ENGENY

BARALABA SOUTH PTY LTD

Baralaba South Project

Flood Impact Assessment

QC018_004-REP-001-0

24 NOVEMBER 2023

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Rev	Date	Description	Author	Reviewer	Project Mgr.	Approver
0	24/11/2023	Final	Aaron Baldwin	Andrew Vitale	Aaron Baldwin	Andrew Vitale
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1. INTRODUCTION

1.1 Project Description

Baralaba South Pty Ltd proposes to develop the Baralaba South Project (the Project), the Project would be located approximately 8 kilometres (km) south of the township of Baralaba and 115 km west of Rockhampton in the lower Bowen Basin region of Central Queensland (Figure 1.2).

The Project is a greenfield, open-cut metallurgical coal mine which would extract up to 2.5 million tonnes per annum (Mtpa) of run-of-mine (ROM) coal to produce pulverised coal injection (PCI) coal for international export to the steel production industry over a life of 23 years. Mining activities are to be undertaken within the area of Mining Lease Application (MLA) 700057, which covers a total of 2,214 ha.

Open-cut coal mining activities would target the Baralaba Coal Measures, including the basal sub-unit Kaloola Member, where the structural dip of the Permian geology brings them to or near the surface within MLA 700057. The total resource targeted comprises 48.6 Mt of ROM coal estimated to produce approximately 34.6 Mt of PCI product coal over the life of the Project. Overburden and interburden will be disposed of in out-of-pit spoil dumps located contiguous with the pit excavation, and in-pit dumps as part of ongoing progressive rehabilitation behind the advancing operations.

The Project will provide a continuation of mining operations within the local area, wherein mining operations decline at the Baralaba North Mine, mining operations will ramp up at the Project.

The main activities associated with the Project include:

- A greenfield open-cut coal mine to be developed within the Mining Lease Application (MLA) 700057, including:
  - Open-cut mining operations using conventional truck and excavator methods.
  - A Coal Handling Preparation Plant (CHPP).
  - A mining infrastructure area, including workshops, administration buildings, fuel and chemical storage facilities, warehouse and hardstand areas.
  - ROM coal and product coal stockpile pads.
  - Topsoil stockpiles, laydown areas and borrow areas.
  - Haul roads and internal roads.
  - Water management infrastructure.
  - Backfilling of mine voids with waste rock behind the advancing open-cut mining operations and the placement of waste rock in out-of-pit emplacements adjacent to the pit extents.
  - Dewatering of CHPP coal rejects and disposal on-site within mine voids behind the advancing open-cut mining operation.
  - Recovery and recycling of processed wastewater through the CHPP.
  - Other associated minor infrastructure, plant, equipment, and activities; and,
  - Exploration activities.
- Realignment of approximately 4.5 km of Moura Baralaba Road to the east of MLA 700057 (Realignment of Moura Baralaba Road is subject to separate approvals),
- Product coal road transport approximately 40 km via the existing Baralaba North Mine haul route on public Council-controlled roads to the existing train load-out facility located approximately 2 km east of Moura; and,
- Product coal rail transport to the Port of Gladstone for export to international markets.

The Project includes development of an electricity transmission line (ETL) of approximately 8 km in length within a 20 m wide easement. The ETL will link the Project with the Baralaba Substation, located approximately 6 km east-south-east of the Baralaba township. Two ETL alignment options are being considered for the Project and the final ETL alignment will be determined at a later date in consideration of the outcomes of the assessments conducted for the EIS. The ETL will be subject to separate approvals, for which the necessary permitting will be undertaken by Ergon.

The Project layout is shown in Figure 1.1.

Figure 1.1: **Project Layout**

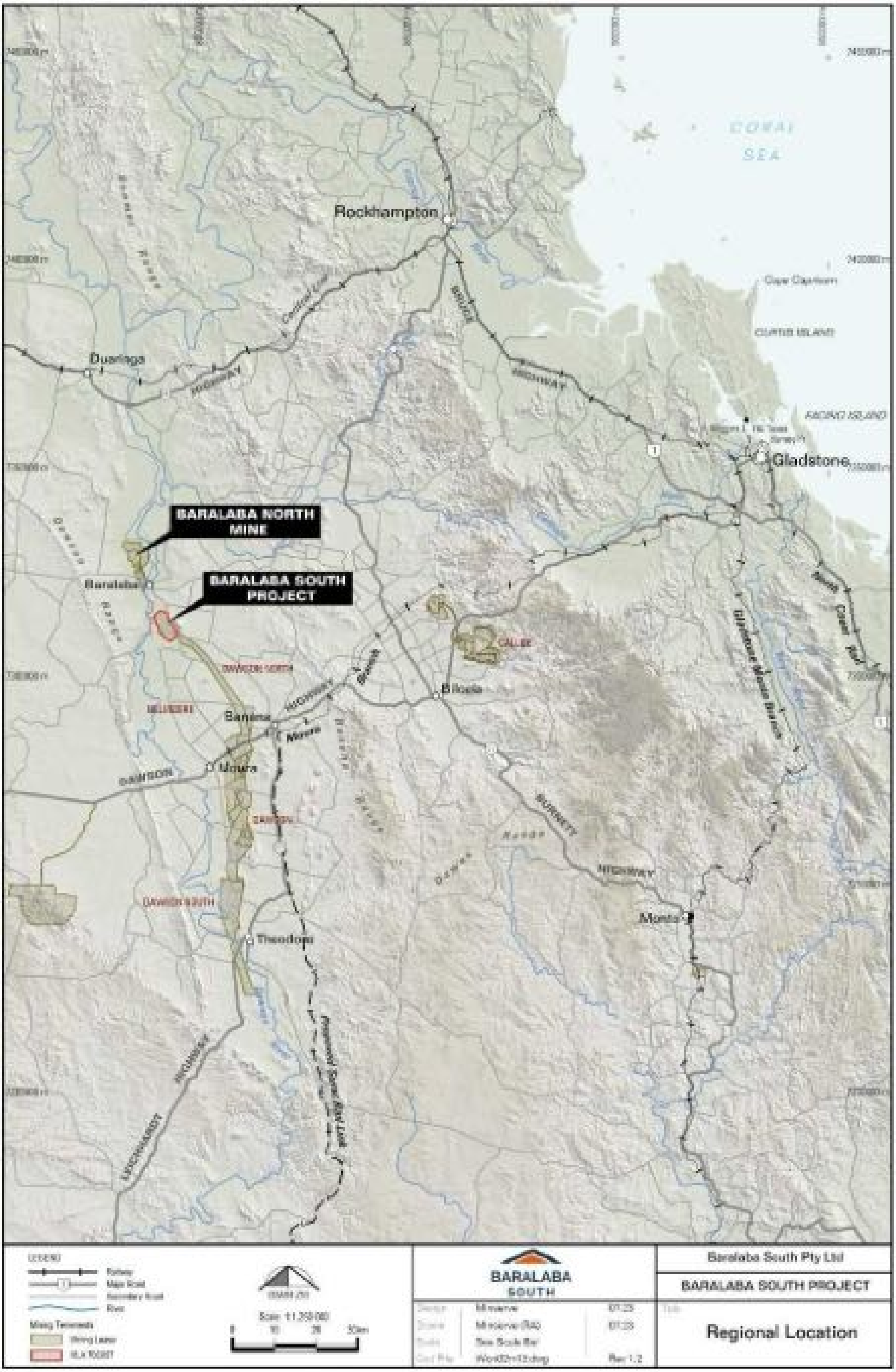

Figure 1.2: **Regional Location**

1.2 Terms of Reference Requirements

The Terms of Reference for the Project Environmental Impact Statement (DEHP, 2017b) have identified three controlling provisions for the Project with regard to its potential impacts on matters of national environmental significance (MNES):

- Listed threatened species and communities.
- Listed migratory species.
- Water resources.

The Terms of Reference for the Project environmental impact statement (DEHP 2017) also sets the scope of critical matters that should be given detailed treatment in the EIS. Nine (9) critical matters have been identified for the Project, three (3) of which are associated with surface water:

- Water Quality.
- Water Resources.
- Flooding and Regulated Dams.

This flood assessment report addresses the critical matters identified for flooding. The report sections where the TOR information requirements relevant to flooding have been addressed are outlined in Table 1.1.

TABLE 1.1: TERMS OF REFERENCE REQUIREMENT

TOR Critical Matter	Information Requirement	Relevant Section of this Report or Reference to another EIS Appendix
Water Resources	8.3.9 (mislabelled in TOR as 8.3.6) and Appendix 2	Appendix A of EIS - Surface Water Impact Assessment Report Section 4.4 and Appendices to this report
Flooding and Regulated Dams	8.4.1	Sections 6 of this report Flood maps provided in Appendices B to J of this report
	8.4.2	Section 7 and Appendices of this report
	8.4.3	Section 6.14.1 and Appendices of this report
	8.4.4 - 8.4.9	Appendix A of EIS - Surface Water Impact Assessment Report

1.3 Independent Expert Scientific Committee Requirements

The flooding information requirements contained in the IESC's information guideline for proposals relating to the development of a large coal mine (IESC, 2018) and associated references to relevant sections of the report are provided in Table 1.2.

TABLE 1.2: IESC REQUIREMENTS (RELEVANT TO FLOODING)

Information Requirement	Report Section
Surface Water	
Context and Conceptualisation	
Describe the hydrological regime of all watercourses, standing waters and springs across the site including:	Refer Surface Water Impact Assessment

Information Requirement	Report Section
• Geomorphology, including drainage patterns, sediment regime and floodplain features, • Spatial, temporal and seasonal trends in streamflow and/or standing water levels, • Spatial, temporal and seasonal trends in water quality data (such as turbidity, acidity, salinity, relevant organic chemicals, metals, metalloids and radionuclides); and, • Current stressors on watercourses, including impacts from any currently approved projects.	Sections 4.4.1 and Appendices B to H (in relation to flooding)
Describe the existing flood regime, including flood volume, depth, duration, extent and velocity for a range of annual exceedance probabilities. Provide flood hydrographs and maps identifying peak flood extent, depth and velocity. This assessment should be informed by topographic data that has been acquired using lidar or other reliable survey methods with accuracy stated.	Section 4.4 and Appendix B
Provide an assessment of the frequency, volume, seasonal variability and direction of interactions between water resources, including surface water/ groundwater connectivity and connectivity with sea water.	Surface Water Impact Assessment
Analytical and Numerical Modelling.	
Provide conceptual models at an appropriate scale, including water quality, stores, flows and use of water by ecosystems.	Surface Water Impact Assessment
Use methods in accordance with the most recent publication of *Australian Rainfall and Runoff* (Ball et al. 2016).	Section 3.4
Develop and describe a program for review and update of the models as more data and information becomes available.	Surface Water Impact Assessment
Describe and justify model assumptions and limitations and calibrate with appropriate surface water monitoring data.	Surface Water Impact Assessment
Provide an assessment of the risks and uncertainty inherent in the data used in the modelling, particularly with respect to predicted scenarios.	Surface Water Impact Assessment and Section 6.13
Provide a detailed description of any methods and evidence (e.g., expert opinion, analogue sites) employed in addition to modelling.	Surface Water Impact Assessment
Impacts to Water Resources and Water-dependant Assets	
Describe all potential impacts of the proposed project on surface waters. Include a clear description of the impact to the resource, the resultant impact to any assets dependent on the resource (including water-dependent ecosystems such as riparian zones and floodplains), and the consequence or significance of the impact. Consider: • Impacts on streamflow under the full range of flow conditions. • Impacts associated with surface water diversions. • Impacts to water quality, including consideration of mixing zones. • The quality, quantity and ecotoxicological effects of operational discharges of water (including saline water), including potential emergency discharges, and the likely impacts on water resources and water-dependent assets. • Landscape modifications such as subsidence, voids, post rehabilitation landform collapses, on-site earthworks (including disturbance of acid-forming or sodic soils, roadway and pipeline networks)	Surface Water Impact Assessment Section 6 and Appendices B to H (in relation to flooding)

Information Requirement	Report Section
and how these could affect surface water flow, surface water quality, erosion, sedimentation and habitat fragmentation of water-dependent species and communities.	
Discuss existing water quality guidelines, environmental flow objectives and requirements for the surface water catchment(s) within which the development proposal is based.	Surface Water Impact Assessment
Identify processes to determine surface water quality guidelines and quantity thresholds which incorporate seasonal variation but provide early indication of potential impacts to assets.	Surface Water Impact Assessment
Propose mitigation actions for each identified significant impact.	Surface Water Impact Assessment
Describe the adequacy of proposed measures to prevent or minimise impacts on water resources and water-dependent assets.	Surface Water Impact Assessment
Describe the cumulative impact of the proposal on surface water resources and water-dependent assets when all developments (past, present and reasonably foreseeable) are considered in combination.	Surface Water Impact Assessment
Provide an assessment of the risks of flooding (including channel form and stability, water level, depth, extent, velocity, shear stress and stream power), and impacts to ecosystems, project infrastructure and the final project landform.	Section 6 and Appendices C to H
Cumulative Impacts	
Context and Conceptualisation	
Provide cumulative impact analysis with sufficient geographic and temporal boundaries to include all potentially significant water-related impacts.	Surface Water Impact Assessment and Section 6
Consider all past, present and reasonably foreseeable actions, including development proposals, programs and policies that are likely to impact on the water resources of concern in the cumulative impact analysis. Where a proposed project is located within the area of a bioregional assessment consider the results of the bioregional assessment.	Surface Water Impact Assessment and Section 6.
Impacts	
Provide an assessment of the condition of affected water resources which includes: • Identification of all water resources likely to be cumulatively impacted by the proposed development, • A description of the current condition and quality of water resources and information on condition trends, • Identification of ecological characteristics, processes, conditions, trends and values of water resources, • Adequate water and salt balances; and, • Identification of potential thresholds for each water resource and its likely response to change and capacity to withstand adverse impacts (e.g., altered water quality, drawdown).	Surface Water Impact Assessment
Assess the cumulative impacts to water resources considering:	Surface Water Impact Assessment and Section 6

Information Requirement	Report Section
 - The full extent of potential impacts from the proposed project, (including whether there are alternative options for infrastructure and mine configurations which could reduce impacts), and encompassing all linkages, including both direct and indirect links, operating upstream, downstream, vertically and laterally, - All stages of the development, including exploration, operations and post closure/decommissioning, - Appropriately robust, repeatable and transparent methods, - The likely spatial magnitude and timeframe over which impacts will occur, and significance of cumulative impacts; and, - Opportunities to work with other water users to avoid, minimise or mitigate potential cumulative impacts.	
Mitigation, Monitoring and Management	
Identify modifications or alternatives to avoid, minimise or mitigate potential cumulative impacts. Evidence of the likely success of these measures (e.g., case studies) should be provided.	Surface Water Impact Assessment and Section 7
Identify measures to detect and monitor cumulative impacts, pre and post development, and assess the success of mitigation strategies.	Surface Water Impact Assessment
Identify cumulative impact environmental objectives.	Surface Water Impact Assessment
Describe appropriate reporting mechanisms.	Surface Water Impact Assessment
Propose adaptive management measures and management responses.	Surface Water Impact Assessment
Final Landform and Voids – Coal Mines	
Identify and consider landscape modifications (e.g., voids, on-site earthworks, and roadway and pipeline networks) and their potential effects on surface water flow, erosion, sedimentation and habitat fragmentation of water-dependent species and communities.	Surface Water Impact Assessment and Section 5
Assess the adequacy of modelling, including surface water and groundwater quantity and quality, lake behaviour, timeframes and calibration.	Surface Water Impact Assessment
Provide an evaluation of stability of void slopes where failure during extreme events or over the long term (for example due to aquifer recovery causing geological heave and landform failure) may have implications for water quality.	Final Landform Stability Assessment
Evaluate mitigating inflows of saline groundwater by planning for partial backfilling of final voids.	Groundwater Modelling and Assessment
Provide an assessment of the long-term impacts to water resources and water-dependent assets posed by various options for the final landform design, including complete or partial backfilling of mining voids. Assessment of the final landform for which approval is being sought should consider: - Groundwater behaviour - sink or lateral flow from void.	Surface Water Impact Assessment and Groundwater Modelling and Assessment

Information Requirement	Report Section
• Water level recovery - rate, depth, and stabilisation point (e.g., timeframe and level in relation to existing groundwater level, surface elevation). • Seepage - geochemistry and potential impacts. • Long-term water quality, including salinity, pH, metals, and toxicity. • Measures to prevent migration of void water off-site. For other final landform options considered sufficient detail of potential impacts should be provided to clearly justify the proposed option.	
Assess the probability of overtopping of final voids with variable climate extremes, and management mitigations.	Surface Water Impact Assessment

2. RECEIVING ENVIRONMENT

2.1 Overview

2.1.1 Regional Catchment

The Project is located in Central Queensland within the Fitzroy Basin (see Figure 2.1) which is a sub-basin of the greater North East Coast Basin. The Fitzroy Basin has a total catchment of 142,900 km^2 with the main tributary rivers being the Mackenzie River, Isaac River, Dawson River and Comet River. The Fitzroy River discharges into the Coral Sea, southeast of Rockhampton. The Fitzroy Basin catchment and its sub-catchments are presented in Figure 2.2.

2.1.2 Local Catchment/s

The Project is located near the confluence of Banana Creek and the Dawson River (Figure 2.1). The Dawson River is one of the major tributaries to the Fitzroy River. The Dawson River sub-basin total catchment area is 50,800 km2 and makes up 35% of the Fitzroy Basin catchment. The Dawson River headwaters are within the Carnarvon Range and the river flows typically in a north easterly direction. Approximately 35 km downstream of the Project, the Don River flows into the Dawson River. The Don River catchment area is approximately 25% of the Dawson River catchment area at the confluence.

Banana Creek is a 5th order watercourse which flows in a north-westerly direction from south of the Banana township towards the Project. Banana Creek flows into the Dawson River to the west of the MLA. The western and northern MLA boundaries lie roughly parallel to Banana Creek and the Dawson River respectively (see Figure 2.1). At the nearest point, the MLA is within 700 m of the Dawson River channel and 500 m from the Banana Creek channel and a proportion of the site lies within the natural floodplain.

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Figure 2.1

BARALABA SOUTH PTY LTD
Flood Impact Assessment
Regional Catchments

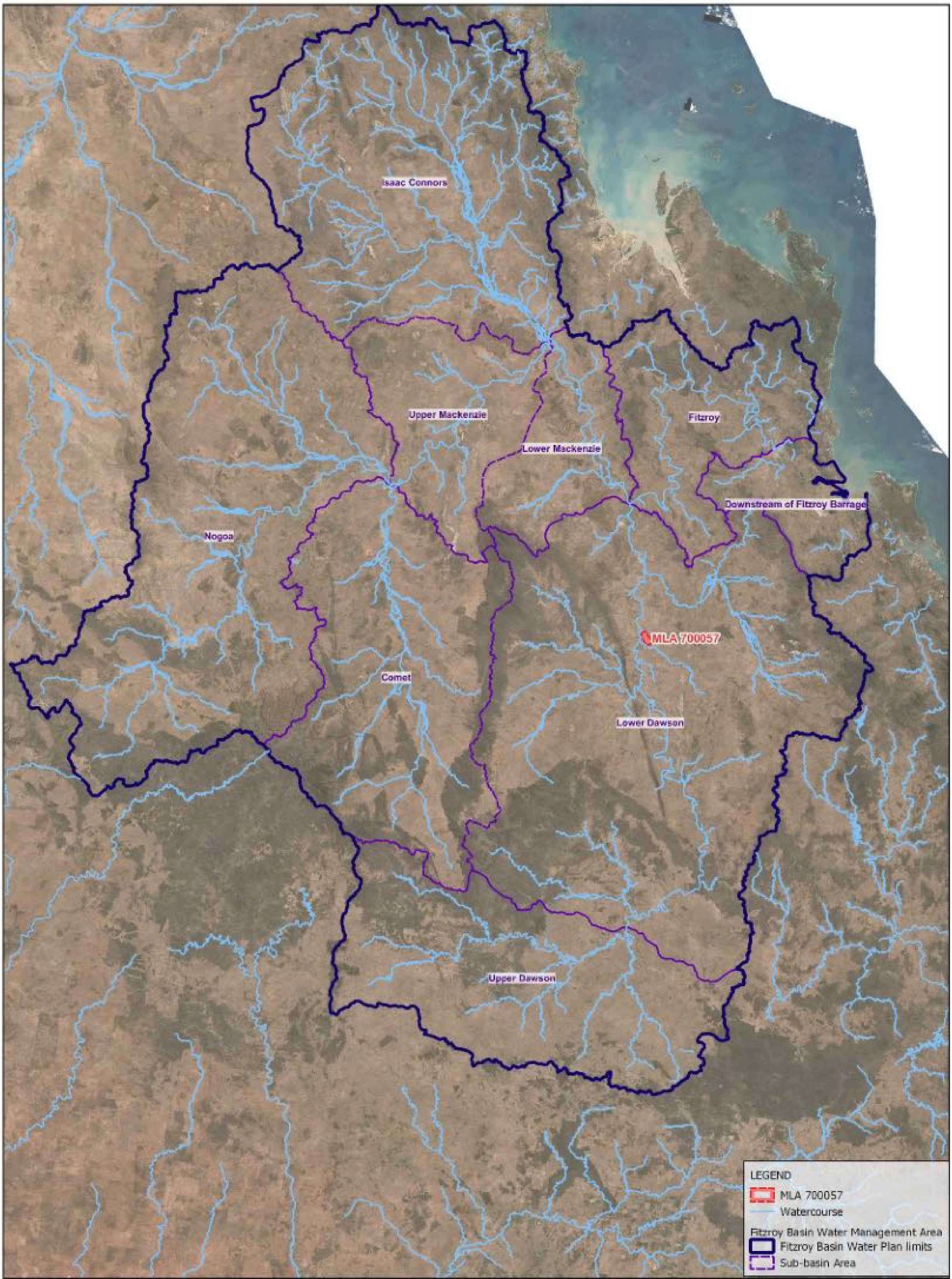

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Figure 2.2

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Flood Impact Assessment
Regional Catchments

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2.2 Dawson River

The Dawson River is defined as a watercourse under the Water Act 2000 and is the largest watercourse in the vicinity of the Project with a catchment of approximately 40,500 km^2 at the Baralaba township. The Dawson River is a perennial watercourse subject to seasonal flooding. The Dawson River flows in a generally northern direction with its headwaters as far inland as Injune and joins the Don River downstream of Baralaba township and the Fitzroy River downstream of Duaringa as depicted in Figure 2.3.

At the Project location, the Dawson River main channel is approximately 150 m wide and 10 m deep and is bordered by a floodplain extending between 1.5-3 km on either side of the river channel. The Dawson River has a number of anabranch channels both upstream and downstream of the Project indicating it is reasonably laterally active (AECOM, 2016).

The Dawson River main channel lies within approximately 700 m of the MLA at its nearest point immediately downstream of the confluence with Banana Creek. An anabranch of the Dawson River, to the north-west of the Project, flows within approximately 400 m of the MLA boundary. The Dawson River proximity to the Project is shown in Figure 2.4.

The Dawson River flows relatively consistently throughout the year as it receives inflow from groundwater sources along the length of the river. Mean daily and annual flow volumes in the Dawson River are approximately 2,790 ML and 1,020 GL, respectively. The Dawson River typically experiences significant seasonal variations in high flows with flooding typically occurring during the wet season (November to April).

Water resources are managed in the lower reaches of the Dawson River via a series of instream water supply storages. The nearest upstream and downstream storages are the Moura Weir (approximately 40 km upstream of the Project) and the Neville Hewitt Weir near Baralaba (approximately 8 km downstream of the Project). Entitlements for water extraction from the Dawson River are managed through the Dawson Valley Water Supply Scheme and the Water Plan (Fitzroy Basin) 2011.

Figure 2.3: Fitzroy Basin (Water Plan (Fitzroy Basin) 2011)

2.3 Banana Creek

Banana Creek is defined as a watercourse under the Water Act 2000 and is the second largest watercourse in the vicinity of the Project with a catchment area of approximately 1,000 km2 at its confluence with the Dawson River. Banana Creek is an ephemeral; 5th order tributary of the Dawson River. Banana Creek flows into the Dawson River approximately 1 km west of the Project MLA. The Project MLA boundary is 500m from Banana Creek at the closest point and the south-western MLA boundary is parallel to the creek alignment with an offset of generally 2 km.

Banana Creek is ungauged. It is an ephemeral system flowing only in response to large rainfall events typically during the wet season (November to April). Banana Creek flows in a north westerly direction to its confluence with the Dawson River at Adopted Middle Threat Distance (AMTD) 97.2 km. Banana Creek in the vicinity of the Project has an approximately 120 m wide 10 m deep main channel, bordered by a floodplain extending approximately 1 km on either side of the main channel. Flooding of Banana Creek in the vicinity of the Project is heavily influenced by flooding in the Dawson River due to the magnitude of flood flows in the Dawson River. Banana Creek is shown in Figure 2.4.

2.4 Unnamed Waterways

There are unnamed waterways of 1st, 2nd, and 3rd stream order within the boundaries of the MLA. All such waterways are tributaries to the Dawson River and combine into a 3rd order waterway at the northern end of the MLA before flowing into an anabranch of the Dawson River. The unnamed waterways catchments extend from Mount Ramsay to the east and to the Dawson River to the west. The 1st order drainages flowing through the MLA area have catchment areas ranging from under 100 ha to as large as 1,300 ha. Flow paths are not well defined with no obvious channel bed or bank features. The total area of the unnamed waterways where the 3rd order drainage feature intersects the MLA has a catchment area of approximately 5,000 ha and a channel width of around 30 m. All of the minor waterways in the vicinity of the MLA are ephemeral and flow only in response to rainfall for short durations. The unnamed waterways are shown in Figure 2.4.

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Figure 2.4

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Flood Impact Assessment
Drainage Features

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2.5 Wetlands

The Map of Queensland wetland environmental values are a state-wide statutory map under the Environmental Protection (Water and Wetland Biodiversity) Policy 2019. It identifies wetlands of high ecological significance (HES) and general ecological significance (GES) across the state.

Matters of State Environmental Significance (MSES) high ecological significance wetlands and general ecological significance wetlands and Vegetation Management Wetlands are mapped in the locality of the Project (Figure 2.5 and Figure 2.6).

A MSES high ecological significance wetland/Vegetation Management Wetland approximately 35 ha in area is near the south-western boundary of the MLA. Two wetlands of general ecological significance (GES) were also identified within the MLA boundary, one of which is also classified as a Vegetation Management Wetland.

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Figure 2.5

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Flood Impact Assessment
MSES Wetlands

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Figure 2.6

BARALABA SOUTH PTY LTD
Flood Impact Assessment
Vegetation Management Wetlands

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2.6 Land Use

The Government's indicative land use mapping (Queensland Globe) for the Project MLA maps the land use for the majority of the MLA as "grazing native vegetation". The surrounding area is also dominated by "grazing native vegetation" mapped land use. There are areas of "irrigated cropping", "managed resource protection" and "residential".

2.6.1 Agriculture

Agriculture has a significant presence in the Baralaba locality. Farming of crops and grazing of livestock is present along the Dawson River both upstream and downstream of the Project (DES, 2019a). A large cropping operation exists on the western bank of Banana Creek at the confluence of Banana Creek and the Dawson River and to the south-west. Agricultural operations based on indicative government mapping are depicted in Figure 2.8 (DES, 2019a).

The Project is located to the east of a Priority Agricultural Area (DSDMIP, 2013) (Figure 2.7). The regional outcome for the Central Queensland Regional Plan (DSDMIP, 2013) is for "agriculture and resource industries within the Central Queensland region continue to grow with certainty and investor confidence". The regional policies that aim to achieve this outcome are:

- Protect Priority Agricultural Land Uses within Priority Agricultural Areas.
- Maximise opportunities for co-existence of resource and agricultural land uses within Priority Agricultural Areas.

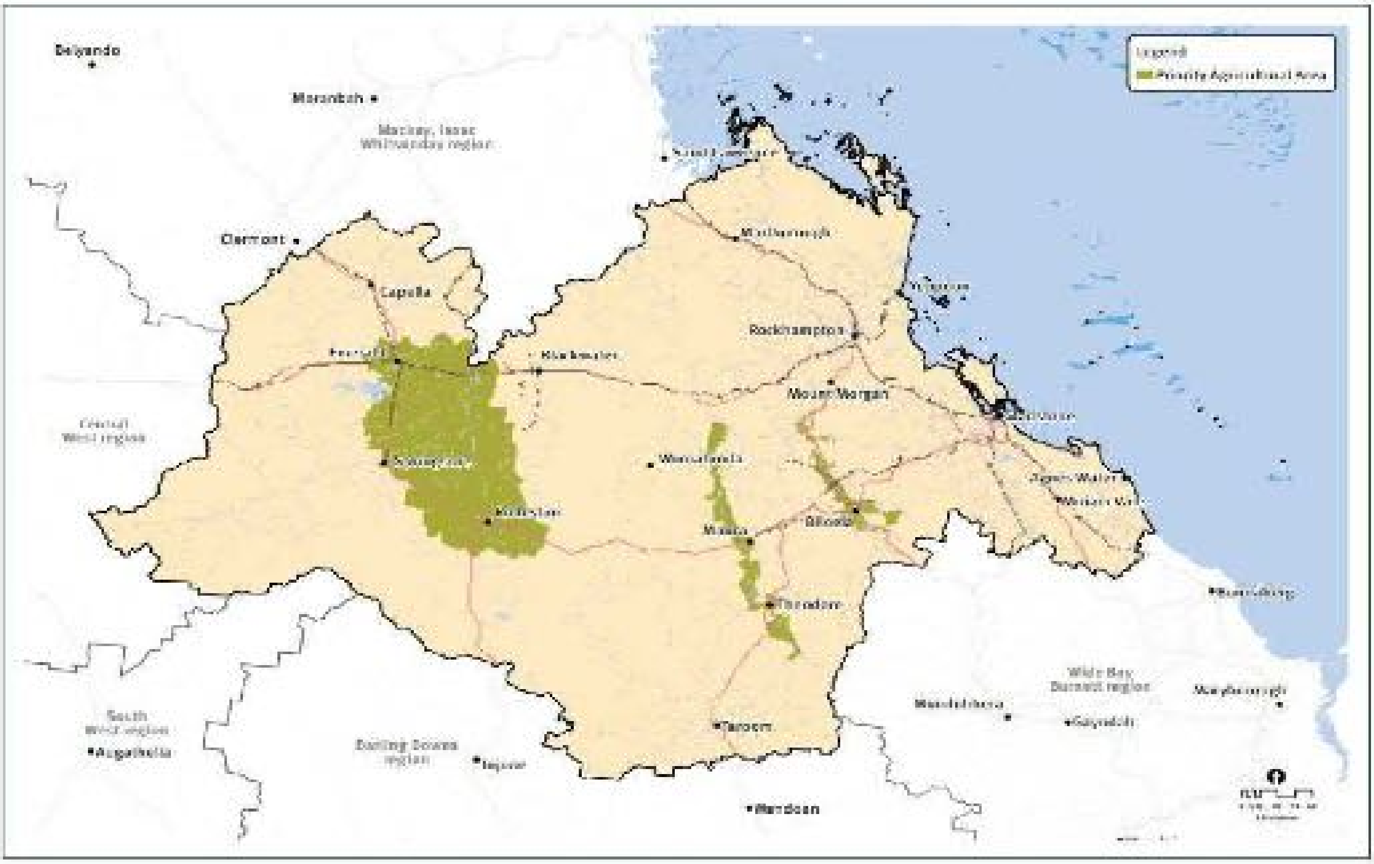

Figure 2.7: Priority Agricultural Areas within the Central Queensland Region (DSDMIP, 2013)

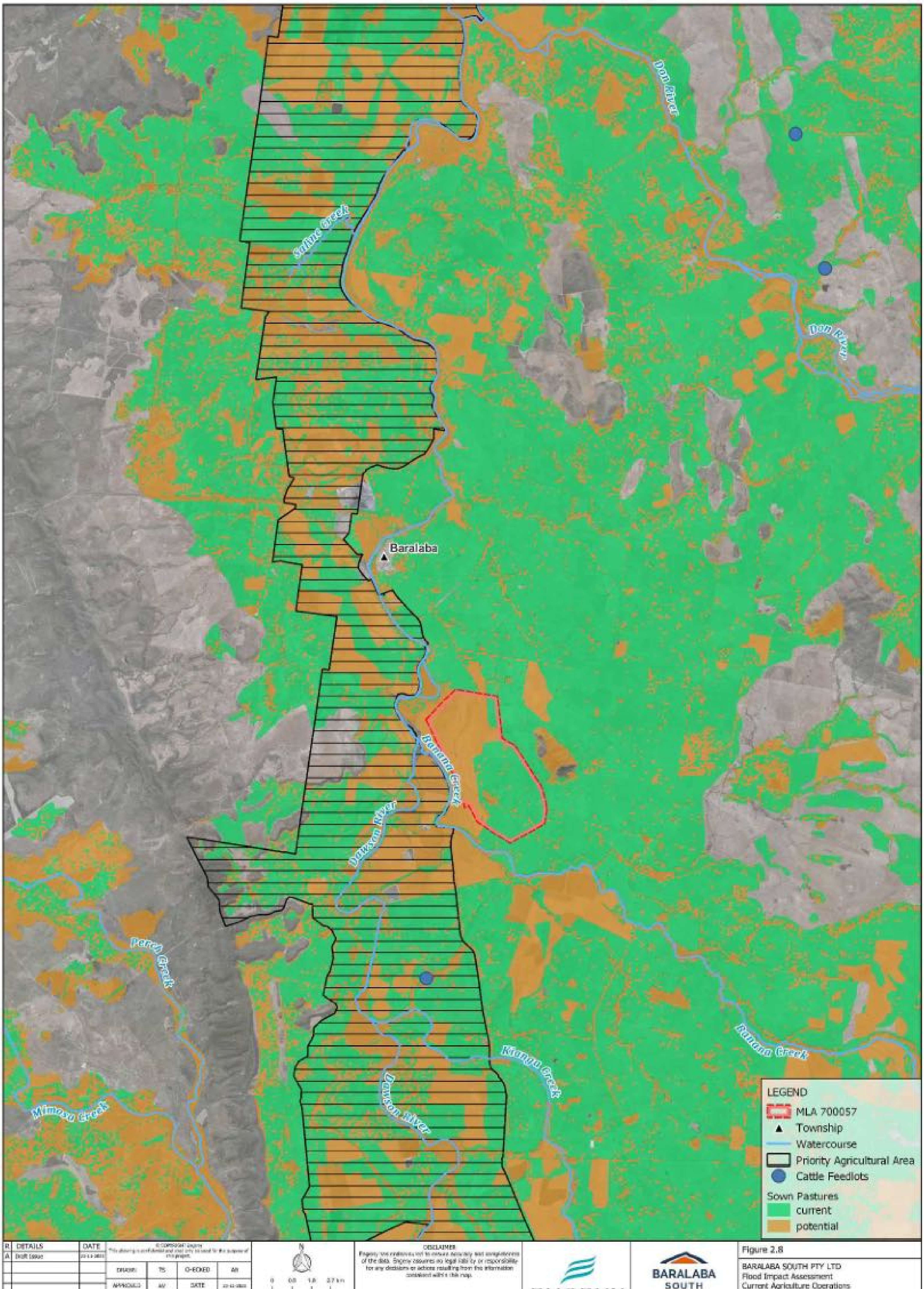

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Figure 2.8

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Flood Impact Assessment
Current Agriculture Operations

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2.6.2 Nearby Mines and Industry

The Fitzroy Basin encompasses one of the most active mining regions of Queensland. There are a number of mines both north and south of the Project as well as within neighbouring catchments. A summary of coal mines and other industry within 150 km of the Project is included in Table 2.1.

Baralaba North Mine is located approximately 11 km downstream of the Project on the Dawson River western floodplain. The Dawson Mine Complex is approximately 27 km upstream of the Project. also located west of the Dawson River,

TABLE 2.1: NEARBY MINES

Name	Proximity	Activity
Baralaba North Mine	11 km north	Active coal mining complex
Dawson Mine Complex	27 km south	Active coal mining complex
Callide Coal Mine	82 km east (Neighbouring Catchment)	Active coal mining complex
Mt Morgan Gold Mine	86 km northeast (Neighbouring Catchment)	Inactive gold mine

2.6.3 Nearby Infrastructure, Towns and Dwellings

Infrastructure and towns near the Project are shown in Figure 2.9. Key public infrastructure near the Project assessed for flooding impacts includes:

- Baralaba Township – 8 km north (downstream) of the Project on the eastern bank of the Dawson River.
- Neville Hewitt Weir – 9 km north (downstream) of the Project on the Dawson River.
- Baralaba Woorabinda Road Bridge – 9 km north (downstream) of the Project spanning across the Dawson River Channel.
- Moura Baralaba Road Bridge – 3 km upstream of the Project spanning across the Banana Creek Channel.
- Moura Baralaba Road – Follows parallel to the Dawson River on the eastern floodplain downstream of the Project. The development of the mine will require the relocation of an approximate 4.5 km section of the existing Moura Baralaba Road from within to outside the MLA area.
- Alberta Road – Follows parallel to the Dawson River on the western floodplain.
- Baralaba Woorabinda Road – Crosses the Dawson River western floodplain 9 km downstream of the Project.

The dwellings near the Project area (located within or proximal to the flood model boundary) are also shown on Figure 2.9.

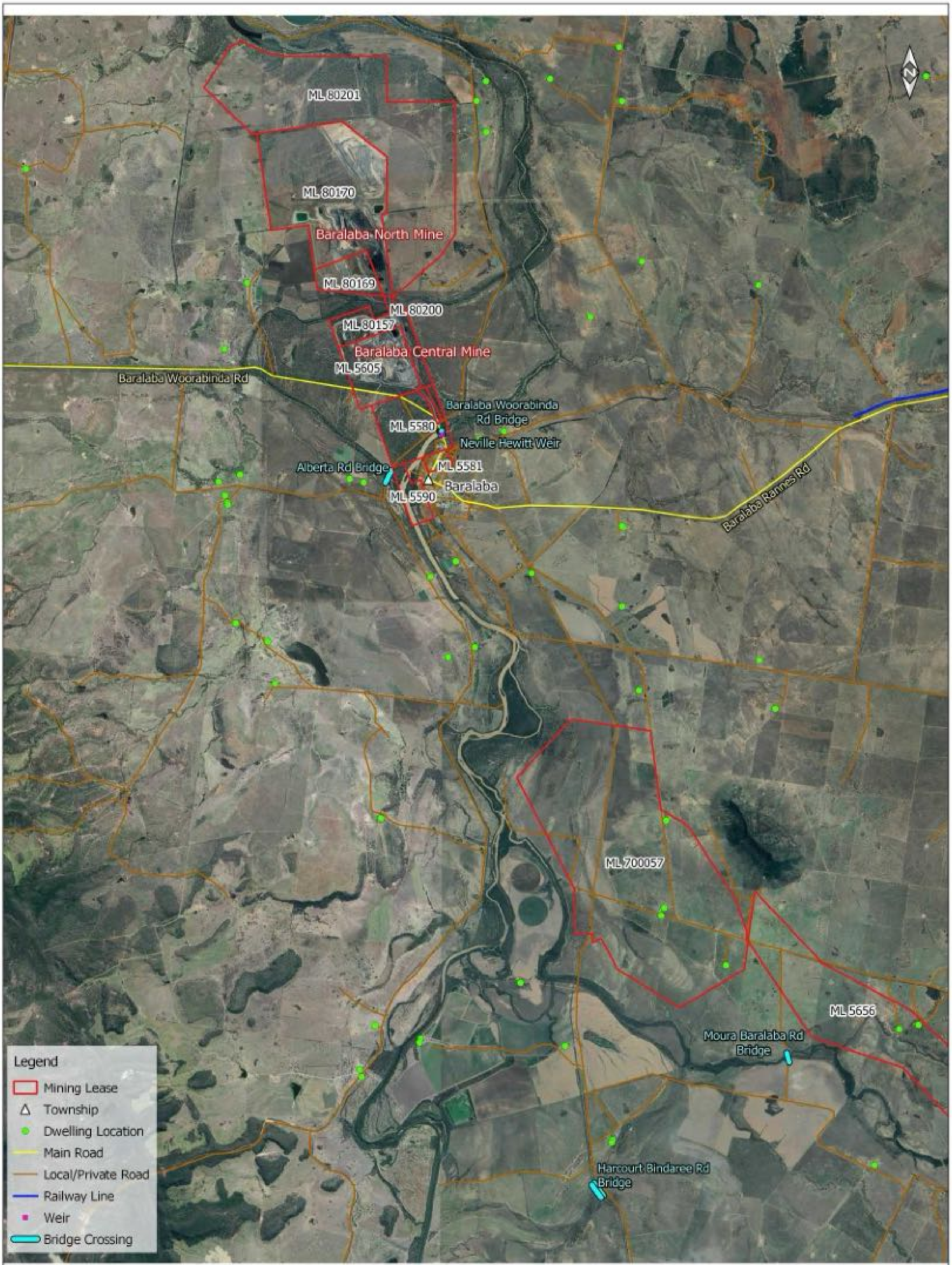

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Figure 2.9

BARALABA SOUTH PTY LTD
Nearby Infrastructure and Roads

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3. REGIONAL HYDROLOGIC ASSESSMENT

3.1 Overview

A hydrology model of the Dawson River and Banana Creek catchments to assess flood hydrology at the Project location was developed using the Unified River Basin Simulator (URBS). The URBS model was used to produce flow hydrographs for design events ranging from the 20% Annual Exceedance Probability (AEP) flood event up to the Probable Maximum Flood (PMF).

The URBS model was calibrated to historic flood events including the following: November 2021, January 2013, December 2010, March 1997, May 1983, and February 1978 (in order of most recent).

The calibrated model was used to assess design storm events and the design event peak flow rates were validated to at-site Flood Frequency Analysis (FFA) using available historic stream gauging records to confirm suitability for assessing design flood events in the hydraulic model.

3.2 URBS Model Development

3.2.1 Overview

An URBS hydrologic model of the Dawson River and Banana Creek catchments was developed and calibrated to six (6) recent large flood events. The calibrated model was then used to assess design event hydrology with the modelled peak flows validated to Flood Frequency Analysis (FFA) of streamflow gauging data and the Regional Flood Frequency Estimation (RFFE) technique.

The following section details the development of the URBS model.

3.2.2 Sub-Catchments and Channel Reaches

The URBS model structure and physical catchment parameters was generated using the CatchmentSIM software. The software was used to simulate a watershed across a 25 m cell size Digital Elevation Model (DEM) of the Dawson River catchment and determine the flow area accumulation for each grid cell. Sub-catchment outlet locations were then manually defined within the total catchment to produce a suitable level of delineation to the various points of interest in the catchment. The software was then used to derive the sub-catchment area delineation for the defined outlets and produce the nodal link arrangement for the hydrology model. The sub-catchment and channel parameters were then calculated from the defined topography data.

The Dawson River CatchmentSIM model was subdivided into 244 sub-catchments (total catchment area 40,800 km^2) as follows:

- 114 sub-catchments representing the Upper Dawson River to the headwaters of the Nathan Gorge (23,660 km^2).
- 62 sub-catchments representing the Mimosa Creek catchment to the confluence with the Dawson River (8,820 km^2).
- 19 sub-catchments representing Banana Creek to the confluence with the Dawson River (1,170 km^2).
- 44 sub-catchments representing the Lower Dawson River to the Beckers stream gauging station downstream of the Baralaba township (11,350 km^2).
- 5 sub-catchments representing the area downstream of the Beckers gauging station within the hydraulic model extent (300 km^2).

The sub-catchments were defined in the URBS model based on catchment area and catchment slope (CS). Channel reaches were represented in the model using channel length (L) and slope (Sc). The sub-catchment layout for the Dawson River URBS model is shown in Figure 3.1.

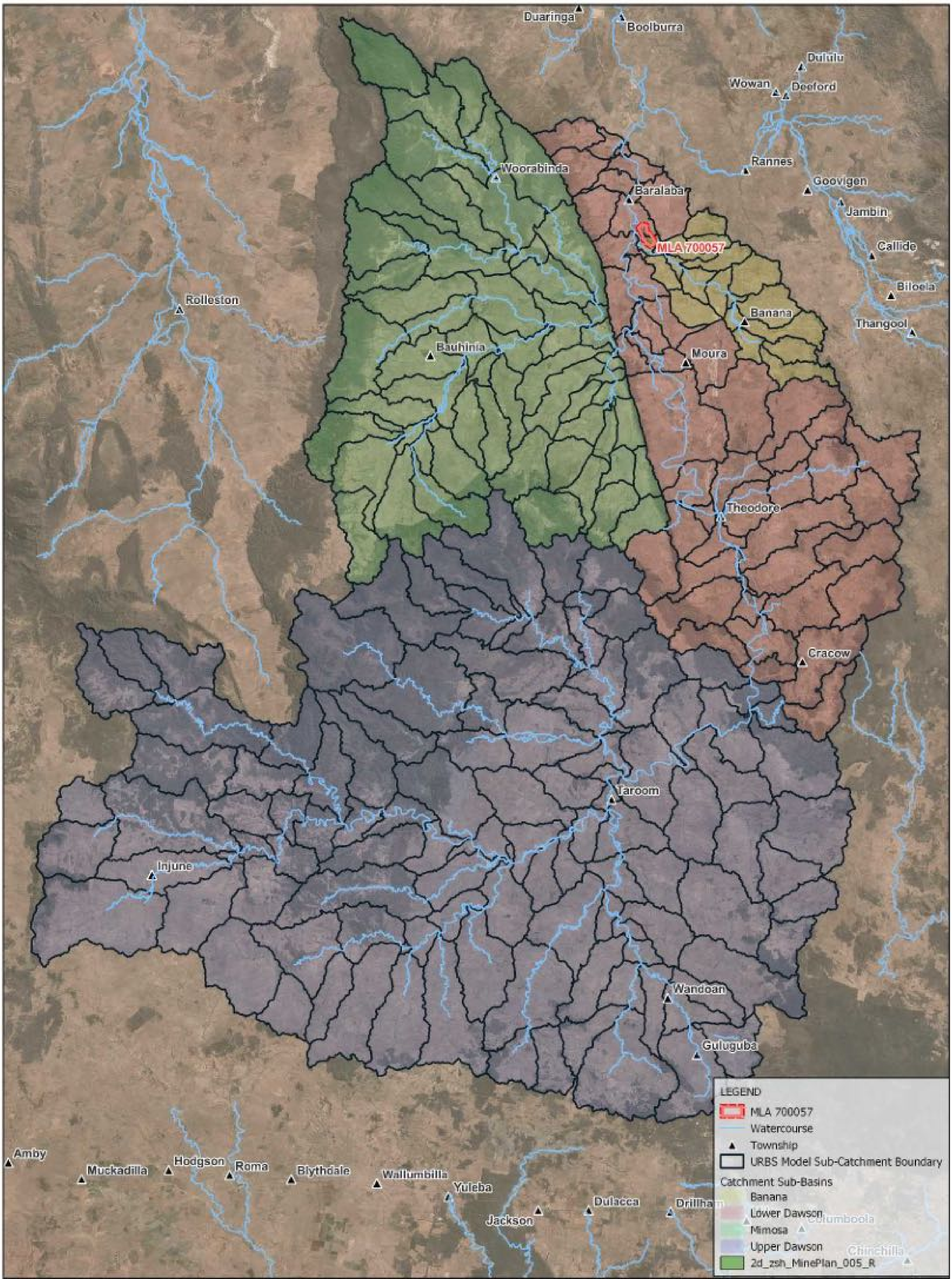

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Figure 3.1

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Flood Impact Assessment
URBS Sub-Catchment Layout

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3.3 URBS Model Calibration

3.3.1 Overview

The URBS model was calibrated against historical rainfall and stream flow gauging data within the Dawson River catchment. Six flood events were selected for the URBS model calibration. The calibration process involved the selection of channel, catchment, and non-linearity routing parameters (α, β and m) and rainfall loss parameters (initial and continuing rainfall losses) to achieve a reasonable comparison between modelled and recorded flow hydrographs at stream gauging stations located in the Dawson River catchment.

3.3.2 Calibration Events

Recorded data from the streamflow gauges in the Dawson River catchment was reviewed to inform the selection of historical flood events for the model calibration. Historical events were selected based on magnitude of the flood and the available rainfall data during the event to inform the model calibration. The following historical flood events were selected for the URBS model calibration for the Dawson River catchment:

- February 1978 event.
- May 1983 event.
- March 1997 event.
- December 2010 event.
- January 2013 event.
- November 2021 event.

3.3.3 Historical Rainfall Data

Data from pluviographic and daily rainfall stations in the vicinity of the Dawson Basin catchment which were operational during the calibration flood events have been sourced from the Bureau of Meteorology (BoM) and DRDMW. The recoded rainfall depth from the daily and pluviographic stations was used to determine the rainfall depth for each sub catchment during each calibration event. The pluviographic rainfall station data was then used to determine hourly rainfall temporal patterns for the event and applied to the nearest sub-catchment based on proximity of the sub-catchment centroid to the gauge location. The rainfall station locations and the time distribution of the rainfall recorded at the available pluviographic stations used for each calibration event are shown in Figure 3.2 to Figure 3.15.

Rainfall data for the calibration events was processed for the individual subcatchments using the URBS rainfall analysis utilities as follows:

- The rainfall depth assigned to each sub-catchment was calculated using the ‘subrain’ utility within the URBS software package. The ‘subrain’ utility calculates an inverse distance weighted average rainfall based on the closest four (4) rainfall stations.
- The temporal pattern of rainfall was determined for each sub-catchment by assigning the temporal pattern from the nearest pluviometer station (distance from pluviometer station to sub-catchment centroid). The assignment of temporal pattern was also undertaken using the ‘subrain’ utility.

The total rainfall distributions for the calibration events are shown in Figure 3.2 to Figure 3.15 as well as the total rainfall depth recorded by each station.

