	07.10.11
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
SURFACE EVLEVATION
LOGAN CREEK / BROWN CREEK - Q50

SHEET SIZE A1

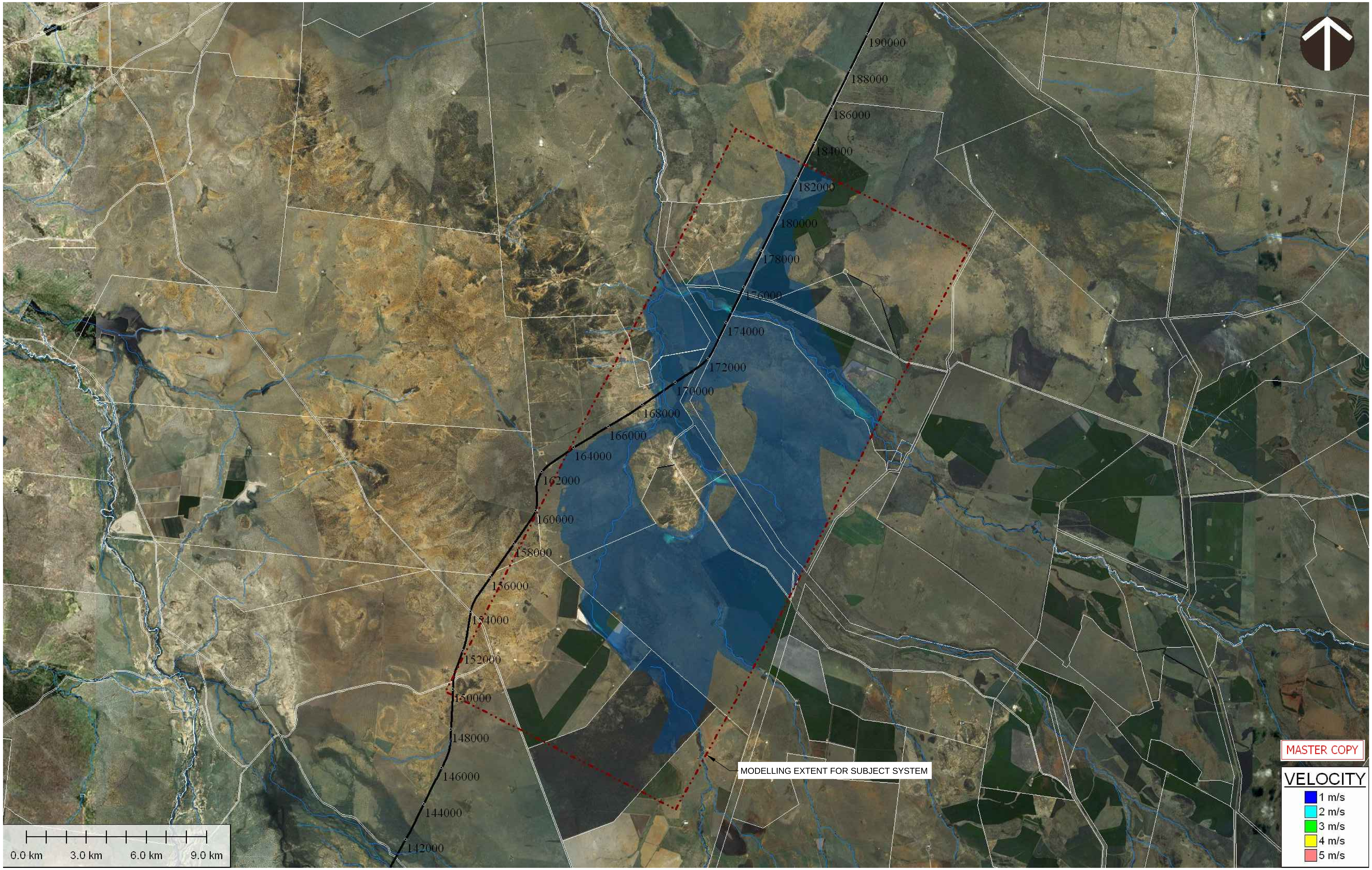
PN No CJVP10007

SCALE NTS

CALIBRE DRAWING No. CJVP10007-DWG-G-718

HANCOCK COAL REFERENCE No. HC-CRL-24100-DRG-0650

REV A



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ALPHA COAL PROJECT
RAIL ALIGNMENT - MINE TO ABBOT POINT
VELOCITY
LOGAN CREEK / BROWN CREEK - Q50

SHEET SIZE A1
PN No CJVP10007
SCALE NTS

CALIBRE DRAWING No. CJVP10007-DWG-G-719
HANCOCK COAL REFERENCE No. HC-CRL-24100-DRG-0651
REV A