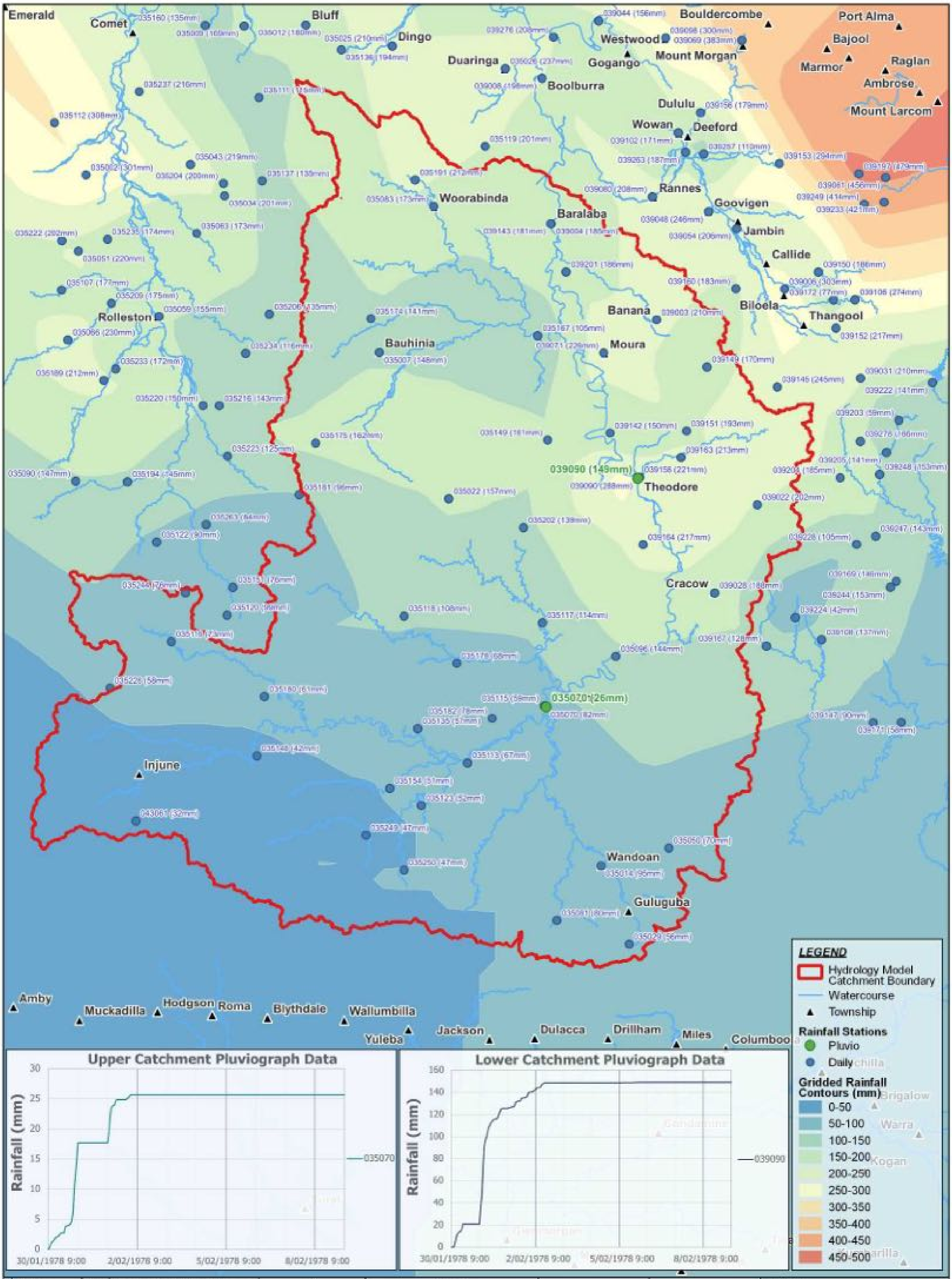

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Figure 3.2

Baralaba South Pty Ltd
Flooding Impact Assessment
Recorded Rainfall Data - February 1978

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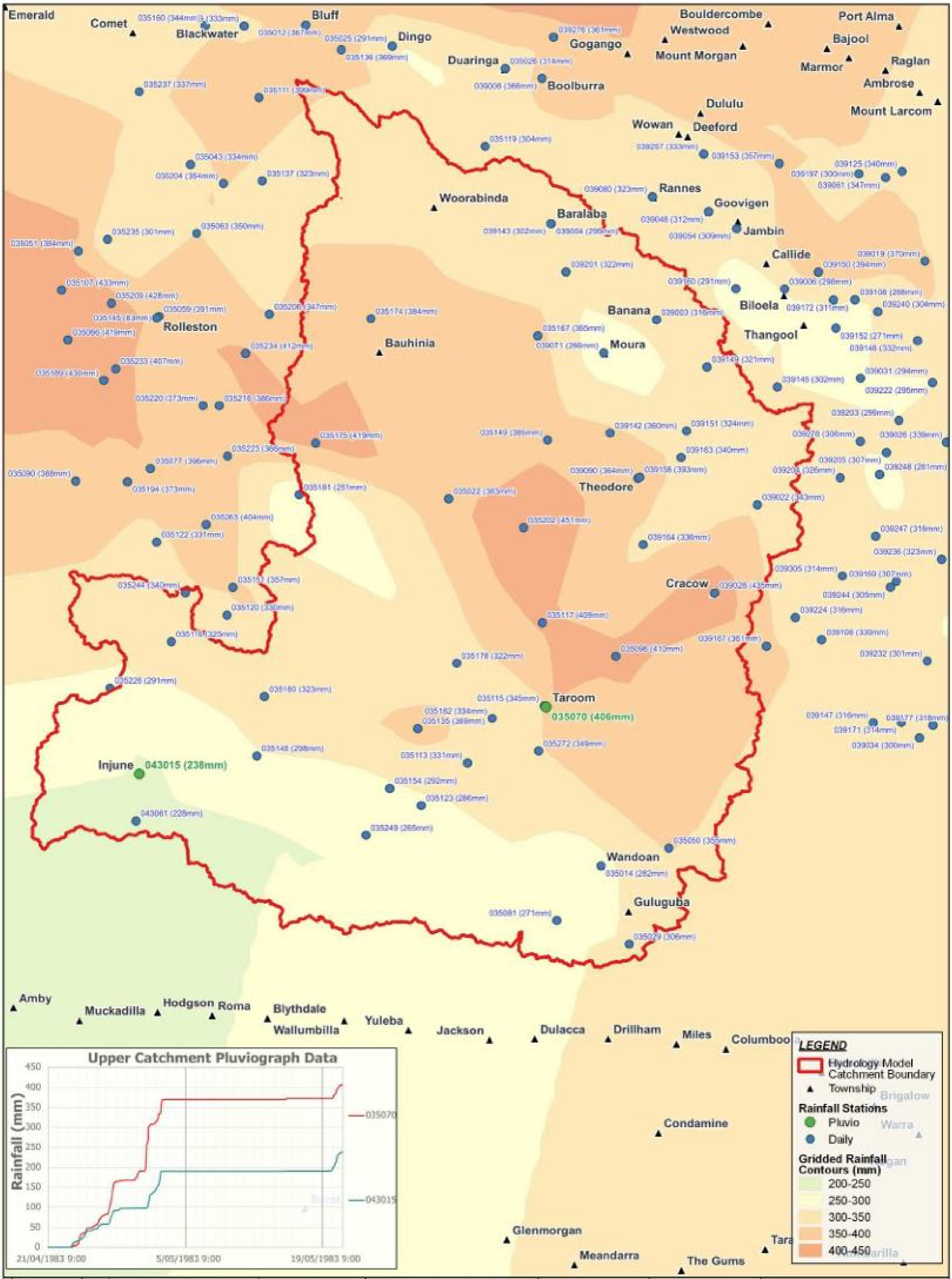

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Figure 3.3

Baralaba South Pty Ltd
Flooding Impact Assessment
Recorded Rainfall Data - May 1983

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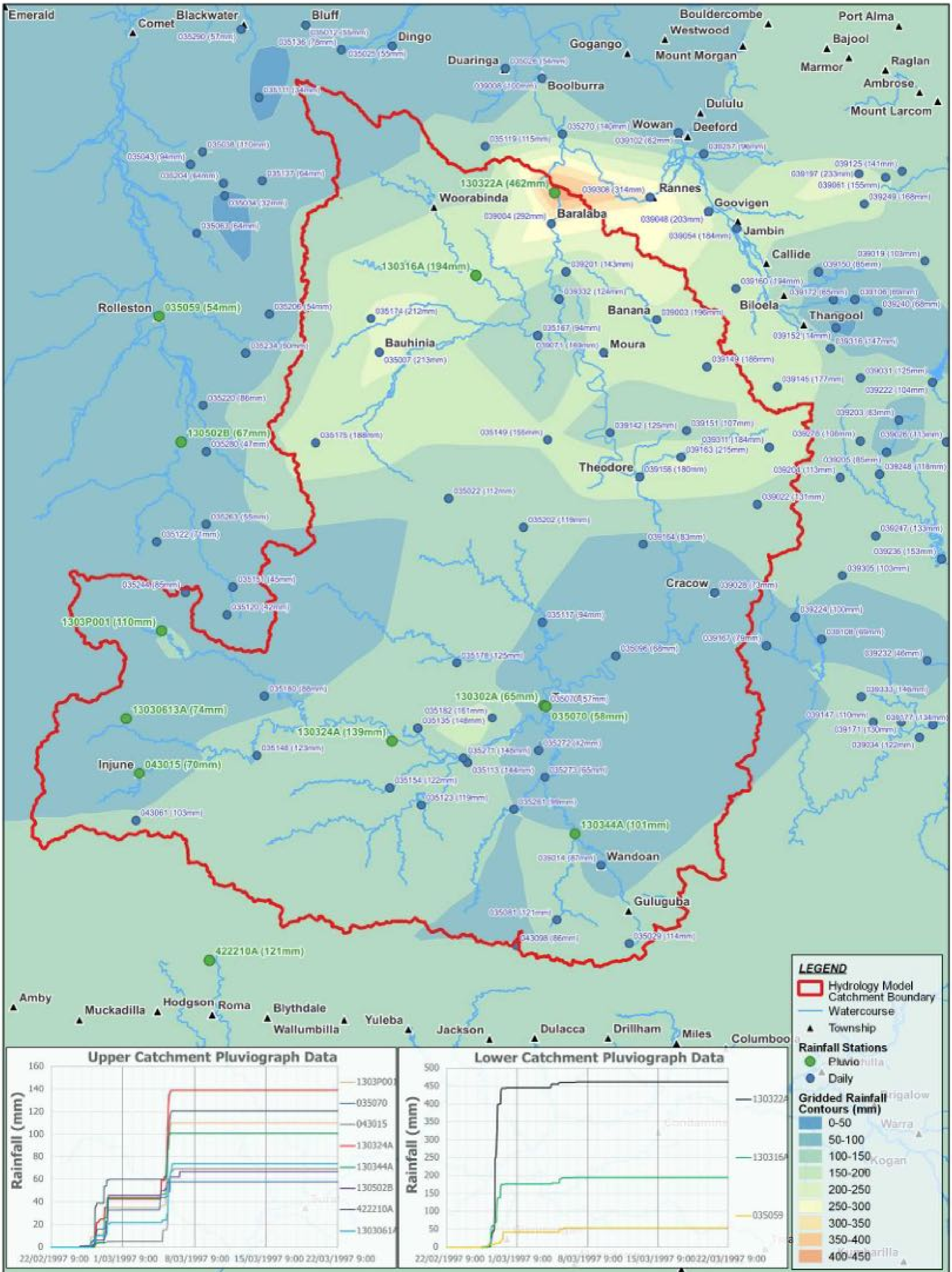

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Figure 3.4

Baralaba South Pty Ltd
Flooding Impact Assessment
Recorded Rainfall Data - March 1997

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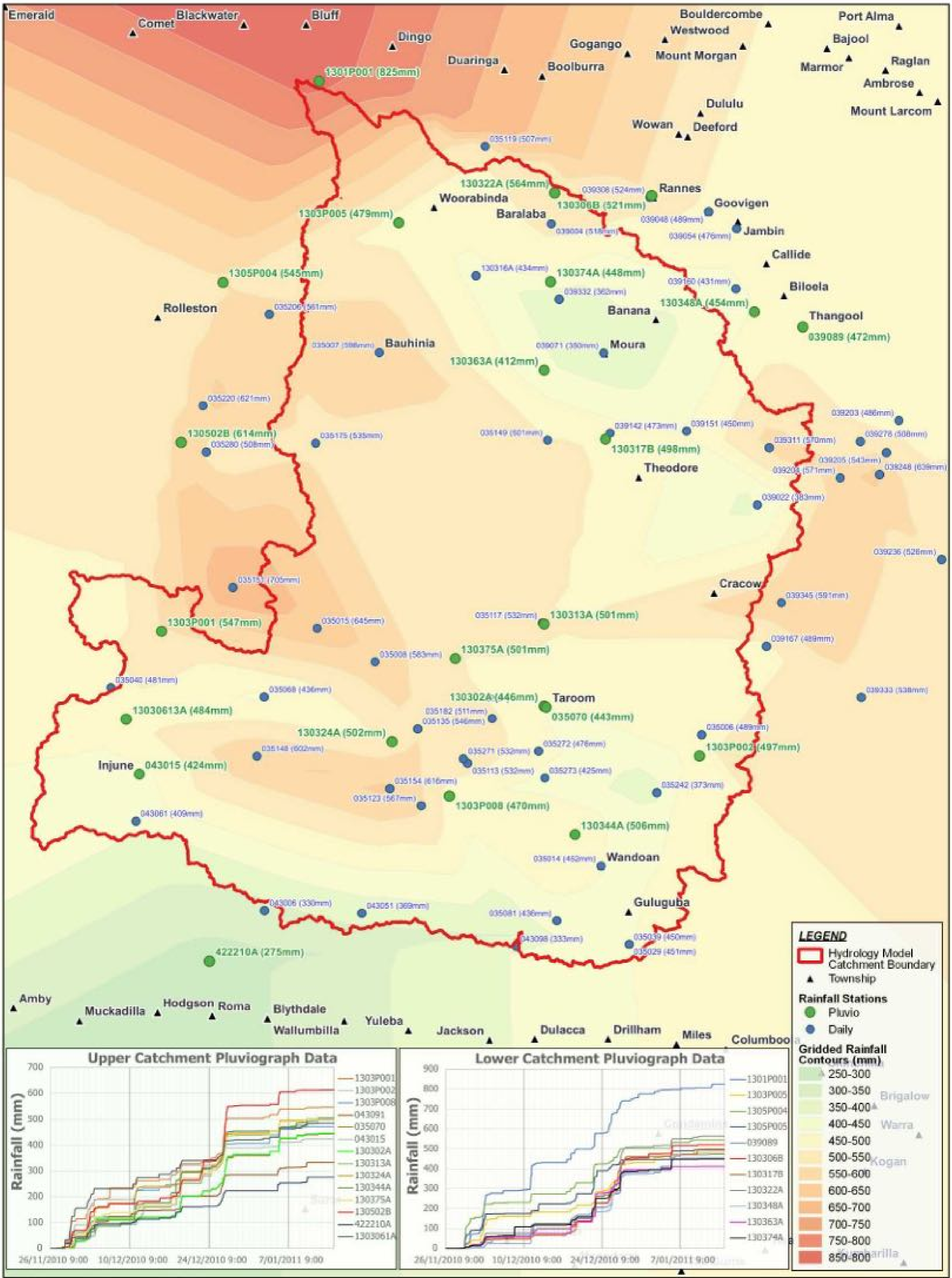

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Figure 3.5

Baralaba South Pty Ltd
Flooding Impact Assessment
Recorded Rainfall Data – December 2010

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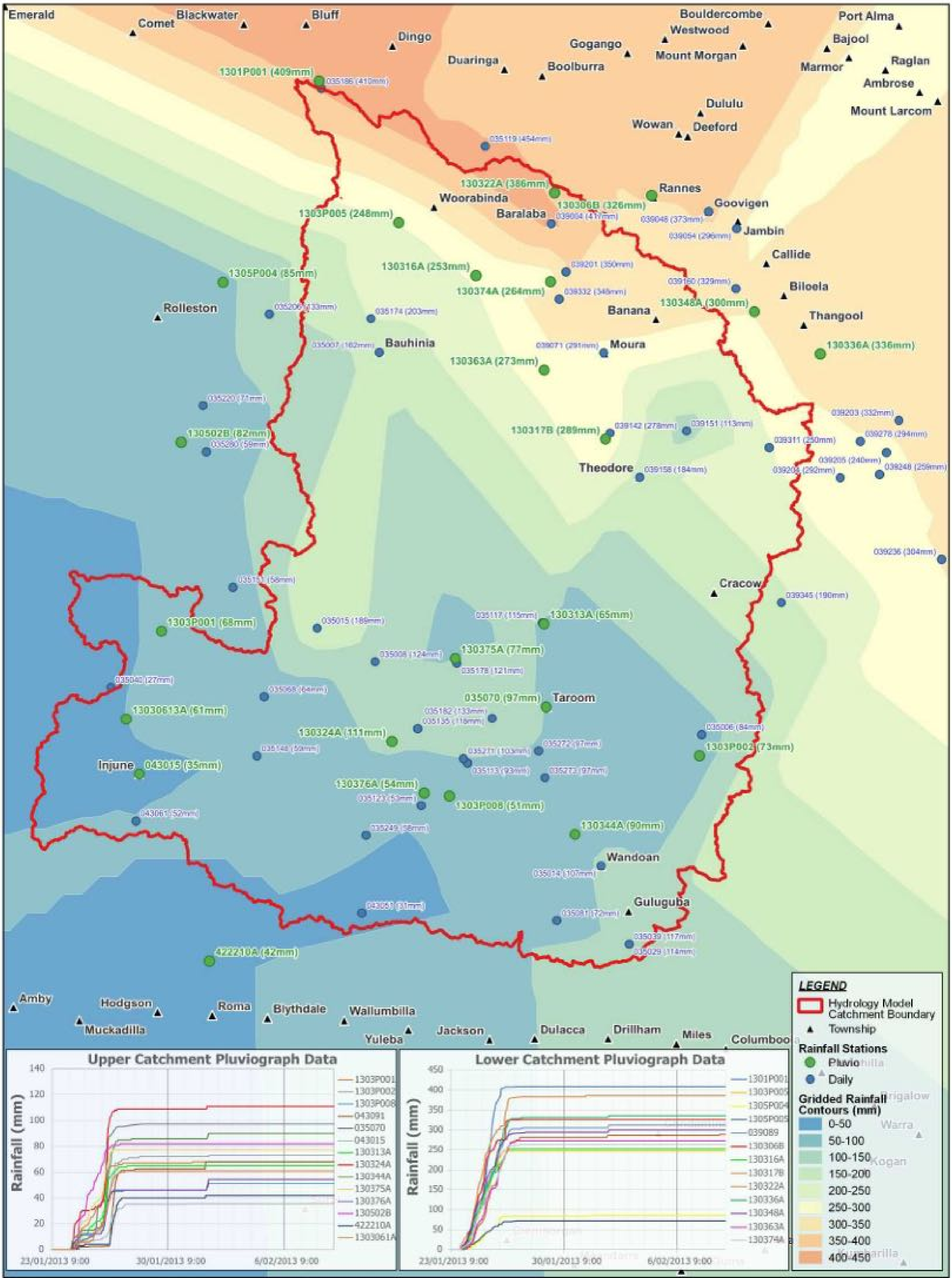

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Figure 3.6

Baralaba South Pty Ltd
Flooding Impact Assessment
Recorded Rainfall Data – January 2013

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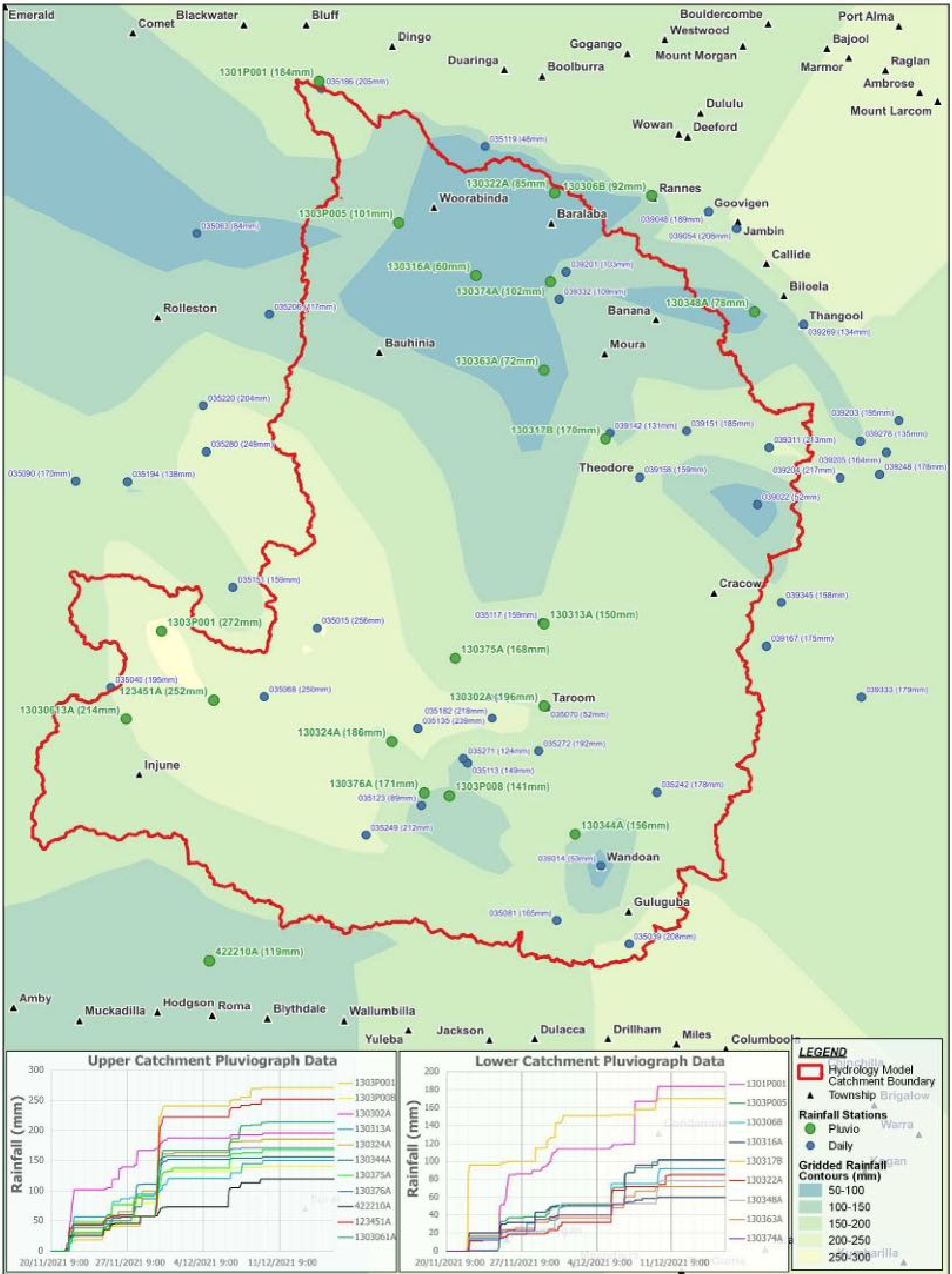

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Figure 3.7

Baralaba South Pty Ltd
Flooding Impact Assessment
Recorded Rainfall Data – November 2021

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3.3.4 Streamflow Gauging Data

Streamflow gauging stations within the Dawson River catchment used in the calibration process are summarised in Table 3.1. Locations of streamflow gauging stations are shown in Figure 3.8.

Based on review of the available gauging data and station information the following observations are made:

- The Beckers gauging station (130322A) gauges a Dawson River catchment of 40,500 km^2, which is similar to the Dawson River catchment to the Project location (40,200 km^2). The gauge is located in a relatively confined river channel section with no high flows by-passing the gauge location.
- In larger flood events, multiple Dawson River flow paths bypass the Bindaree gauging station (130347A) location. The surveyed section used to develop the DRDMW rating curve for the Bindaree station does not capture the extent of break-out flow across the Dawson River floodplain and therefore the rating curve is not expected to be accurate for flows above 2,000 m^3/s and shown by the recoded peak flow during the December 2010 event compared to the Beckers(130322A) and Woodleigh (130317B) streamflow gauging stations. As such, the Bindaree station was not used to inform the peak flow calibration during the 2010 event.
- The Woodleigh stream gauging station (130317B) gauges a Dawson River catchment area of 28,500 km2, which is approximately two-thirds of the catchment area to the Project site. The Woodleigh station has been used as a key gauge in the hydrologic calibration process as an indicator of peak flow and timing upstream of the Site and the Mimosa Creek confluence with the Dawson Rive. Additionally, site Flood Frequency Analysis (FFA) at the Woodleigh gauging station has been used for design hydrology validation.
- The Taroom stream gauging (130302A) has been used primarily to check variable flood peak timing in the upper Dawson catchment for the calibration events. The DRDMW rating curve for this gauge is not considered to be reliable for very high flows. The estimated discharge for the December 2010 flood event is approximately 10% greater than that for the Beckers gauging station (130322A) while having a 60% smaller contributing catchment area.
- The Mimosa Creek at Redcliffe (130316A) and Roundstone Creek at Roundstone Creek Highway stream gauging stations have been used to understand flood peak timings within the Mimosa Creek catchment. The sites rating curve accuracy is uncertain due to having a maximum manual gauged flow much lower than the maximum recorded flow.

Table 3.1: Flow Gauging Stations Adopted for Hydrology Model Calibration

Station ID	Station Name	Catchment Area (km²)	Control Type	Record Length (years)	Record Period	Max Manual Gauged Flow (m³/s)	Max Recorded Flow (m³/s)
130342A	Hutton Creek at Fairview	2,871	Gravel	51	Dec 1972 - Sep 1988	0.2	528 (May 1983)
130324A	Dawson River at Utopia Downs	6,039	Sand	57	Jun 1966 - Open	394	1,468 (Dec 2010)
130376A	Eurombah Creek at Brookfield	2,524	Sandstone blocks and gravel	12	Nov 2011 - Open	5	306 (Feb 2012)
130344A	Juandah Creek at Windamere	1,678	Sand	49	Jun 1974 - Open	124	1,057 (Dec 2010)
130302A	Dawson River at Taroom	15,846	Control weir	113	Jan 1911 - Open	1,109	5,859 (Dec 2010)
130313A	Palm Tree Creek at La Palma	2,660	Sand	67	Dec 1956 - Open	32	250 (Dec 2010)
130325A	Palm Tree Creek at Bloomfield	3,133	Blacksoil clay	57	Jun 1966 - Sep 1988	31	503 (May 1983)
130341A	Robinson Creek at Glenleigh	1,056	Sand	51	Dec 1972 - Dec 1992	7	866 (May 1983)
130375A	Robinson Creek at Broadmere	1,597	Sand silt	17	Apr 2006 - Open	4	1,073 (Dec 2010)
130303B	Dawson River at Glebe Recorder	21,938	Control weir	67	Oct 1956 - Jul 1984	154	2,500 (May 1983)
130338A	Dawson River at Glebe Weir Headwater	23,067	Control weir	19	Jan 1983 - Jul 2002	1,160	2,090 (May 1983)
130320A	Dawson River at Nathan Gorge	23,308	Sand and gravel	69	Oct 1954 - Sep 1986	4,289	4,278 (Feb 1956)
130354A	Dawson River at Gyranda Weir Headwater	24,618	Control weir	36	Jun 1987 - Jul 2002	358	1,185 (Jan 1996)
130318A	Castle Creek at Old Walloon	683	Sand	67	Apr 1957 - Jun 1984	206	561 (Mar 1959)
130305A	Dawson River at Theodore	27,331	Control weir	100	Feb 1924 - Jul 2002	1,980	4,247 (Feb 1956)

Station ID	Station Name	Catchment Area (km²)	Control Type	Record Length (years)	Record Period	Max Manual Gauged Flow (m³/s)	Max Recorded Flow (m³/s)	
130317A/B	Dawson River at Woodleigh	28,503	Gravel crossing	67	Feb 1957 - Open	1,763	3750	(Jan 2011)
130339A	Conciliation Creek at Barranga	407	Sand and rock	51	Dec 1972 - Sep 1988	12	223	(Dec 1975)
130316A	Mimosa Creek at Redcliffe	2,473	Sand	67	Jan 1957 - Open	55	1,037	(Dec 2010)
130363A/**B**	Roundstone Creek at Dawson Highway	999	Bedrock and gravel	24	Jun 1999 - Open	116	1,271	(Dec 2010)
130374A	Dawson River at Bindaree	38,694	Sand	18	Apr 2005 - Open	1,767	3,762	(Dec 2010)
130322A	Dawson River at Beckers	40,500	Gravel	59	Jun 1964 - Open	1,842	5,073	(Dec 2010)

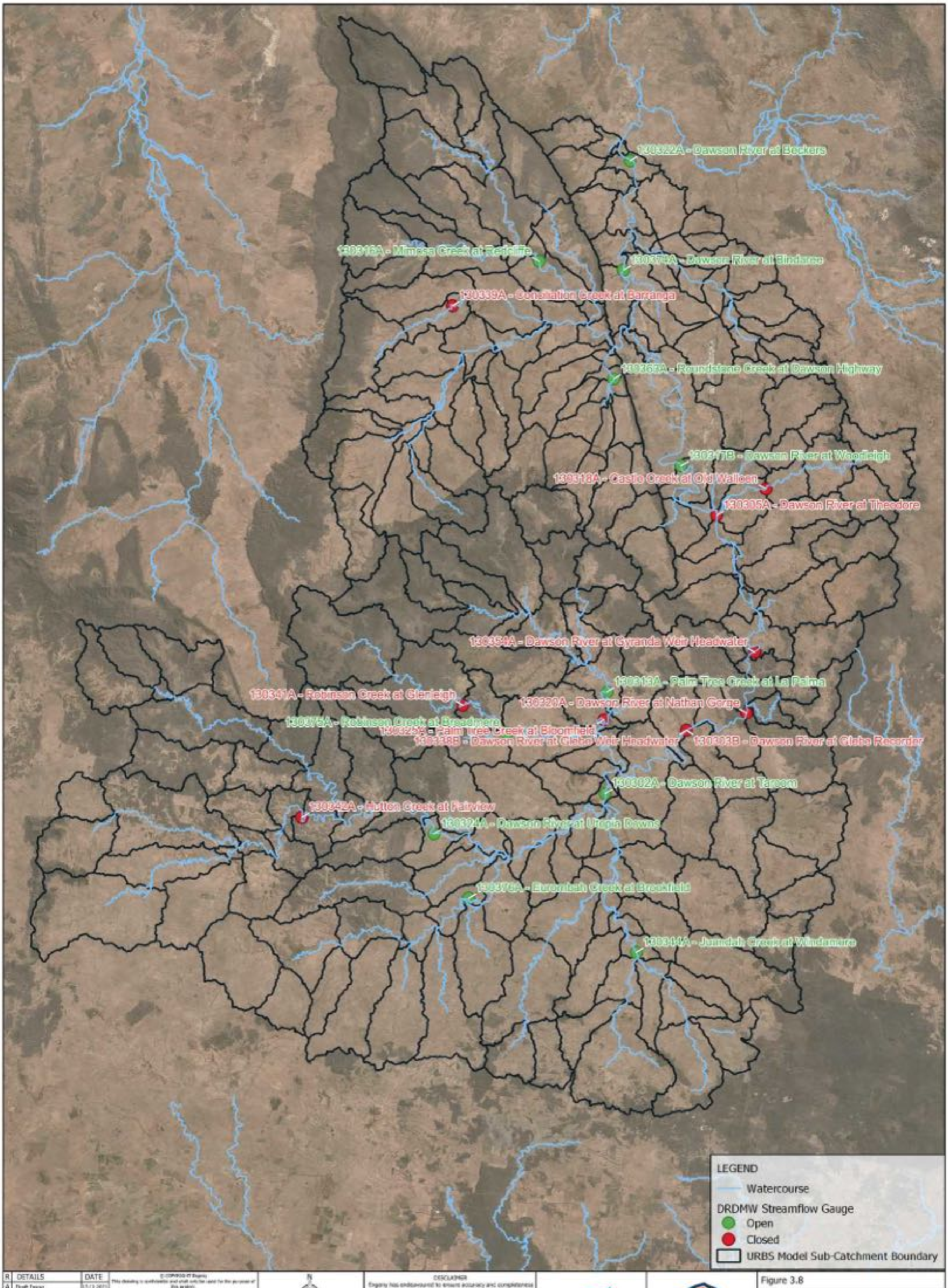

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Figure 3.8

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Flood Impact Assessment
Streamflow Gauging Station Locations

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3.3.4.1 Beckers Gauging Station Rating Curve Review

The Beckers gauging station (130322A) is close to the Project and is the key gauging station in the calibration process for flood flows in the Dawson River. The gauging station is located in a confined channel section formed by the natural topography with no breakout flow paths around the gauging station. This allows for reliable measurement of large flood flows however is still dependant on the accuracy of the rating curve used to convert gauged water levels to flow rate.

Rating curves are developed by DRDMW for the gauging stations by fitting an open channel hydraulic calculation relationship for the gauged cross section to manual flow gauging during flow events. The hydraulic calculation is then typically extrapolated to higher water levels to allow measurement of flow above the maximum manual gauged water level and flow. Rating curve accuracy is typically dependent on the maximum gauged flow used for fitting the hydraulic calculation, the surveyed channel cross section and the flood flow behaviour at the gauging station location being suitable for extrapolation.

The gauging data shows four (4) historic flood events have exceeded the highest manual gauged flow rate (1,842 m^3/s) at the Beckers site. Communication with the DRDMW (previously DNRME) (P.Voltz 2019, pers. comm. 25th January 2019) indicated that the current rating curve at the Beckers gauging site may under-predict peak flows for the December 2010 flood event due to the surveyed cross section at this site not extending across the full floodplain width. As such, a rating curve calibration and extrapolation exercise was undertaken to confirm flow rates above the maximum manual gauged level to support the model calibration and flood frequency analysis at the Beckers gauging site (130322A).

The calibration and extrapolation of a rating curve to match the DRDMW rating curve was undertaken through simulation of a linearly increasing hydrograph through the TUFLOW hydraulic model documented in Section 4. Flows and corresponding water surface levels were extracted at the gauge location and compared to manual flow gauging's and the DRDMW rating curve. The hydraulic model parameters were refined (roughness coefficients) to improve the comparison and fit to the range of manual gauging's. Once a suitable fit was achieved the model was used to extrapolate the rating curve to the peak water level recorded during the December 2010 event.

Results of the rating curve investigation are presented in Figure 3.9. This shows the model produces a good correlation against the range of manual gauging's however appears to slightly overestimate low flows. The modelled rating curve intersects the DRDMW rating curve at 1,500 m^3/s and 4,200 m^3/s, with the modelled results showing high water levels for flows between 1,500m^3/s and 4,200m^3/s and then lower water levels for flow rates >4,200 m^3/s. Based on this review, the Beckers streamflow gauging station rating curve was modified for the hydrology model calibration as follows:

- DRDMW rating curve adopted for flows below 1,500 m^3/s.
- Modelled rating curve from the TUFLOW model adopted for flows greater than 1,500 m^3/s.

The revised Beckers gauging station rating curve was used to adjust historical flow estimates based on recorded water levels for the full period of record. Table 3.2 summarises the revised peak flow estimates for the calibration events.

A similar revision of the Beckers streamflow rating curve for the December 2010 event has previously been completed for the 2014 Dawson River flood hydrology study undertaken by Water Solutions (Water Solutions, 2014) as part of the Baralaba North Continued Operations Project (BNCOP) EIS. Water Solutions determined a peak flow estimate for the December 2010 event of 6,100 m^3/s which is only slightly lower than the estimate determined from this study (Water Solutions, 2014).

TABLE 3.2: REVISED CALIBRATION EVENT PEAK FLOW RATES

Event	DRDMW Rating (m^3/s)	Engeny Adopted Rating (m^3/s)
February 1978	1,891	1,843
May 1983	3,127	2,750
March 1997	2,167	2,035
December 2010	5,000	6,060

Event	DRDMW Rating (m³/s)	Engeny Adopted Rating (m³/s)
January 2013	2,300	2,010
November 2021	1,030	1,030

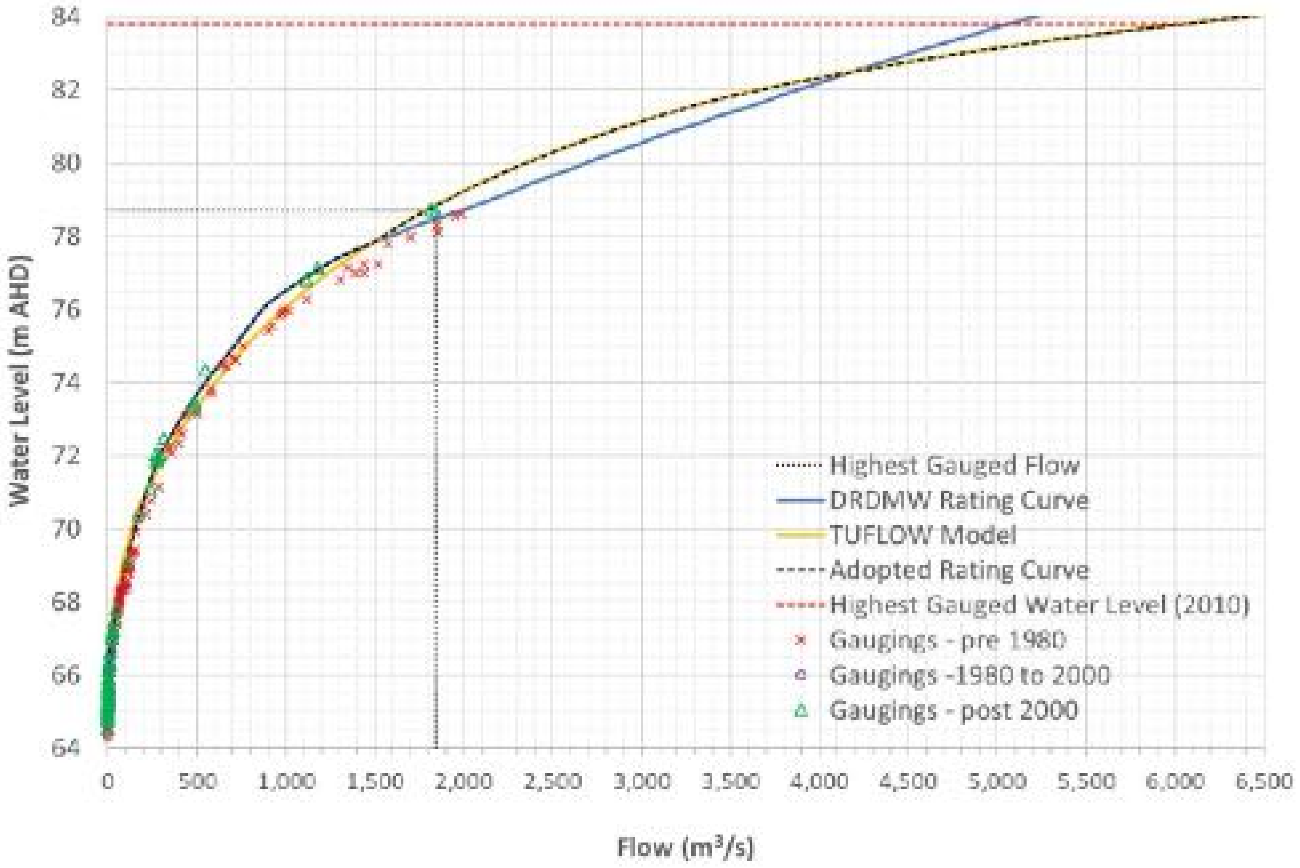


Figure 3.9: Adopted Rating Data for Beckers Gauging Station

3.3.5 Calibration Event Simulation

The URBS model was calibrated by varying model parameters to achieve the best possible comparison between modelled and recorded flood hydrographs at the stream gauging stations listed in Table 3.1. The calibration process involved achieving the best fit possible at the Beckers (130322a) gauging station while maintaining a reasonable fit at the various upstream gauges to ensure the spatial accuracy of the model calibration.

The following URBS model parameters were varied for the calibration:

- Channel routing parameter, α – Defines channelised flow storage attenuation and travel time.
- Catchment routing parameter, β – Defines individual sub-catchment rainfall runoff response and lag.
- Catchment non-linearity parameter, m – Defines the linearity of routing calculations between low and high flows.
- Initial rainfall loss, IL – Initial rainfall loss during the simulation before rainfall excess can occur and contribute to runoff routing.
- Continuing rainfall loss, CL – A constant loss rate applied to rainfall after the initial loss has been exhausted.

The calibration process involved initially fitting the channel routing parameter and the non-linearity parameter to match recorded flood travel time and attenuation along the Dawson River for all events. Then the catchment routing parameter and rainfall losses were adjusted to fit catchment response and flood volume and timing. The calibration process also focused on deriving a single set of channel, catchment and non-linearity parameters that produced the best fit across all calibration events that could be adopted for the design hydrology simulations.

The model calibration simulation results are presented in Figure 3.10 to Figure 3.15 for each event. Comparison of recorded and modelled hydrographs for all available gauging stations during each calibration event is presented. The following sections discuss the model calibration results for each event.

3.3.5.1 November 2021 Event

The November 2021 flood event was a dominant Upper Dawson catchment flood with the peak flood wave travelling from Taroom to the Beckers gauging station over approximately 7 days. The November 2021 event was smallest calibration event with a peak flow of 1,030 m^3/s at the Beckers gauging station with an approximate annual exceedance probability (AEP) of 20%, based on Flood Frequency Analysis (FFA) at the Beckers Gauging Station (refer Section 3.5).

The recorded and modelled flood hydrographs are closely aligned for peak flow and timing at the Taroom, Woodleigh, Bindaree and Beckers gauging stations. This indicates the channel routing parameter (alpha) is suitable for replicating the Dawson River floodplain routing from the Upper Dawson to the Beckers gauging station.

Recorded peak flow in the smaller gauged creek systems was minor. The model calibration results show a similar magnitude of peak flow however poor accuracy in the hydrograph shape and timing. Achieving good match for minor event flood hydrographs requires accurate pluviograph data and catchment specific losses which was typically unavailable for these systems.

3.3.5.2 January 2013 Event

The January 2013 flood event was a dominant Lower Dawson catchment flood with significant rainfall over the Lower Dawson due to Cyclone Oswald. The flood event was produced by high intensity rainfall over 3 days with over 400 mm rainfall recorded by gauges near the Baralaba Township. Flooding in the Upper Dawson catchment was minor, with a recorded peak flow less than 250 m^3/s at Taroom. The recorded data shows a large increase in flow between the Woodleigh and Bindaree gauging stations, indicating the peak flood was primarily produced in the Mimosa Creek catchment. The January 2013 event recorded a peak flow of 2,068 m^3/s at the Beckers gauging station with an approximate flood event AEP of 10%, based on FFA (refer Section 3.5).

Modelled results for the January 2013 event show good alignment to recorded flood hydrograph shape, timing and peak flow at the Beckers, Bindaree and Mimosa Creek at Redcliffe gauging station. The model also reproduced the observed minor flooding conditions in the Upper Dawson catchment and a reasonable match to the recorded hydrograph at the Woodleigh gauging station.

Comparing the recorded flood hydrographs at the Beckers and Bindaree gauging stations show a considerable increase in flood volume during the hydrograph rising limb, with an approximate peak flow of 1600 m^3/s. This information indicates the increase in flood volume was a result of major flooding in Banana Creek and/or the local catchments near the Baralaba Township. The model was not able to reproduce the increase in flood volume at Beckers due to poor rainfall data availability for the Banana Creek catchment as more intense rainfall likely occurred.

The results show the model was able to accurately reproduce the Lower Dawson dominated flooding conditions during the January 2013 flood event and matched peak flow accurately at the Beckers gauging station.

3.3.5.3 December 2010 Event

The December 2010 event included large widespread flooding in the Dawson River catchment due to Cyclone Tasha and Monsoonal conditions producing sustained rainfall between the 26th of November 2010 to the 6th of January 2011 with a large rainfall burst during the 27th of December. The 2010 flood is the largest flood on record for all gauging stations in the Dawson River catchment operating during the event. The December 2010 event recorded a peak flow of 6,060 m^3/s at the Beckers (130322A) gauging station with an approximate flood event AEP of 1%, based on FFA (refer Section 3.5).

Peak flood flow and timing correlate very well between the URBS model results and recorded values at the Beckers (130322A) gauging station. The URBS model results show similar volume in the hydrograph to the gauged data for the full event. Modelled and recoded flood hydrographs match well for all Dawson River gauging stations besides Taroom (130302A) and Bindaree (130374A). The Taroom gauging station recorded a peak flow of approximately 6,000 m^3/s which is significantly higher than the peak flood Woodleigh and Utopia Downs indicating the rating curve for the Taroom gauging station is inaccurate for large flood events. The Bindaree gauge recorded a peak flow of

3700 m³/s which is much lower than the peak at Beckers. Flood flows greater than 2,000 m³/s begin to breakout of the Dawson River channel at the Bindaree gauging station location and result in the gauging station underestimating peak flow during large flood events.

The gauged sequence for the Woodleigh (130317B) gauging station shows two similar magnitude flood peaks for the December 2010 event, whereas the model does not replicate the first peak. This discrepancy is expected to be from localised intense rainfall downstream of the Nathan Gorge and upstream of Woodleigh (130317B) that was not captured within the rainfall gauging network.

The calibration results at the Redcliffe (130316A) and Roundstone Creek (130363A) gauging stations show reasonable alignment with peak flood timing, however there are differences in the predicted peak flows. The gauges also recorded a number of isolated peaks in flow which was not captured by the model. This discrepancy is expected to be due to poor pluviograph rainfall data coverage in the southern areas of the Mimosa Creek catchment.

3.3.5.4 March 1997 Flood Event

The March 1997 was a Lower Dawson catchment dominated flood event with peak flows increasing from 400 m³/s to 2,000 m³/s between the Woodleigh (130317B) and Beckers (130322A) gauging stations. All gauging stations upstream of the Woodleigh (130317B) station recorded minor flows indicating the flood was produced in the Mimosa Creek and Lower Dawson catchments. The peak recorded flow at the Beckers (130322A) gauging station was 2,000 m³/s, with an approximate flood event AEP of 10%, based on FFA (refer Section 3.5).

Both peak flood flows and timing are reproduced reasonably well at the Beckers (130322A) gauging station. The model also reproduces a similar peak flow during the first flood peak at the Woodleigh gauging station (130317B). Modelled and recorded hydrographs have varying degrees of correlation at the other upstream gauges which is due to small magnitude of flooding recorded by the other gauges and reduced pluviograph rainfall data coverage (compared to 2010 and later).

3.3.5.5 May 1983 Event

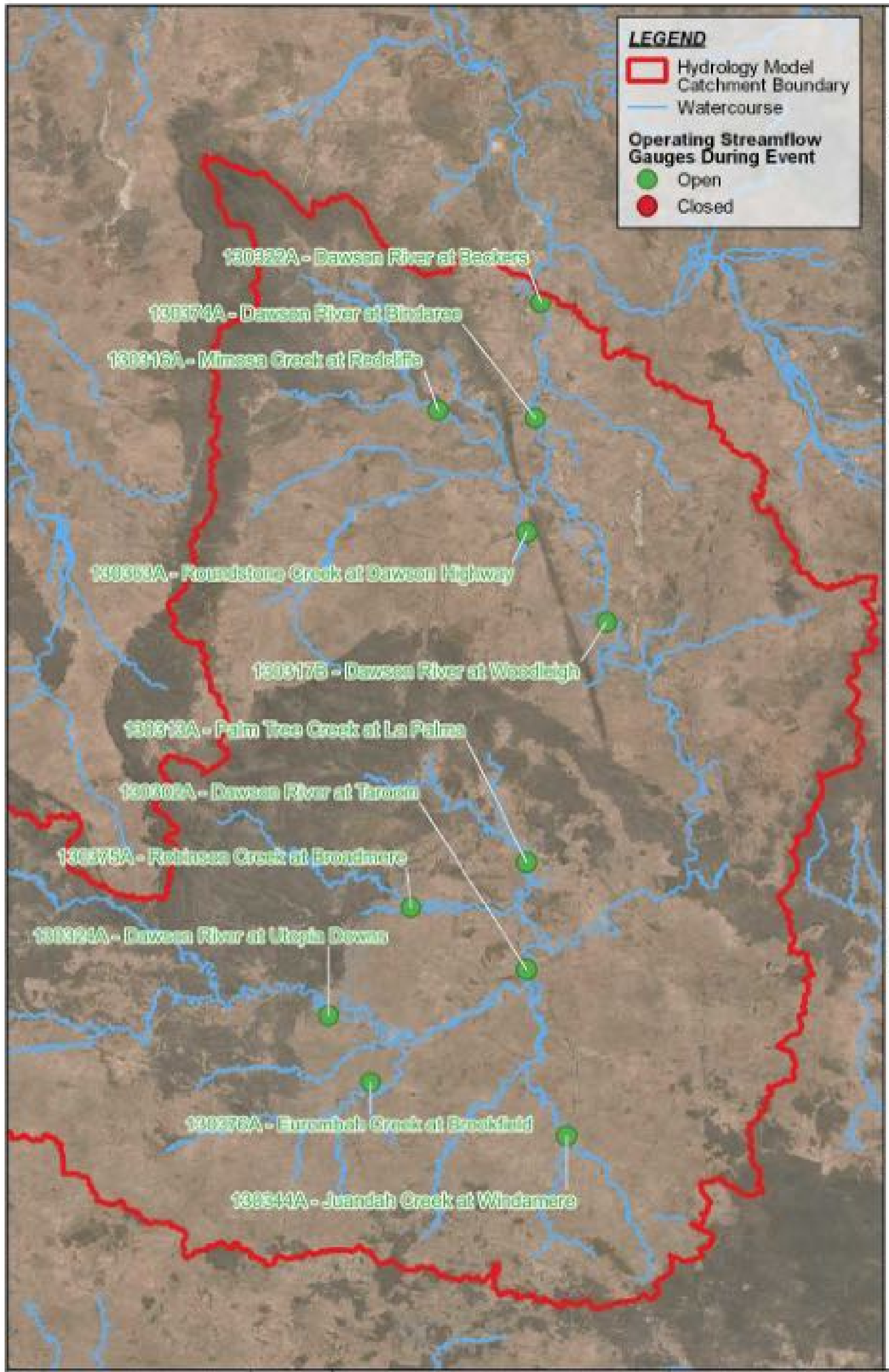
The May 1983 flood event included widespread flooding of the Dawson River Catchment. The Beckers (130322a) gauging station recorded data shows two flood peaks during the event with larger initial peak produced from rainfall over the Lower Dawson catchment and the second peak produced from rainfall in the Upper Dawson catchment. Rainfall distribution during the event shows higher rainfall in the Upper Dawson catchment near Taroom and the Mimosa Creek catchment, which resulted in the two flood peaks at the Beckers gauging station. A peak flow of 2,750 m³/s was recorded at the Beckers gauging station with an approximate flood event AEP of 5%, based on FFA (refer Section 3.5).

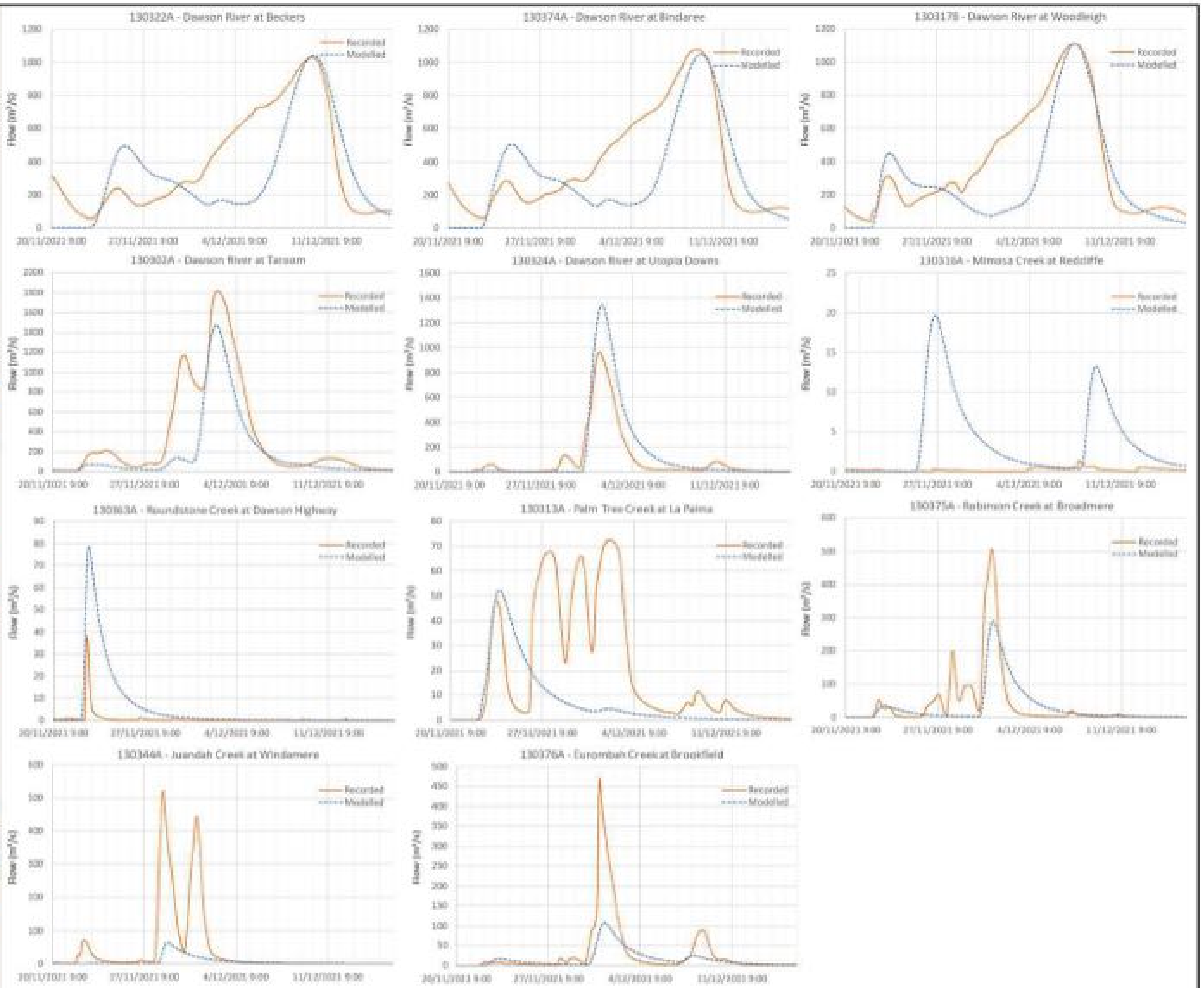
Sub-daily rainfall records are poor for the 1983 flood event, with only two pluviograph stations available which significantly limits the model calibration performance. Besides the poor rainfall records a reasonable match to peak flow and timing was achieved at the Beckers (130322A), Theodore (130305A) and Woodleigh (1303177B) gauging stations. The calibration accuracy at the other gauges is varied due to the small magnitude of recorded flows at the gauges and poor rainfall data records for the event.

3.3.5.6 February 1978 Event

The February flood event was a dominant Lower Dawson catchment flood with less than 60 m³/s recorded at the Taroom (130302A) gauging station. A peak flow of 1,843 m³/s was recorded at the Beckers gauging station with an approximate flood event AEP between 20% and 10%, based on FFA (refer Section 3.5).

As per the 1983 event, sub-daily rainfall records are poor for the February 1976 flood event, with only two pluviograph stations available. A reasonable match to peak flow and timing was achieved at the Beckers (130322A), Theodore (130305A) and Woodleigh (1303177B) gauging stations however the calibration accuracy at the other gauges is varied due to the poor rainfall data records for the event.





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BARALABA SOUTH

Figure 3.10

Baralaba South Pty Ltd
Flooding Impact Assessment
Hydrology Calibration Results - November 2021

QC1018_004

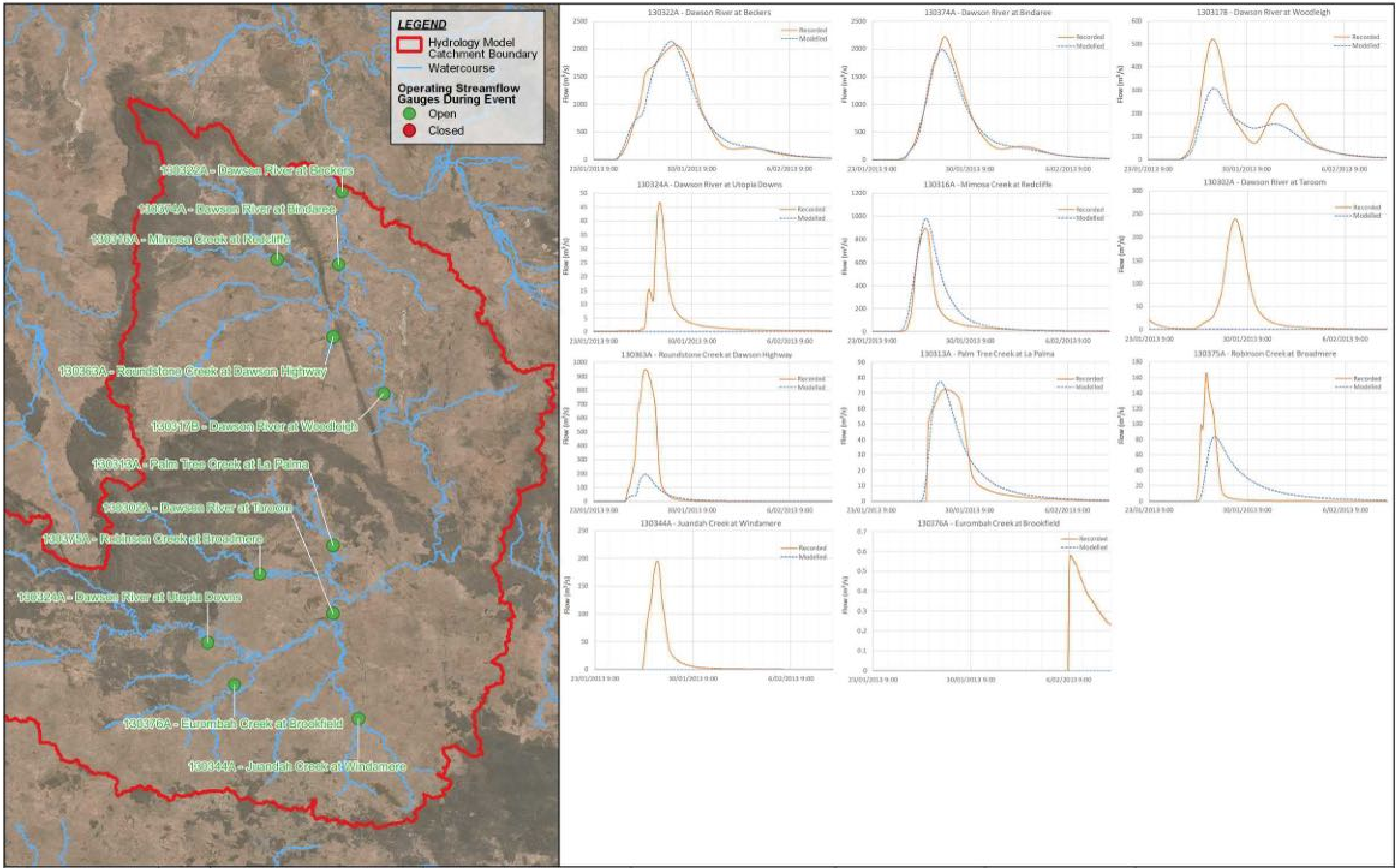

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Figure 3.11

Baralaba South Pty Ltd
Flooding Impact Assessment
Hydrology Calibration Results - January 2013

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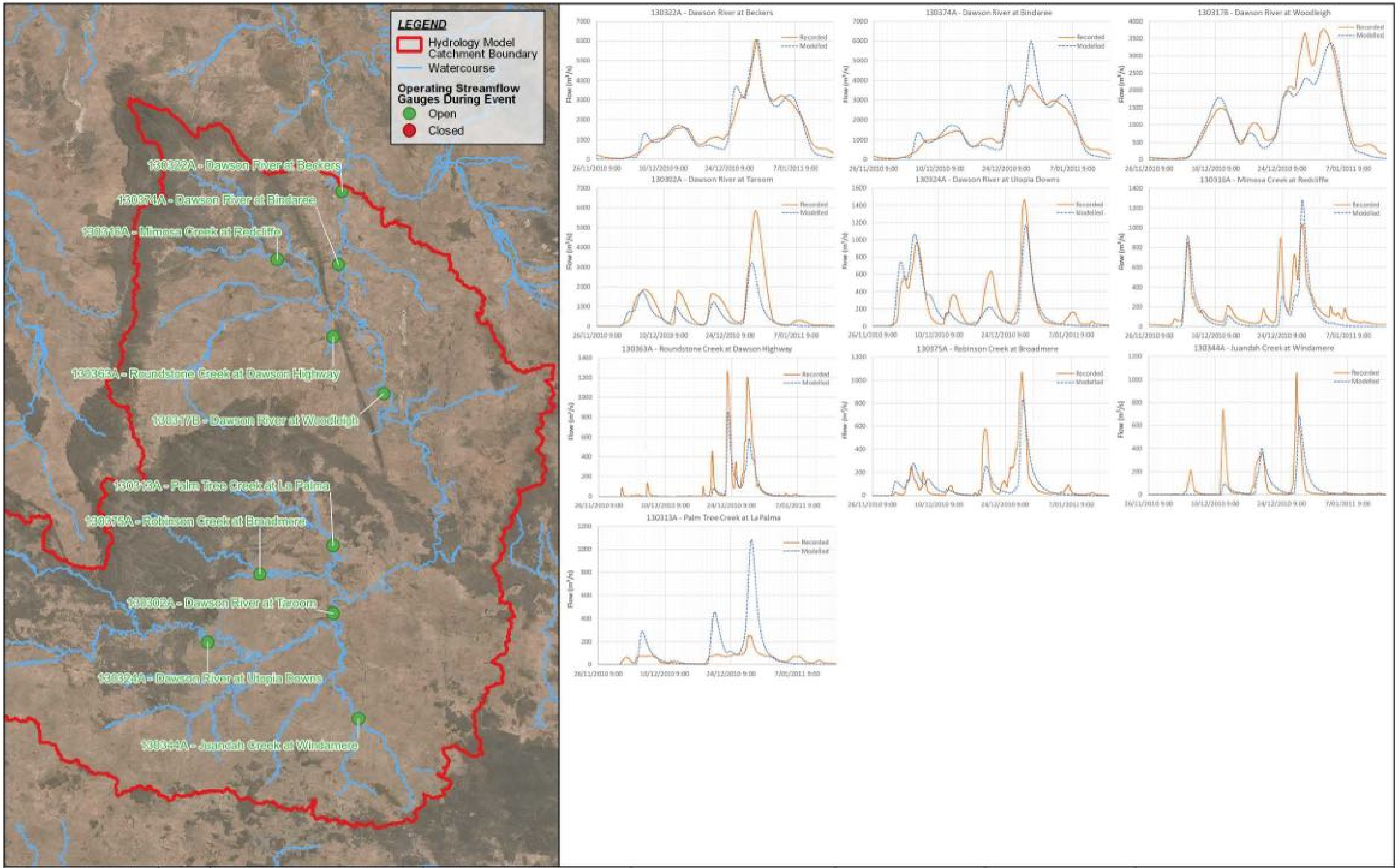

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Figure 3.12

Baralaba South Pty Ltd
Flooding Impact Assessment
Hydrology Calibration Results - December 2010

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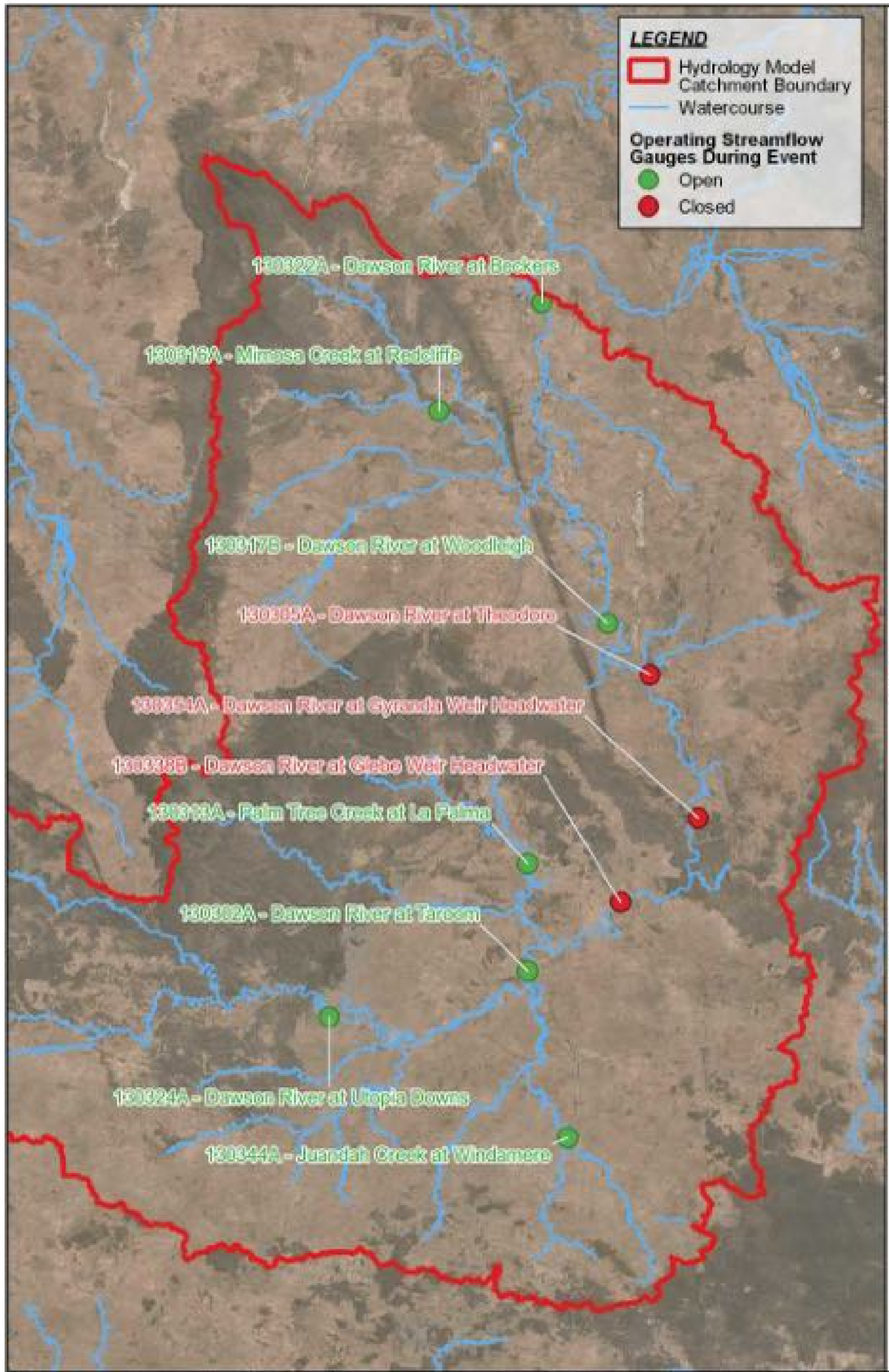

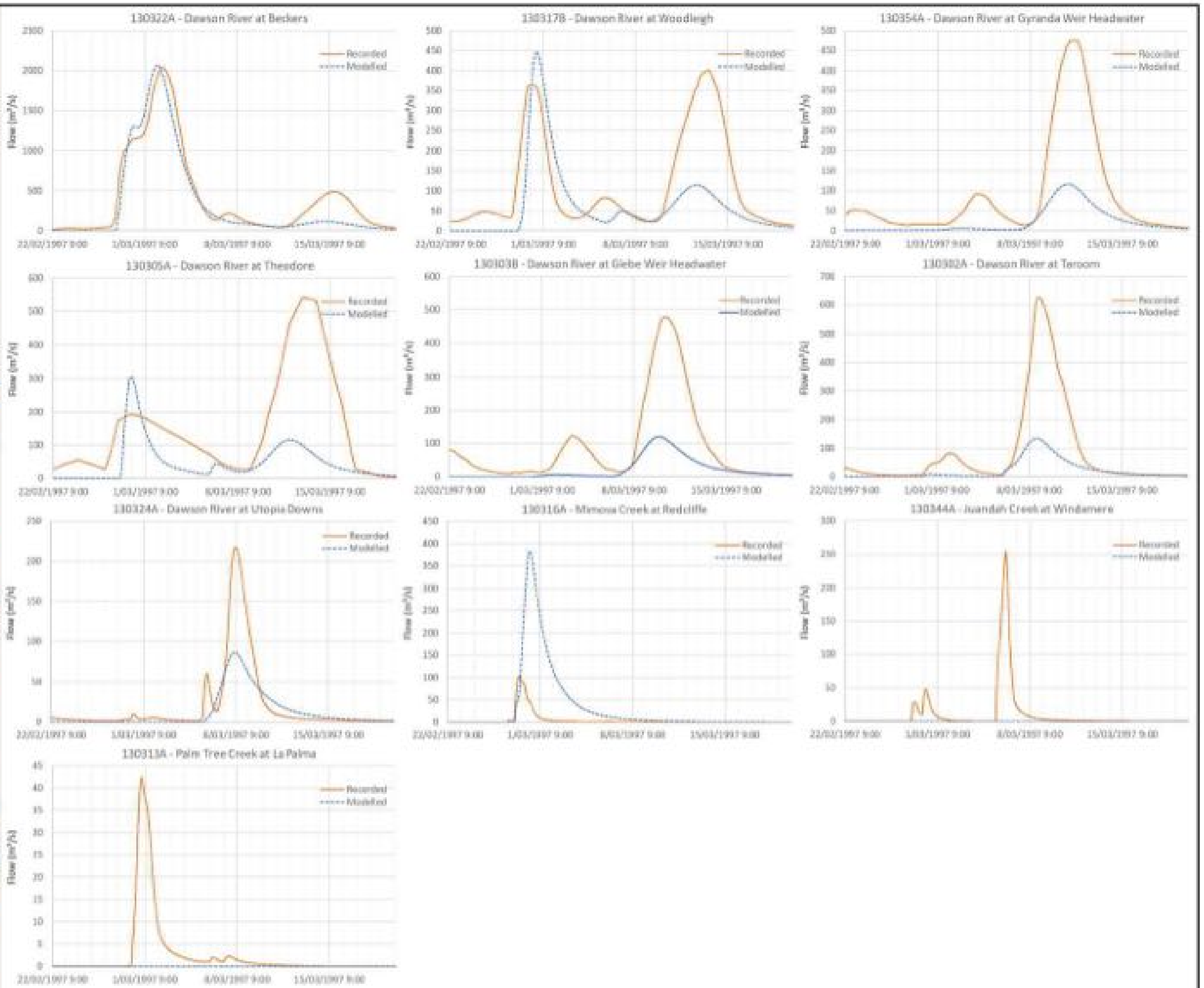

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Figure 3.13

Baralaba South Pty Ltd
Flooding Impact Assessment
Hydrology Calibration Results - March 1997

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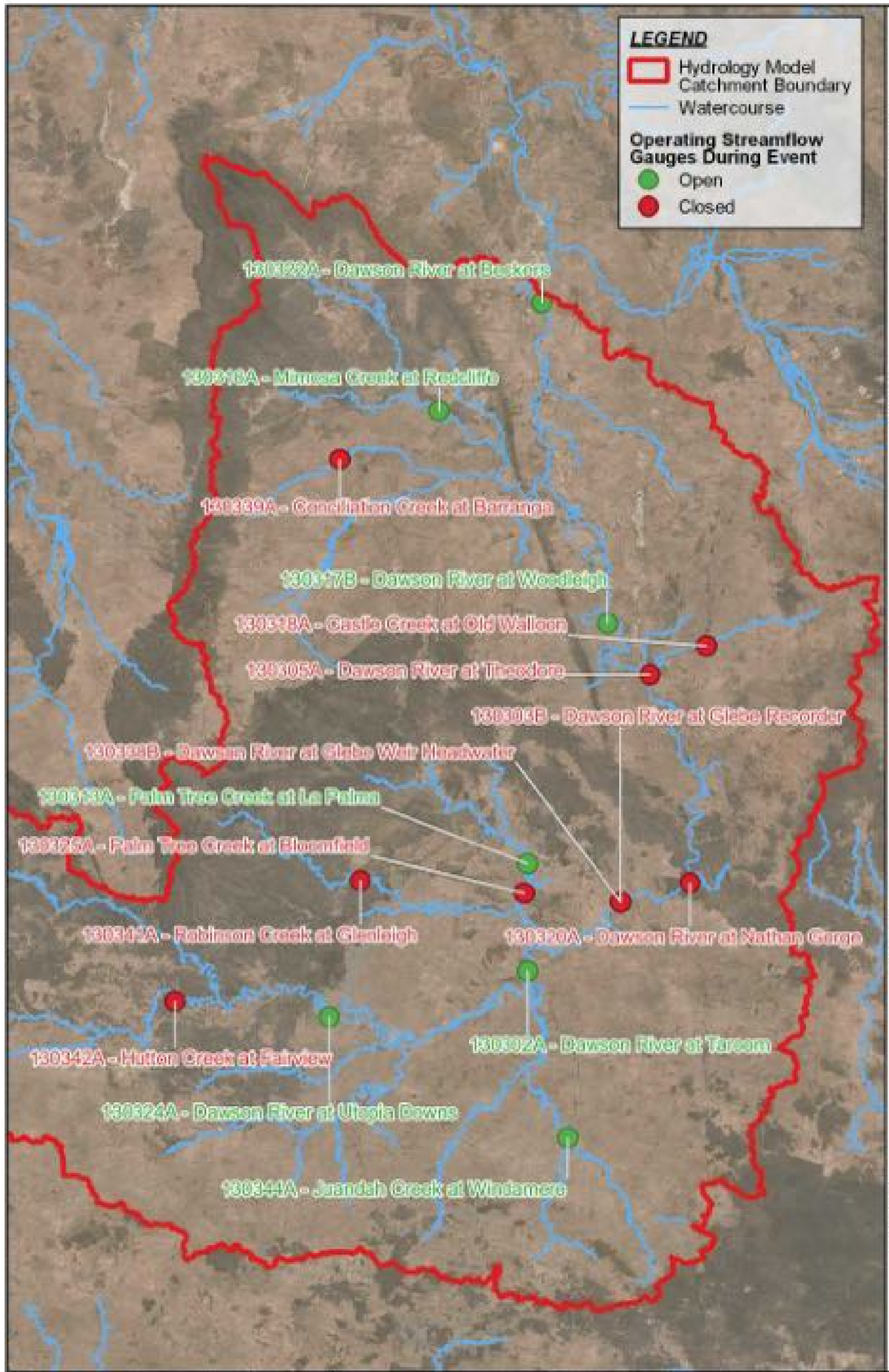

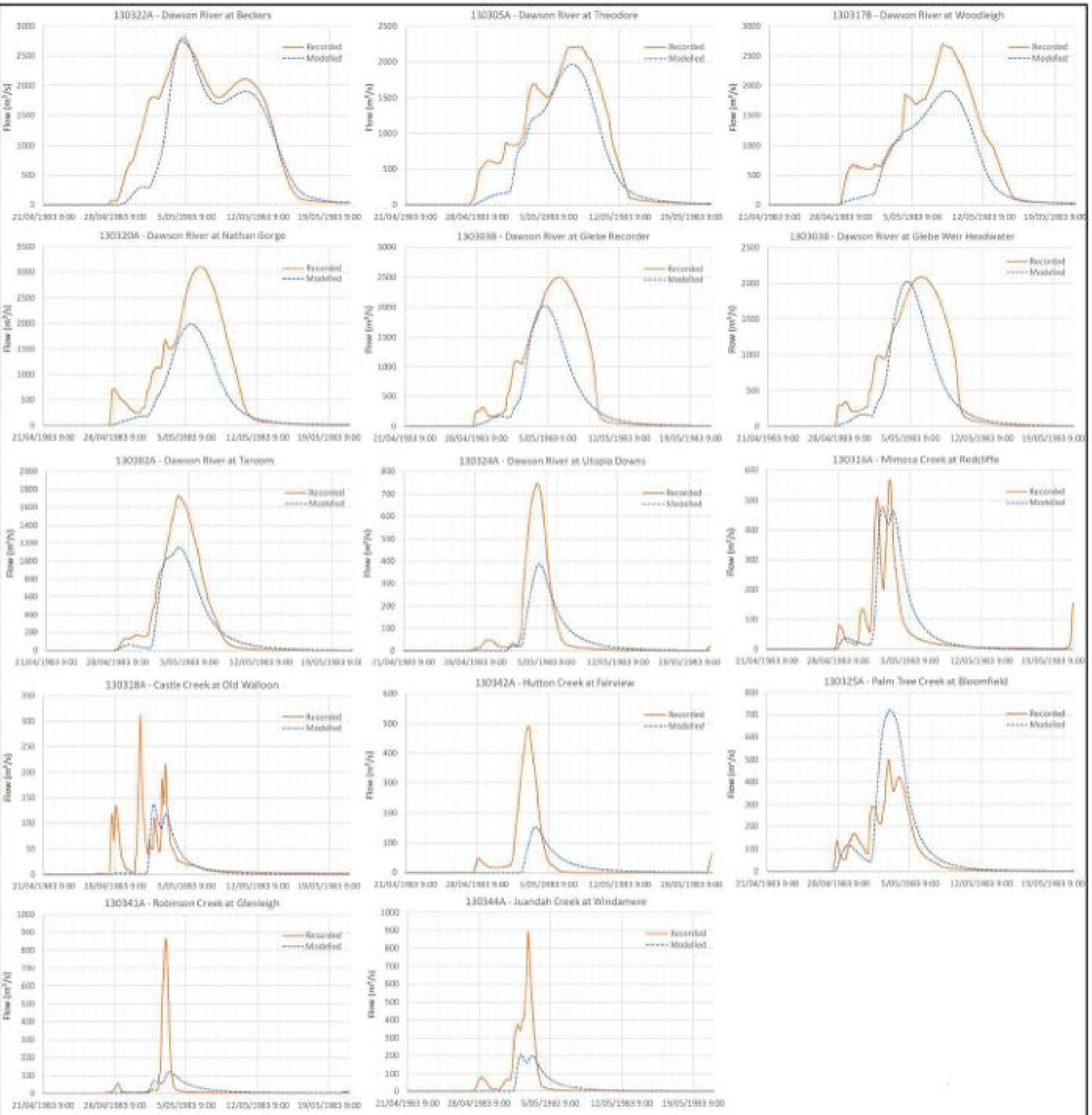

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Figure 3.14

Baralaba South Pty Ltd
Flooding Impact Assessment
Hydrology Calibration Results - May 1983

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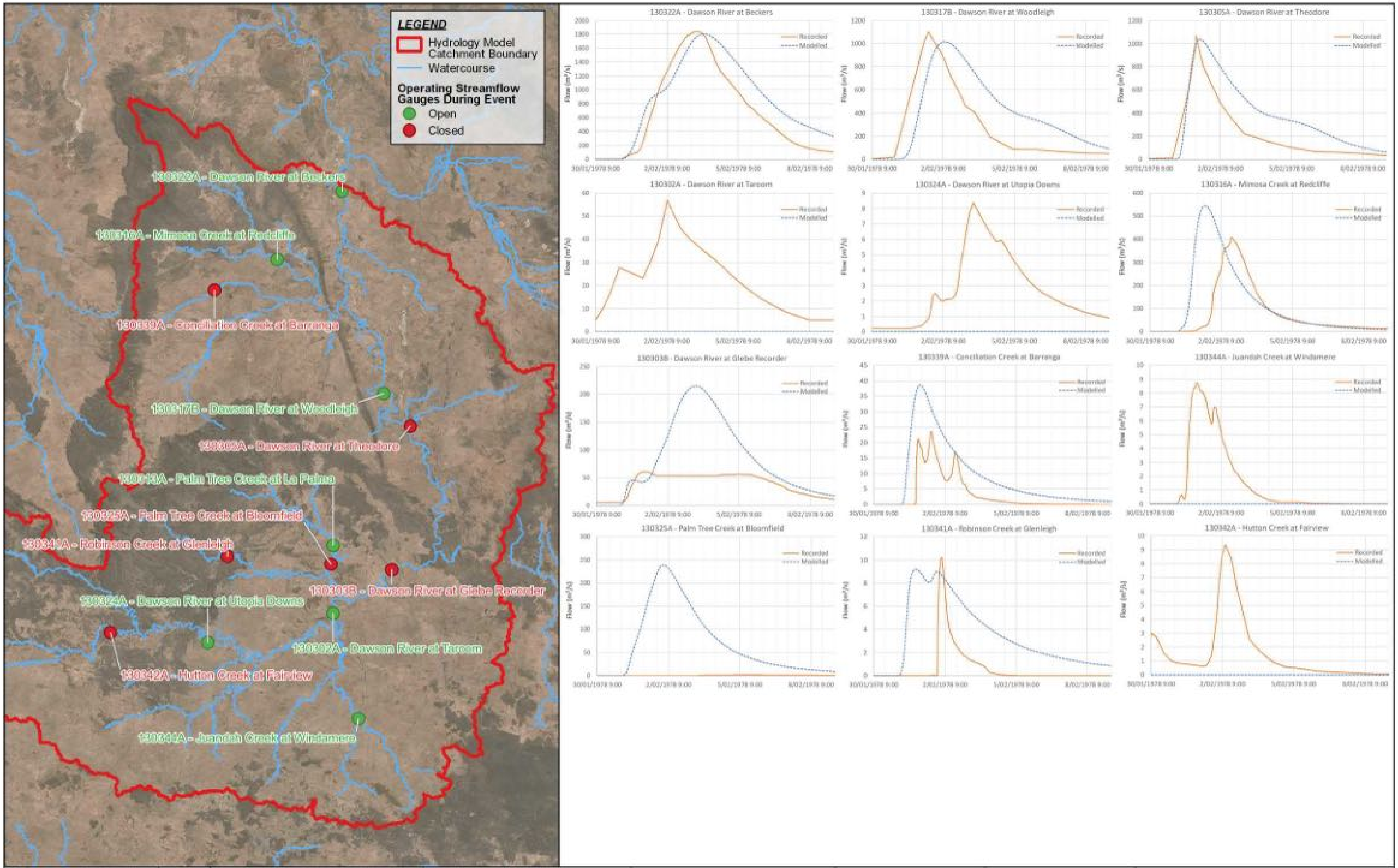

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Figure 3.15

Baralaba South Pty Ltd
Flooding Impact Assessment
Hydrology Calibration Results - February 1978

QC1018_004

3.3.6 Model Calibration Summary

The model parameters determined for each calibration event are listed Table 3.4. A summary of recorded and modelled peak flood flows at the Beckers (130322A) gauging station for each of the calibration events is provided in Table 3.3.

The following observations are made regarding the calibration model parameters:

- Initial losses adopted for the calibration events varied between 30mm and 70mm with an average of 50mm across the 6 events. The initial loss values adopted for each event do not appear to correlate with event magnitude or duration.
- Continuing losses adopted for the calibration events showed some variation with the December 2010 event adopting the lowest continuing loss of 1.3 mm/hour and all other events adopting between 3.5 mm/hour and 4 mm/hour. The lower continuing losses adopted for the December 2010 event aligns with it being the largest magnitude event (peak flow at Beckers).

Discussion of URBS model parameters adopted for design event simulations is presented in Section 3.4.5.

TABLE 3.3: MODEL CALIBRATION SUMMARY – BECKERS (130322A) GAUGING STATION

Result	Calibration Event Peak Flow Summary (m³/s)					
	February 1978	May 1983	March 1997	December 2010	January 2013	November 2021
Recorded	1,843	2,750	2,035	6,060	2,068	1,030
Modelled	1,805	2,807	2,066	6,053	2,133	1,039
Difference	38 (2.1%)	-57 (-2.1%)	-32 (-1.6%)	7 (0.1%)	-65 (-3.2%)	-9 (-0.9%)

TABLE 3.4: URBS MODEL CALIBRATION PARAMETERS

Event	Initial Loss (mm)	Continuing Loss (mm/hr)	α	β	m
February 1978	45	3.7	0.007	5	0.8
May 1983	40	4			
March 1997	65	3.7			
December 2010	55	1.3			
January 2013	70	3.5			
November 2021	30	3.7			

3.4 Design Event Simulations

3.4.1 Overview

The calibrated Dawson River URBS model was used to derive design flood hydrology for flood events ranging from the 20% AEP flood event up to the PMF event. The design flood hydrology was derived using the design flood estimation methods described in the 2019 revision of Australian Rainfall and Runoff (ARR 19) (Ball J, 2019).

3.4.2 Design Rainfall

Design rainfall data for the Dawson River catchment was derived for rainfall events between the 20% AEP event and the Probable Maximum Precipitation (PMP) event. The design rainfall data was derived using the following methods:

- Rainfall totals in the AEP range 20% to 0.1% were generated for all sub-catchment centroids using the BoM IFD tool (www.bom.gov.au/water/designRainfalls/revised-ifd/). Each sub-catchment has been assigned an individual Intensity Frequency Duration (IFD) table.
- PMP rainfall estimates were calculated using the Revised Generalised Tropical Storm Method, GTSM-R (Bureau of Meteorology, 2003) for durations 24 hour and longer. The AEP of the PMP was assigned a value of 1:25,000 in accordance with Figure 8.3.2 Book 8 of the ARR 19 (Ball J, 2019).

Design rainfall totals (point values) were generated for the centroid of each sub-catchment within the URBS model.

3.4.3 Design Temporal Patterns

An ensemble of 10 temporal patterns was simulated for each design storm AEP and storm duration as recommended by ARR 19 (Ball J, 2019). Temporal patterns for the design storm events were assigned as follows:

- 20% AEP to 0.1% AEP design storms – ensemble temporal patterns for “North East Coast” sourced from ARR 16 Data Hub (http://data.arr-software.org/) were applied.
- For the PMP event the GTSMR ensemble temporal patterns were applied.

The ensemble results closest to the average of all ensemble results was adopted as the design flood estimate for the 20% to the 0.1% AEP storm events. The maximum of all ensemble results was selected as the peak flow for the PMF event.

3.4.4 Design Rainfall Losses

Design storm IL for the Dawson Catchment to the Project (IL = 37 mm) were sourced from the ARR 16 Data Hub (http://data.arr-software.org) for design events ranging from the 20% AEP to the 0.1% AEP. Median pre-burst rainfall depths for the Dawson River catchment sourced from the Data Hub were subtracted from the storm initial loss to produce a burst loss that is applied to the modelled storm event. The adopted design event initial loss is at the lower end of the range of initial loss values adopted for the calibration simulations (30 mm to 70 mm).

Continuing loss (CL) rates sourced from the ARR 16 Data Hub shows large variation in values in the upper, lower and Mimosa Creek sub-catchments of the Dawson River. CL varied from 2.1 mm/hour for the Upper Dawson catchment to 1.2mm/hour for the Lower Dawson catchment. The range of CL rates were tested in the design hydrology simulations and a CL of 1.2mm/hour was found to provide the best match of design hydrology peak flows and the at-site flood frequency analysis (FFA) validation as discussed in Section 3.5. It is noted the adopted continuing loss of 1.2mm/hour aligns with the loss adopted for the 2010 model calibration (1.3 mm/hour). The at-site FFA was also used to validate the initial losses adopted for the design hydrology.

Zero IL and 1 mm/hr CL values were adopted for the PMF event.

3.4.5 Model Parameters

Table 3.5 presents the URBS model parameters adopted for the design event simulations. The URBS routing parameters were determined from the model calibration as discussed in Section 3.3.

TABLE 3.5: URBS MODEL PARAMETERS ADOPTED FOR DESIGN EVENT SIMULATIONS

Parameter	Value
Initial Loss	20% to 0.1% AEP = 37 mm PMF = 0 mm
Continuing Loss	1.2 mm/hour

Parameter	Value
α	0.007
β	5
m	0.8

3.4.6 Design Event Simulations

Design event simulations were undertaken using the calibrated URBS model for AEPs ranging from 20% to the PMF event, and for storm durations ranging from 12 hours to 144 hours. As described in Section 3.4.3, the ensemble temporal pattern modelling approach recommended by ARR19 was adopted and the temporal pattern that produced the closest peak flow result to the average of the ensemble was selected as the design storm (Ball J, 2019).

Table 3.6 summarises design hydrology peak flow results for the Dawson River at the Project location as well as the critical storm duration and temporal pattern ensemble number.

TABLE 3.6: DAWSON RIVER DESIGN HYDROLOGY PEAK FLOW RESULTS

AEP (%)	Peak Flow (m^3/s)	Critical Duration (h)	Ensemble Number
20	884	72	7
10	1,981	72	7
5	2,831	72	10
2	3,789	72	4
1	6,244	72	1
0.1	10,600	72	1
PMF	31,862	96	3

3.5 At-Site Flood Frequency Analysis

3.5.1 Overview

Flood Frequency Analysis (FFA) was undertaken for the Dawson River at Beckers (130322A) and Dawson River at Woodleigh (130317A) streamflow gauging stations to produce design event peak flow estimates based on historical gauging. The FFA peak flow estimates were used to validate the design hydrology peak flow estimates from the calibrated URBS model. The Dawson River at Beckers FFA validation was used validate design hydrology at the Project location and the Dawson River at Woodleigh FFA validation was used as a secondary validation location at the upstream extent of the hydraulic model. The FFA were undertaken using RMC-BestFit which is a distribution fitting and Bayesian estimation software developed by the Risk Management Center, U.S. Army Corps of Engineers for flood hazard assessments (U.S. Army Corps of Engineers, 2020).

3.5.2 Flood Frequency Analysis Methodology

The Flood Frequency Analysis were undertaken using the methodologies outlined in ARR19. ARR19 provides guidance on several fitting distribution functions and methods for processing gauged data for the analysis. Several ARR19 FFA methodologies were tested including use of the Generalised Extreme Value (GEV) and Log-Pearson Type III (LPIII) distribution functions as well as analysis of gauged annual maximum (AM) series and peak over threshold (PoT) series. The following FFA approach was found to produce the best fit for the Beckers and Woodleigh gauging stations:

- Development of an annual maxima (AM) flow series for the two gauging stations.
- Removal of potentially influential low and high flow outliers from the AM series using the Grubbs-Beck test.
- Fitting a Log-Pearson Type III (LPIII) distribution to the AM series using the Cunnane plotting position parameter (α), 0.4.
- Bayesian analysis to produce a predictive LPIII distribution fit to the AM flow series.

The approach above produced two FFA results including an expected value and a predicted value. The expected value is the standard LPIII distribution result, and the predicted value is the Bayesian analysis approach for the LPIII distribution.

3.5.3 Annual Maximum Sequence

The annual maximum (AM) flow series was developed based on the peak recorded flow between July and June for each complete year of record. The Dawson River at Beckers streamflow gauging station (130322A) historical peak flows were based on the revised rating curve detailed in Section 3.3.4. an AM series with 59-year values was developed for the Dawson River at Beckers gauging station.

The Dawson River at Beckers AM series was extended an additional 37 years using an AM series developed for the Dawson River at Baralaba gauging station (130304A). The Dawson River at Baralaba gauging station was operational from 1925 to 1961 and captured the historical February 1947 flood event with an estimated peak flow of 7,079 m^3/s, as well as several other significant flood events ranging between 2,000 m^3/s and 3,000 m^3/s. The Baralaba gauging station was located 15 km upstream of the current Beckers gauging station location with negligible difference in total catchment area. Therefore, it was considered acceptable to extend the Beckers AM series using the Baralaba AM series to produce a combined AM series length of 96 years for the FFA.

FFA for the Dawson River at Woodleigh gauging station was performed on annual peak flows generated using the DRDMW derived rating curve for the full period of available monitoring data. The Dawson River at Woodleigh FFA was based on 67 years of annual maxima peak flows. The AM series data for the Beckers and Woodleigh gauging station locations is presented in Figure 3.16.

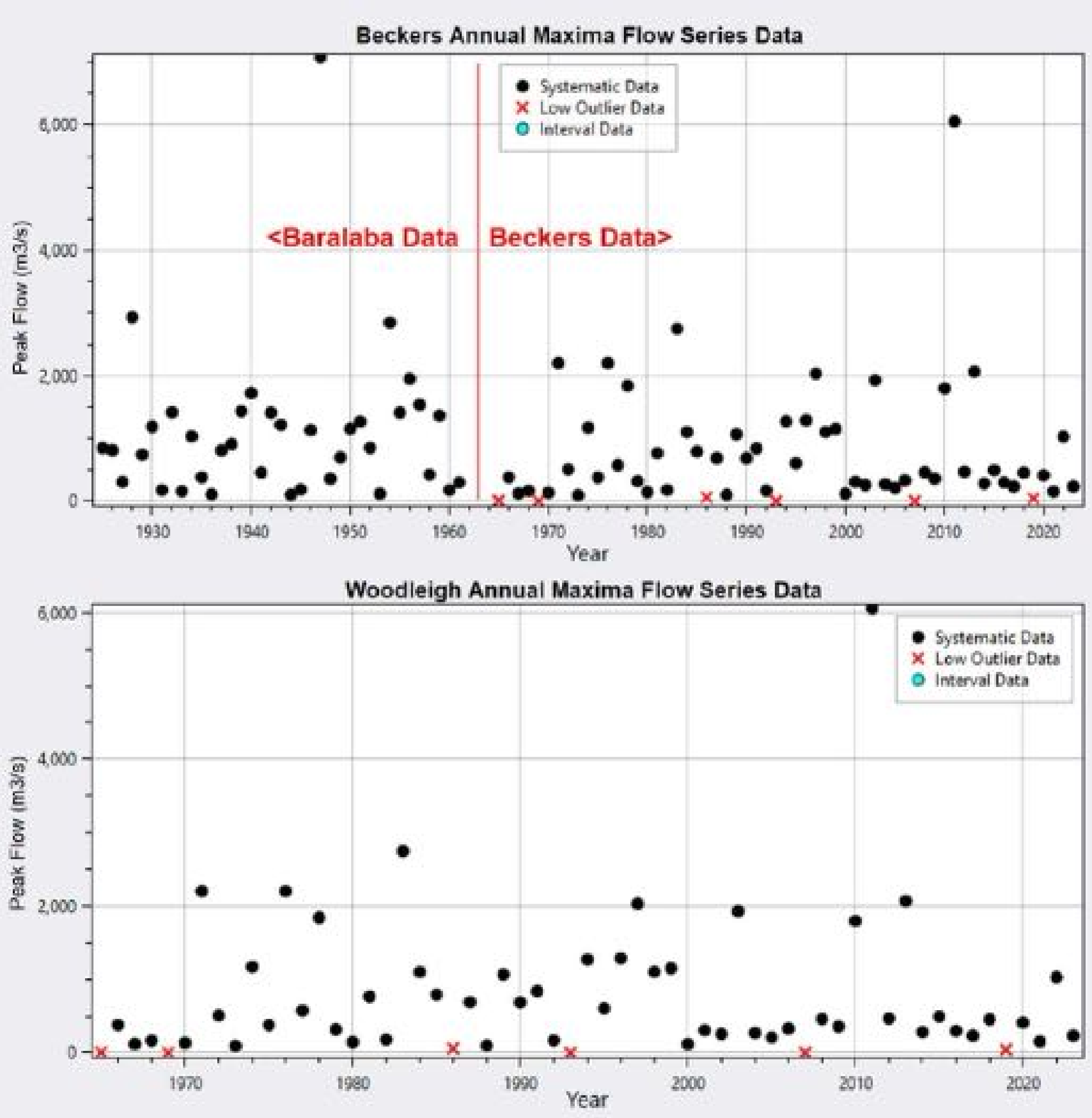

Figure 3.16: Annual Maxima Flow Series Data

3.5.4 At-Site FFA Results

Tabulated results of the at-site FFA for the Beckers (130322A) and Woodleigh (130317B) gauging stations are shown in Table 3.7 and Table 3.8 respectively. The at-site FFA results for the Beckers and Woodleigh gauging stations are presented in Figure 3.17 and Figure 3.18. FFA results are presented for both the expected value (standard LPIII distribution) and the predicted value (LPIII Bayesian analysis).

The design hydrology developed using the calibrated URBS model shows reasonable consistency with the FFA results at both the Beckers (130322A) and Woodleigh (130317B) gauging stations. For both sites, the URBS model results for infrequent AEPs (20% to 5% AEP) provide a better match to the FFA expected values. The long gauge period used for the FFA (96 years) provides a suitable sample size of annual peak flows to allow standard distribution techniques to produce reasonable flow estimates for frequent and infrequent AEP flood events.

Considering this it is considered acceptable to adopt the Expected values from the FFA to compare against design hydrology peak flow results for AEPs up to the 5% AEP.

The URBS model peak flow results for rare flood events (2% and 1%) provide a better match to the predicted values. The gauged period duration is not sufficient to provide confidence in standard distribution estimates for rarer AEP's and therefore comparing against the predicted values is considered more appropriate. The design hydrology results are more conservative for frequent flood events, however, remain within the confidence intervals of the FFA predicted values.

Based on the results of the at-site FFA at the Beckers (130322A) and Woodleigh (130317B) gauging stations, it is considered that the design hydrology estimates calculated using the calibrated URBS model provide a good representation of Dawson River design hydrology for the Project location.

TABLE 3.7: COMPARISON OF FFA AND URBS HYDROLOGY RESULTS - BECKERS GAUGING STATION (130322A)

AEP	Calibrated URBS Results (m^3/s)	Predicted Value (m^3/s)	Expected Value (m^3/s)	5% Quantile Limit (m^3/s)	95% Quantile Limit (m^3/s)
20%	884	1,388	1,355	1,115	1,709
10%	1,981	2,200	2,096	1,742	2,803
5%	2,831	3,170	2,951	2,424	4,322
2%	3,789	4,761	4,249	3,403	7,214
1%	6,244	6,257	5,356	4,148	10,297

TABLE 3.8: COMPARISON OF FFA AND URBS HYDROLOGY RESULTS - WOODLEIGH GAUGING STATION (130317A)

AEP	Calibrated URBS Results (m^3/s)	Predicted Value (m^3/s)	Expected Value (m^3/s)	5% Quantile Limit (m^3/s)	95% Quantile Limit (m^3/s)
20%	751	826	793	624	1,096
10%	1,686	1,355	1,255	1,009	1,858
5%	2,264	2,003	1,780	1,438	2,914
2%	2,911	3,005	2,554	2,023	4,949
1%	4,589	3,983	3,190	2,471	7,179

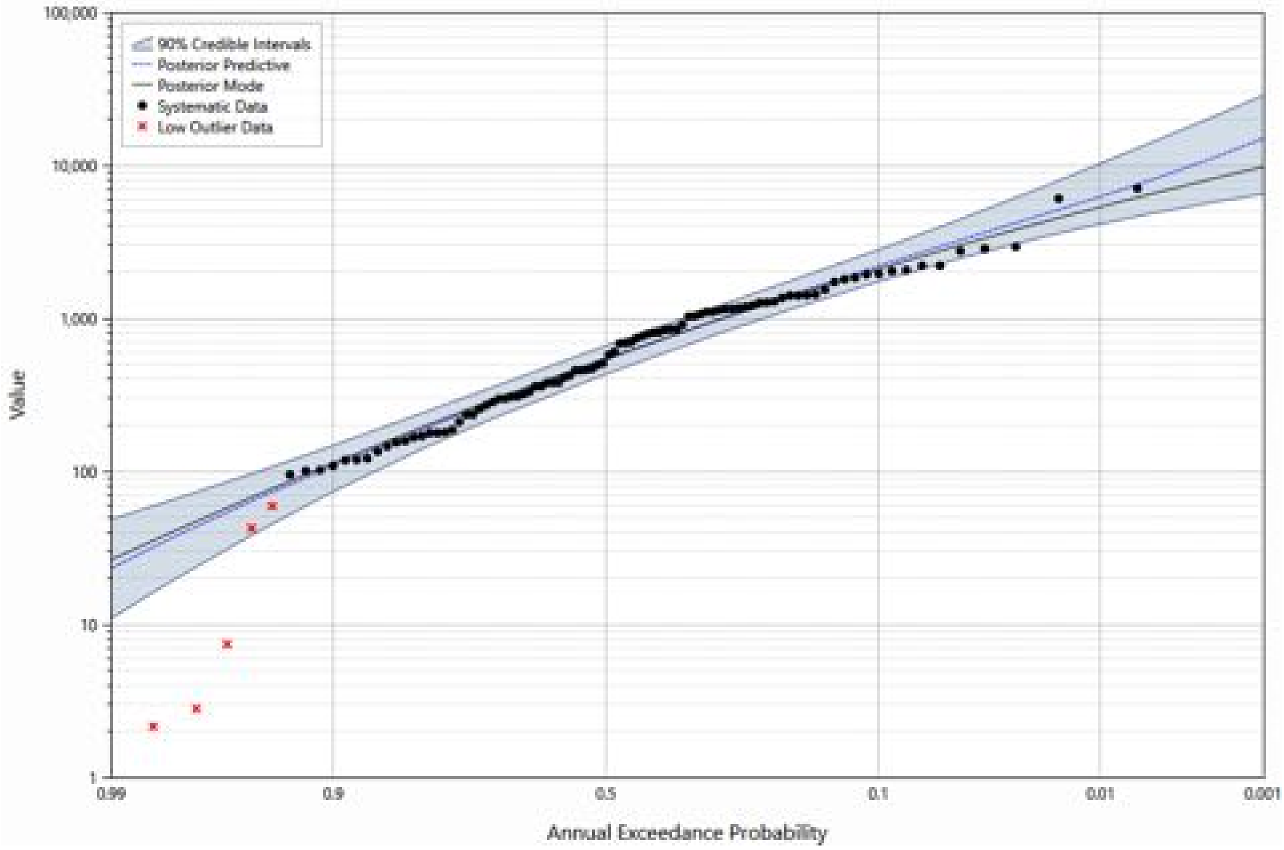

Figure 3.17: FFA Results - Beckers Gauging Station (130322A)

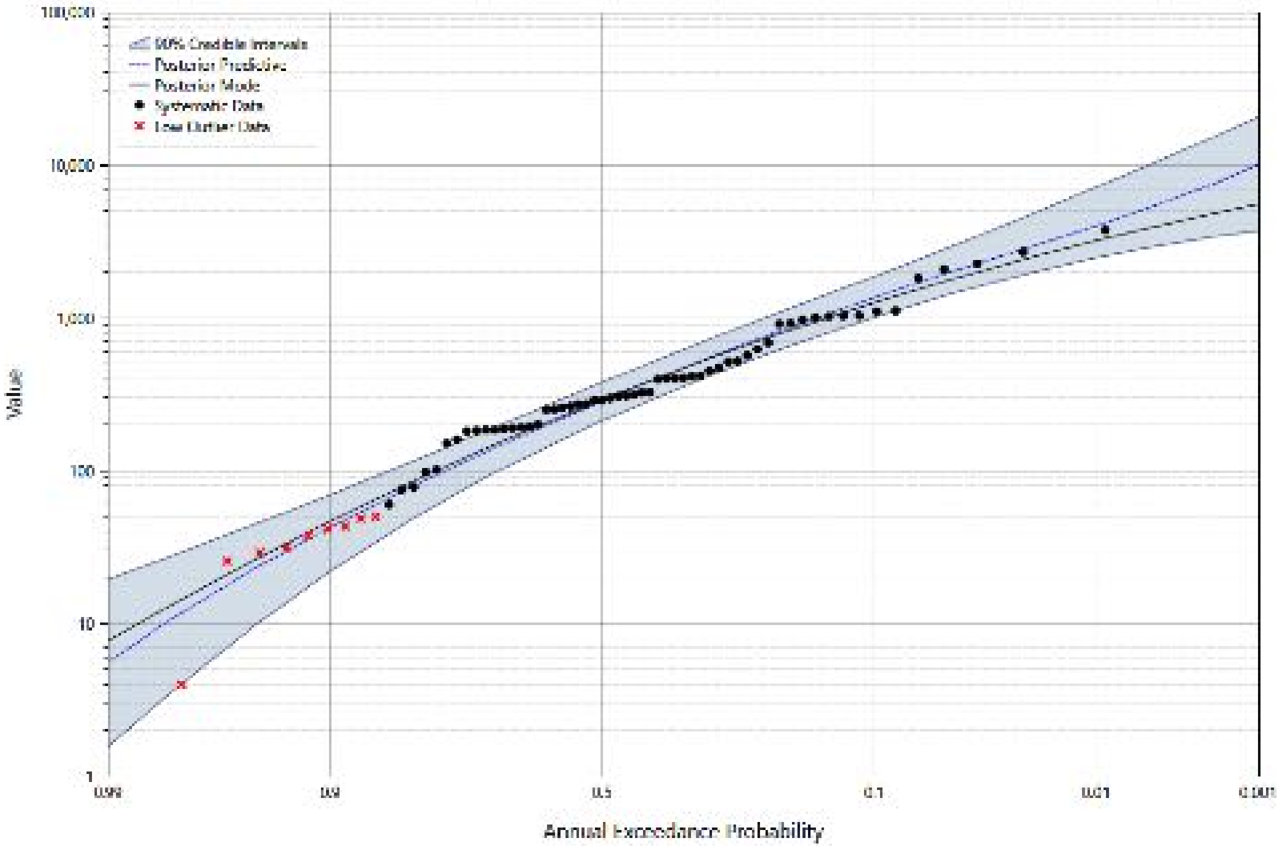

Figure 3.18: FFA Results - Woodleigh Gauging Station (130317A)

3.6 Banana Creek Hydrology

Historical pluviographic rainfall and streamflow gauging data is unavailable for the Banana Creek catchment making it not possible to calibrate Banana Creek hydrology. To develop design hydrology for Banana Creek and assess Banana Creek dominated flooding scenarios, the Dawson River URBS model was reduced to the Banana Creek catchment and simulated in a Basic modelling approach. This allowed use of routing parameters derived from regional relationships for the Banana Creek design hydrology. Design hydrology from the Banana Creek URBS model was then validated to scaled flood frequency analysis of streamflow gauging on a nearby creek. The following sections outline the model extent, parametrisation, design hydrology results and validation.

3.6.1 Banana Creek Model Extent

The Banana Creek hydrology model was developed from reducing the Dawson River URBS model to the Banana Creek catchment and adopting a Basic modelling approach (discussed in Section 3.6.2). The Banana Creek catchment is represented by 19 sub-catchments representing Banana Creek to the confluence with the Dawson River (1,170 km^2). The Banana Creek URBS model layout is shown in Figure 3.19.

3.6.2 Model Parameters

The Banana Creek URBS Model was simulated using the Basic modelling approach which assumes that the catchment and channel storage for each sub-catchment is lumped together and represented as a single non-linear reservoir (Carroll, 2020). This modelling approach is a similar runoff routing method to the RORB model (Laurenson, Mein, & Nathan, 2010). The reach length was adopted as the main routing parameter input to the model which allows the model to be calibrated by adjusting the alpha (α) and non-linearity exponent (m) parameters.

As the Basic model closely resembles the RORB model, routing parameter alpha (α) can be translated to regional relationships developed for the RORB routing parameter (Kc) using the following relationship (Carroll, 2020):

$$\alpha = \frac{K_c}{f_{av}}$$

Where: α *= URBS routing parameter*

K_c *= RORB routing parameter*

f_{av} *= Model routing constant output by URBS based on modelled catchment area and stream length*

As discussed in Section 3.6, there is insufficient data to calibrate hydrology for Banana Creek. Therefore, the model routing parameters have been derived from regional relationships for the RORB routing parameter Kc (Weeks, 1986) and then translated to the URBS routing parameter alpha (α) using the relationship above. The Queensland regional relationship developed by Weeks (1986) for determining Kc based on total catchment area and a non-linearity exponent (m) of 0.8 was used to define a K_c routing parameter which was then related to the URBS alpha (α) routing parameter as shown below:

- RORB K_c relationship (Weeks, 1986) $\mathrm{K_c} = 0.88\mathrm{A}^{0.53}$ with *A* being the total catchment area in km^2.
- For a total catchment area (A) of 1,172 km^2, the relationship produces a K_c of 37.23.
- Using the relationship described above and the URBS model output for $f_{av} = 45.4$, this produces an alpha (α) value of 0.82.

The alpha (α) routing parameter of 0.82 and a non-linearity exponent (m) of 0.8 have been validated through comparison of design hydrology peak flow estimates to scaled flood frequency analysis of streamflow gauging on a nearby creek, as detailed in Section 3.6.4.

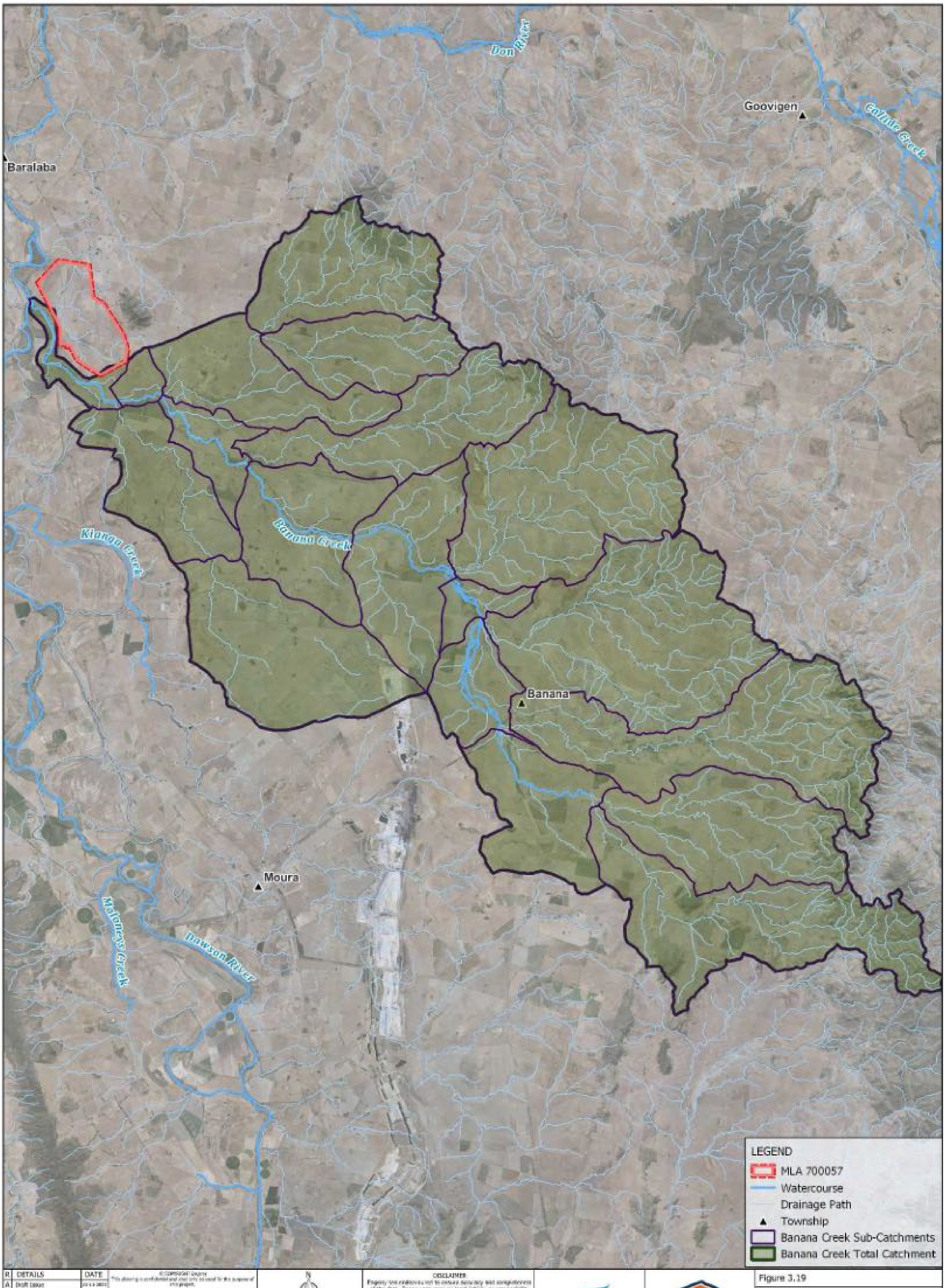

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Figure 3.19

BARALABA SOUTH PTY LTD
Flood Impact Assessment
Banana Creek URBS Sub-Catchment Layout

Job Number:
QC1018_004

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3.6.3 Banana Creek Design Hydrology

The same rainfall inputs and approach from the Dawson River design hydrology has been adopted for the Banana Creek design hydrology (refer section 3.4). Rainfall losses specific to Banana Creek have been adopted from the ARR 16 Data Hub (http://data.arr-software.org) and are summarised as:

- Initial Loss – 50 mm.
- Continuing Loss – 1.2 mm/hour.

Areal reduction factors, temporal patterns and median rainfall pre-burst losses have also been revised for the Banana Creek catchment using the same methodology outlined in Section 3.4.

The Banana Creek design hydrology model was simulated for design events ranging from the 20% AEP to the 1% AEP. Banana Creek design hydrology peak flow results upstream of the confluence with the Dawson River are presented in Table 3.9.

TABLE 3.9: BANANA CREEK DESIGN HYDROLOGY RESULTS (UPSTREAM OF DAWSON RIVER CONFLUENCE)

AEP	Peak Flow (m^3/s)	Critical Duration (h)	Ensemble Number
20%	316	36	10
10%	755	24	2
5%	1,123	24	3
2%	1,584	18	3
1%	2,742	18	3

3.6.4 Banana Creek Hydrology Validation

Banana Creek design hydrology peak flow results have been validated to scaled Flood Frequency Analysis of the Prospect Creek at Red Hill gauging station (130348A). This gauge has been used for the FFA validation as it is the closest gauged creek of similar catchment size and shares a catchment boundary with Banana Creek. The Prospect Creek at Red Hill gauging station has a catchment area of 369 km^2 and has a gauged period of 48 years. The Prospect Creek at Red Hill gauging station FFA was completed using the same methodology outlined in Section 3.5 and the FFA results are presented in Figure 3.20. The peak flows from the FFA were scaled to the Banana Creek catchment (1,172 km^2) for validation of the design hydrology results using the catchment area ratio scaling exponents from the Quantile Regression Technique (Palmen & Weeks, 2011).

The Banana Creek design hydrology was also validated against the Regional Flood Frequency Estimation (RFFE) technique outline in ARR19 (Ball J, 2019). The RFFE provides peak flow estimations based on the catchment area and a catchment shaping factor, determined using the catchment centroid and outlet coordinates. The RFFE peak flow estimates were calculated using the AR&R RFFE Model online tool (http://rffe.arr-software.org/).

The Banana Creek design hydrology validation to scaled FFA and the RFFE is presented in Table 3.8. The validation results show:

- The design hydrology matches well with the scaled FFA expected values (standard LPIII distribution) for the majority of AEPs with the exception of the 20% AEP being lower and the 1% AEP being higher than the Scaled FFA expected values.
- The 1% AEP Predicted value (Bayesian estimation) from the scaled FFA is higher than the modelled peak flow.
- Modelled peak flows match well with the RFFE for all AEPs with the exception of the 20% AEP which is lower than the scaled FFA and RFFE.
- The Banana Creek design hydrology results are generally consistent with the scaled FFA values as well as the RFFE and provides confidence in the design hydrology results for assessing Banana Creek dominated flooding scenarios.

TABLE 3.10: BANANA CREEK HYDROLOGY VALIDATION TO SCALED FFA AND RFFE

AEP	Calibrated URBS Results (m^3/s)	Prospect Creek Red Hill Gauging Station (130348A) Scaled FFA Results (m^3/s)				RFFE (m^3/s)
		Predicted Value	Expected Value	5% Quantile	95% Quantile	
20%	**316**	521	481	132	259	463
10%	**755**	864	768	362	744	767
5%	**1,123**	1,346	1,133	584	1,360	1,170
2%	**1,584**	2,231	1,718	845	2,459	1,900
1%	**2,742**	3,276	2,248	1,207	5,154	2,630

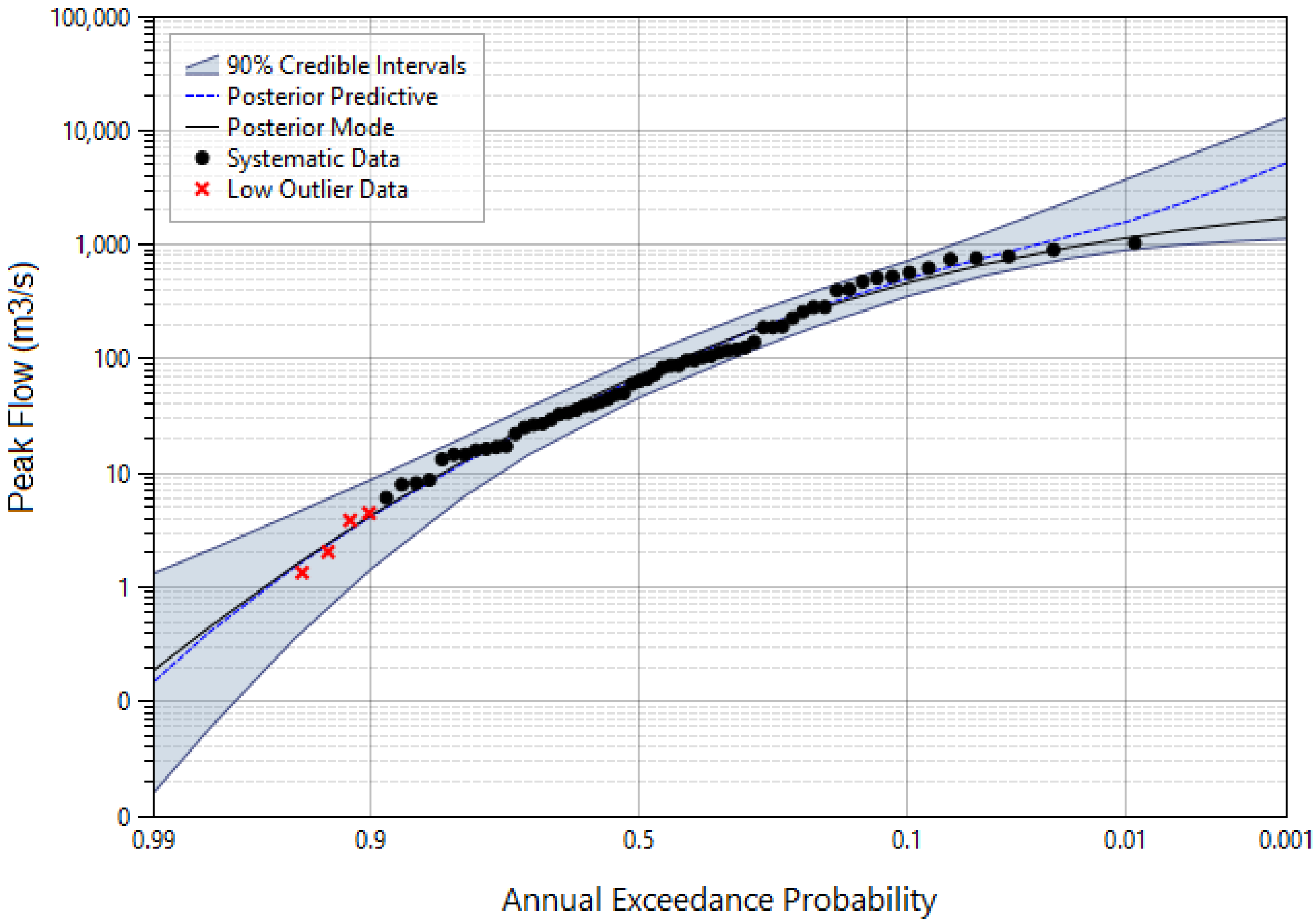

Figure 3.20: FFA Results – Prospect Creek at Red Hill Gauging Station (130317A) (369 km^2)

4. DAWSON RIVER HYDRAULIC ASSESSMENT

4.1 Overview

A 1D/2D hydrodynamic model has been developed to assess Dawson River hydraulics and potential flood impacts resulting from the development of the Project. The TUFLOW HPC software package was adopted to develop the hydrodynamic model. TUFLOW HPC leverages computational parallelisation to be able to model large areas at relatively fine resolutions. The TUFLOW software has been used for similar applications throughout Australia and is considered suitable for undertaking the current assessment.

4.2 Hydraulic Model Development

4.2.1 Model Bathymetry, Extent and Grid Resolution

The two-dimensional model extent covers a 44km length of the Dawson River and Banana Creek floodplain with an upstream extent approximately 15 km upstream of the Bindaree (130374A) gauging station and a downstream extent 18.5km downstream of the Beckers (130322A) gauging station. The upstream and downstream extents of the model were located to avoid influence of the adopted inflow and outflow boundary conditions on the model results at the Project location and the model calibration point locations.

The two-dimensional model bathymetry has been developed using multiple topographic survey datasets to cover the entire model extent. The model bathymetry was defined with a grid resolution of 15 m which produced a suitable number of cells to define the major channel cross sections and the Dawson River floodplain geometry, while also maintaining practical model simulation times.

The following sources of topographic survey data were used to develop the base model bathymetry:

- LiDAR survey (1 m DEM format) covering the Dawson River and floodplain extents downstream of the Baralaba Township captured by AAM Pty Limited during February 2021.
- LiDAR survey (1 m DEM format) of the Baralaba Township area sourced from Geosciences Australia through the Elevation Foundation Spatial Data portal (http://elevation.fsdf.org.au/). The date of LiDAR capture was 10th May 2011.
- LiDAR survey (1 m DEM format) covering the majority of the study area, captured by Vekta Pty Ltd on 25th March 2011.
- Shuttle Radar Topography Mission (SRTM) data. This data is available in a 1s (~25 m) resolution DEM and was used to fill the remaining areas not covered by LiDAR survey datasets. A -0.3 m vertical shift was applied to the SRTM dataset to improve the interface with the LiDAR data.

The extent of the LiDAR sources used in the model bathymetry is shown on Figure 4.3. The following additional modifications were made to the base model bathymetry:

- 3D breaklines have been incorporated into the model bathymetry to enforce bund and road elevations associated with farming enterprises within the floodplain.
- For the December 2010 flood event simulations, the Baralaba Central operation was represented using topographic survey captured during March 2011 without manipulation. The date of the survey is close to the time of the flood event and provides the best available representation of the mine configuration at the time of the flood.
- For the January 2013 flood event simulation, the flood protection levee surrounding the Baralaba Central operations was represented in the model as it had been constructed prior to this flood event.
- For all design event simulations, the Baralaba North and Central operations were incorporated into the model including pit flood protection levees.

The model topography is shown in Figure 4.3.

4.2.2 Dawson River Bathymetry and Neville Hewitt Weir

The Neville Hewitt Weir has a crest level of 80.3m AHD (sourced from the *Fitzroy Basin Resource Operations Plan* (DNRME, 2015)), and stores water up to this level. The available LiDAR captures the ponded water within the Neville Hewitt Weir and does not represent the actual river channel surface. Bathymetric survey of the Dawson River channel upstream of the Neville Hewitt weir is not available. Therefore, the modelled Dawson River channel bathymetry upstream of the Neville Hewitt Weir has been developed using the following methods and assumptions.

- Assumed varying river channel bed widths between 20m and 40m (based on LiDAR survey of the Dawson River channel upstream and downstream of the weir and reservoir area).
- The channel bed was assumed to have a constant longitudinal grade from the upstream area of the Neville Hewitt Weir impoundment area to the river invert level downstream of the weir.
- The assumed channel bed was then smoothly merged with the available LiDAR survey above 80.3m AHD (Neville Hewitt Weir crest level).

Figure 4.1 shows a typical cross section of the modelled Dawson River channel and the LiDAR survey capturing the ponded water behind the Neville Hewitt Weir.

The Neville Hewitt Weir was then represented in the model topography using a two-dimensional break line, raising the model topography at the weir location to RL 80.3m AHD.

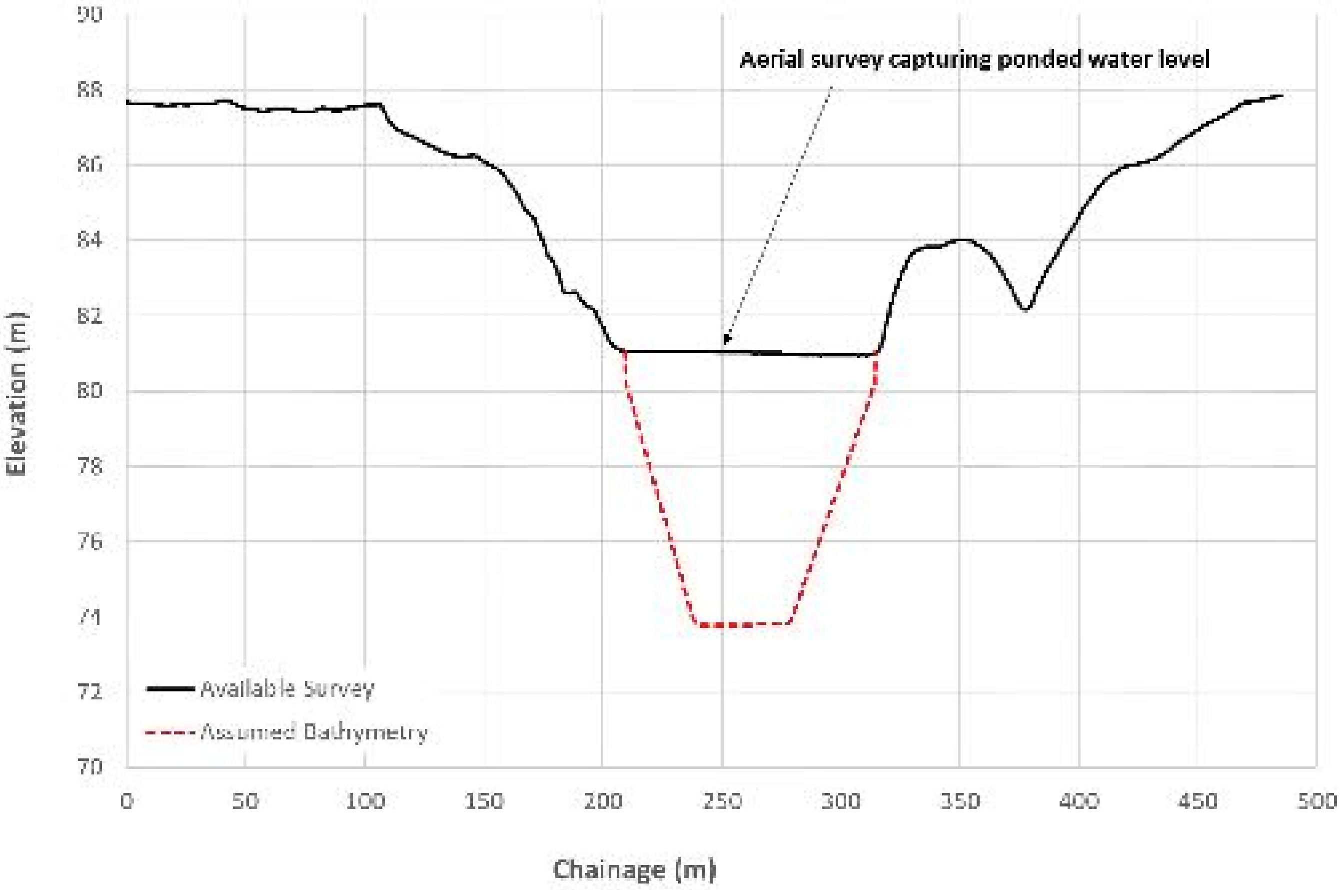

Figure 4.1: Assumed Dawson River Bathymetry – Typical Cross Section

4.2.3 Hydraulic Roughness

Hydraulic roughness was defined using Manning's roughness coefficients applied to various landuse and vegetation types delineated from aerial photography. The Manning's roughness coefficients applied to each land use was determined from the model calibration. The Manning's roughness values for the delineated land use categories are summarised in Table 4.1.

TABLE 4.1: MANNING'S ROUGHNESS VALUES

Land Use	Manning's 'n' Roughness Coefficient
Open space/light vegetation	0.06
River channel (Sandy/light vegetation)	0.035
River channel (standing water)	0.025
Riverbank riparian zone (dense vegetation)	0.11
Moderate vegetation	0.07
Vegetated anabranch channel	0.09
Urban areas	1.00

4.2.4 Hydraulic Structures

The following hydraulic structures have been incorporated into the hydraulic model:

- Neville Hewitt Weir – located in the Dawson River channel at the Baralaba Township,
- The Baralaba-Woorabinda Road bridge – Crossing of the Dawson River downstream of the Neville Hewitt Weir; and,
- Culvert crossing associated with the Baralaba North operations haul road – Crossing of the Dawson River anabranch between the Baralaba North and Central mining areas.

The Neville Hewitt Weir was then represented in the model topography using a two-dimensional break line, raising the model topography at the weir location to RL 80.3m AHD.

The Baralaba-Woorabinda Road bridge crossing of Banana Creek was represented in the model by applying a layered flow constriction at the Bridge location and enforcing the bridge approaches in the model bathymetry using 3D breaklines. The layered flow constriction applies hydraulic losses at the bridge location based on the bridge support pier size and configuration and the roadway deck elevation and thickness.

Culvert crossing associated with the Baralaba North operations haul road was represented using a one-dimensional culvert element based on the culvert dimensions, length, grade and entry and exit configurations (to define minor hydraulic losses). Road levels at the crossing were defined in the model bathymetry using a 3D breakline.

The structure details were sourced from design drawings. Small drainage structures and low-level creek/river crossing structures (minor causeways) within the vicinity of the Project are not likely to impact predicted flooding behaviour in larger flood events.

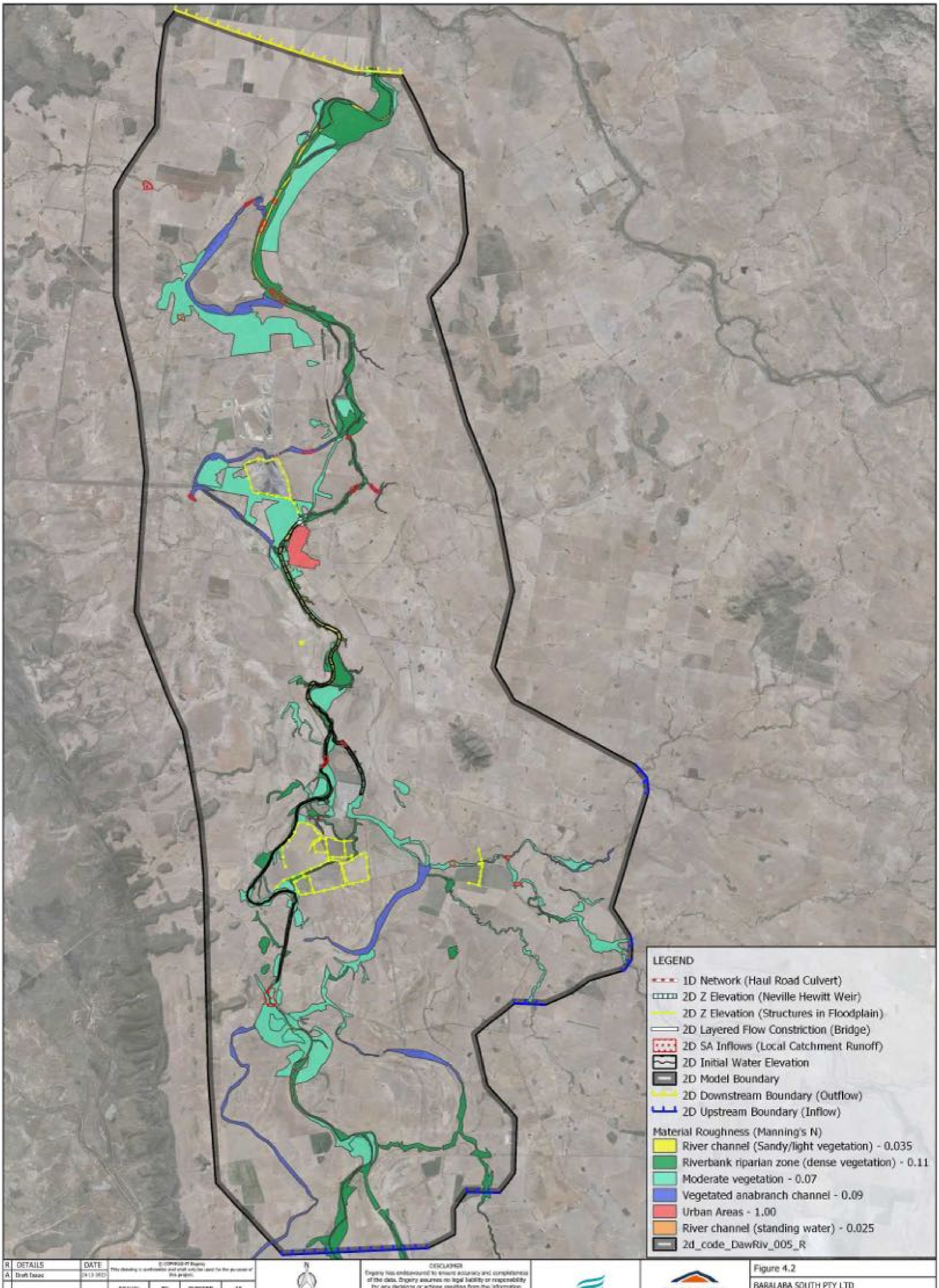

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Figure 4.2

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Flood Impact Assessment
TUFLOW Model Layout

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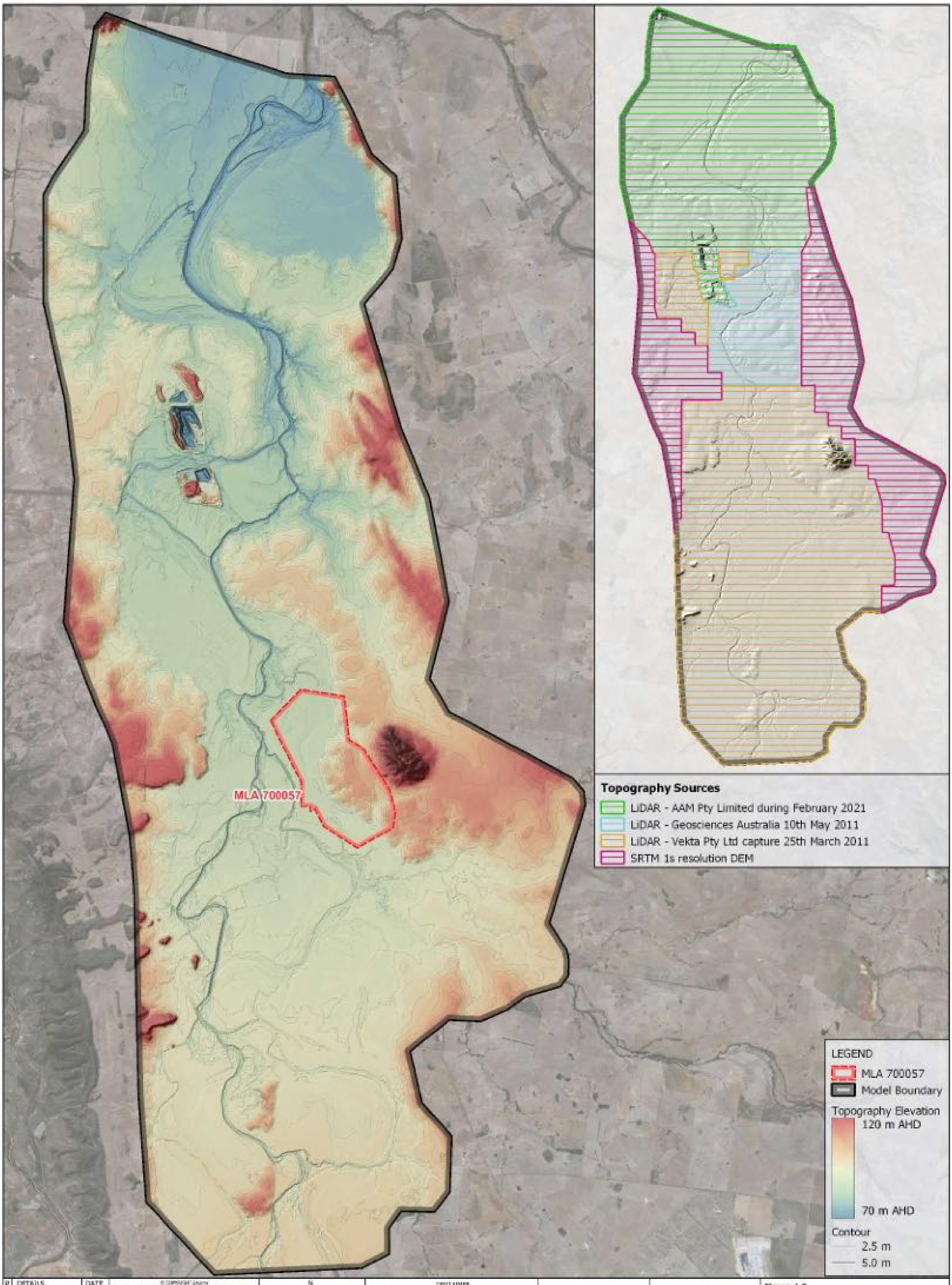

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Figure 4.3

BARALABA SOUTH PTY LTD
Flood Impact Assessment
TUFLOW Model Topography

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QC1018_004

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4.2.5 Boundary Conditions

4.2.5.1 Inflow Boundary Conditions

Routed rainfall runoff hydrographs calculated from the URBS model have been applied to the TUFLOW model at the relevant inflow locations. Runoff hydrographs for the Dawson River, Banana Creek and a number of small creek systems were applied using 2D boundary lines at the upstream extents of the model code boundary. Runoff hydrographs from Individual catchments with outlet locations inside the model boundary are applied using 2D flow over area regions at the outlet location.

4.2.5.2 Outflow Boundary Condition

The hydraulic model has a single outflow boundary (downstream boundary) located on the Dawson River, 35 km downstream of the Project and 18 km downstream of the Dawson River at Beckers streamflow gauging station. The outflow boundary is represented by a stage-discharge relationship calculated from normal depth flow conditions at the outflow boundary channel cross section. The stage discharge relationship is automatically generated by TUFLOW which requires input of a hydraulic grade for the normal depth flow calculation. A Dawson River channel slope of 0.05%, estimated from LiDAR survey data was adopted for the downstream boundary condition hydraulic grade.

The downstream boundary is located 4.5 km upstream of the Don River confluence with the Dawson River which has the potential to produce tailwater influences at the model downstream extent. Therefore, influences from the adopted outflow hydraulic grade and Don River tailwater on the hydraulic model results at the Beckers gauging station and near the Project have been investigated.

To assess the influence of the adopted downstream condition a one-dimensional (1D) hydraulic model (HEC-RAS) of the Dawson River was developed extending from the Baralaba township to12 km downstream of the Don River confluence. The extent and layout of the 1D HEC-RAS model used to assess the hydraulic model downstream boundary condition is shown in Figure **4.4**. The 1D HEC-RAS model was simulated with steady state flows for the following scenarios:

- Dawson River 1% AEP Peak Flow.
- Dawson River 1% AEP Peak Flow and Don River 1% AEP Peak flow applied at the confluence location.

The difference between flood levels for the scenarios above show the extent where the tailwater effects from the Don River influences flood levels in the Dawson River. Figure **4.4** shows a comparison of the flood level profile for the two scenarios above with the extent the Don River influences Dawson River flood levels inferred from where the flood profiles diverge between the two scenarios. The results show tailwater from the Don River only influences Dawson River flood levels within 3.5km of the TUFLOW hydraulic model downstream boundary which remains approximately 14 km downstream of the Beckers gauging station. It is determined the adopted downstream boundary conditions only influence the TUFLOW model results near the boundary location (3.5km) and does not influence results or modelled flood impacts at the Beckers gauging station or further upstream at the Project location.

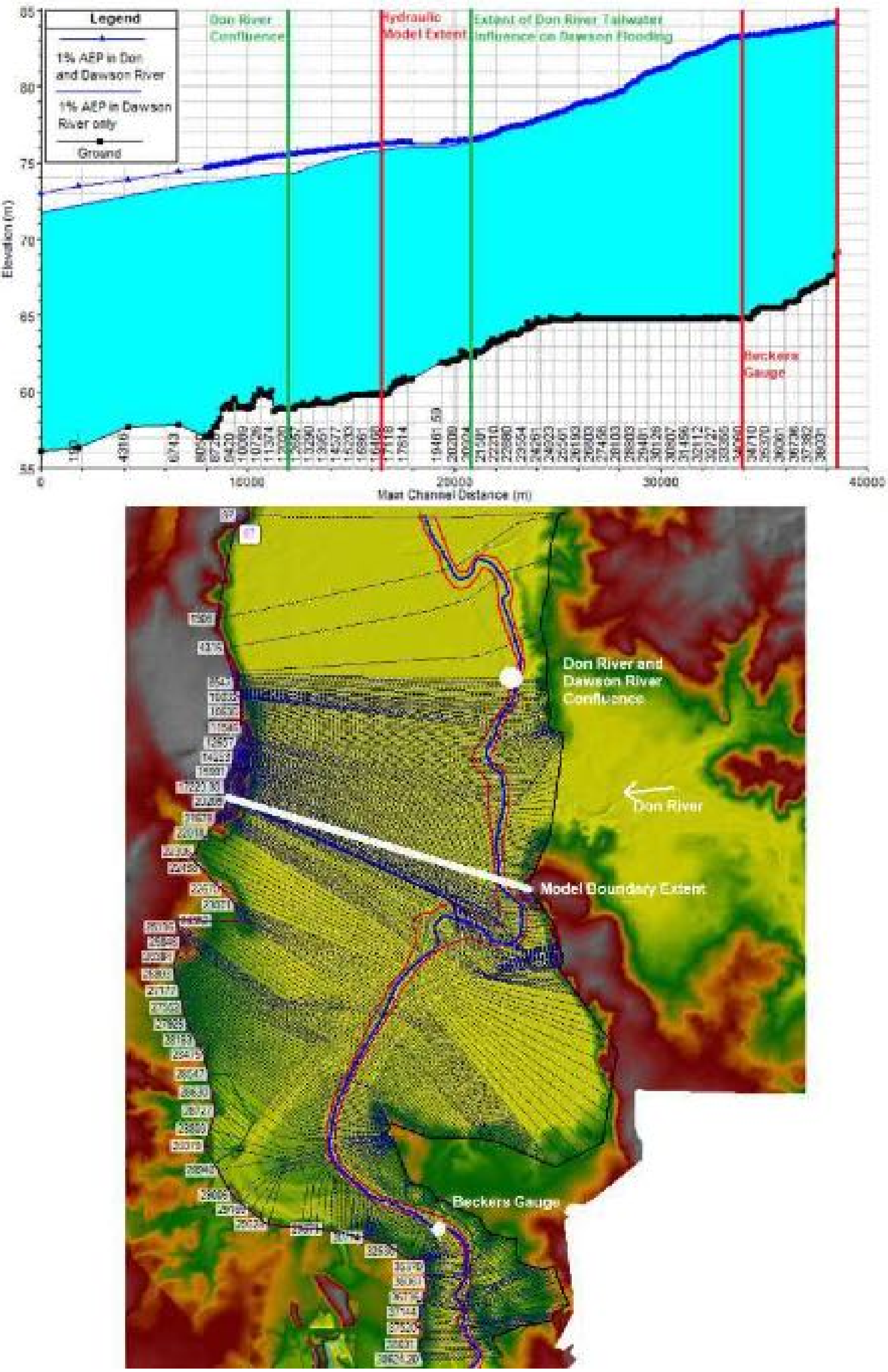

FIGURE 4.4: DOWNSTREAM BOUDNARY CONDITION ASSESSMENT (HEC-RAS)

4.3 Hydraulic Model Calibration

4.3.1 Historic Event Simulations

The Dawson River TUFLOW hydraulic model was calibrated to the December 2010 and January 2013 historic flood events used in the hydrologic model calibration. For both the historic flood events the model has been calibrated to stream height gauging data at Beckers (130322A) and Bindaree (130374A) gauging stations. Modelled and recorded flood levels have also been compared for the Neville Hewitt Weir Headwater gauge operated by Sunwater (130304B) which records flood level only. The Neville Hewitt Weir Headwater gauge malfunctioned during the 2010 flood event with recorded levels increasing by over 1m over 10 minutes near the peak, however, was operational during the 2013 event.

A flood debris survey for the 2010 flood event was undertaken as part of the investigations for the Baralaba North Continued Operations Project (Water Solutions, 2014). Flood debris survey is typically captured by surveying the elevation of water lines or debris caught on houses, sheds, trees, fences or other infrastructure after the flood event. The 2010 flood event debris survey has concerns about reliability as it was completed up to a month after the event and included surveying locations nominated by local landholders instead in addition to water marks and debris visible during the survey (Water Solutions, 2014). Despite concerns of reliability, the flood debris survey was used to infer peak flood levels for the 2010 flood event and compared against modelled peak flood levels to assess the model accuracy.

Landholder consultation undertaken for the Project also produced anecdotal flood information from local landholders present during the 2010 flood event near the Project MLA. The local landholder anecdotal flooding information during the 2010 flood event were used as an additional validation of the model calibration in section 4.3.2.1.

The following sources of flow input data were used in the modelling process:

- Hydrologically routed hydrographs sourced from the Dawson River URBS hydrologic model calibration (refer section 3.3) were adopted at the upstream inflow boundaries for the Dawson River, upstream of the Bindaree gauging station and Banana Creek.
- Local catchment runoff hydrographs from the Dawson River URBS hydrologic model calibration (refer section 3.3) were applied within hydraulic model extent based on the catchment outlet location.

The calibration process involved iteratively simulating the calibration model while modifying key model parameters to improve the fit to the available calibration information. The 2010 flood event was the key focus for the model calibration due to the magnitude of the event and extensive available calibration information. The 2010 and 2013 flood events correspond to approximately a 1% AEP and 10% AEP respectively (refer section 3.4) which allows calibration of parameters suitable for both frequent and rare flood events.

4.3.2 2010 Flood Event Calibration Results

A summary of peak flood level and flood timing calibration performance to the 2010 flood event is provided in Table 4.2. Figure 4.5 presents the model calibration results with a comparison to the December 2010 flood debris survey. Figure 4.5 also presents comparison plots of modelled and recorded times series of water surface elevations at the Bindaree (130374A) and Beckers (130322A) gauging stations.

As mentioned in the previous section, The 2010 flood event debris survey has concerns about reliability as it was completed up to a month after the event and included surveying locations nominated by local landholders instead in addition to water marks and debris visible during the survey (Water Solutions, 2014). The comparison of surveyed and modelled peak flood elevations includes comments on the survey point accuracy as recorded by the surveyors (Water Solutions, 2014).

The following observations are made on the December 2010 flood model calibration results:

- The TUFLOW model reproduces observed peak flood levels accurately at the Beckers gauging station with the modelled peak flood elevation within 0.04 m of recorded.
- The model slightly overestimated peak flood level at the Bindaree gauging station by 0.73m.
- Modelled peak flood levels were within +/- 0.4 m for the majority of the flood debris survey locations with the exception of a small number of outliers due to poor reliability of the surveyed mark used to infer the peak flood height. On average the modelled peak flood levels were within 0.13 m of the flood debris survey when excluding the surveyed flood level outliers. This level of correlation with the

flood debris survey levels is considered reasonable considering the uncertainty associated with inferring absolute peak flood levels from flood debris marks.

- The three flood debris survey marks with “excellent” reliability (sites 12, 16 and 22) are all within 100mm of the modelled peak flood level.
- The flood debris survey marks located on the edge of the historical flood extent match well with the modelled peak flood extent (as shown in Figure 4.5).
- Peak flood timing of the TUFLOW model was slightly later than the recorded data with the modelled flood peak at both gauging stations with the modelled peak flood level being 12.7 to 13.2 hours later than the recorded peaks. The delay in the modelled peak timing aligns with the timing of the input hydrographs from the hydrology model calibration (refer section 3.3.5).
- The modelled travel time of the flood peak timing between the Bindaree and Beckers gauging station matches well with the recorded data with the model predicting 17.5 hours compared to the recorded 17 hours.

TABLE 4.2: 2010 FLOOD EVENT CALIBRATION SUMMARY

		Bindaree Gauging Station (130374A)	Beckers Gauging Station (130322A)
Peak Flood Level (m AHD)	Recorded	94.46	83.81
	Modelled	95.19	83.77
	Difference	**0.73**	**-0.04**
Peak Flood Timing	Recorded	29/12/2010 6:00	29/12/2010 23:00
	Modelled	29/12/2010 18:45	30/12/2010 12:15
	Difference	**+12.7 hours**	**+13.2 hours**
Flood Peak Travel Time Between Bindaree and Beckers Gauging Stations	Recorded	17 hours	
	Modelled	17.5 hours	
	Difference	**0.5 hours**	

4.3.2.1 Model Calibration Results Validation to Landholder Consultation Material

Landholder consultation was undertaken by Baralaba South Pty Ltd, with assistance from AARC for the preparation of the Project EIS from November 2020 to March 2021 and again in October 2023. The landholder consultation produced local insight and information for consideration with the model development and validation. The landholder consultation also produced anecdotal flooding information from local landholders present during the December 2010 flood event which allowed further validation of the 2010 flood model calibration results. The landholder anecdotal flooding information and comparison with the December 2010 flood model results are presented on Figure 4.6. Validation of the 2010 flood model calibration results against the anecdotal flood information shows:

- The flood model accurately reproduced the anecdotal flood extent on the Belvedere property located south of Banana Creek.
- Reports of the flood protection levees on the Harcourt property breaching from overtopping flows was replicated in the model results at the same locations.
- The flood model results showed flooding at the reported dwellings with the model results showing similar depths to the anecdotal information including:
  - Harcourt property reported a flood depth of 0.3 m in the western low set dwelling, and the flood model results show a flood depth of 0.3 m at the same location (no difference).
  - Harcourt property reported a flood depth of 0.85 m below the western high set dwelling (0.15 m below the 1 m high raised floor), and the flood model results show a flood depth of 0.4 m at the same location (0.35m lower).
  - Harcourt property reported a flood depth of 1 m below highset eastern dwelling, and the flood model results show a flood depth of 1.2 m at the same location (0.2 m higher).
  - Riverland property reported a flood depth of 0.75 m at the raised dwelling, and the flood model results show a flood depth of 0.6 m at the same location (0.15 m lower).

- Alberta Vale property reported a flood depth of 0.9 m inside the lowset dwelling, and the flood model results show a flood depth of 1.2 m at the same location (0.3m higher).

TABLE 4.3: DECEMBER 2010 CALIBRATION EVENT COMPARISON WITH FLOOD SURVEY MARKS

Location	Surveyed (m AHD)[1]	Modelled (m AHD)	Difference (m)	Comment on Reliability (Water Solutions, 2014).
1	86.15	86.49	0.34	Good (signs of debris nearby)
2[1]	84.18[1]	85.50	1.32	Fair
3	86.75	87.31	0.56	Good (signs of debris nearby)
4[1]	88.91	89.80	0.89	Fair
5[1]	92.48[1]	93.49	1.01	Good (signs of debris nearby)
6	85.86	86.26	0.40	Reliable (confirmed by waterline on nearby tree)
7	-	87.00	-	Deleted
8	87.97	88.68	0.71	Fair
9	84.49	84.56	0.07	Fair (not much debris as position is in quite long grass)
10	86.36[1]	85.94	-0.42	Good (photographs by Becker Family confirm the marked position)
11	84.34	84.03	-0.31	Fair (mark is within 20-30mm according to Grant, how determined, not known)
12	83.99	84.03	0.04	Excellent
13	84.62	84.27	-0.35	Unverifiable (no debris or other evidence nearby)
14	84.21	84.27	0.06	Unverifiable (no debris or other evidence nearby)
15	85.80	86.09	0.29	Reliable
16	86.96	87.05	0.09	Excellent (does not agree with Sites 17 or 22 which are nearby)
17	86.62	87.06	0.44	Confirmed by other fence Posts nearby
18[1]	83.68[1]	85.50	1.82	Good (Signs of Debris nearby)
19	85.22	85.32	0.10	Reliable (Confirmed by debris in nearby trees)
20	85.54	85.91	0.37	Reliable (Confirmed by Site 21)
21	85.54	85.91	0.37	Reliable (Confirmed by Site 20)
22	87.11	87.10	-0.01	Excellent
Average difference (m)			0.37	
Average difference excl. outliers (m)			0.13	

Note: Survey levels, locations and comments on reliability adopted from the Baralaba North Continued Operations Project Flood Study report *(Water Solutions, 2014)*

[1] Surveyed flood levels considered outliers or inaccurate due to the survey levels not consistent (significantly higher or lower) with other nearby surveyed levels or the surveyed flood level being lower than the ground elevation (inferred from available aerial survey data).

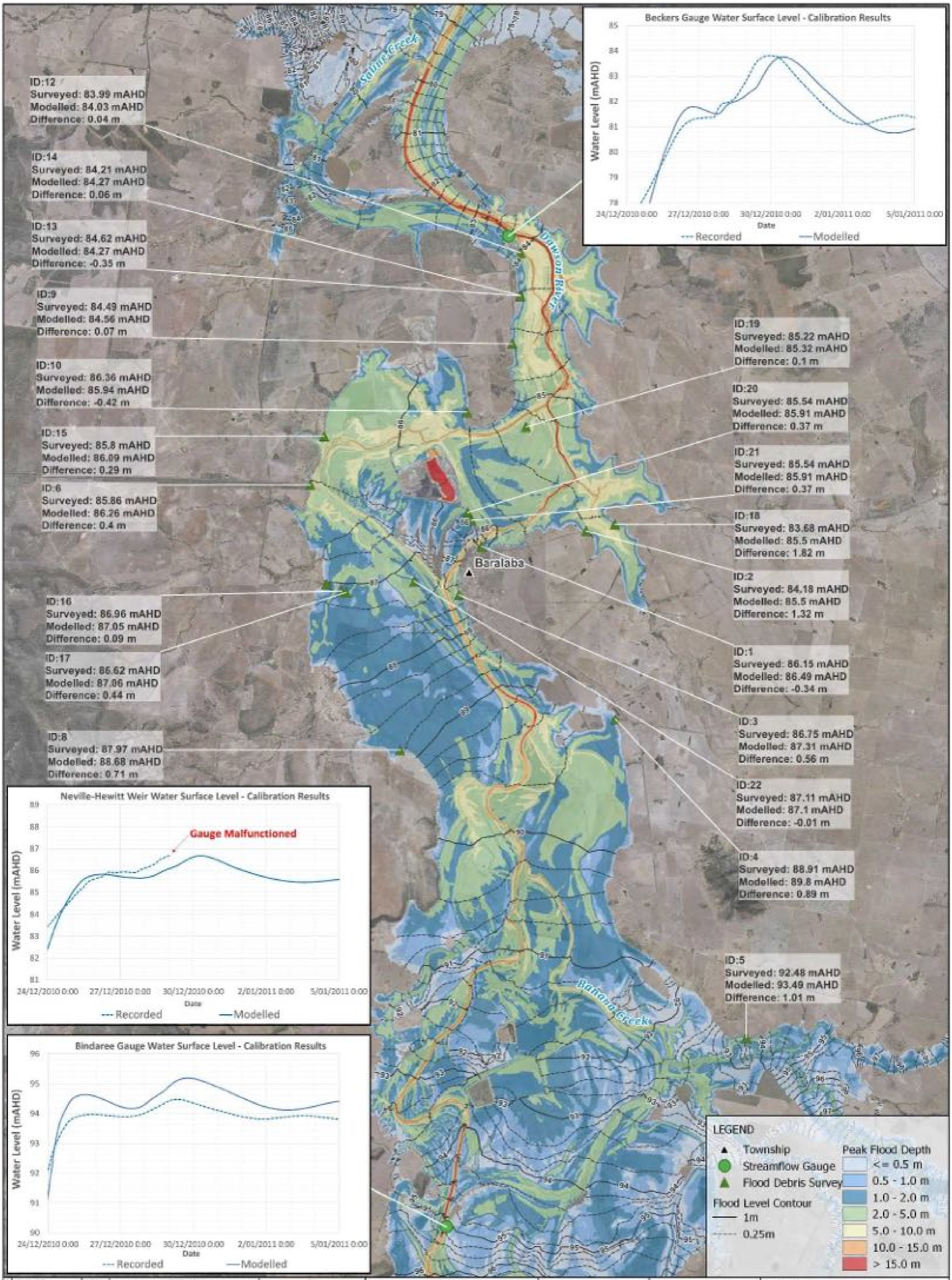

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Figure 4.5

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Flooding Impact Assessment
December 2010 Hydraulic Model Calibration
Results and Comparison with Flood Debris Survey

Job Number:
QC1318_004

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Location	Landholder Flooding Information	Model Results
Belvedere - Approximate flood extent during December 2010 event	The 2010 flood waters came close to a shed located in the north-west of property as marked on a map during consultation in 2020	The flood model results show a similar flood extent to the marked flood extent.
Harcourt - Flood levees breached during December 2010 event	The flood levees within the property were breached during the 2010 flood	Food results show the levees breaching in multiple locations as reported during consultation in 2020.
Harcourt - Flooding at western lower dwelling	The Lower section of house and walkway reported as being under a foot of water (30 cm).	Modelled flood depth of 0.3m at the lower building
Harcourt - Flooding at eastern dwelling	Flood depth was approximately 1m deep beneath the high-set dwelling during the December 2010 event (located at the eastern side of the property)	Modelled flood depth of 1.2m which shows a good comparison to the reported 1m depth.
Riverland - Flooding at dwelling	The 2010 flood was waist deep (approximately 0.75m) at the dwelling location (raised dwelling)	Modelled flood depth of 0.6m at the dwelling location
Alberta Vale - Flooding at dwelling	Flood depth was approximately 0.9 m inside the low set dwelling.	Modelled flood depth of 1.2m at the Alberta Vale dwelling which would be a good match with the reported 0.9m flood depth inside the dwelling with an assumed of house slab thickness of 0.3m.
Harcourt - Flooding at western upper dwelling	Flood waters up to middle step of upper house and 6 inches (0.15 m) below the floor boards with an assumed floor height of 1m.	Modelled flood depth of 0.4m at the upper dwelling.

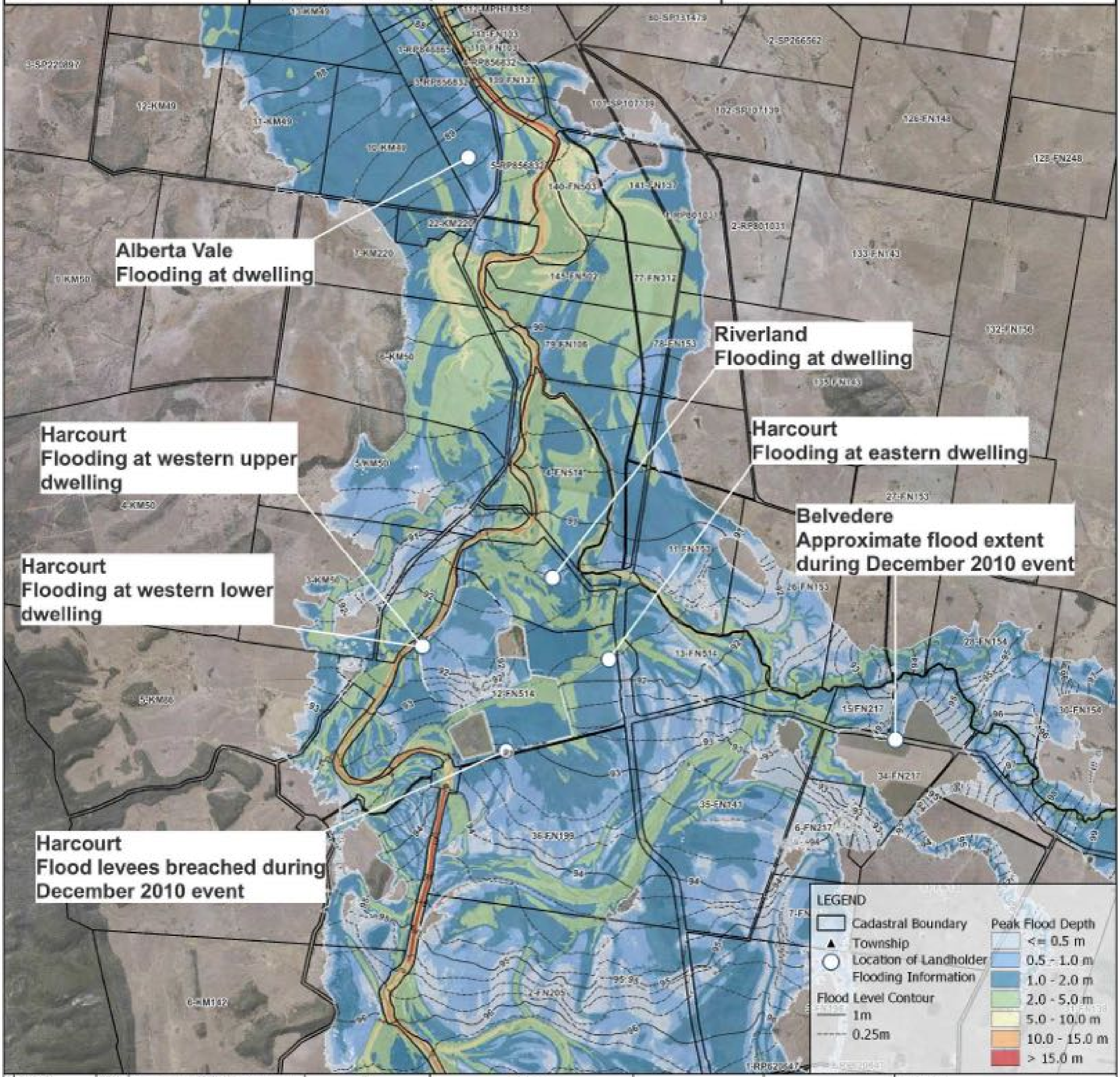

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Figure 4.6

BARALABA SOUTH PTY LTD
Flooding Impact Assessment
December 2010 Flood Event Validation to Anecdotal Flood Information

Job Number:

4.3.3 2013 Flood Event Calibration Results

A summary of peak flood level and flood timing calibration performance to the January 2013 flood event is provided in Table 4.4. Figure 4.7 presents the model calibration results, including comparison plots of modelled and recorded times series of water level at the Bindaree (130374A) and Beckers (130322A) gauging stations.

The following observations are made on the January 2013 flood model calibration results:

- The TUFLOW model was able to reproduce peak flood levels within 0.03 m of those recorded at the Bindaree gauging station, 0.07 m at the Beckers gauging stations and 0.02m at the Neville Hewitt Weir headwater gauge.
- The peak flood level travel time between the Bindaree and Beckers gauging stations is reproduced well by the calibration model with the model estimating a travel time of 17 hours and the recorded data showing 16 hours.
- The TUFLOW model reproduces a similar water level rate of rise during the event at both gauging stations showing the model accurately reproduces flood travel time along the Dawson River between the two gauges.

TABLE 4.4: 2013 FLOOD EVENT CALIBRATION SUMMARY

		Bindaree Gauging Station (130374A)	Neville Hewitt Weir Headwater (130304B)	Beckers Gauging Station (130322A)
Peak Flood Level (m AHD)	Recorded	93.42	84.86	79.39
	Modelled	93.39	84.84	79.32
	Difference	**-0.03**	**-0.02**	**-0.07**
Peak Flood Timing	Recorded	28/01/2013 13:00	29/01/2013 between 16:15-23:45[1]	29/01/2013 5:00
	Modelled	28/01/2013 17:30	29/01/2013 2:45	29/01/2013 10:30
	Difference	**4.5 hours**	**3 to 7.5 hours[1]**	**5.5 hours**
Flood Peak Travel Time Between Bindaree and Beckers Gauging Stations	Recorded		16 hours	
	Modelled		17 hours	
	Difference		**1 hour**	

[1] *Neville Hewitt Weir Headwater gauging station data did not have recordings of the peak timing however shows it occurred between 4:15pm and 11:24pm on 29 September 2013.*

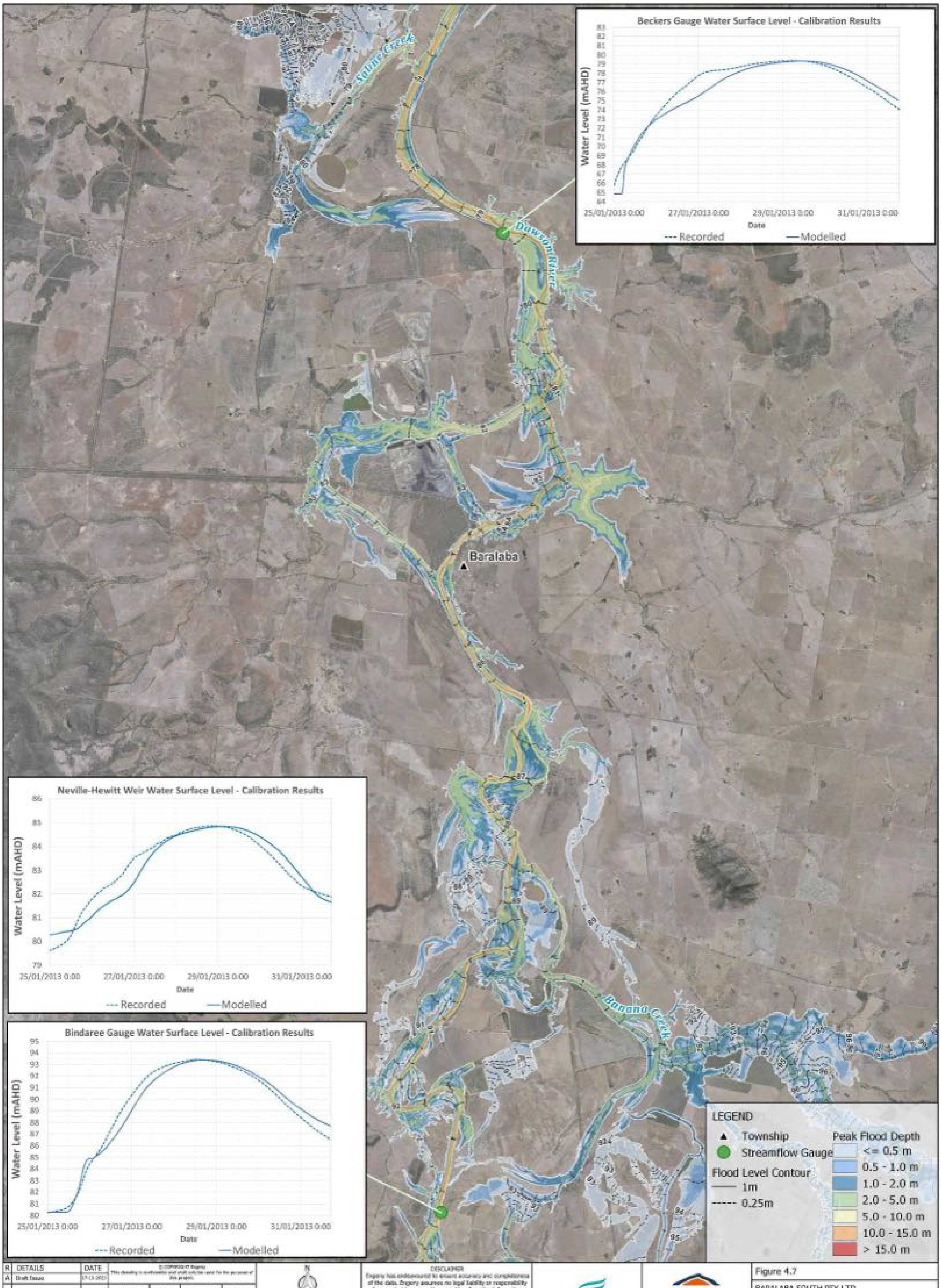

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Figure 4.7

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Flooding Impact Assessment
January 2013 Hydraulic Model Calibration Results

Job Number:
QC1018_004

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4.3.4 Hydraulic Model Calibration Summary

The hydraulic model was able to reproduce peak flood levels at both the Bindaree gauging station and the Beckers gauging station for the 2010 and 2013 calibration events. The hydraulic model provided a close match to recorded peak flood level timing between the Beckers and Bindaree gauging stations, indicating good representation of flood velocity and flood wave travel time along the modelled extent of the Dawson River. The model also matched well with flood survey marks captured from the December 2010 flood event. Based on the model calibration results the hydraulic model is considered suitable to assess the flooding impacts associated with the Project.

4.4 Baseline Flooding

The baseline model was simulated for the 10%, 2%, 1% AEP to determine baseline flood results for comparison against the mine developed case model (refer Section 4.5) and assess the associated flood impacts of the Project. The model was also simulated for the extreme events including the 0.1% AEP and PMF to determine potential impacts and flood risks for the Project. The baseline flood result maps for peak flood depth, velocity and flood inundation duration are provided in Appendix B for 10% to 1% AEP flood events. Extreme event flood maps (0.1% and PMF) are provided in Appendix G. The following section provides a description of the baseline flood behaviour and existing flood risk.

4.4.1 Baseline Flooding Behaviour

The baseline flood behaviour and current flood risk within the vicinity of the Project is described below:

- Flood flows begin to break out of the Dawson River and Banana Creek channel in events greater than the 10% AEP and flow across the eastern floodplain at the Project site. The Project MLA area is partially inundated in the 2% AEP flood event but is not inundated in the 10% AEP flood event.
- The Dawson River floodplain has a flow width of approximately 5.5 km in flood events greater than 2% AEP adjacent to the Project.
- The flood extent in the 1% AEP event inundates approximately 50% of the Project MLA area however inundates less than 16% of the proposed Project disturbance area.
- Flooding of the Dawson River at the Baralaba township is largely confined to the main river channel although minor flooding of the local school and properties boarding the river channel results in the 1% AEP flood event.
- Peak flow velocities in the 1% AEP flood event within the Dawson River channel adjacent to the Project are generally between 1.0 m/s and 3.0 m/s and peak flood velocities on the floodplain areas are generally below 1.0 m/s.
- Properties located on the Dawson River floodplain near the Project site are inundated for >250 hours in the 1% AEP flood event. It is noted the duration of inundation is heavily dependent on the storm duration.
- Figure 4.8 shows the baseline flood wave travel time between the Bindaree (130374A) gauging station and the Beckers (130322A) gauging station. This shows the peak flood wave travel time between the Bindaree (130374A) and Beckers (130322A) gauging stations is approximately 22 hours in the 10% AEP flood event and 18 hours in the 1% flood event.

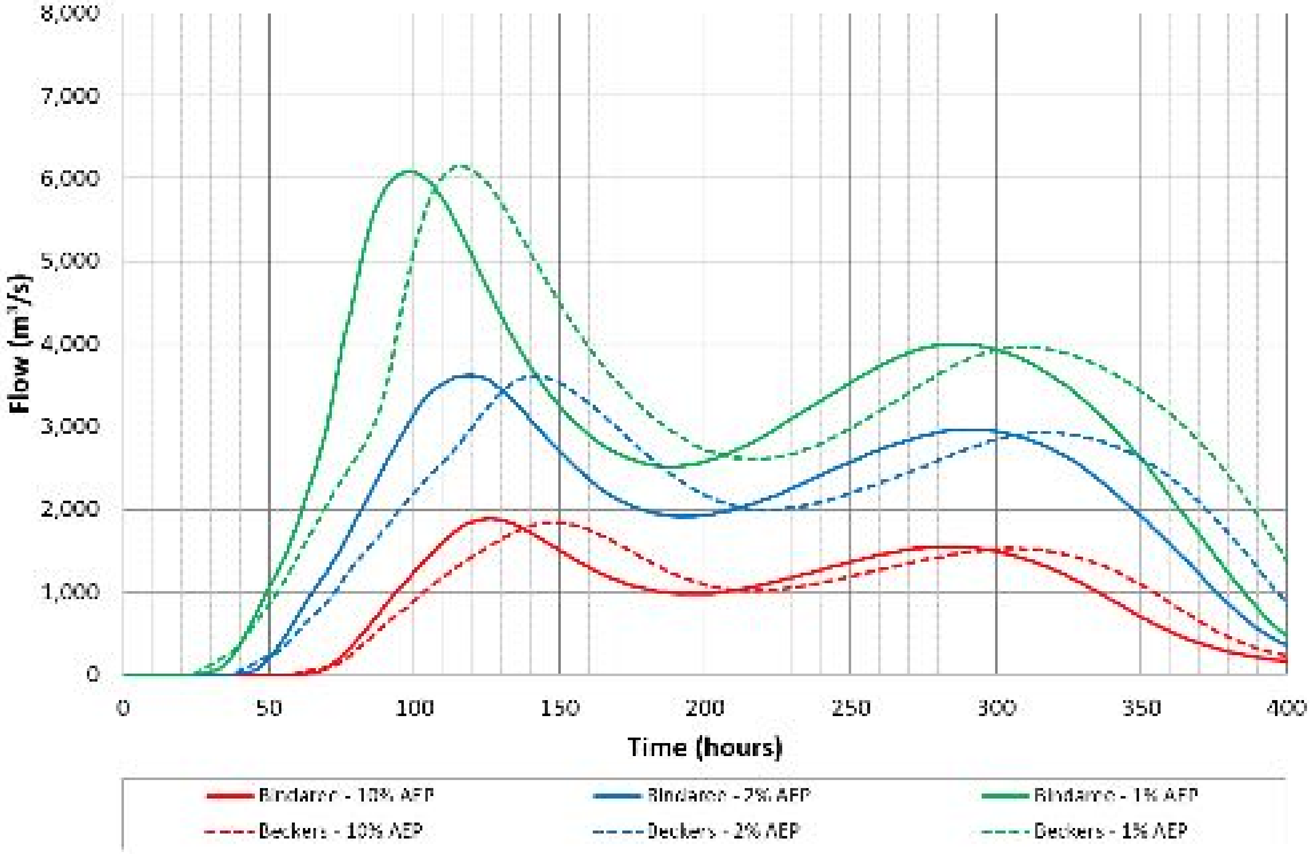

Figure 4.8: Baseline Flood Wave Travel Time

4.5 Banana Creek Dominated Flooding

Banana Creek flows around the southern extent of the MLA and enters Dawson River to the west of the MLA. Banana Creek dominated flooding scenarios have been assessed to determine if the Project results in larger flooding impacts for a major flood in Banana Creek with minor flooding in the Dawson River. Banana Creek design hydrology peak flows are much lower than the Dawson River, however flood impacts may be increased due to the removal of tailwater influences from the Dawson River on Banana Creek.

Banana Creek dominated Flooding scenario has been simulated for a 1% AEP Banana Creek peak flow and a 10% AEP peak flow in the Dawson River. The 10% AEP flow is similar to the 2013 historical event, with the Dawson River flood flow is contained in the main channel. The 1% AEP flow in Banana Creek then results in widespread flooding of the lower reaches of Banana Creek before the Dawson River confluence adjacent the Project. Banana Creek dominated flooding results are presented in Appendix I. The baseline Banana Creek flooding results show:

- The 10% AEP flood event is mostly contained within the Banana creek channel, however there is a small breakout flow path through the eastern side of the MLA before entering the Dawson River via an anabranch channel at the northern extent of the MLA.
- 1% and 0.1% AEP Banana Creek flood events engage the floodplain with floodwater breaking out of the Banana Creek channel upstream of the Project, flowing towards the Dawson River.
- The 1% and 0.1% AEP Banana Creek flood events also has a breakout flow path through the eastern side of the MLA, with flood waters spilling from the floodplain into the Dawson River channel at the eastern and northern extents of the MLA.
- Peak flood velocities for the Banana Creek dominated flooding are similar to the Dawson River scenario with peak flood velocities on the floodplain within the Project MLA between 0.6 m/s and 1.0 m/s.
- The extent of flooding for the 1% and 0.1% AEP Banana Creek flood events is similar to the Dawson River scenarios at the southern extent of the Project area however is smaller at the Dawson River and Banana Creek confluence as waters enter the Dawson River channel.

Analysis of the Banana Creek dominated flooding impacts associated with the Project are presented in Section 6.12.

5. MINE DEVELOPED CASE MODELLING

The calibrated Dawson River hydrology and hydraulic flood models were used to assess the flood impacts associated with the operational and post mining phases of the Project. Over the duration of the Project the out-of-pit overburden dump will be developed at the northern extent of the mining pit and will remain as a post mining landform. The out-of-pit dump is not required to perform the function of pit flood protection immunity, however the northern section of it is located partially within the Dawson River 0.1% AEP flood extent and may result in flooding impacts. The proposed surface water infrastructure associated with the Project is shown in Appendix A and described in the Surface Water Impact Assessment report (Engeny, 2023)

The out-of-pit overburden dump is developed during the early years of the Project and then overburden is used to progressively backfill the pit as it progresses south as shown in Appendix A. The landform at end of mining and post mining result in the largest obstruction of the Dawson River floodplain and therefore would produce the largest flooding impacts associated with the Project. Therefore, the end of mining landform has been used for the Mine Developed Case flooding simulations and used to assess changes in flood behaviour and impacts associated with the Project. Figure 5.1 shows the end of mining landform relative to the 1% AEP flood extent that was used to assess flooding impacts for the Project. The scenarios assessed are summarised in Table 5.1.

The Mine Developed Case flood results for peak flood depth, velocity and flood inundation duration are provided in Appendix C for 5% to 1% AEP flood events. Extreme event flood maps (0.1% and PMF) are provided in Appendix G and demonstrate the pit maintains 0.1% AEP flood protection for the Project duration and that the final void will maintain Probable Maximum Flood (PMF) immunity. The Project is located outside of the 10% AEP flood extent for the Dawson River and Banana Creek, therefore flood maps for the 20% AEP event have not been presented or discussed.

Existing Case and Mine Developed Case flood results for the Banana Creek dominated flooding scenario are presented in Appendix I.

TABLE 5.1: MINE DEVELOPED CASE MODEL SIMULATION DESCRIPTION

Scenario	Description
Existing Case	Represents the baseline flooding described in Section 4.4 used to assess flooding impacts of the Project. The Existing Case Model represents current conditions prior to the development of the Project. This model incorporates an assessment of cumulative impacts as it includes infrastructure and landforms associated with the Baralaba North Mine.
Mine Developed Case	Represents the operational and post mining phases of the Project. The Existing Case model was updated to include the mine landform within the Dawson River floodplain. The Mine Developed Case was compared against the Existing Case to determine the associated flood impacts for the Project operational and post mining phases. The realignment of the Moura Baralaba Road was not represented in the Mine Developed Case because it was beyond the influence of the effective flow area of the Dawson River flood plain and would not change the predicted flood impacts associated with the operational flood levee and final post mining landform.

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Figure 5.1

BARALABA SOUTH PTY LTD
Flood Impact Assessment
Mine Landform Compared to Existing Case 0.1% AEP Flood Extent

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6. FLOOD IMPACT ASSESSMENT

The impacts of the Project on existing flooding conditions are described in the following sections. As described in Section 5, the flood impact assessment reflects a cumulative impact assessment as it takes into account landforms associated with the Baralaba North Mine that may affect flood behaviour. There are no other known planned or future developments that would influence flood behaviour near the Project location. Table 6.1 below summarises the location of the Mine Developed Case flood results and flood impact mapping.

TABLE 6.1: FLOOD IMPACT MAPPING LOCATION

Flood Mapping Set	Location in This Report
Mine Developed Case Flood Results	Appendix C:
Flood Level Afflux	Appendix D:
Flood Velocity Change	Appendix E:
Change in Flood Inundation Duration	Appendix F:
Extreme Event Flood Results	Appendix G:
Stream Power and Shear Stress Assessment	Appendix H:
Banana Creek Dominated Flooding	Appendix I:
Sensitivity Scenario Flood Depth and Afflux.	Appendix J:

6.1 Project Flood Impact Objectives

The flood impact objectives adopted for the Project are outlined in Table 6.2. Assessment of modelled flood impacts up to the 1% AEP flood event against the flood impact objectives is provided in Sections 6.8, 6.9 and 6.10.

TABLE 6.2: FLOOD IMPACT OBJECTIVES (FOR EVENTS UP TO THE 1% AEP)

Land Use	Objective
Existing habitable structures (e.g., dwellings)	• Where flooding is predicted to occur above habitable floors in the existing case, flood level afflux of ≤1 cm; and, • Where flooding occurs below habitable floors in the existing case, flood level afflux does not cause above habitable floor flooding.
Existing non-habitable structures (e.g., agricultural sheds, carports, containers, meter boxes)	• Flood level afflux of ≤5 cm.
Property with agricultural (cropping) land use	• Flood level afflux of 20 cm.
Property with agricultural (grazing) land use	• Flood level afflux of 40 cm.
Roads	• Less than 10% increase in untrafficable road length.

6.2 Flood Depth Afflux

Mapping showing the flood depth afflux for the Mine Developed Case is provided in Appendix D. Key observations are:

- There is no change in flood depth in flood events up to an including the 10% AEP since the Project footprint is located outside of the 10% AEP Existing Case flood extent.
- Flood afflux up to 200 mm is predicted for the 2% AEP and 1% AEP flood events in localised areas against the mine landform within the Project MLA.
- Flood afflux outside of the Project MLA will be less than 10mm for the 2% AEP flood event.
- Flood afflux of up to 40mm is predicted to occur outside of the Project MLA in a 1% AEP flood event between Banana Creek and the Project MLA, with up to 20 mm of flood afflux predicted on the Dawson River floodplain to the west of the Project MLA.
- Areas with flood afflux between 10mm and 20 mm in a 1% AEP are limited to the area immediately to the west of the Project MLA.
- The Project will cause a small (less than 10 mm) reduction in peak flood levels in the Dawson River channel and on the eastern floodplain downstream of the Project MLA in a 1% AEP flood event. This is due to the Project directing slightly more flood waters in larger flood events to the western floodplain and anabranch.
- The flood modelling of the Project shows no change in peak flood levels at the Baralaba township greater than 0.001 m for flood events up to the 1% AEP event.

6.3 Flood Velocity Change

Mapping showing the change in peak velocity for the Mine Developed Case is provided in Appendix E. Key observations on the velocity changes include:

- The Project will not impact flood velocities for all events up to and including the 10% AEP flood event.
- Areas with changes in peak flood velocity greater than 0.1m/s are limited to very localised areas immediately adjacent to the Project within the Project MLA for the 2% AEP and 1% AEP flood events.
- For all AEP flood events assessed, flood velocity changes greater than 0.1 m/s are not expected to occur outside of the Project MLA boundary.

In summary, the changes in flow velocity up to and including the 1% AEP event are predicted to be within 0.1 m/s to 0.3 m/s adjacent to the northern out-of-pit dump and will be contained within the MLA boundary. There are negligible changes to peak flood velocity outside of the Projects MLA boundary.

6.4 Flood Timing and Flood Travel Times

The Mine Developed Case results in alteration to the Dawson River floodplain by reducing floodplain storage and potentially impacting flood travel times and peak flood flows along the Dawson River. The potential changes to flood timing and flood travel time as a result of the Project has been assessed using the TUFLOW model between the Bindaree (130374A) gauging station and the Beckers (130322A) gauging station locations.

Table 6.3 shows a comparison of peak flows calculated from the TUFLOW model at the Beckers (130374A) gauging station and flood peak travel times between the Bindaree (130374A) gauging station and Beckers (130374A) gauging station for the Existing Case and Mine Developed Case.

Figure 6.1 compares design event flood hydrographs from the Existing Case and Mine Developed Case calculated from the TUFLOW model at the Beckers (130322A) gauging station location. The comparison of flood timing and travel times shows:

- There is negligible change to peak flow rates at the Beckers gauging station downstream of the Project for all flood events up to the 1% AEP event.
- There is no change in the flood peak travel time from the Bindaree (130374A) gauging station to the Beckers (130322A) gauging station for all flood events up to the 1% AEP event.

TABLE 6.3: FLOOD TIMING AND TRAVEL TIMES IMPACT SUMMARY

Value	Scenario	Flood Event Annual Exceedance Probability (AEP)		
		10% AEP	2% AEP	1% AEP
Peak Flow at Beckers Gauging Station (m^3/s)	Existing Case	1,844	3,610	6,149
	Mine Developed Case	1,844	3,611	6,152
	Change	0	1 (<0.03%)	3 (<0.05%)
Flood Peak Travel Time from Bindaree to Beckers Gauging Stations (hours)	Existing Case	22.0	22.0	18.0
	Mine Developed Case	22.0	22.0	18.0
	Change	0.00	0.00	0.00

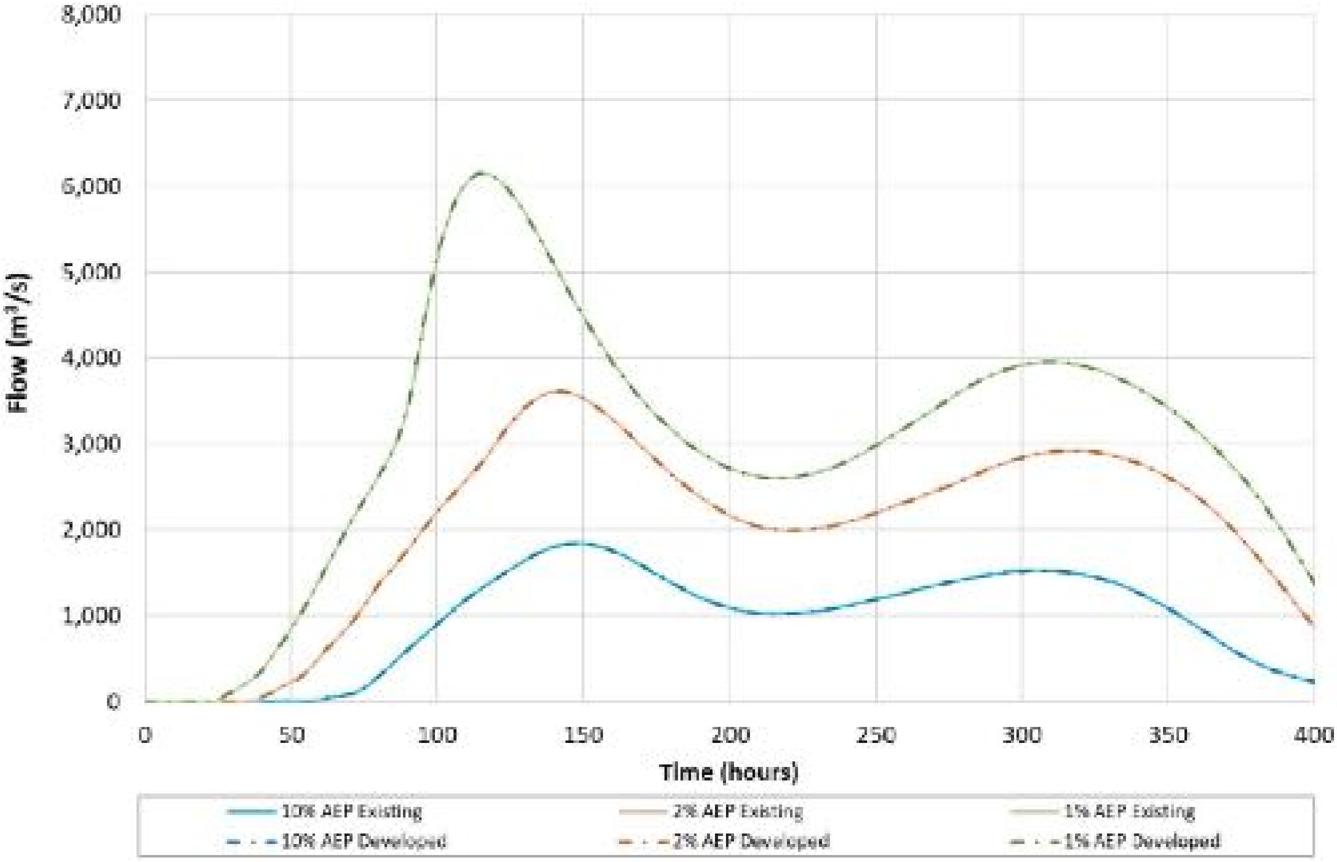

Figure 6.1: Comparison of Flood Hydrographs at Becker's Gauging Station

6.5 Flood Inundation Duration

To assess the time of flood inundation, the TUFLOW model was used to provide the duration (hours) for which a model cell had a flood depth of greater than 0.1 m during the flood model simulation. The time of inundation results for the Existing Case and the Mine Developed Case were compared to infer the spatial change in inundation time for each AEP flood event. It is important to note the time of inundation duration is a function of storm duration adopted for the design event. Flood inundation duration has been assessed only for the critical storm events for each AEP (storm duration that produces the highest peak flow).

Mapping of the change to flood inundation duration for the Mine Developed Case is provided in Appendix F. Reviewing the results show that inundation duration is unchanged for flood events up to and including the 1% AEP.

6.6 Stream Power and Bed Shear Stress Assessment

Change to stream power and bed shear stress in the Dawson River channel and floodplain areas has been assessed for the 10% and 1% AEP flood events. Appendix H provides stream power and bed shear stress maps for the Existing Case and difference mapping for the Mine Developed Case. The stream power and bed shear stress assessment shows:

- Stream power in the Existing Case is typically less than 10 W/m^2 on the Dawson River floodplain and less than 100 W/m^2 in the Dawson River channel for the 10% and 1% AEP flood events. Higher stream power is reported at channel meanders and locations with an increase in channel grade.
- Bed shear stress in the Existing Case is typically less than 10 N/m^2 on the Dawson River floodplain and less than 50 N/m^2 in the Dawson River channel for the 10% and 1% AEP flood events.
- The Mine Developed Case results show no change to stream power and bed shear stress in the 10% AEP flood event.
- Only minor changes in stream power and bed shear stress are predicted for the 1% AEP flood event and isolated to areas inside the MLA boundary, adjacent to the mine landforms.

6.7 MSES Wetland Area

As discussed in Section 2.5, there is a mapped wetland classified as a MSES high ecological significance wetland situated within and adjacent to the MLA between the Dawson River and the Project. The modelled flood impacts at the wetland location are summarised in Table 6.4. The flood model results show the wetland becomes flooded at AEP’s smaller than 10%, however no change in flooding conditions occur in a 2% AEP flood event. Peak flood depths are increased by 0.02 m for a 1% AEP flood event which is expected to have negligible impact to the wetland condition. Peak flood velocity remains unchanged for all flood events, which indicates no increased risk of erosion during flood events. Based on the assessment, the Project is not expected to result in flooding impacts to the MSES wetland.

TABLE 6.4: MSES HIGH ECOLOGICAL SIGNIFICANCE WETLAND FLOOD IMPACTS

Flood Event AEP	Peak Flood Depth (m)			Peak Flood Velocity (m/s)		
	Existing Case	Mine Developed Case	Change	Existing Case	Mine Developed Case	Change
10% AEP	Wetland not inundated in a 10% AEP flood event					
2% AEP	0.85	0.85	**<0.01**	0.15	0.15	**<0.01**
1% AEP	1.99	2.01	**0.02**	0.38	0.38	**<0.01**

6.8 Habitable and Non-Habitable Structures

Flood Impacts in the location of habitable and non-habitable structures have been assessed against the Project flood impact objectives (Section 6.1). The flood model shows there are no changes in flooding at existing habitable and non-habitable structures in all events up to the 2% AEP flood event.

Afflux between 1 cm and 2 cm is predicted at a number of non-habitable structures in the 1% AEP flood event including:

- Two unidentified structures on the Riverland property (4/FN514) adjacent the Banana Creek channel with predicted afflux up to 2.6cm (26mm).
- Two sheds on the Alberta property (5/KM50) with predicted afflux of up to 1.4cm (14mm).
- One silo on the Alberta property (6/KM50) with predicted afflux of up to 1.1cm (11mm).

Although flood afflux between 1 cm and 2 cm is predicted at 5 non-habitable structures, it impacts remain below the flood impact objective of 5 cm for non-habitable structures. Afflux greater than 1 cm is not predicted to occur at any existing habitable dwelling for flood events up to the 1% AEP event.

6.9 Agricultural Land Use (Cropping and Grazing)

Flood impacts to agricultural land (cropping and grazing) have been assessed against the Project flood impact objectives (Section 6.1). All properties with cropping or grazing lands were assessed as meeting the flood impact objectives. Afflux to agricultural land outside of the Project MLA does not exceed 1cm for flood events up to the 2% AEP. Afflux of 1 cm to 3 cm in the 1% AEP flood event is predicted on the nearby properties 'Riverland', 'Alberta' and 'Mount Ramsay', however remains well below the flood impact objective of 20 cm and 40 cm for cropping and grazing land uses respectively. The flood level afflux maps in Appendix D illustrate the spatial variation in afflux across each of the properties.

Impacts to agricultural crops and grazing land as a result of changes to flooding will depend on a large number of factors including soil types, flow velocity, depth and duration of inundation, amount of soil and debris deposited, the pasture species/crop type and the season or growth phase of the crop/pasture. For the purposes of the study, the flood impact objectives of 20 cm and 40 cm afflux have been adopted for cropping and grazing lands respectively and will be used as a trigger to identify properties with potential impacts.

6.10 Roads

Flood impacts to roads in the vicinity of the Project have been assessed against the Project flood impact objective for roads (Section 6.1). The flood impact objective for existing roads is less than a 10% increase in un-trafficable road length for the Mine Developed Case. Roads have been assessed as un-trafficable when flood depths over the road are greater than 0.3 m which is the depth limit for when small sized vehicles become unstable (Ball J, 2019).

Negligible changes to road inundation lengths are predicted for all events up to the 1% AEP flood event, therefore road trafficability is not expected to be impacted.

6.11 Impacts to Other Nearby Infrastructure and Towns

Infrastructure with potential to be affected by flooding as a result of the Project is shown in Figure 2.9 in Section 2.6.2. Table 6.5 summarises the identified flood afflux impacts to nearby infrastructure for the Mine Developed Case. The flood model shows there are negligible flood impacts (less than 0.01m flood afflux) to nearby infrastructure and the Baralaba township for flood events up to the 0.1% AEP event.

TABLE 6.5: FLOOD IMPACTS TO NEARBY INFRASTRUCTURE AND TOWNS

Infrastructure ID	Potential Impact
Baralaba Township	<0.01 m flood level increase in all events up to the 0.1% AEP flood event

Infrastructure ID	Potential Impact
Neville Hewitt Weir	<0.01 m flood level increase in all events up to the 0.1% AEP flood event
Baralaba Woorabinda Road Bridge	<0.01 m flood level increase in all events up to the 0.1% AEP flood event
Moura Baralaba Road Bridge	<0.01 m flood level increase in all events up to the 0.1% AEP flood event
Baralaba North Mine	<0.01 m flood level increase in all events up to the 0.1% AEP flood event

6.12 Banana Creek Dominated Flooding

Banana Creek dominated flooding was assessed for the Existing Case and Mine Developed Case scenarios for the 10%, 1% and 0.1% AEP event to determine the extent of flooding impacts compared to the Dawson River flood discussed above. The Banana Creek dominated 10%, 1% and 0.1% AEP flood results for the Existing Case and Mine Developed Case are presented in Appendix I, as well as the change to flood depth (afflux) and peak velocity. The Banana Creek dominated flooding scenario shows:

- Similar to the Dawson River flooding scenarios there are no impacts for the Banana Creek 10% AEP flood event.
- The extent of flooding impacts for the Banana Creek 1% and 0.1% AEP events is less than the Dawson River scenarios, however, shows larger increases in flood afflux within the MLA.
- The Banana Creek dominated flood afflux shows the Project results in flood depth increases of up to 30mm outside of the MLA boundary in the 1% AEP event, however, is limited to the area between the MLA and Banana Creek. Afflux between 10mm and 20mm is also predicted on the western Dawson River floodplain adjacent to the Project in a small number of isolated locations.
- Although the extent of impacts is less, the magnitude of impacts is predicted to be slightly higher immediately adjacent to the mine landform within the Project MLA.
- Banana Creek 1% AEP flood impacts for both peak flood depth (afflux and velocity) is lower than the Dawson River 1% AEP flood impacts outside of the Project MLA.

Based on the Banana Creek dominated flooding assessment it was determined that the Project will result in larger flooding impacts for a Dawson River dominated flood and represents the overall flood impacts for the Project.

6.13 Project Flood Risks

The following sections outline flood risks for the Project for flood events up to the 0.1% AEP during the operational phase of the mine and the PMF post closure.

6.13.1 Site Infrastructure

The water management infrastructure stage plans presented in Appendix A show the proposed mine landform over the Project Life. The flood model results show all mine water storages and site infrastructure proposed for the Project are located outside of the 0.1% AEP flood extent besides the northern section of the out of pit dump and number of small sediment dams.

There are a number of sediment dams and located at the downstream toe of the out-of-pit dump. These dams have greater than 10% AEP flood immunity from the Dawson River. The sediment dams are used to contain sediment runoff from the out-of-pit dumps and do not contain hazardous materials and are designed and proposed to be operated in accordance with the Best Practice Erosion and Sediment Control Guidelines (IECA, 2018). The sediment and clean water dams located within the 0.1% AEP flood extent are to be of mostly excavated construction (embankment to provide spillway freeboard) to prevent risk of dam break during flooding of the Dawson River.

6.13.2 Operational Mining Pit

The proposed extent of open cut mining over the Project duration relative to the modelled existing 0.1% AEP flood extent is shown in Figure 6.2. Figure 6.2 also presents cross sections showing the flood level and underlying topography relative to the open cut pit location. The flood results show the open cut pit is located outside of the pre-mining 0.1% AEP flood extent for the duration of the Project and artificial landforms are not required to provide flood immunity.

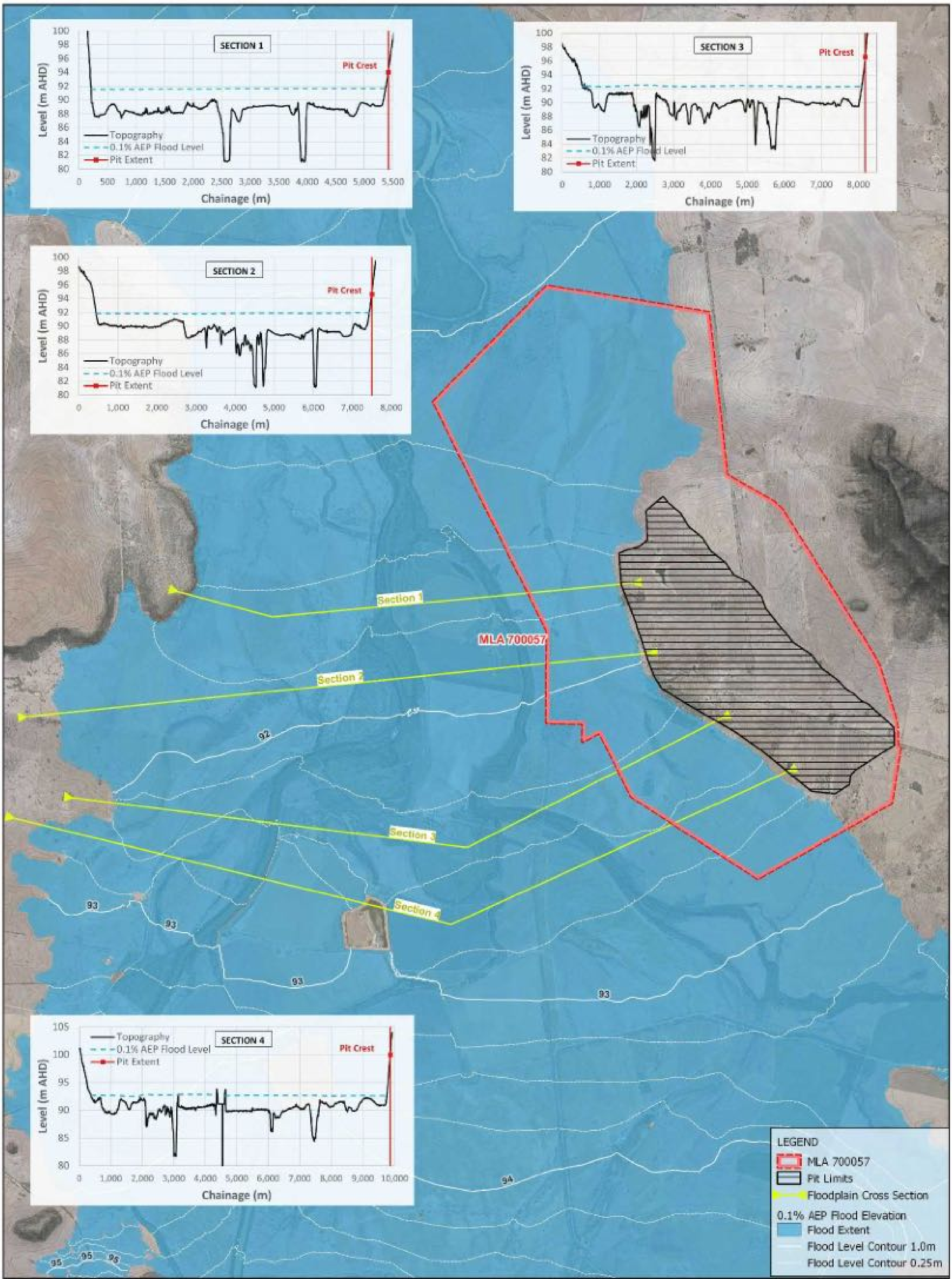

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Figure 6.2

BARALABA SOUTH PTY LTD
Flood Impact Assessment
Mining Pit Extent Relative to 0.1% AEP
Pre-mining Flood Extent

Job Number:
QC1018_004

6.13.3 Final Void

The climate change sensitivity identified flood levels are likely to increase due to climate change impacts on the Dawson River hydrology. The mining pit maintains 0.1% AEP climate change flood immunity without flood protection levees. The closure mine landform includes a rehabilitated final landform bund located around the southern extent of the final void with a crest elevation above the predicted PMF level to provide the residual void PMF immunity post closure.

6.13.4 Localised Flood Velocity Increase Against Mine Landforms

Localised increases in peak flood velocity are identified in flood events greater than 10% AEP at the downstream toe of the out-of-pit dump landform at the northwest corner of the site. Flood velocities are expected to increase locally by up to 0.35m/s, however, remain below 0.6 m/s in the Mine Developed Case for the 1% AEP flood event. Although the expected flood velocities are low, localised erosion protection works such as rock armouring and establishment of floodplain vegetation (trees) may be implemented to prevent scouring and degradation of this area.

6.14 Climate Change and Sensitivity Analysis

To understand the sensitivity of the identified flood impacts a number of sensitivity scenarios were simulated using the Dawson River flood model. The sensitivity scenarios assessed include climate change and the historical December 2010 flood event. The sensitivity scenarios were assessed using the Existing Case and Mine Developed Cased flood models to determine the change in base case flooding and the extent of potential impacts from the Project. Detailes of the assessed sensitivity scenarios are provided in Table 6.6. The sensitivity analysis flood maps are provided in Appendix J.

TABLE 6.6: SENSITIVITY SCENARIOS

Sensitivity Scenario	Description
Climate Change	The 2070 climate change planning horizons has been assessed for the 1% AEP and 0.1% AEP design flood events. The 2070 planning horizon has been assessed as it extends slightly beyond the end of the Project mine life and may demonstrate potential flooding conditions post closure.
December 2010 Flood Event	Peak flow for the December 2010 flood event is estimated to be slightly lower than a 1% AEP at the Beckers gauging station (130322A) based on the flood frequency analysis (Section 3.5). However, the duration of the December 2010 event resulted in significantly more flood volume than a design flood event of similar AEP. Assessment of this event was undertaken to understand potential changes to flood impacts based on increased flood volume.

6.14.1 Climate Change Sensitivity Assessment

The climate change sensitivity assessment was undertaken using the methodology outlined in ARR 19 (Ball J, 2019). Climate change design hydrology was developed for the 1% and 0.1% AEP storm events by increasing design rainfall intensities using climate change factors provided on the ARR Data hub for the Dawson River Catchment. The following climate change projection was adopted for the sensitivity assessment:

- Climate change projection year 2070 was adopted as it extends slightly beyond the proposed life of mine.
- Representative Concentration Pathway 6 (RCP6) was selected as this represents some application of mitigation strategies and technologies to reduce CO_2 emissions but does not represent an overly ambitious intervention.

The above climate change projection for the Dawson River catchment produces design rainfall intensity increases of 8.7% for 1% AEP and 0.1% AEP. The URBS hydrology model was simulated using the predicted increases in rainfall intensity to produce climate change adjusted 1% and 0.1% AEP flood hydrographs for use in the TUFLOW flood model. The TUFLOW flood model was then simulated for the Existing Case and Mine Developed Case climate change adjusted flood hydrographs to determine changes in peak flood depths and flood impacts associated with the Project. The climate change sensitivity assessment shows:

- The climate change scenario peak flow estimates for the 1% AEP and 0.1% AEP events are:

  - 1% AEP – 7,152 m^3/s (15% increase on the baseline design hydrology 1% AEP peak flow of 6,244 m^3/s)
  - 0.1% AEP – 11,902 m^3/s (12% increase on the baseline design hydrology 0.1% AEP peak flow of 10,600 m^3/s)
- The increase in peak flood levels in the Dawson River adjacent to the Project for the Mine Developed Case for the climate change scenario compared to no climate change (baseline design hydrology) is:
  - 0.25 m peak flood level increase for the 1% AEP flood event; and,
  - 0.3 m peak flood level increase for the 0.1% AEP flood event.
- The extent of flood impacts for the 1% and 0.1% AEP climate change scenarios are very similar to the base case based on the following observations:
  - The 1% and 0.1% AEP climate change scenario results in only a very minor change in the extent of flood depth impacts greater than 10mm compared to the base case flood impact results.
  - Flood depth increase is limited to 20mm for the 1% AEP climate change scenario on the western floodplain of the Dawson River, as per the base case flood impact results.
  - Flood velocity impacts in the 1% AEP climate change scenario occurs in isolated locations immediately adjacent to the Project landforms as per the base case flood impact results.

The changes to flood levels under the climate change projections are negligible and as a result, there are no key risk areas for climate change vulnerability for the Project and no alternative adaptation strategies are considered to be required.

6.14.2 December 2010 Flood Event Sensitivity Assessment

The December 2010 historical event sensitivity assessment was undertaken to assess flood impacts for a flood event with significantly more flood volume than a design flood event of a similar AEP. The December 2010 flood event sensitivity assessment was undertaken using the design hydrographs adopted for the TUFLOW flood model calibration (see Section 3.3.5). The historical flood event hydrographs were simulated with the Existing Case and Mine Developed Case models to assess flood impacts. The sensitivity assessment results show:

- The December 2010 flood event peak flow in the Dawson River is assessed to be slightly lower than a 1% AEP flood event.
- The Project-generated change in peak flood levels for the December 2010 sensitivity assessment are slightly lower than the 1% AEP flood event impacts discussed in Section 6.1. This is in line with the assessed AEP of the event which indicates peak flood level impacts associated with the Mine Developed Case are not highly sensitive to the volume of the hydrograph and are instead more dependent on the peak flow rate in the Dawson River.

7. MITIGATION AND MANAGEMENT MEASURES

The management and mitigation strategies proposed for the Project are summarised in Table 7.1.

TABLE 7.1: MANAGEMENT AND MITIGATION STRATEGIES FOR FLOODING

Related Impacts	Mitigation / Monitoring Measure	Function
Existing habitable structures (i.e., dwellings)	Mine planning has targeted minimal impact to the Dawson River floodplain to reduce flood impacts which has achieved the Project's flood impact objectives for habitable structures.	-
Existing non-habitable structures (e.g., agricultural sheds, carports containers, meter boxes)	Mine planning has targeted minimal impact to the Dawson River floodplain to reduce flood impacts which has mostly achieved the Project's flood impact objectives for non-habitable structures. Further consultation will be conducted with relevant landholders to assess whether the flood level afflux predicted to occur at non-habitable structures on their property will result in a material impact, and to identify whether any localised mitigation measures may be appropriate.	The potential impacts associated with the predicted flood level afflux will vary between different infrastructure and different properties and will depend on a variety of factors including the nature and type of infrastructure, floor heights, storage contents, and existing flood levels.
Final Landform Design	Mine planning has targeted minimal impact to the Dawson River floodplain to reduce flood impacts which has achieved the Project's flood impact objectives.	Mine development and landforms are mostly outside of the Dawson River floodplain to reduce flooding impacts associated with the Project and maintain existing flooding behaviour.
Localised velocity impacts at the north west extent of the out-of-pit dump landform	Erosion protection works and monitoring of the areas identified as having localised increases in peak flood velocity near the north west extent of the out-of-pit dump landform.	Erosion protection works and floodplain vegetation establishment to prevent localised scouring and degradation of the area identified with increases in peak flood velocity. Monitoring may be required to observe the performance of the erosion protection works following large flood events.
Climate change impacts to Dawson River hydrology and flood immunity of the operational mining pit and final void post closure	The climate change sensitivity identified flood levels are likely to increase due to climate change impacts on the Dawson River hydrology. Operational pit flood protection is maintained for the 0.1% AEP climate change scenario and the final void maintains Probable Maximum Flood (PMF) immunity	-
Proposed mine plan and infrastructure interaction with flooding	Site infrastructure, access road and haul roads are to be located above the Dawson River 0.1% AEP peak flood level.	With all site infrastructure located above the Dawson River 0.1% AEP peak flood level there is no potential for additonal flood impacts associated with the Project.
	Sediment Dams and clean water dams located within the 0.1% AEP flood extent are to be of	There are several sediment dams that are inundated in flood events rarer than the 10% AEP and more

Related Impacts	Mitigation / Monitoring Measure	Function
	mostly excavated construction to reduce risk of dam break during flooding of the Dawson River	frequent than the 0.1% AEP. The dams are proposed to be mostly excavated preventing the possibility of erosion and failure of a dam embankment in a large flood event.
	Hazardous materials will be stored at the infrastructure areas at the eastern extent of the MLA boundary, which maintains Probable Maximum Flood (PMF) immunity.	Any storage containers that hold hazardous materials will be secured in line with relevant Australian Standards to prevent the removal of the containers from the site by a flood event.

8. QUALIFICATIONS

(a) In preparing this document, including all relevant calculation and modelling, Engeny Australia Pty Ltd (Engeny) has exercised the degree of skill, care and diligence normally exercised by members of the engineering profession and has acted in accordance with accepted practices of engineering principles.

(b) Engeny has used reasonable endeavours to inform itself of the parameters and requirements of the project and has taken reasonable steps to ensure that the works and document is as accurate and comprehensive as possible given the information upon which it has been based including information that may have been provided or obtained by any third party or external sources which has not been independently verified.

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  (ii) Engeny considers it prudent to revise any aspect of the works in light of any information which becomes known to it after the date of submission.

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(g) This Report does not provide legal advice.

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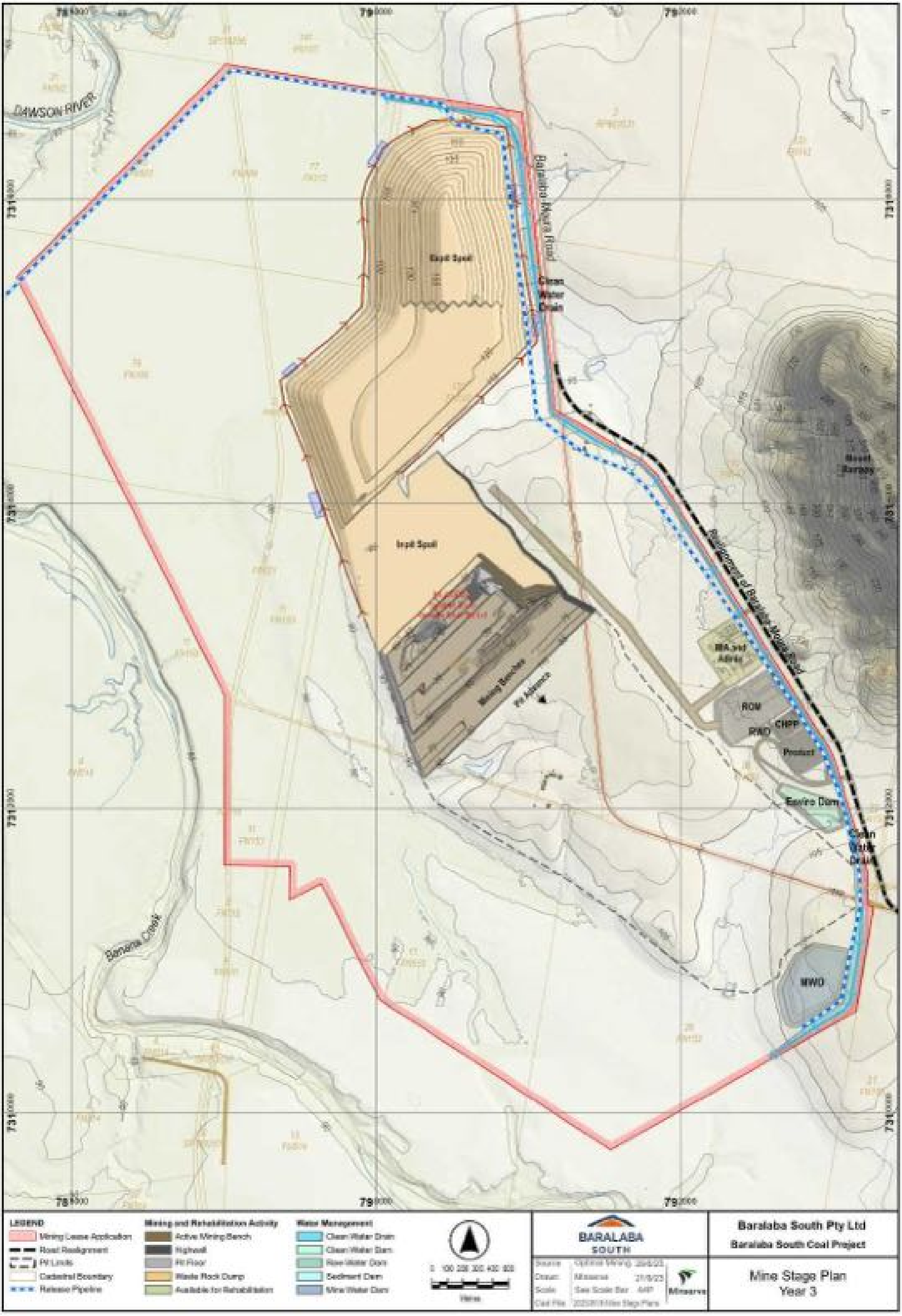
APPENDIX A: SURFACE WATER INFRASTRUCTURE STAGE PLANS

Baralaba South Pty Ltd

Baralaba South Coal Project

Mine Stage Plan
Year 1

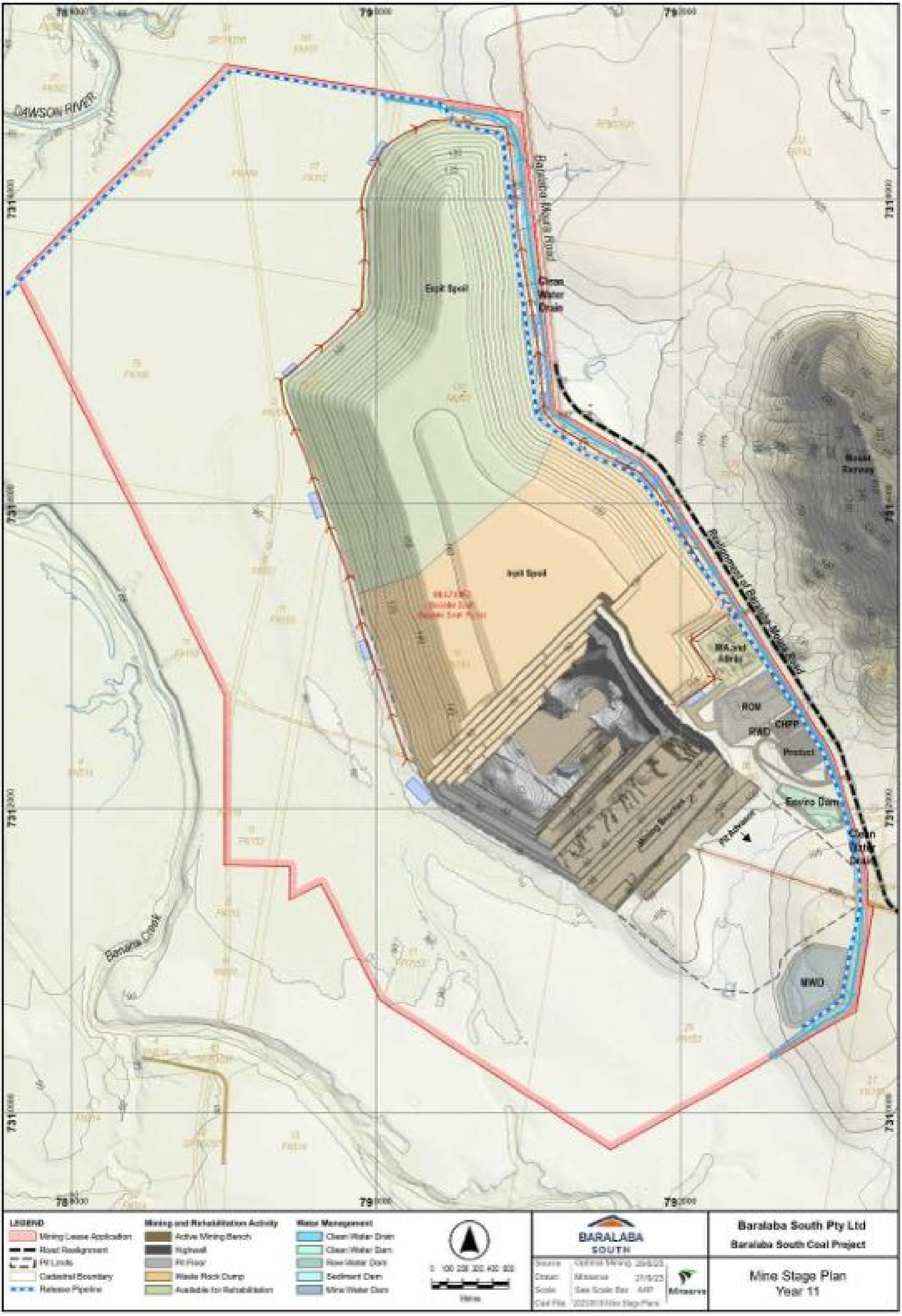
Source: Optimal Mining 20/6/23
Drawn: Minserve 27/6/23
Scale: See Scale Bar A4P
Cad File: 2023/61 Mine Stage Plans


DAWSON RIVER
Banana Creek
Baralaba Moura Road
Clean Water Drain
Expit Spoil
Inpit Spoil
Mining Benches
Pit Advance
Realignment of Baralaba Moura Road
MIA and Admin
ROM
RWD
CHPP
Product
Enviro Dam
Clean Water Drain
MWD
Mount Ramsay
LEGEND
Mining Lease Application
Road Realignment
Pit Limits
Cadastral Boundary
Release Pipeline
Mining and Rehabilitation Activity
Active Mining Bench
Highwall
Pit Floor
Waste Rock Dump
Available for Rehabilitation
Water Management
Clean Water Drain
Clean Water Dam
Raw Water Dam
Sediment Dam
Mine Water Dam
0 100 200 300 400 500
Metres
BARALABA SOUTH
Source Optimal Mining
Drawn Minserve
Scale See Scale Bar A4P
Minserve
Baralaba South Pty Ltd
Baralaba South Coal Project
Mine Stage Plan
Year 3

Baralaba South Pty Ltd

Baralaba South Coal Project

Mine Stage Plan
Year 6



Baralaba South Pty Ltd

Baralaba South Coal Project

Mine Stage Plan
Year 11

BARALABA SOUTH

Source: Optimal Mining 20/8/23
Drawn: Minserve 21/8/23
Scale: See Scale Bar A4P
Cad File: 20230818 Mine Stage Plans

Minserve

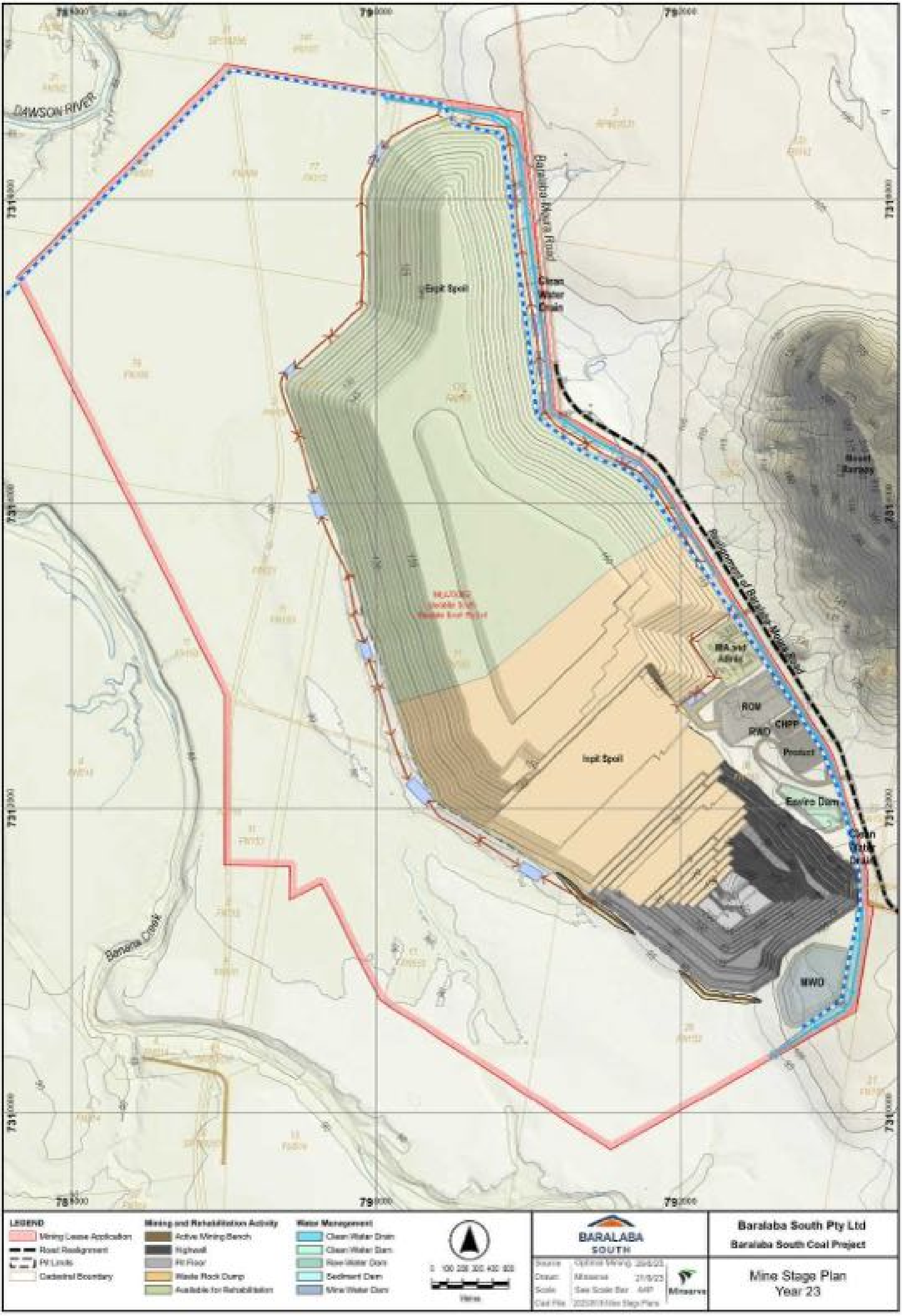
Baralaba South Pty Ltd

Baralaba South Coal Project

Mine Stage Plan
Year 14

Baralaba South Pty Ltd
Baralaba South Coal Project

Mine Stage Plan
Year 19



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Baralaba South Coal Project

Mine Stage Plan
Year 23

LEGEND

🟥 Mining Lease Application
▬ ▬ Road Realignment
Pit Limits
Cadastral Boundary
▬ Highwall Safety Bund
🟦 Final Water Level

0 100 200 300 400 500
Metres

BARALABA SOUTH

Source: Optimal Mining 20/6/23
Drawn: Minserve 27/6/23
Scale: See Scale Bar A4P
Cad File: 2023... Mine Stage Plans

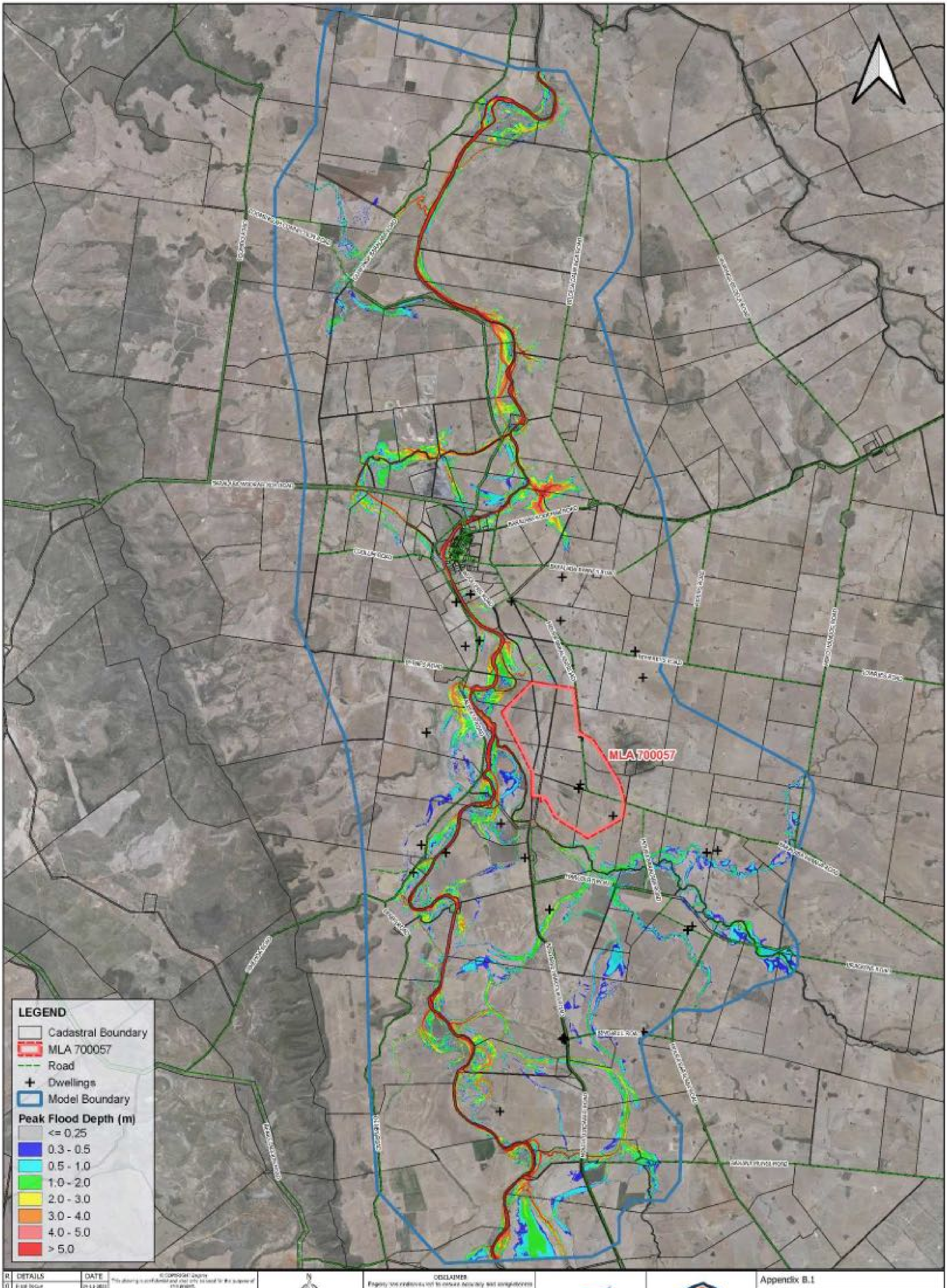
Minserve

Baralaba South Pty Ltd

Baralaba South Coal Project

Final Landform

APPENDIX B: EXISTING CASE FLOOD MAPS



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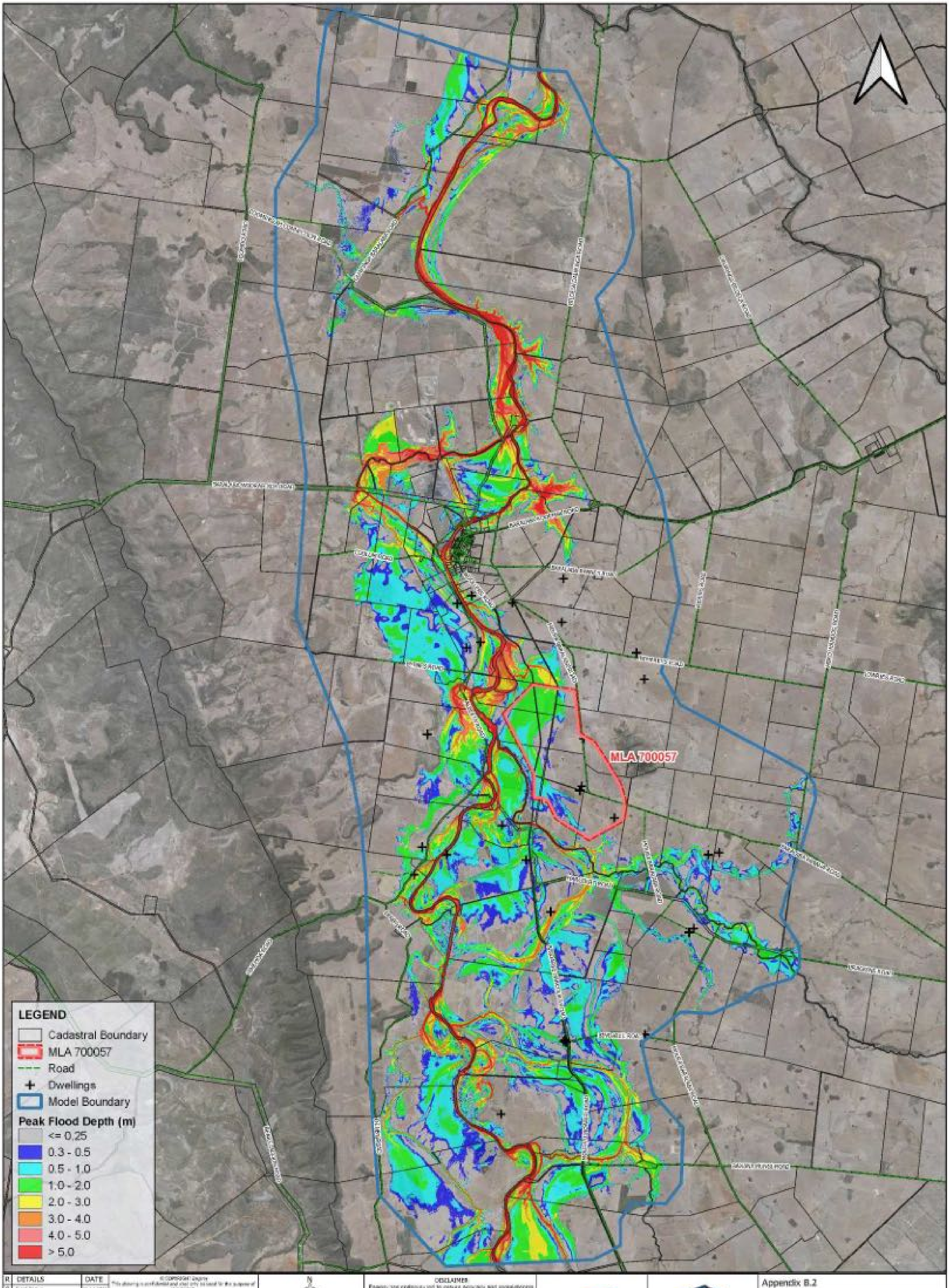
Appendix B.1

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
10% AEP Flood Depth - Existing Case

Job Number:



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Appendix B.2

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
2% AEP Flood Depth - Existing Case

Job Number:
QC1018_004986-002-1

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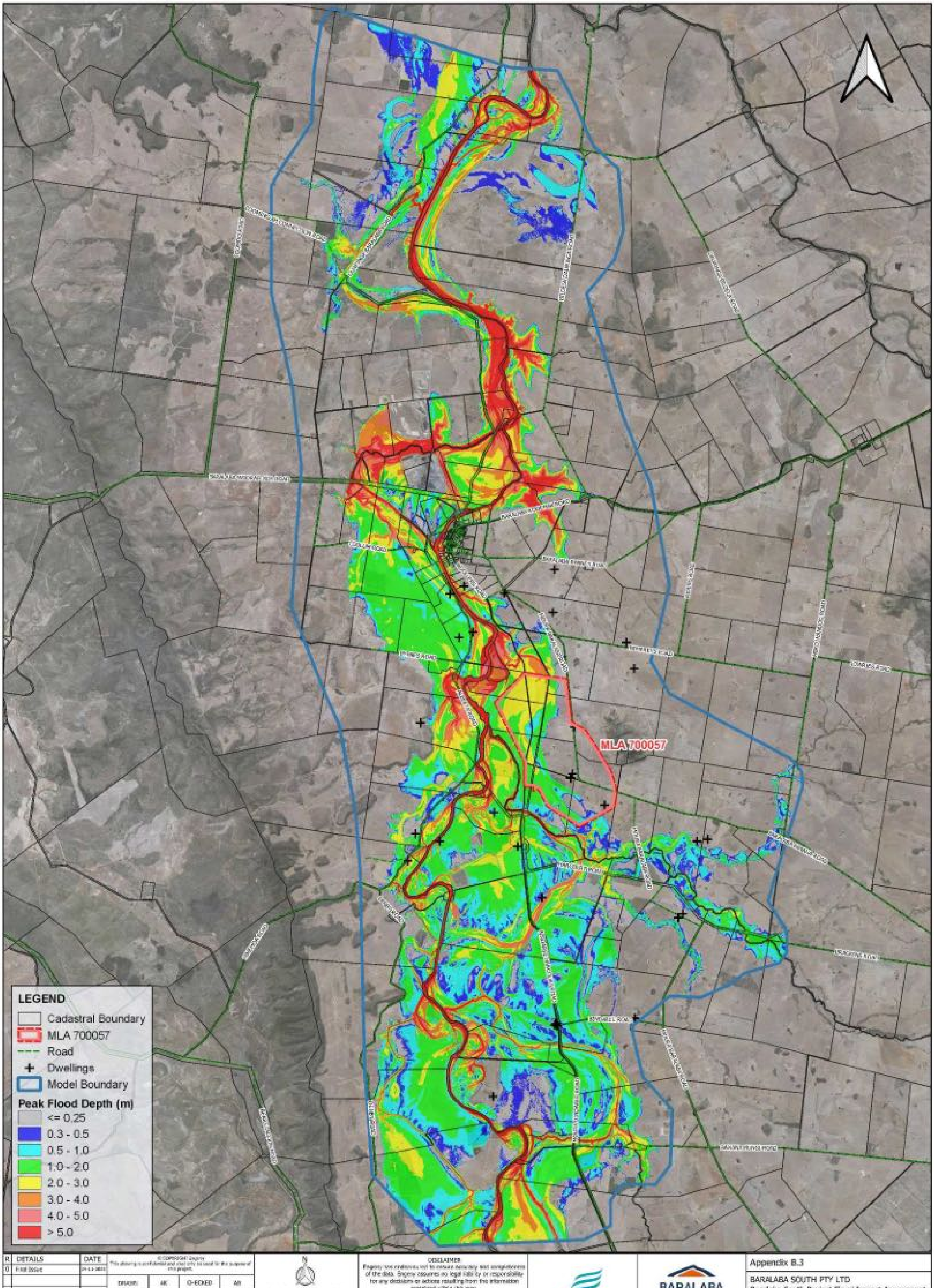

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Appendix B.3

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
1% AEP Flood Depth - Existing Case

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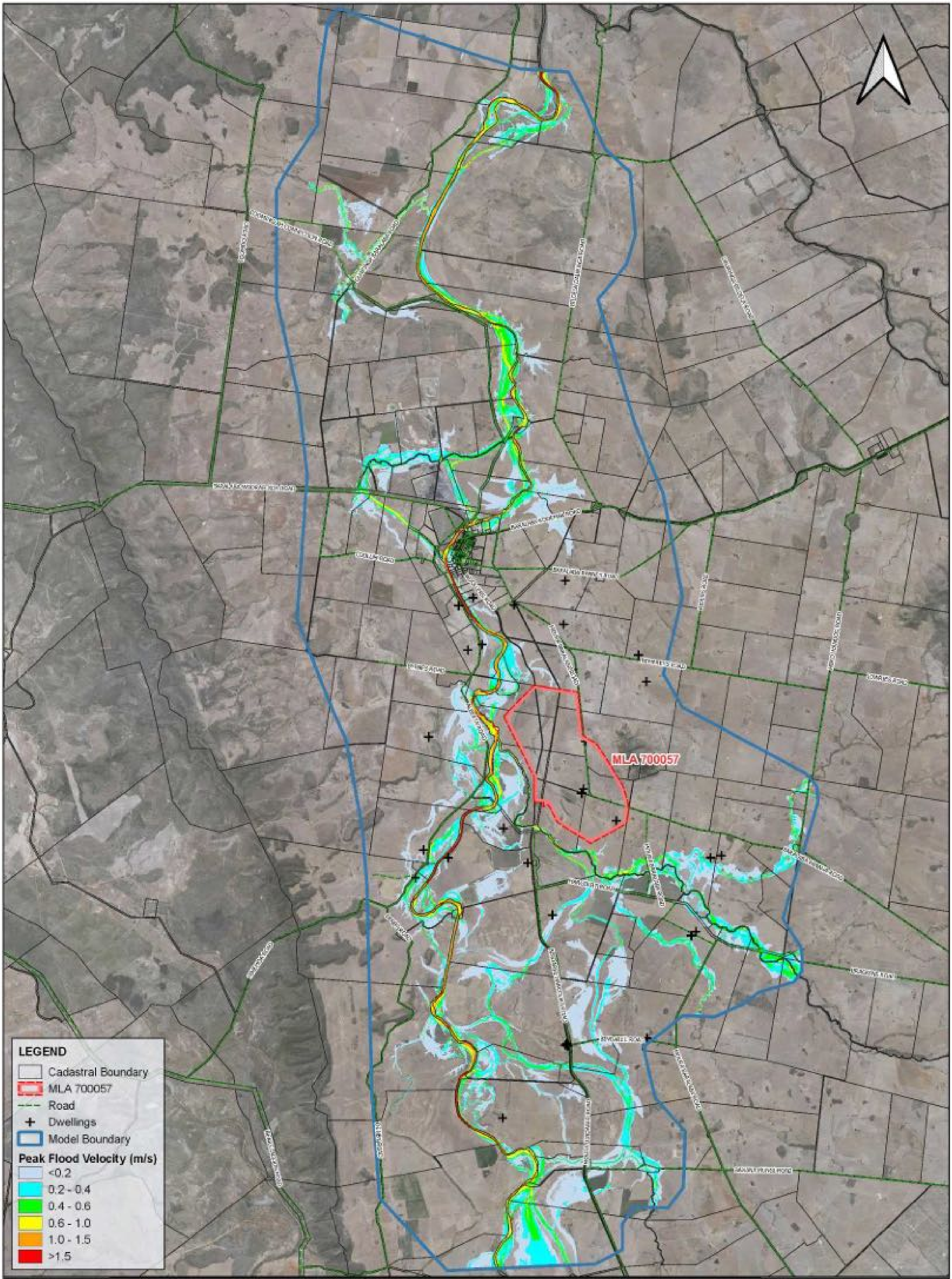

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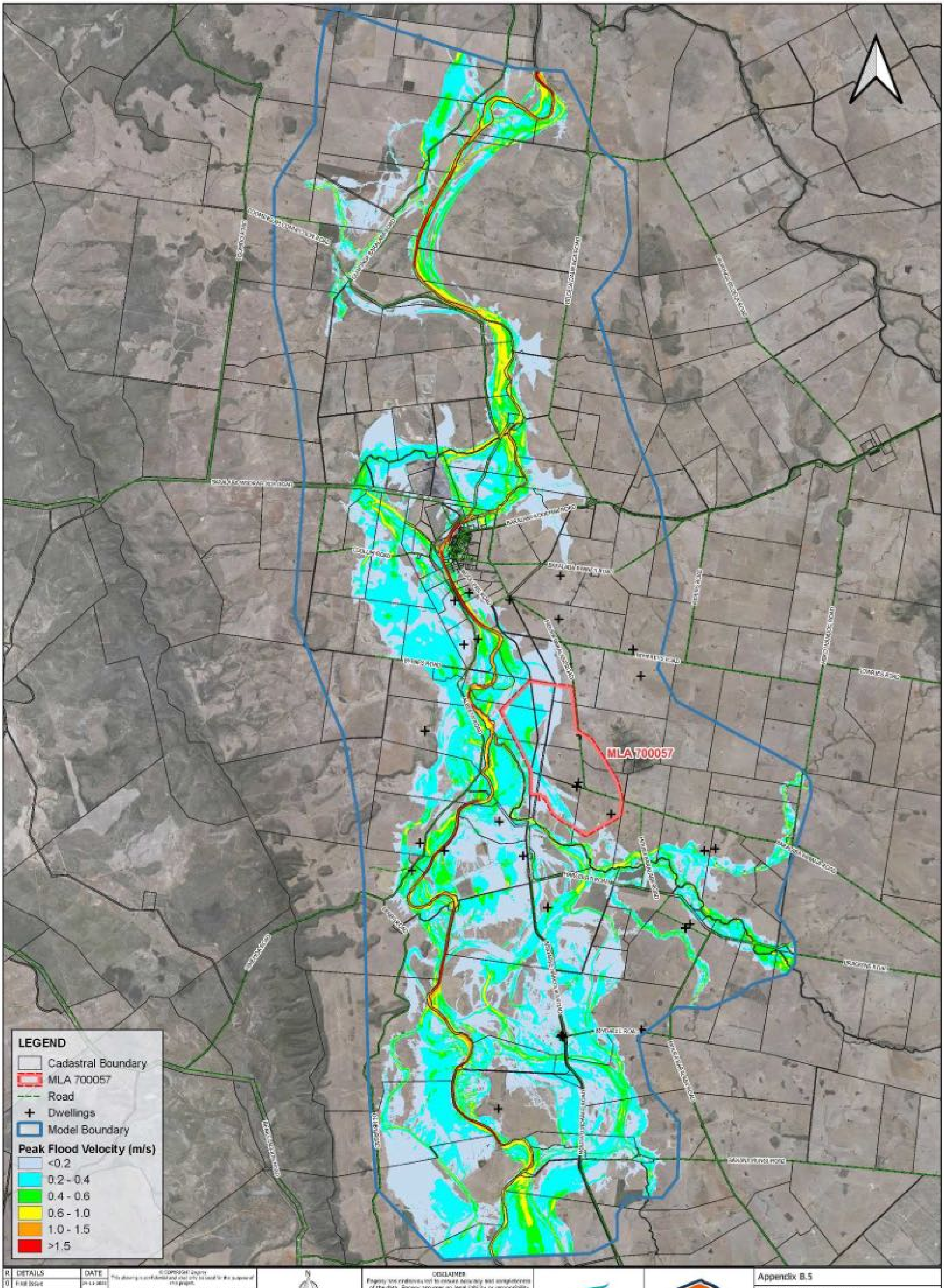
Appendix B.4

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
10% AEP Flood Velocity - Existing Case

Job Number:



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Appendix B.5

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
2% AEP Flood Velocity - Existing Case

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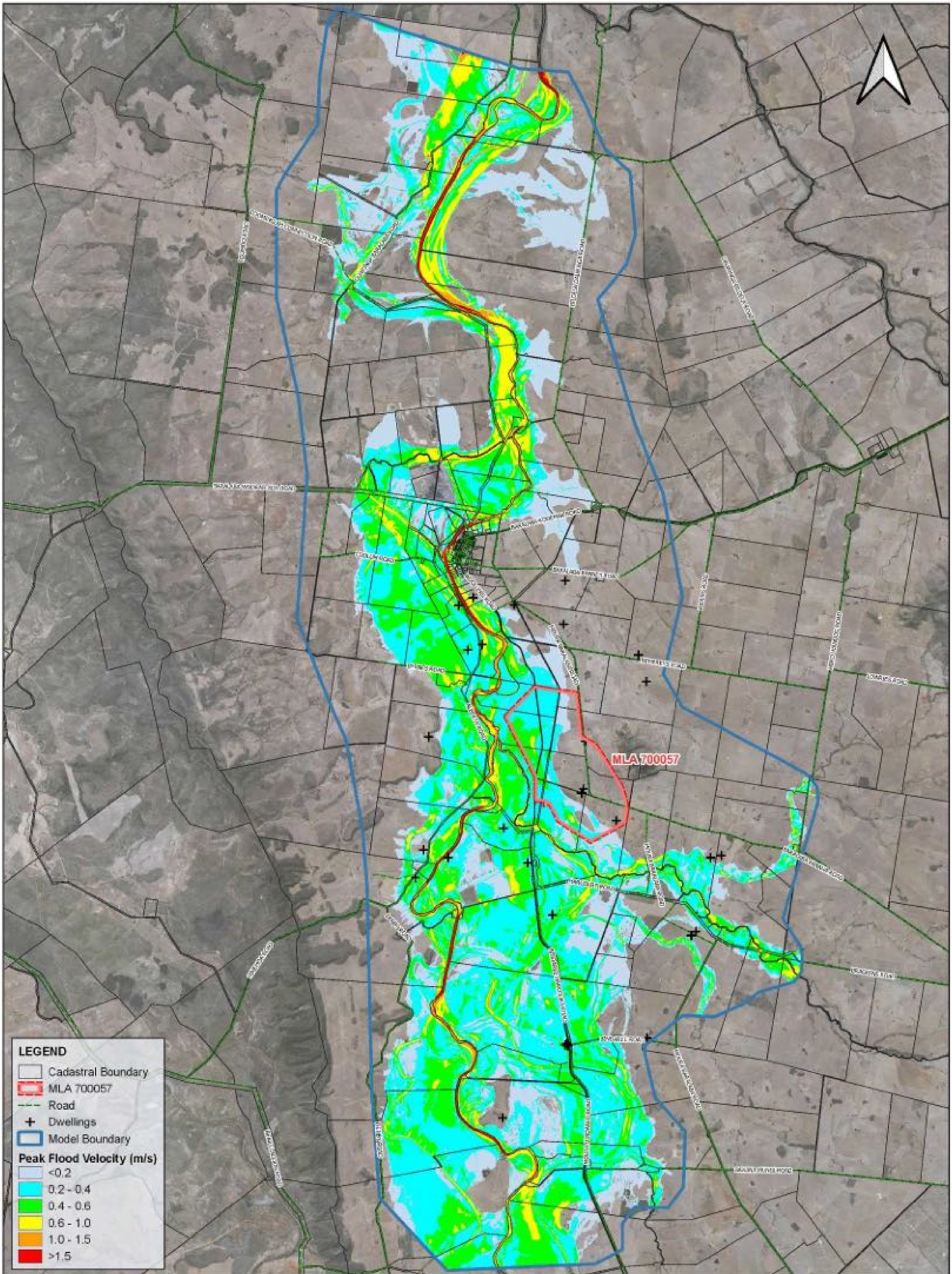

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Appendix B.6

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
1% AEP Flood Velocity - Existing Case

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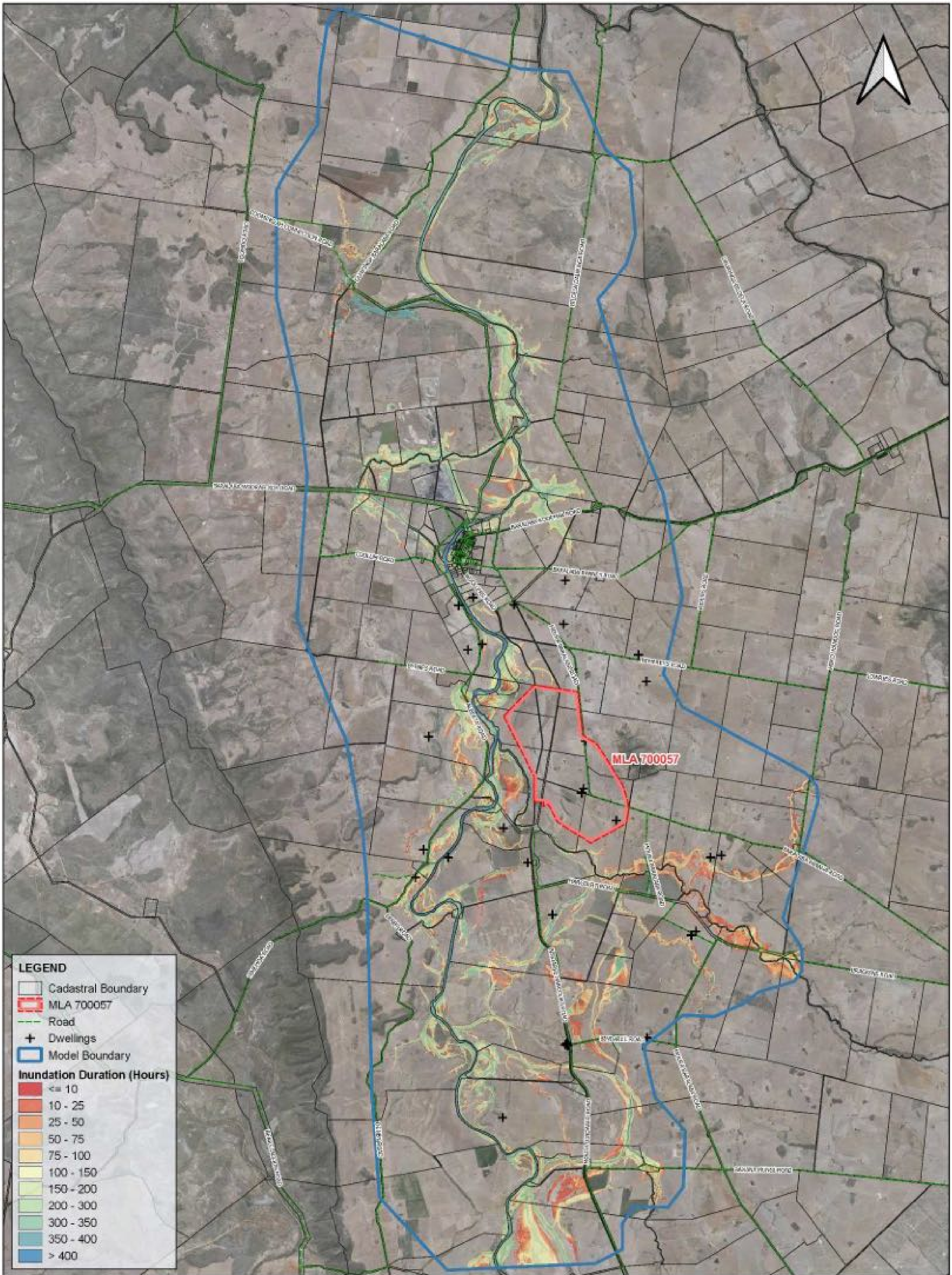

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Appendix B.7

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
10% AEP Flood Inundation Duration - Existing Case

Job Number:
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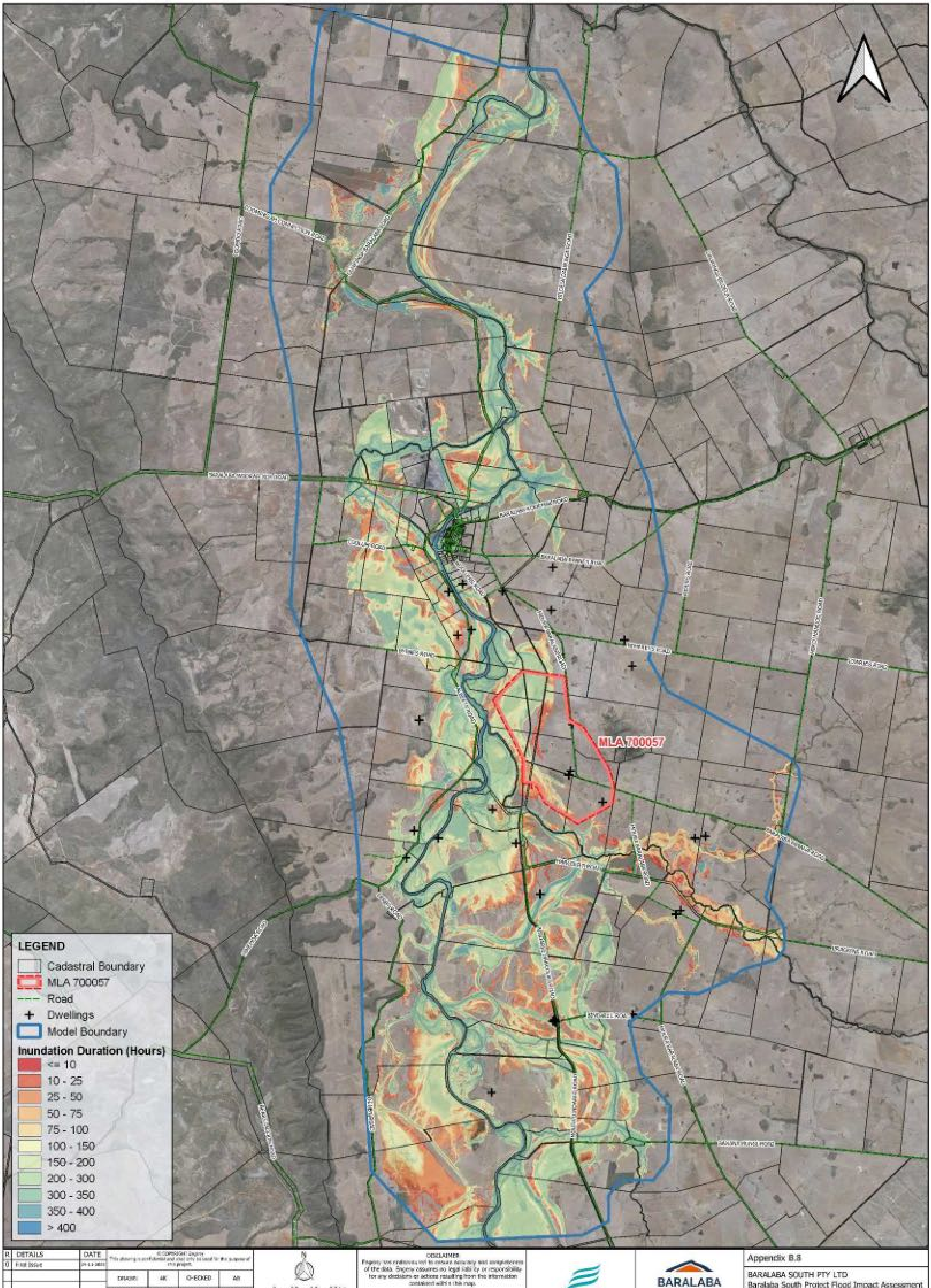
[illegible]



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Appendix B.8

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
2% AEP Flood Inundation Duration - Existing Case

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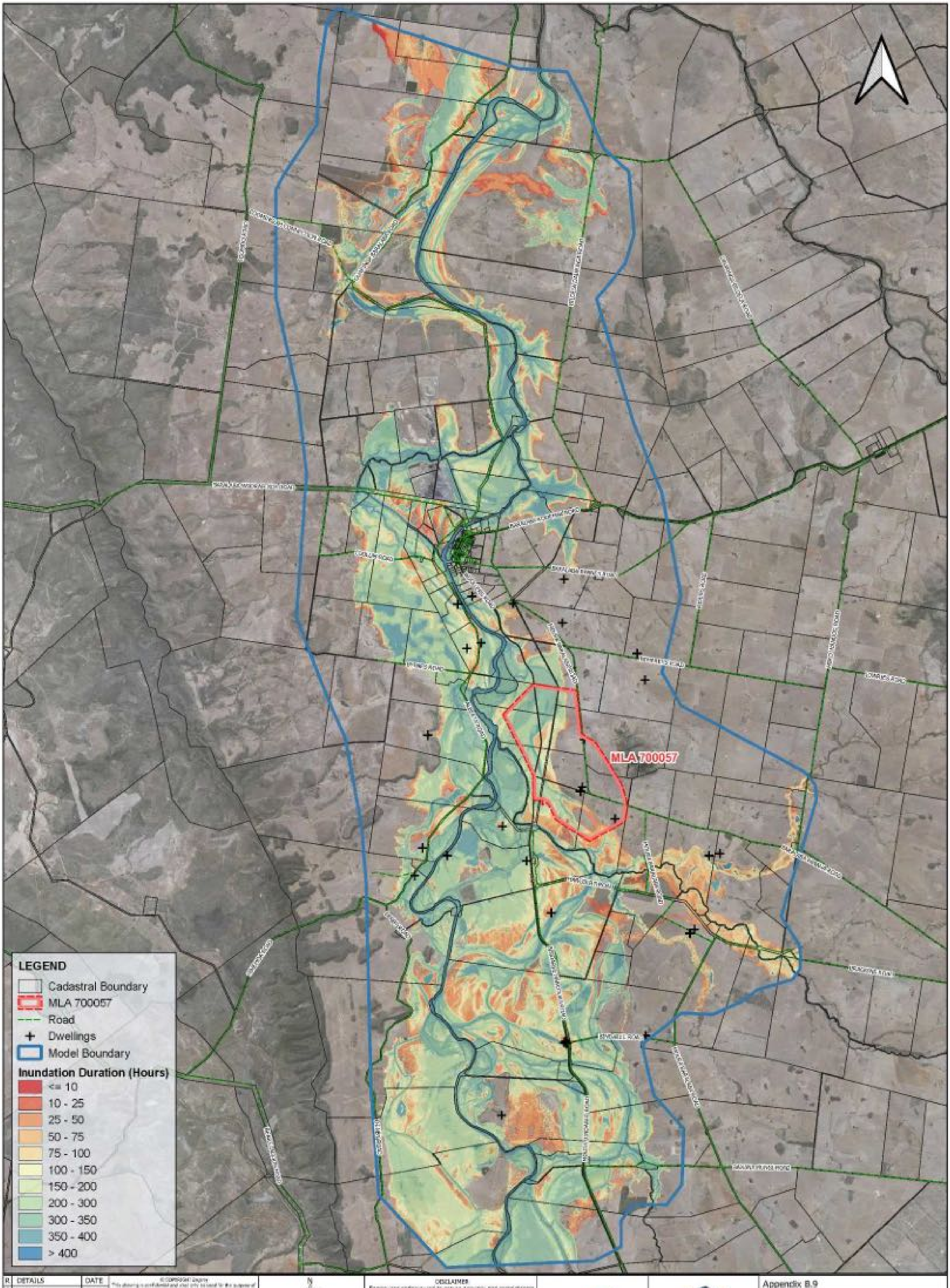

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Appendix B.9

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
1% AEP Flood Inundation Duration - Existing Case

Job Number:
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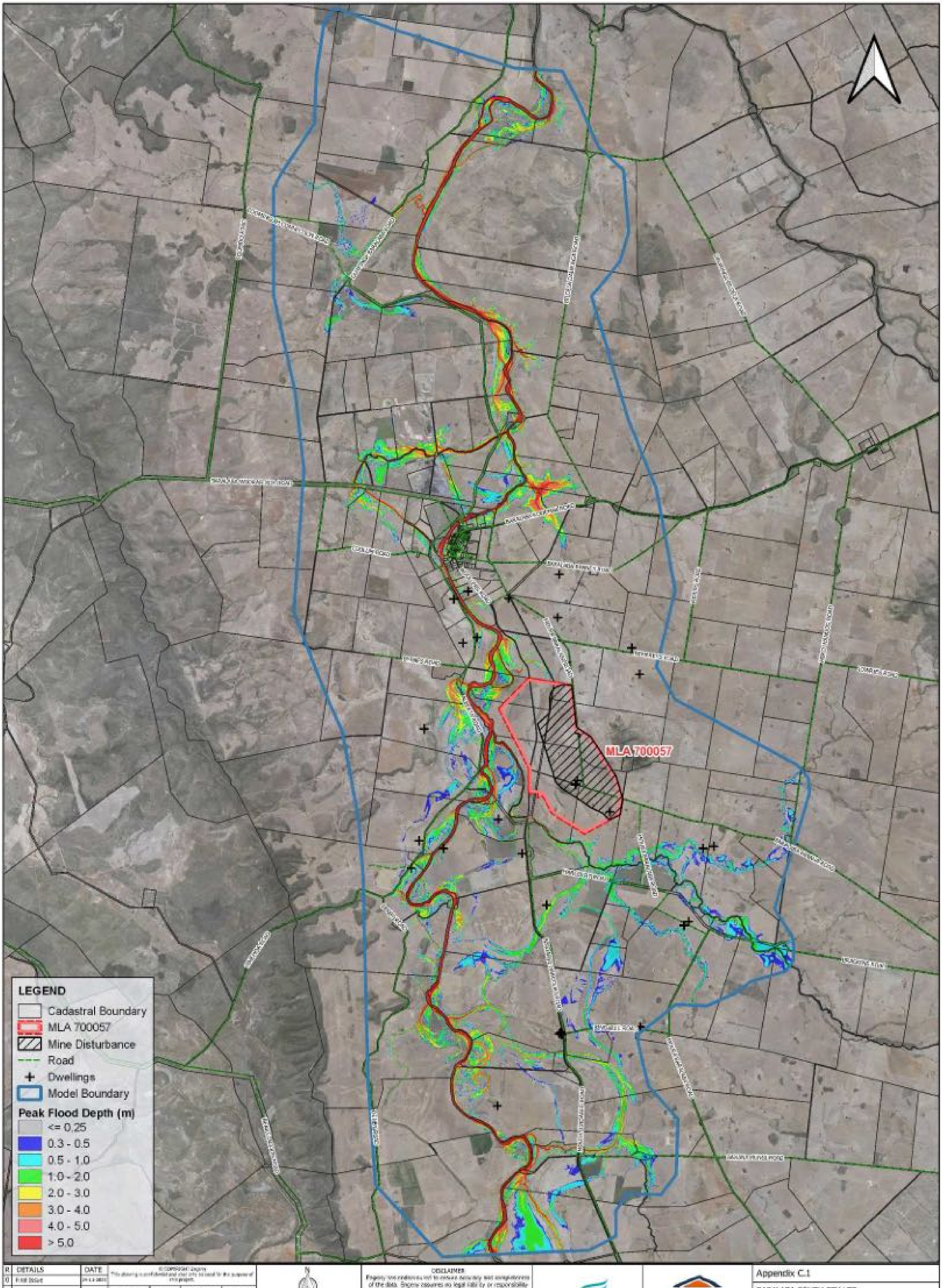
APPENDIX C: MINE DEVELOPED CASE FLOOD MAPS



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Appendix C.1

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
10% AEP Flood Depth - Mine Developed Case

Job Number:
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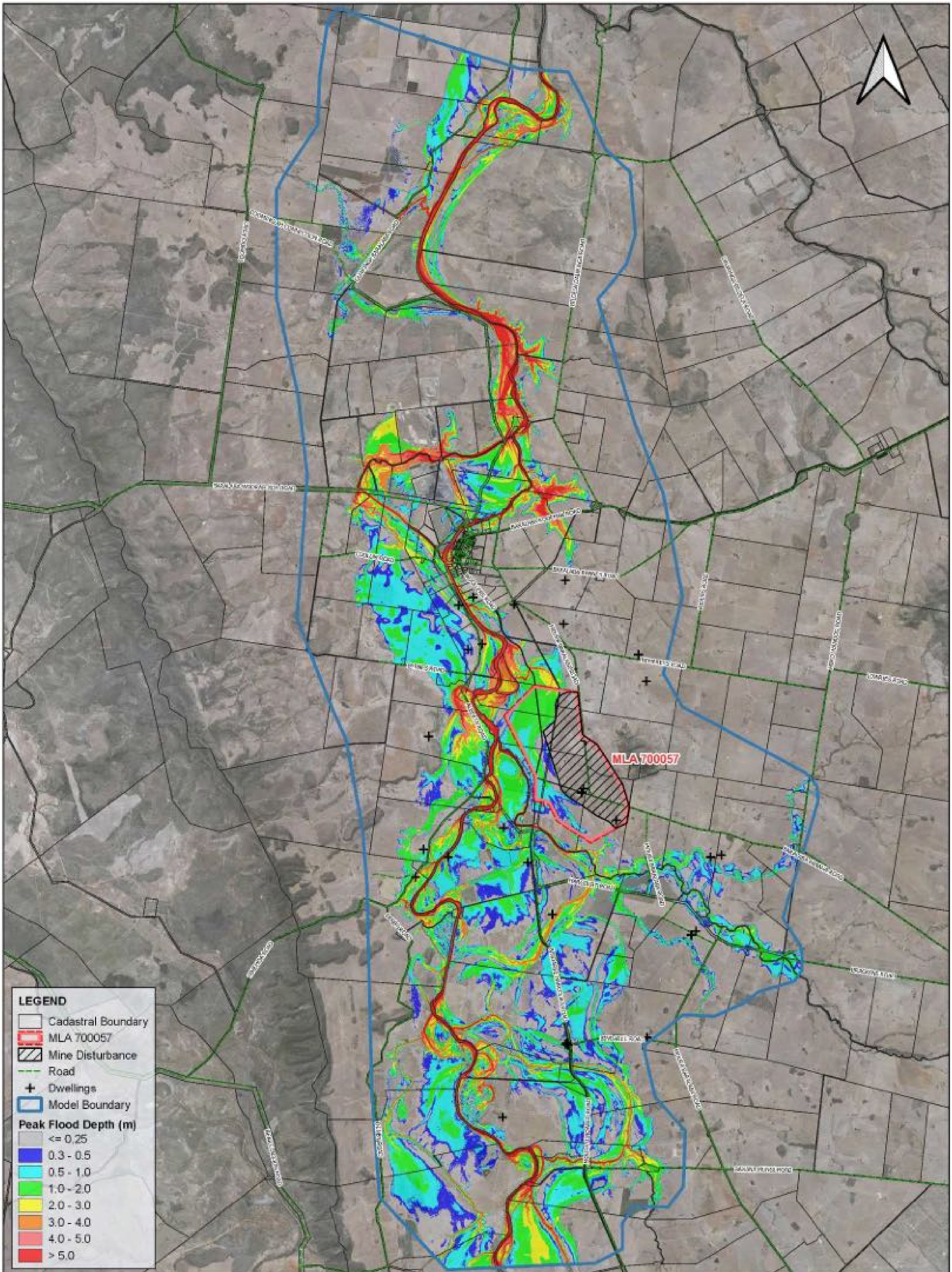

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APPROVED	AV	DATE	[illegible]

NOTES

0 0.9 1.8 2.7 km

SCALE @ A3 - 1:150,000

GDA94 / MGA zone 55

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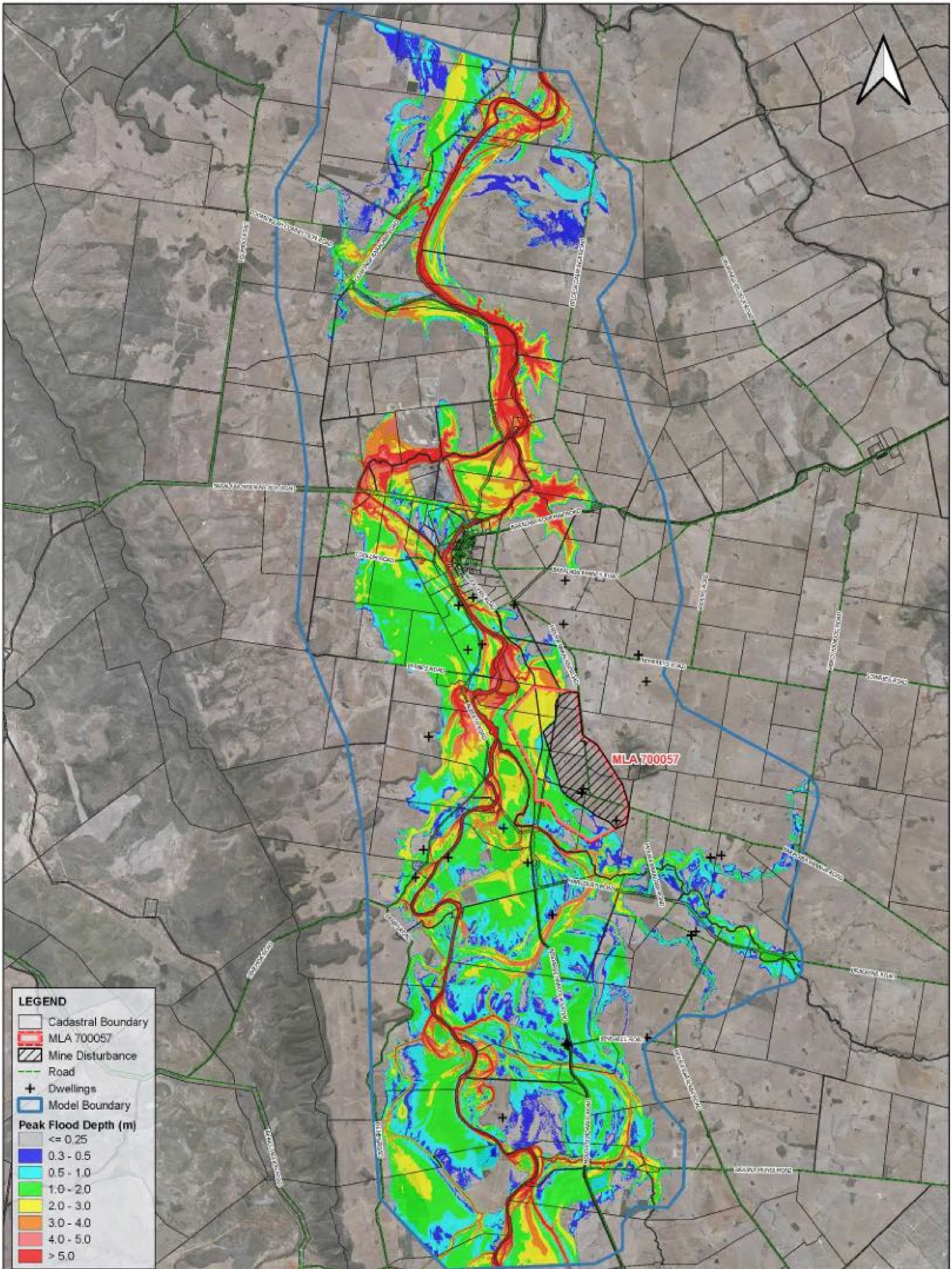
BARALABA SOUTH

Appendix C.2

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
2% AEP Flood Depth - Mine Developed Case

Job Number:
[illegible]

[illegible]



R	DETAILS	DATE
0	First Issue	[illegible]

DRAWN	AK	CHECKED	AB
APPROVED	AV	DATE	[illegible]

0 0.9 1.8 2.7 km

SCALE @ A3 - 1:150,000

GDA94 / MGA zone 55

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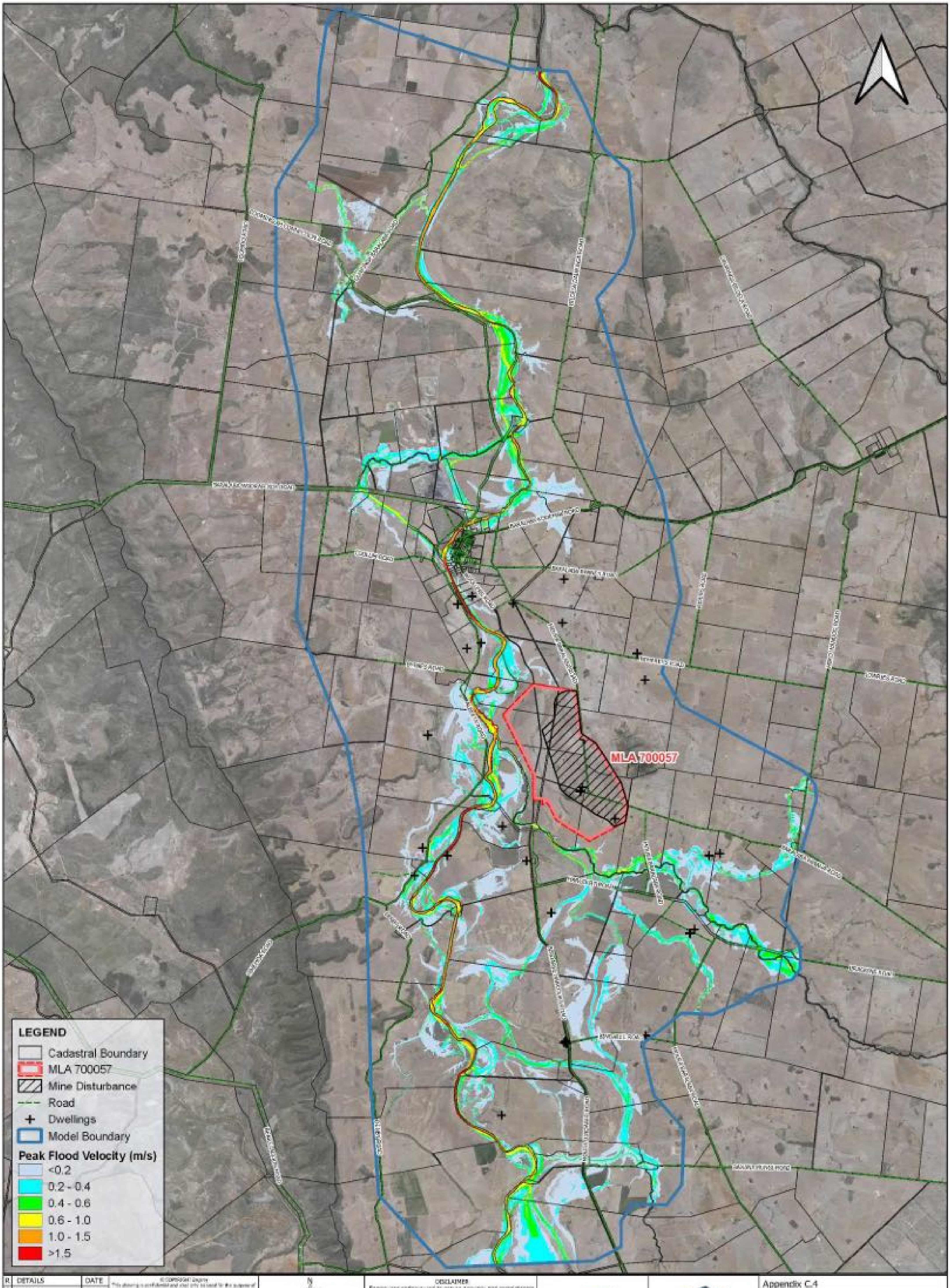
BARALABA SOUTH

Appendix C.3

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
1% AEP Flood Depth - Mine Developed Case

Job Number:
[illegible]



R	DETAILS	DATE
0	First Issue	24-11-2023

DRAWN	AK	CHECKED	AV
APPROVED	AV	DATE	24-11-2023

0 0.8 1.6 2.7 km

SCALE @ A3 - 1:150,000

GDA94 / MGA zone 55

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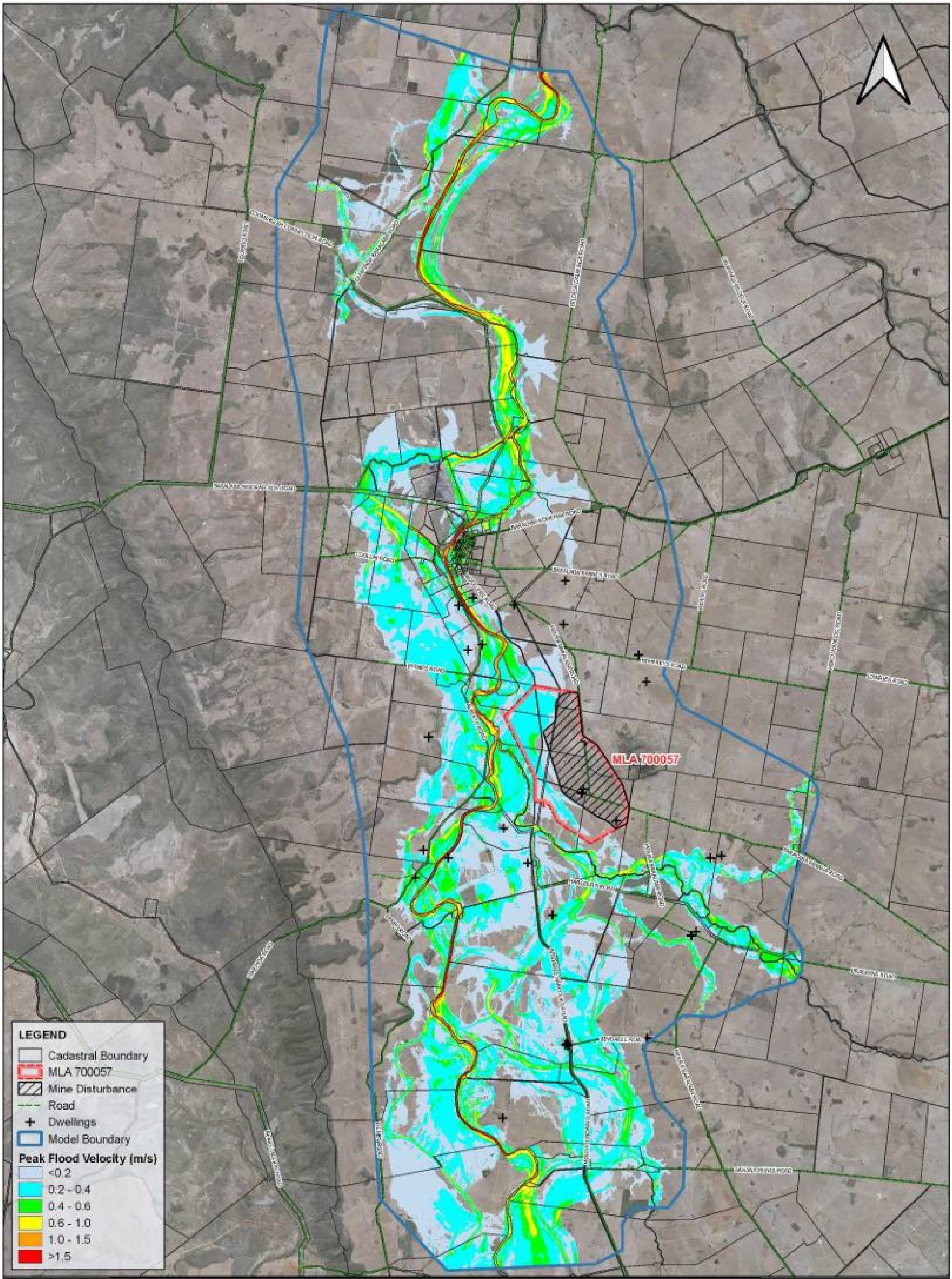
BARALABA SOUTH

Appendix C.4

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
10% AEP Flood Velocity - Mine Developed Case

Job Number:



R	DETAILS	DATE
0	First Issue	24-11-2023

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APPROVED	AV	DATE	24-11-2023

0 0.9 1.8 2.7 km

SCALE @ A3 - 1:150,000

GDA94 / MGA zone 55

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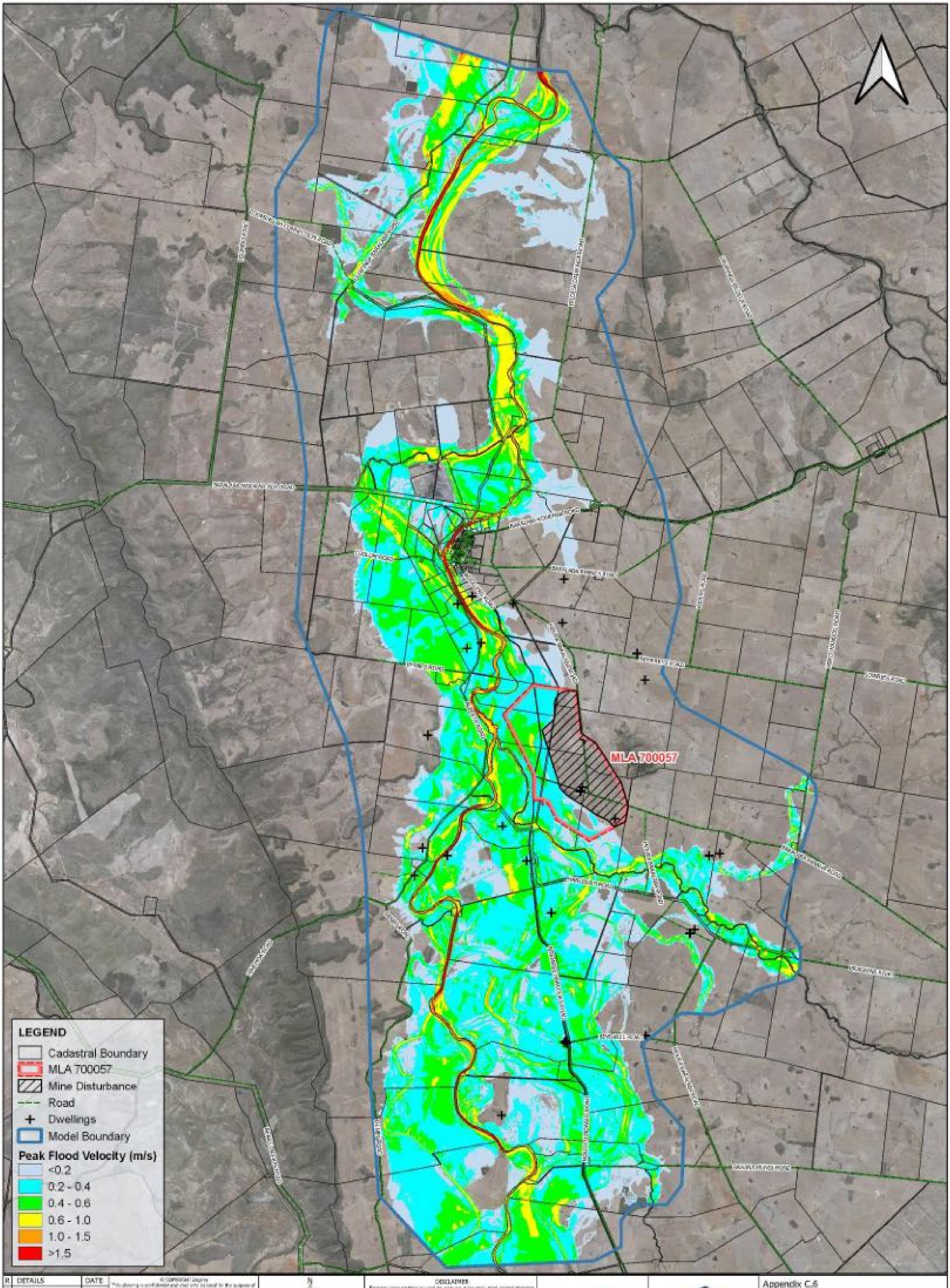
BARALABA SOUTH

Appendix C.5

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
2% AEP Flood Velocity - Mine Developed Case

Job Number:
QC1018_004986-114-2



R	DETAILS	DATE
0	First Issue	[illegible]

DRAWN	AK	CHECKED	AB
APPROVED	AV	DATE	[illegible]

NOTES

0 0.8 1.6 2.7 km

SCALE @ A3 - 1:150,000

GDA94 / MGA zone 55

DATA SOURCE
QLD Government Open Data Source

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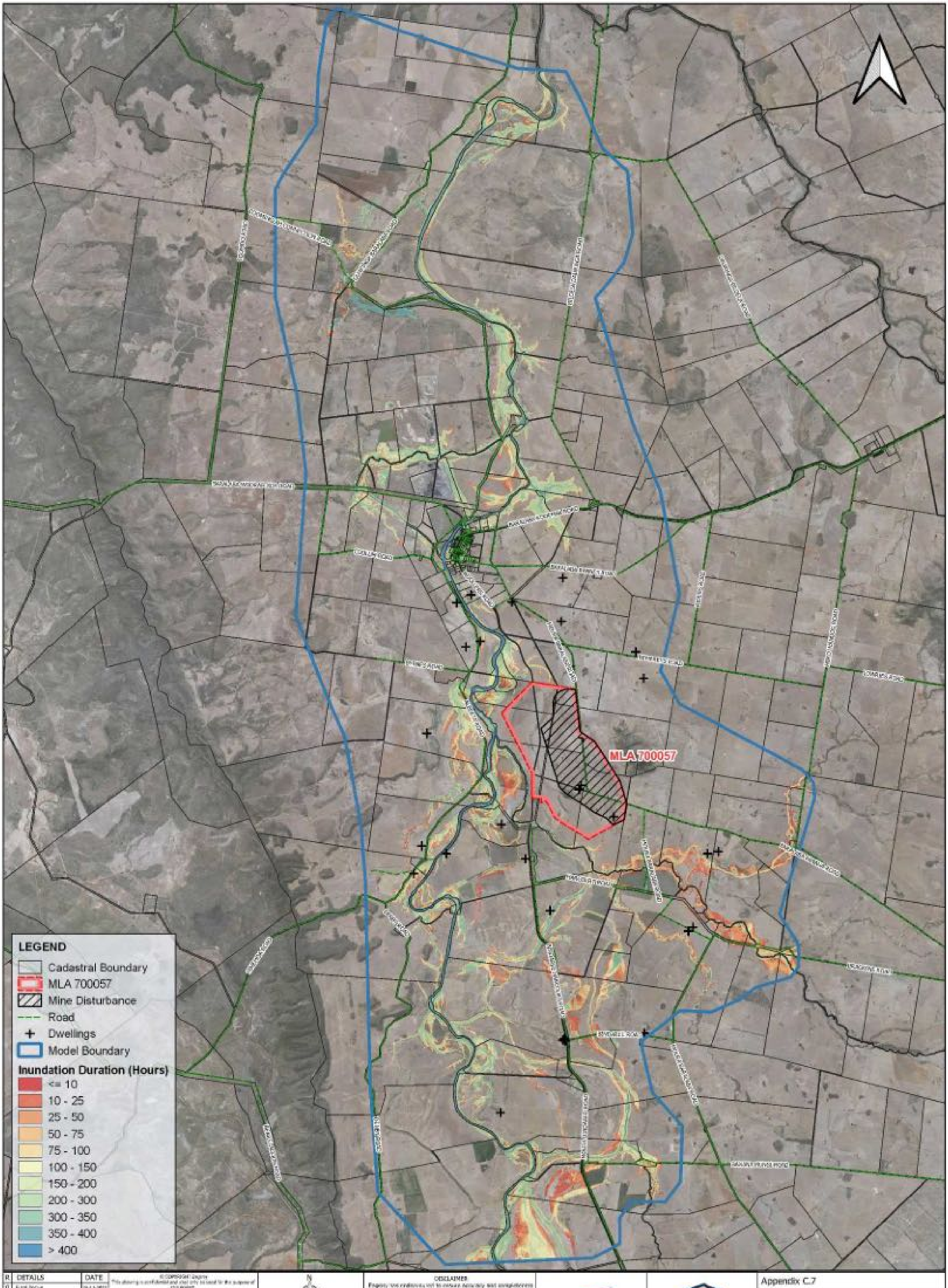
BARALABA SOUTH

Appendix C.6

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
1% AEP Flood Velocity - Mine Developed Case

Job Number:
[illegible]



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0	First Issue	[illegible]

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DRAWN	AK	CHECKED	AR
APPROVED	AV	DATE	[illegible]

0 0.9 1.8 2.7 km

SCALE @ A3 - 1:150,000

GDA94 / MGA zone 55

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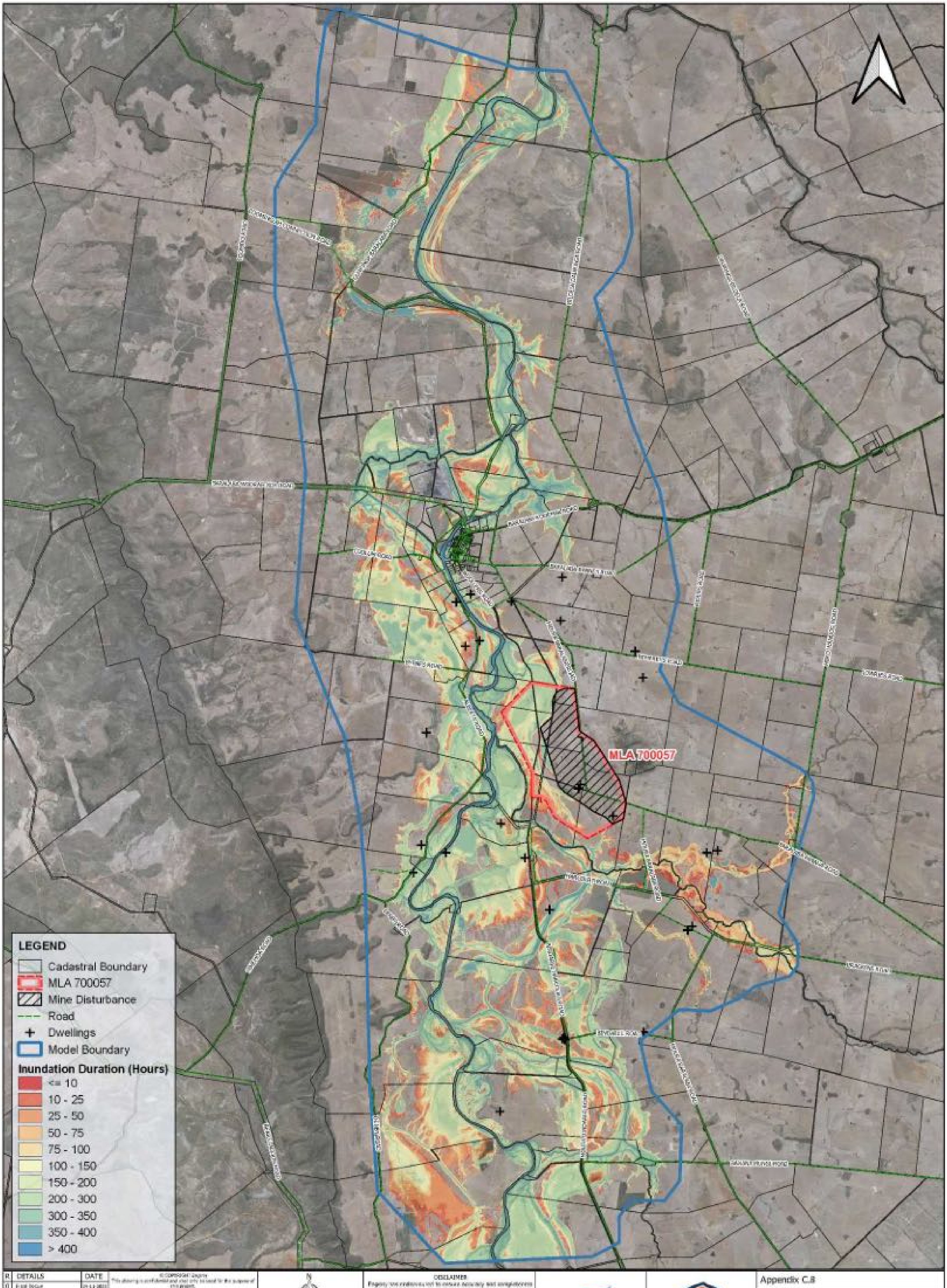
BARALABA SOUTH

Appendix C.7

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
10% AEP Flood Inundation Duration - Mine Developed Case

Job Number:
[illegible]



R.	DETAILS	DATE
0	First Issue	24-11-2023

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APPROVED	AV	DATE	24-11-2023

0 0.8 1.6 2.7 km
SCALE @ A3 - 1:150,000
GDA94 / MGA zone 55

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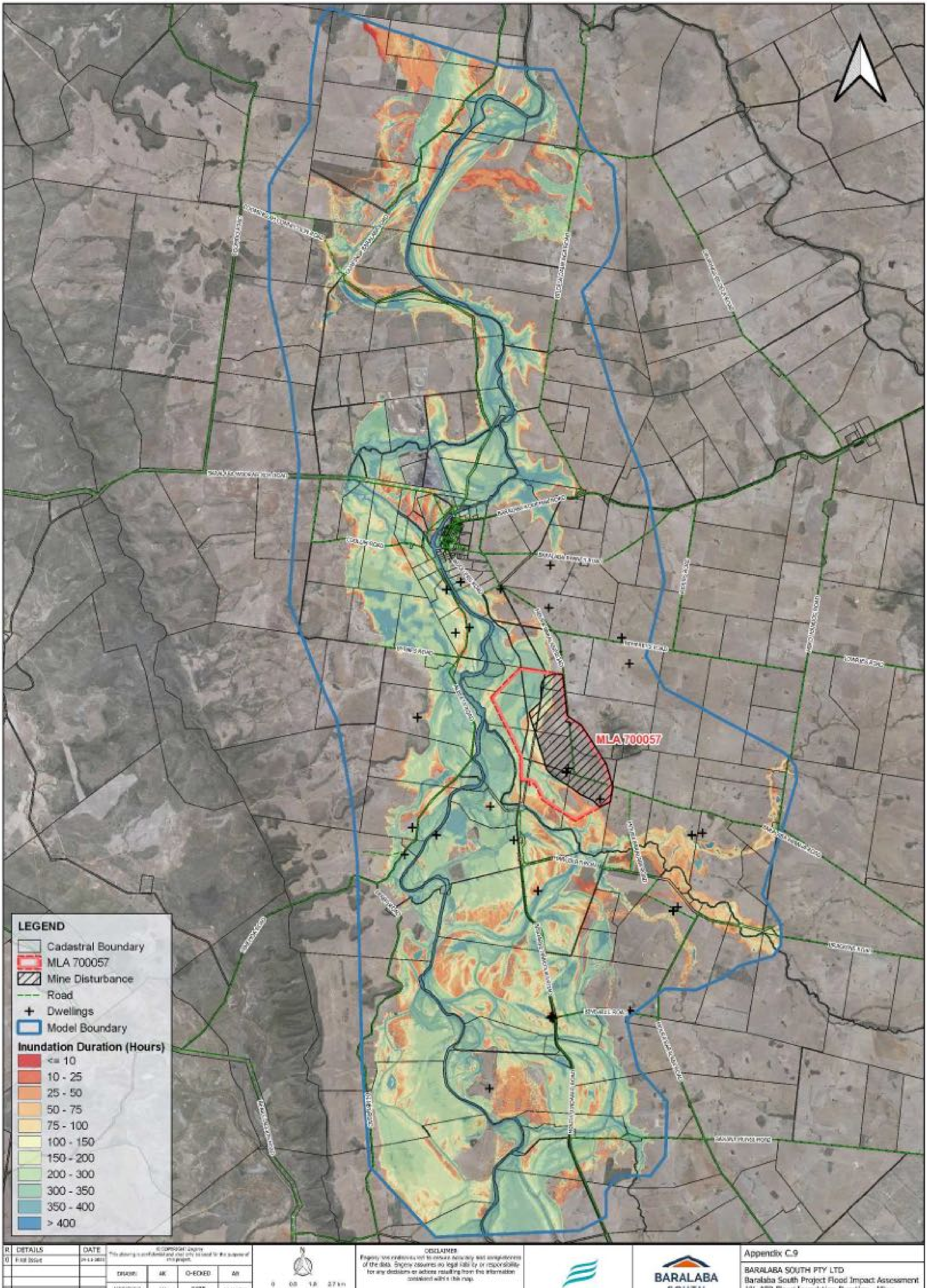
BARALABA SOUTH

Appendix C.8

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
2% AEP Flood Inundation Duration - Mine Developed Case

Job Number:
QC1018_004986-117-0



R	DETAILS	DATE
0	First Issue	[illegible]

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DRAWN	AK	CHECKED	AV
APPROVED	AV	DATE	[illegible]

NOTES

0 0.9 1.8 2.7 km

SCALE @ A3 - 1:150,000

GDA94 / MGA zone 55

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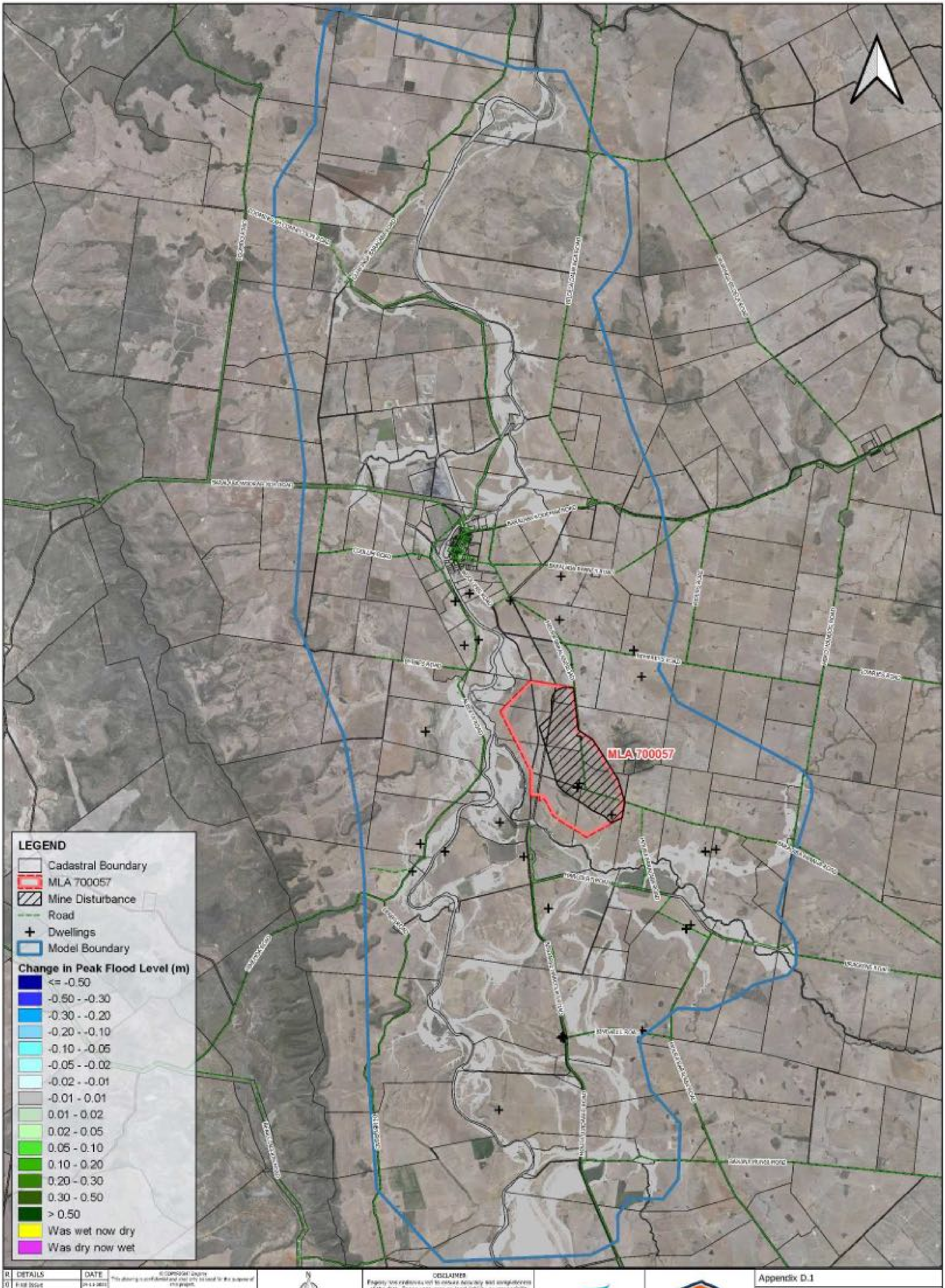
BARALABA SOUTH

Appendix C.9

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
1% AEP Flood Inundation Duration - Mine Developed Case

Job Number:
[illegible]

APPENDIX D: FLOOD DEPTH IMPACT MAPS



R	DETAILS	DATE
0	First Issue	[illegible]

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APPROVED	AV	DATE	[illegible]

SCALE @ A3 - 1:150,000

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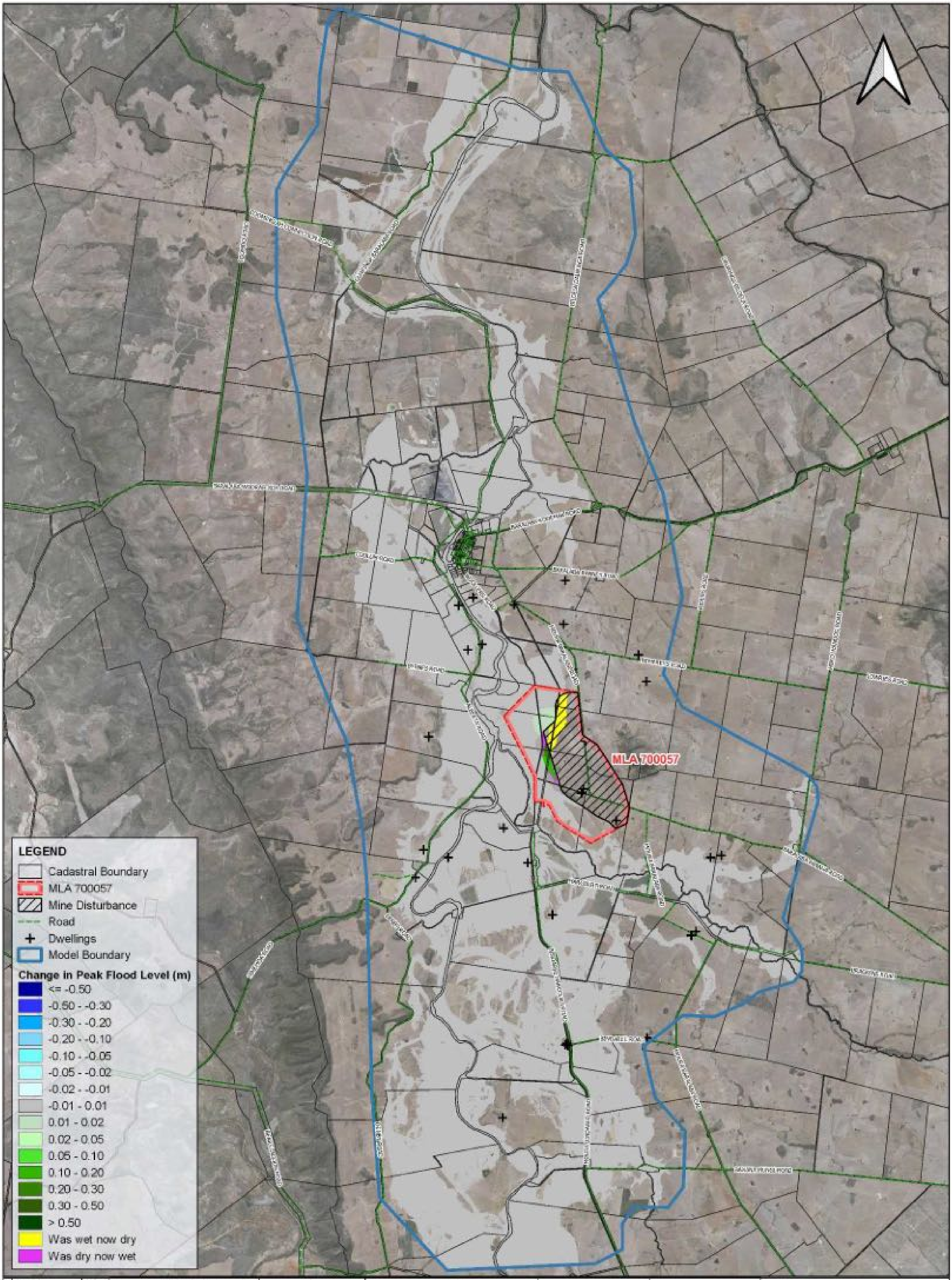
Appendix D.1

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
10% AEP Flood Afflux (Mine Developed Case - Existing Case)

Job Number:
[illegible]



R.	DETAILS	DATE
0	First Issue	24-11-2023

DRAWN	AK	CHECKED	AB
APPROVED	AV	DATE	24-11-2023

NOTES

N

0 0.9 1.8 2.7 km

SCALE @ A3 - 1:150,000

GDA94 / MGA zone 55

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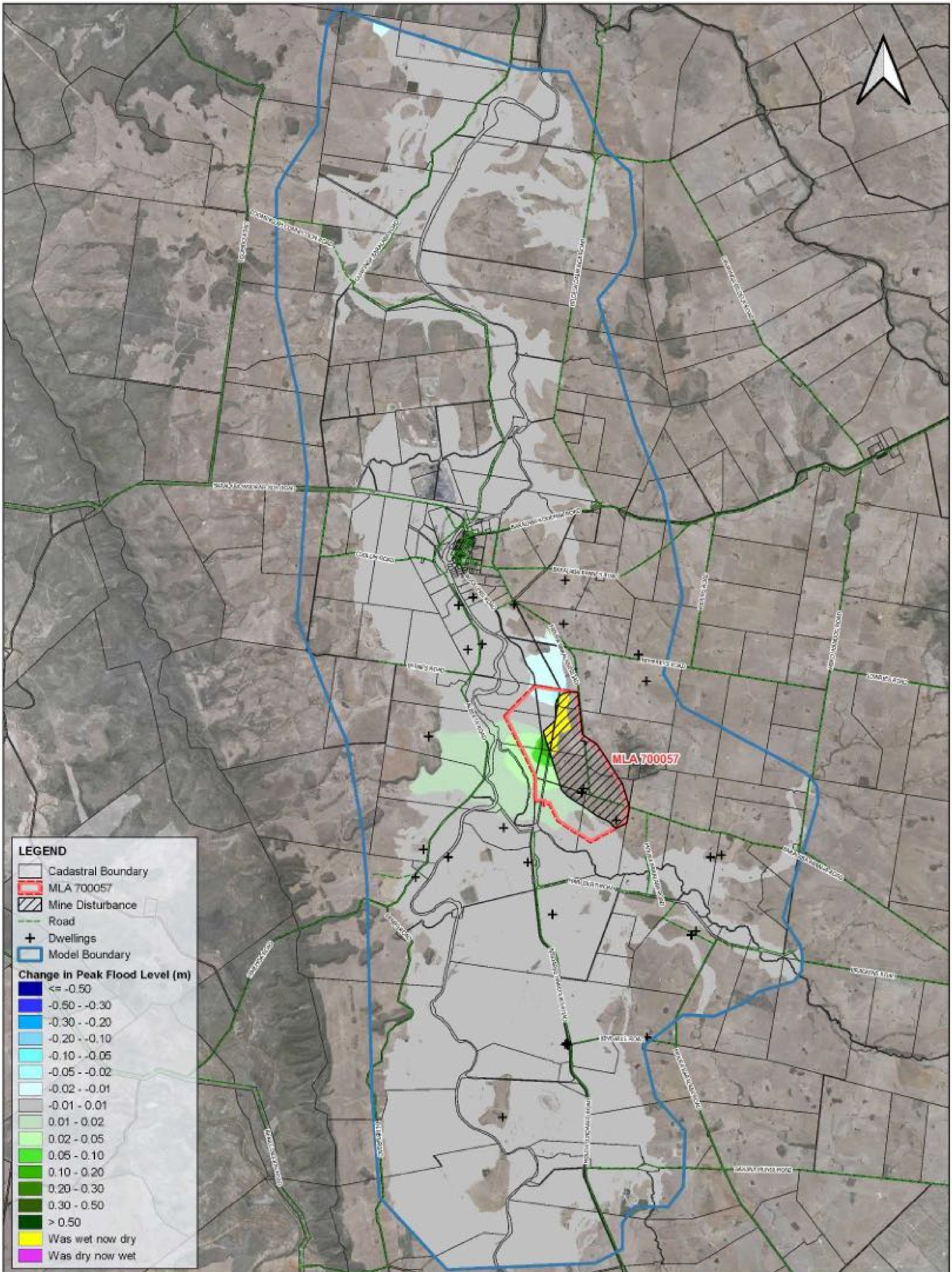
BARALABA SOUTH

Appendix D.2

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
2% AEP Flood Afflux (Mine Developed Case - Existing Case)

Job Number:
[illegible]

[illegible]



R	DETAILS	DATE
0	First Issue	24-11-2023

DRAWN	AK	CHECKED	AV
APPROVED	AV	DATE	24-11-2023

NOTES

0 0.9 1.8 2.7 km

SCALE @ A3 - 1:150,000

GDA94 / MGA zone 55

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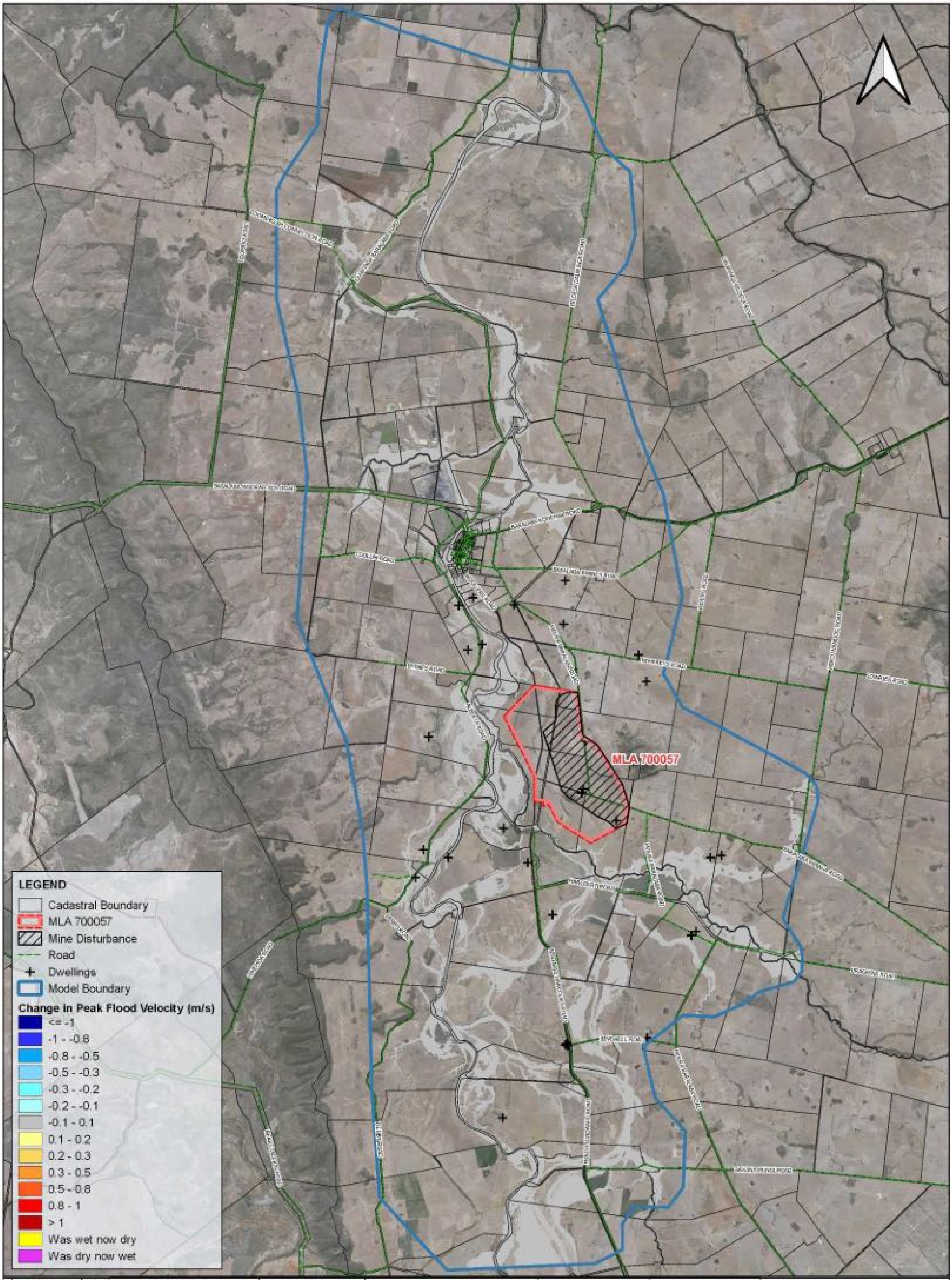
Appendix D.3

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
1% AEP Flood Afflux (Mine Developed Case - Existing Case)

Job Number:
[illegible]

Q:\Projects\QC1018 Baralaba Coal\QC1018_004986 [illegible]\QC1018_004986R01-001-C-Flood_Figures.qgz

APPENDIX E: FLOOD VELOCITY IMPACT MAPS



R.	DETAILS	DATE
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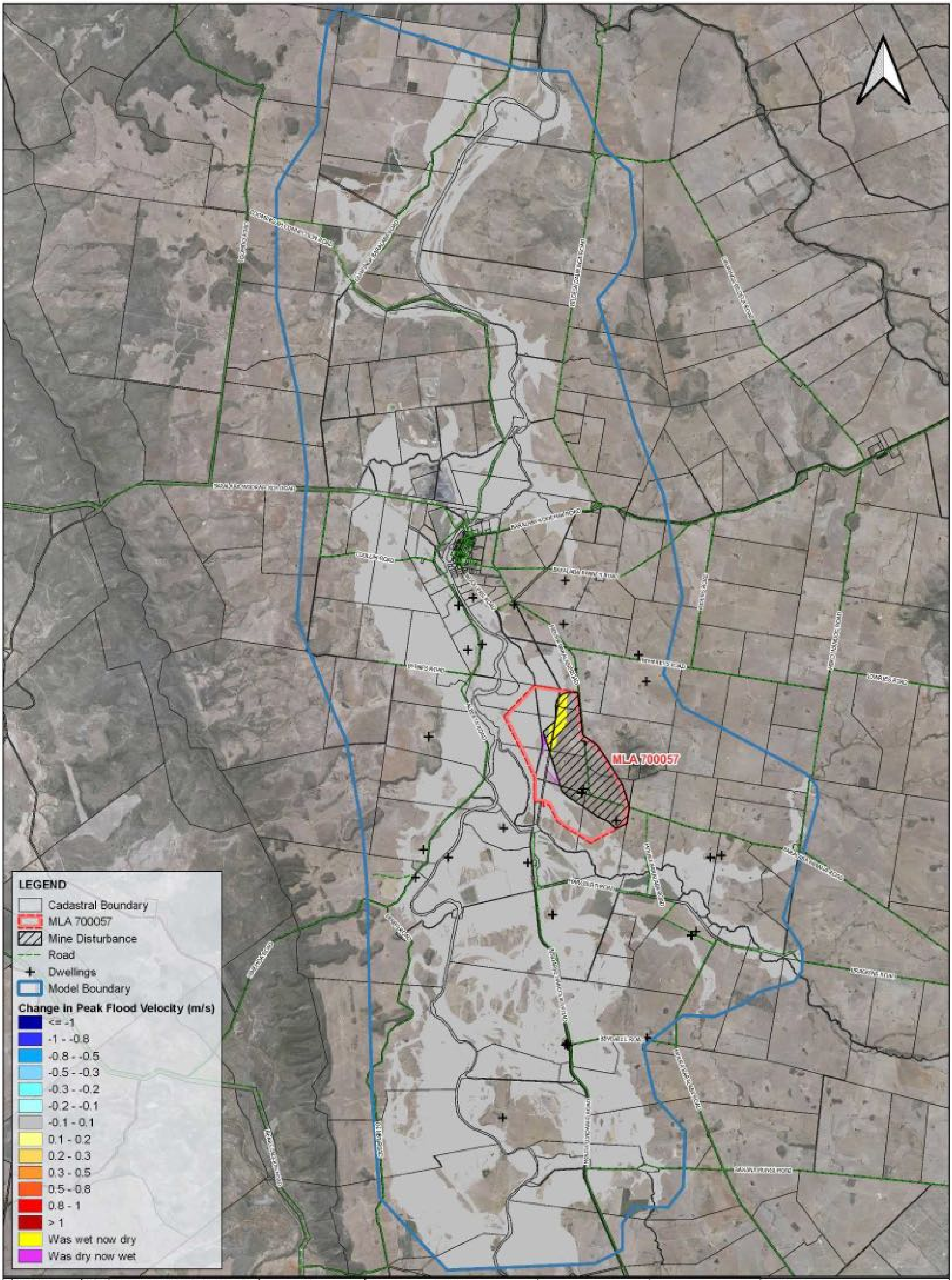
BARALABA SOUTH

Appendix E.1

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
10% AEP Change in Peak Flood Velocity (Mine Developed Case - Existing Case)

Job Number:
[illegible]

[illegible]



R	DETAILS	DATE
0	First Issue	[illegible]

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DRAWN	AK	CHECKED	AV
APPROVED	AV	DATE	[illegible]

NOTES

0 0.9 1.8 2.7 km

SCALE @ A3 - 1:150,000

GDA94 / MGA zone 55

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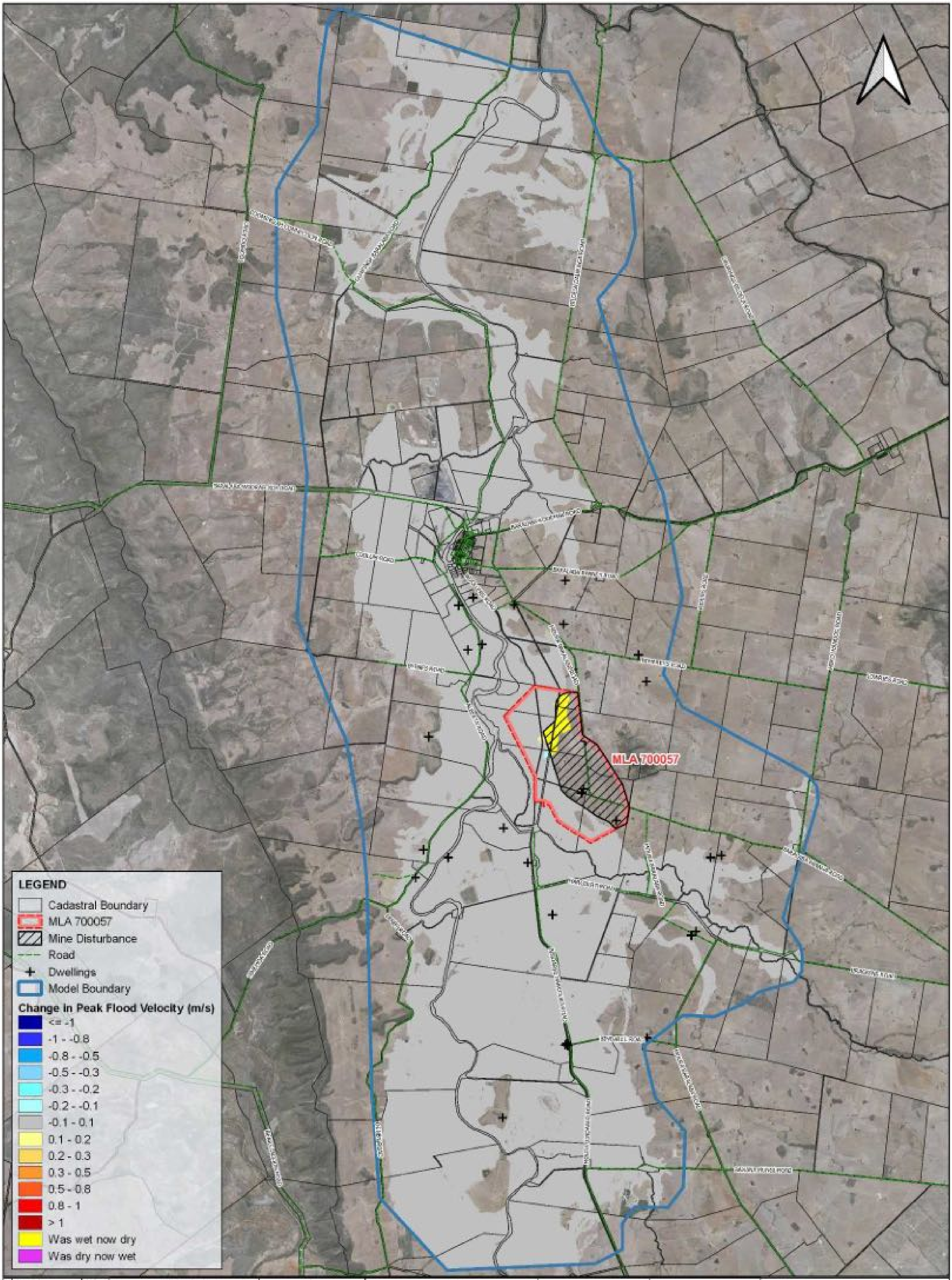
BARALABA SOUTH

Appendix E.2

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
2% AEP Change in Peak Flood Velocity (Mine Developed Case - Existing Case)

Job Number:
[illegible]

[illegible]



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APPROVED	AV	DATE	24-11-2023

NOTES

0 0.9 1.8 2.7 km

SCALE @ A3 - 1:150,000

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BARALABA SOUTH

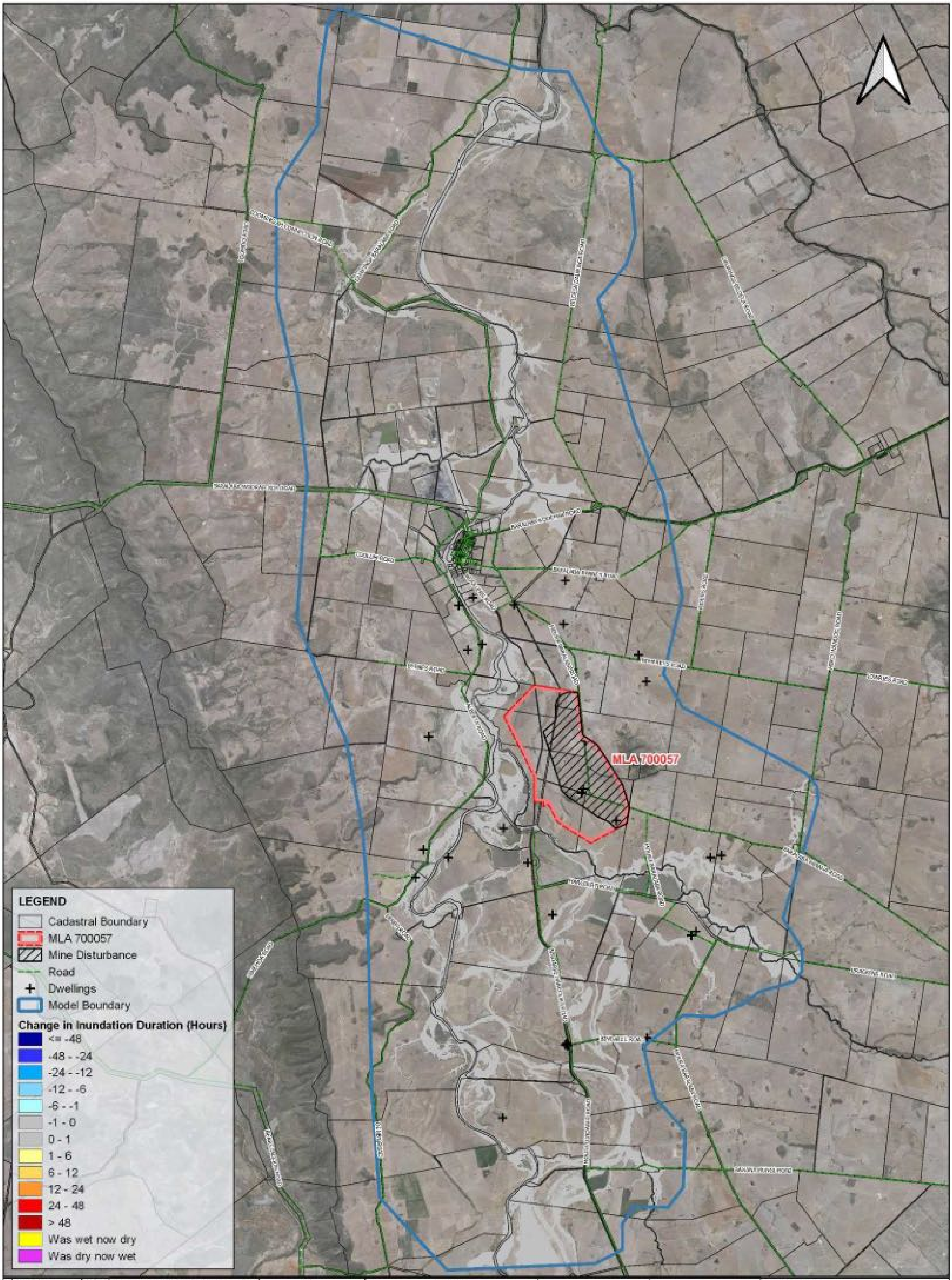
Appendix E.3

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
1% AEP Change in Peak Flood Velocity (Mine Developed Case - Existing Case)

Job Number:
[illegible]

[illegible]

APPENDIX F: FLOOD INUNDATION DURATION IMPACT MAPS



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APPROVED	AV	DATE	[illegible]

0 0.9 1.8 2.7 km

SCALE @ A3 - 1:150,000

GDA94 / MGA zone 55

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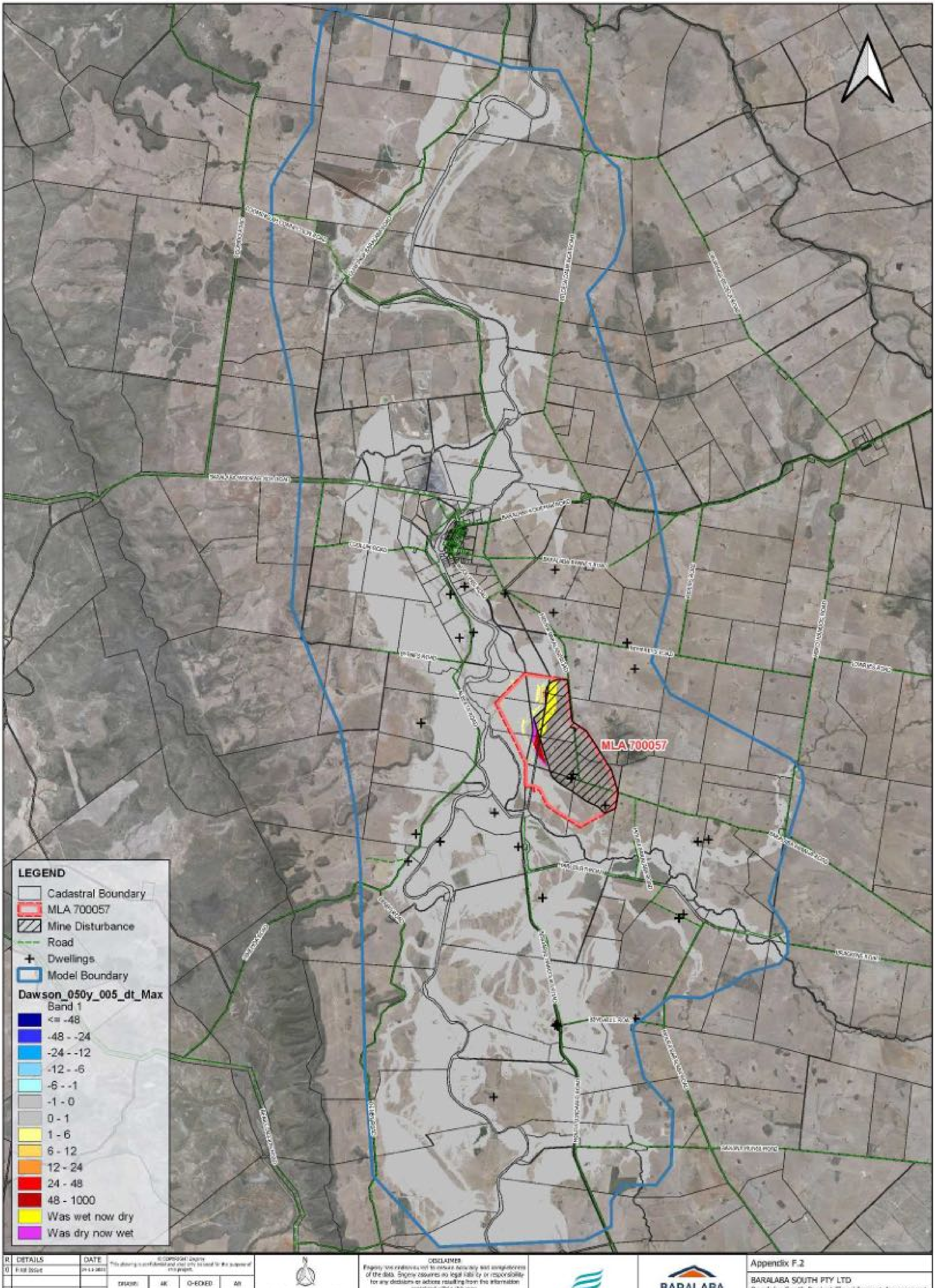
BARALABA SOUTH

Appendix F.1

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
10% AEP Change in Inundation Duration (Mine Developed Case - Existing Case)

Job Number:



R.	DETAILS	DATE
0	First Issue	[illegible]

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NOTES

SCALE @ A3 - 1:150,000

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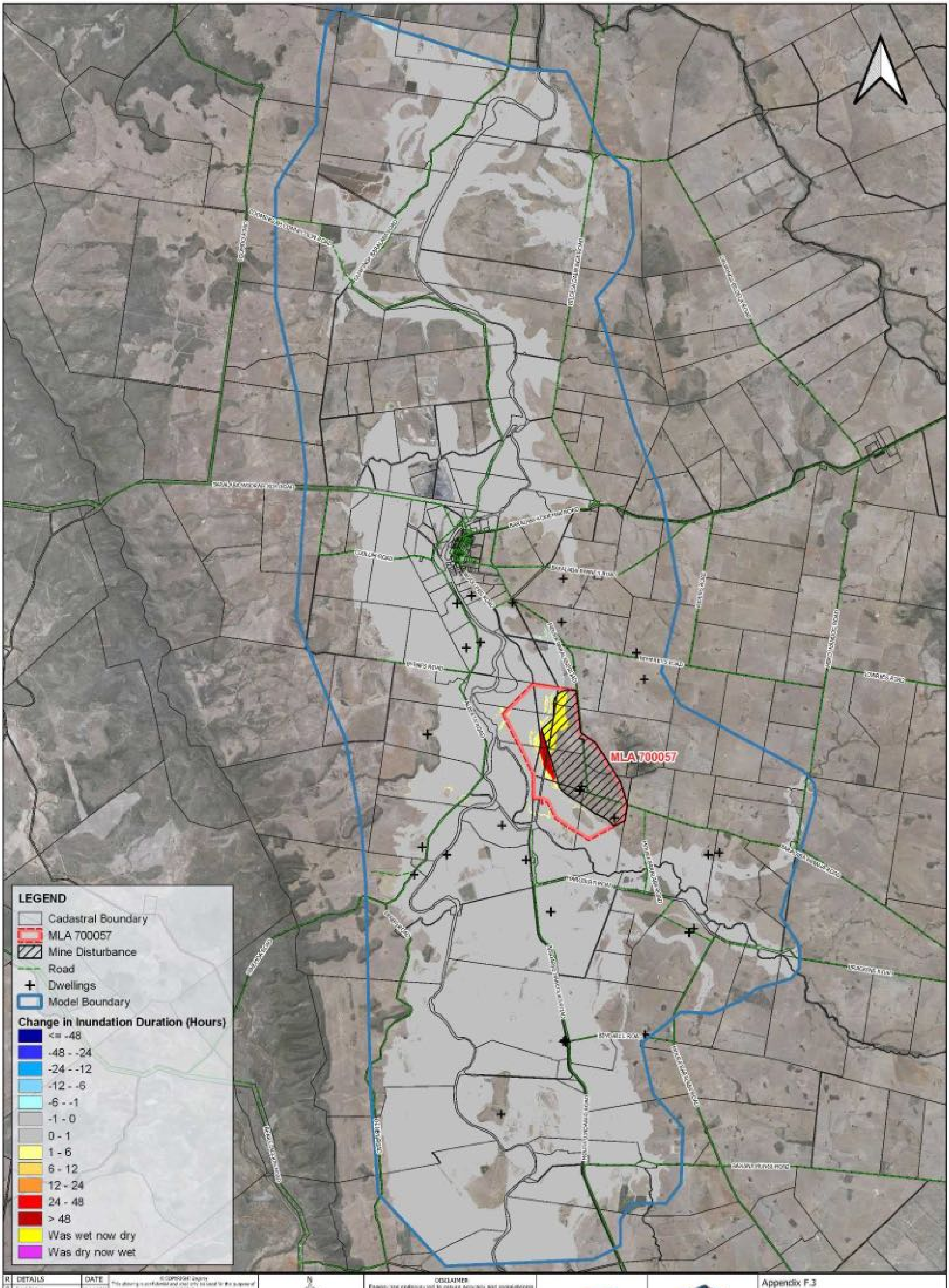
BARALABA SOUTH

Appendix F.2

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
2% AEP Change in Inundation Duration (Mine Developed Case - Existing Case)

Job Number:
[illegible]

[illegible]



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NOTES

SCALE @ A3 - 1:150,000

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BARALABA SOUTH

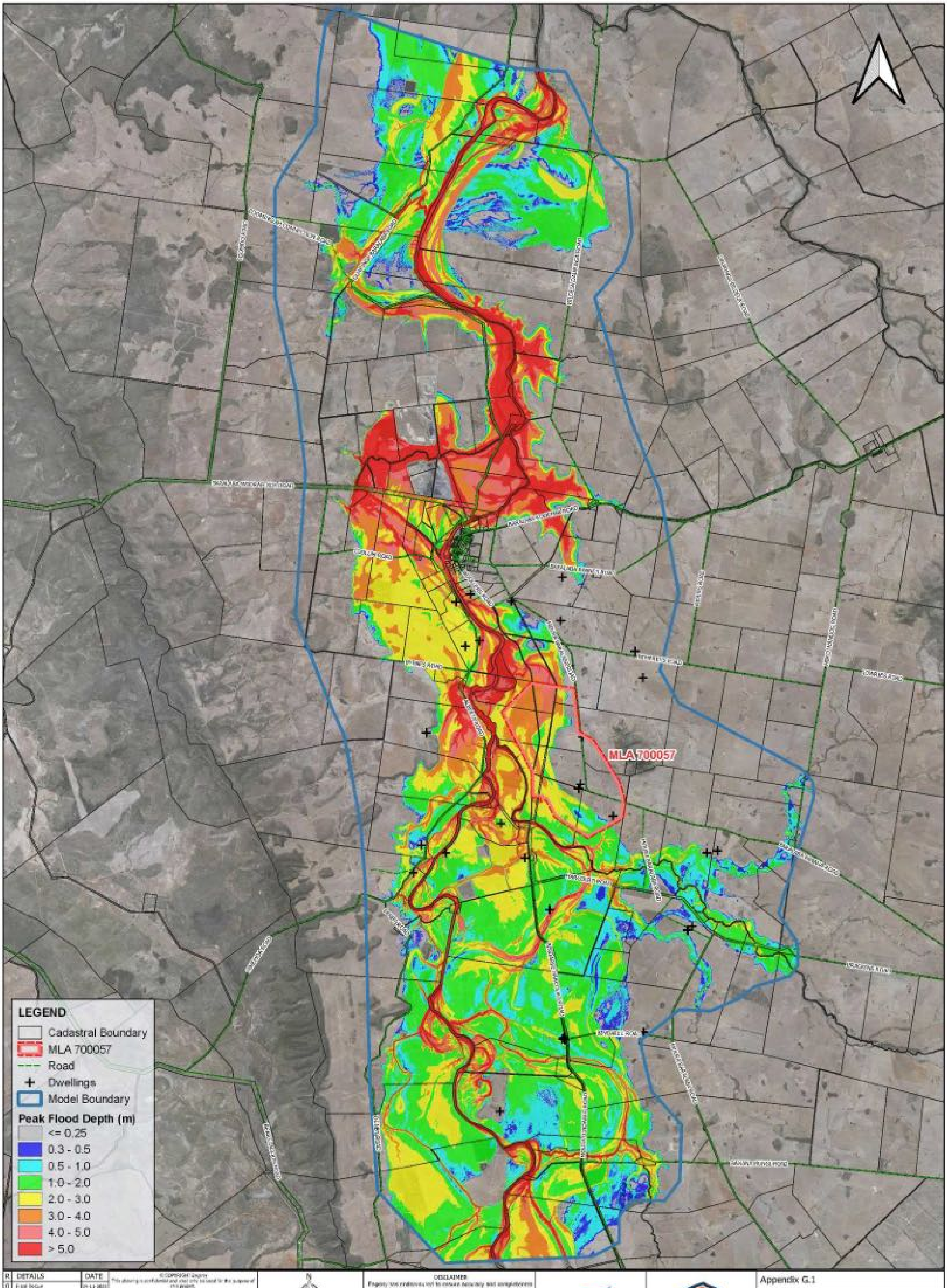
Appendix F.3

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
1% AEP Change in Inundation Duration (Mine Developed Case - Existing Case)

Job Number:
[illegible]

[illegible]Flood_Figures.qgz

APPENDIX G: EXTREME EVENT FLOOD MAPS



R	DETAILS	DATE
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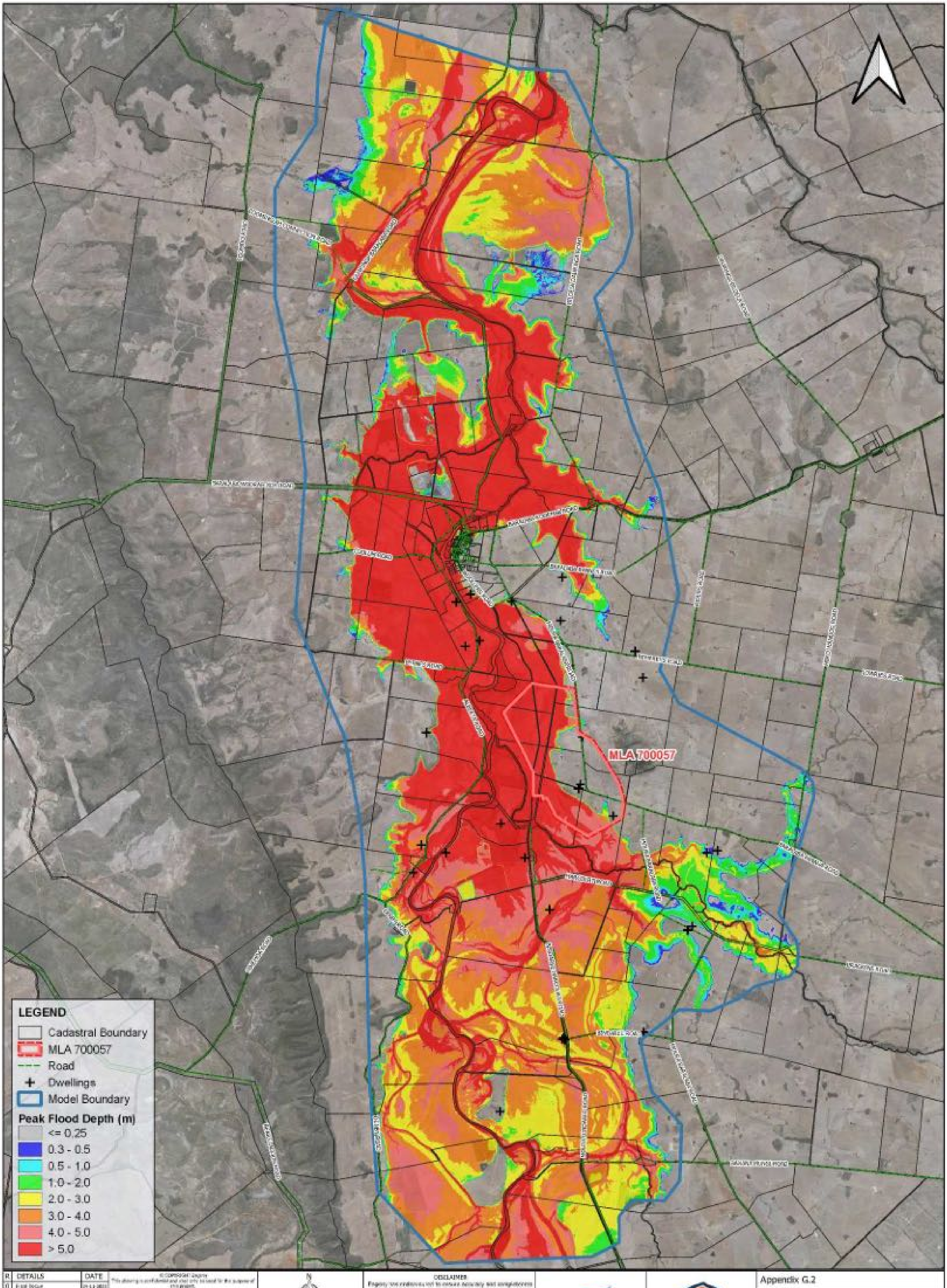
BARALABA SOUTH

Appendix G.1

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
0.1% AEP Flood Depth - Existing Case

Job Number:
[illegible]

[illegible]



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APPROVED	AV	DATE	[illegible]

SCALE @ A3 - 1:150,000

GDA94 / MGA zone 55

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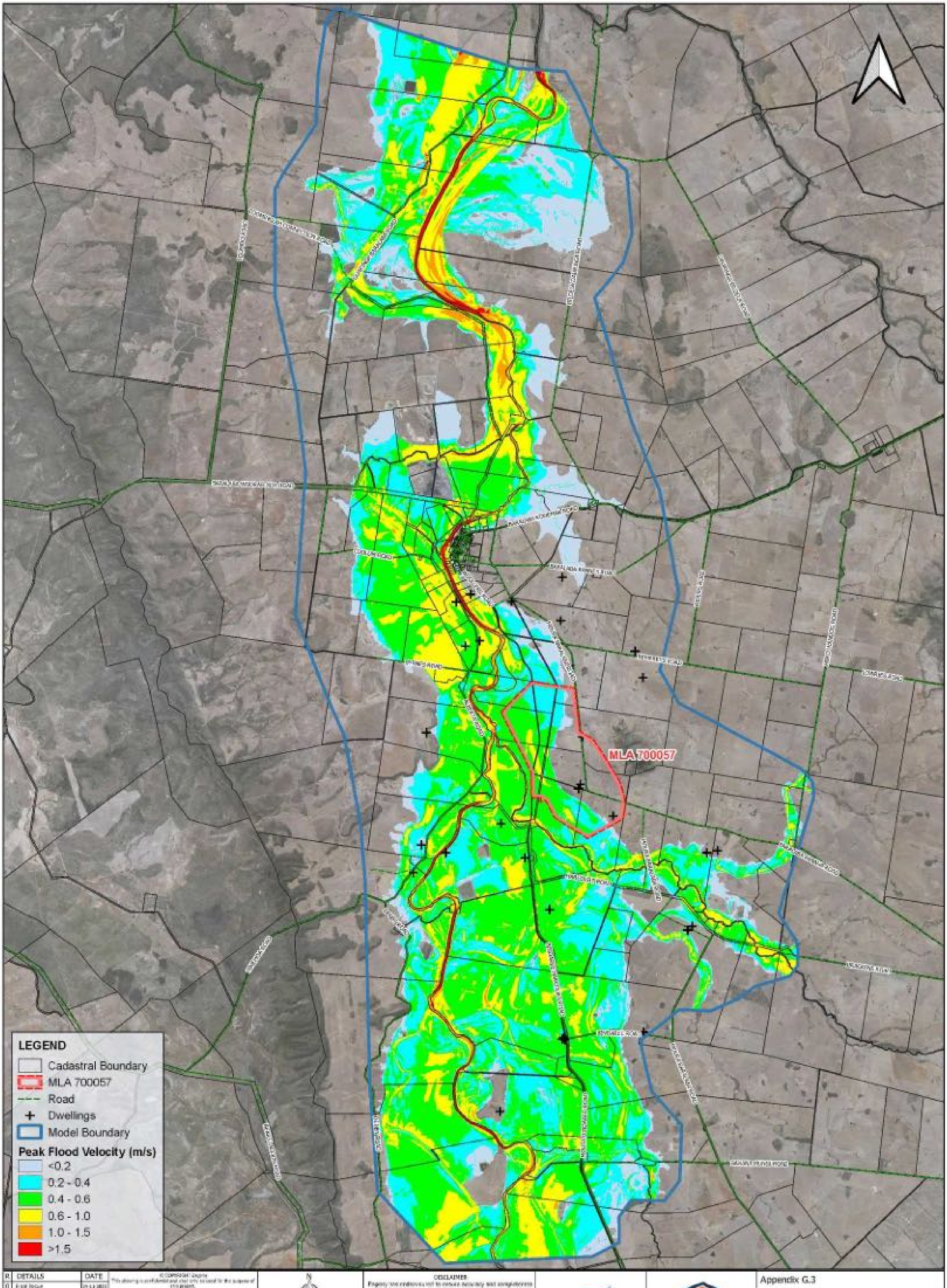
BARALABA SOUTH

Appendix G.2

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
PMF Flood Depth - Existing Case

Job Number:
[illegible]



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0	First Issue	[illegible]

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APPROVED	AV	DATE	[illegible]

0 0.9 1.8 2.7 km

SCALE @ A3 - 1:150,000

GDA94 / MGA zone 55

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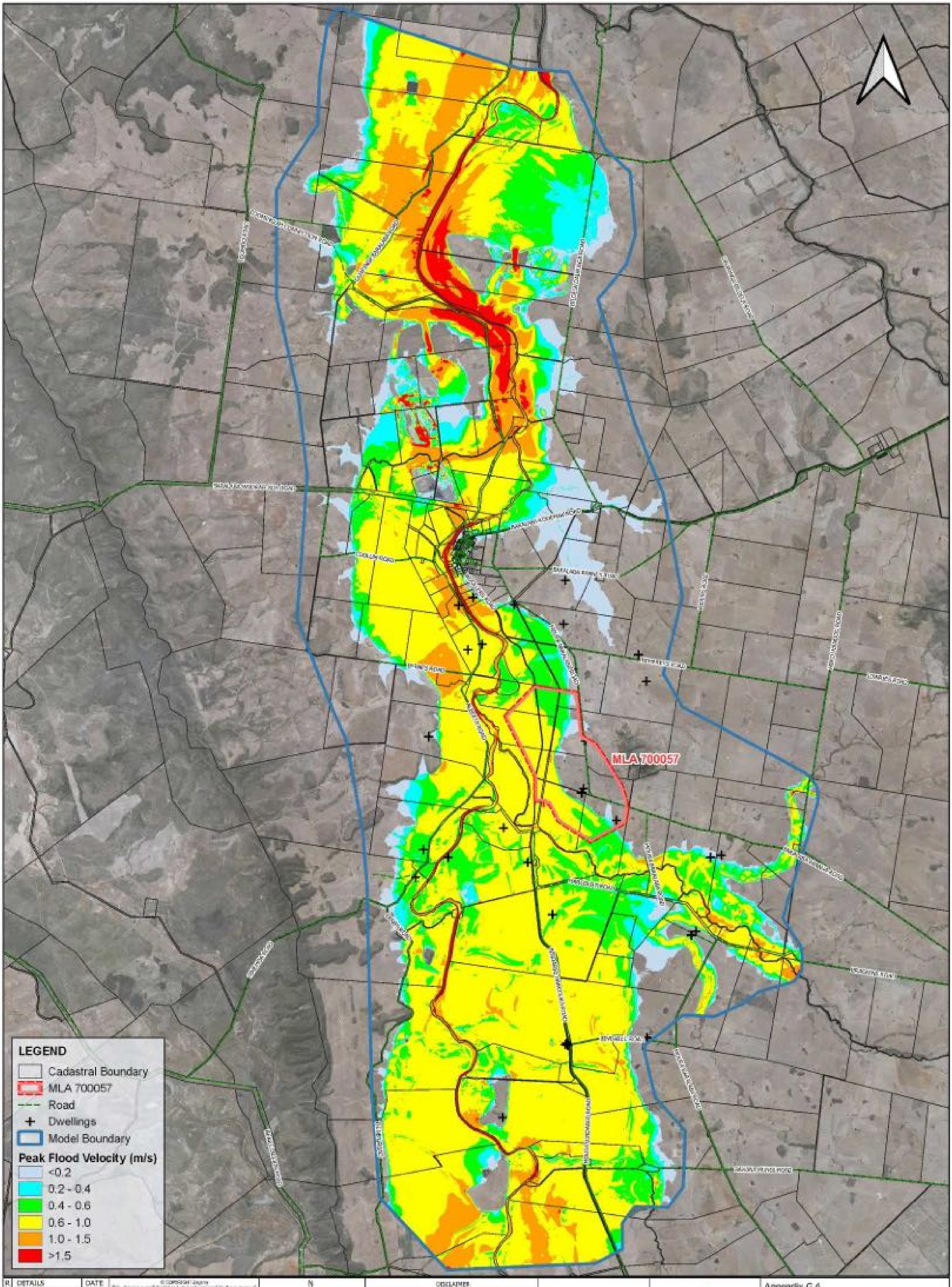
BARALABA SOUTH

Appendix G.3

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
0.1% AEP Flood Velocity - Existing Case

Job Number:
[illegible]



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APPROVED	AV	DATE	24-11-2023

NOTES

0 0.8 1.6 2.7 km

SCALE @ A3 - 1:150,000

GDA94 / MGA zone 55

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BARALABA SOUTH

Appendix G.4

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
PMF Flood Velocity - Existing Case

Job Number:
QC1018_004986-LC-1

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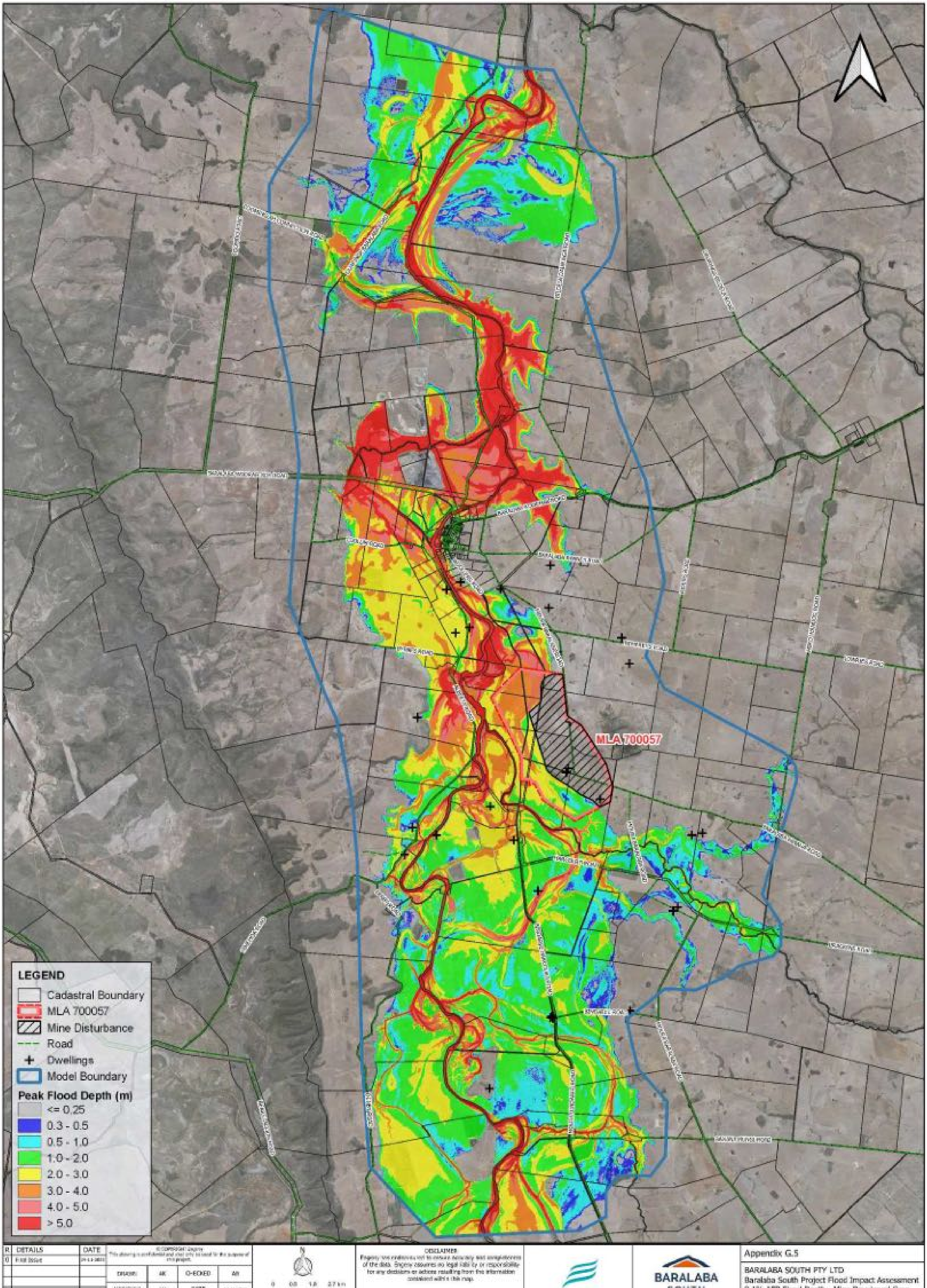

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APPROVED	AV	DATE	[illegible]

SCALE @ A3 - 1:150,000
GDA94 / MGA zone 55

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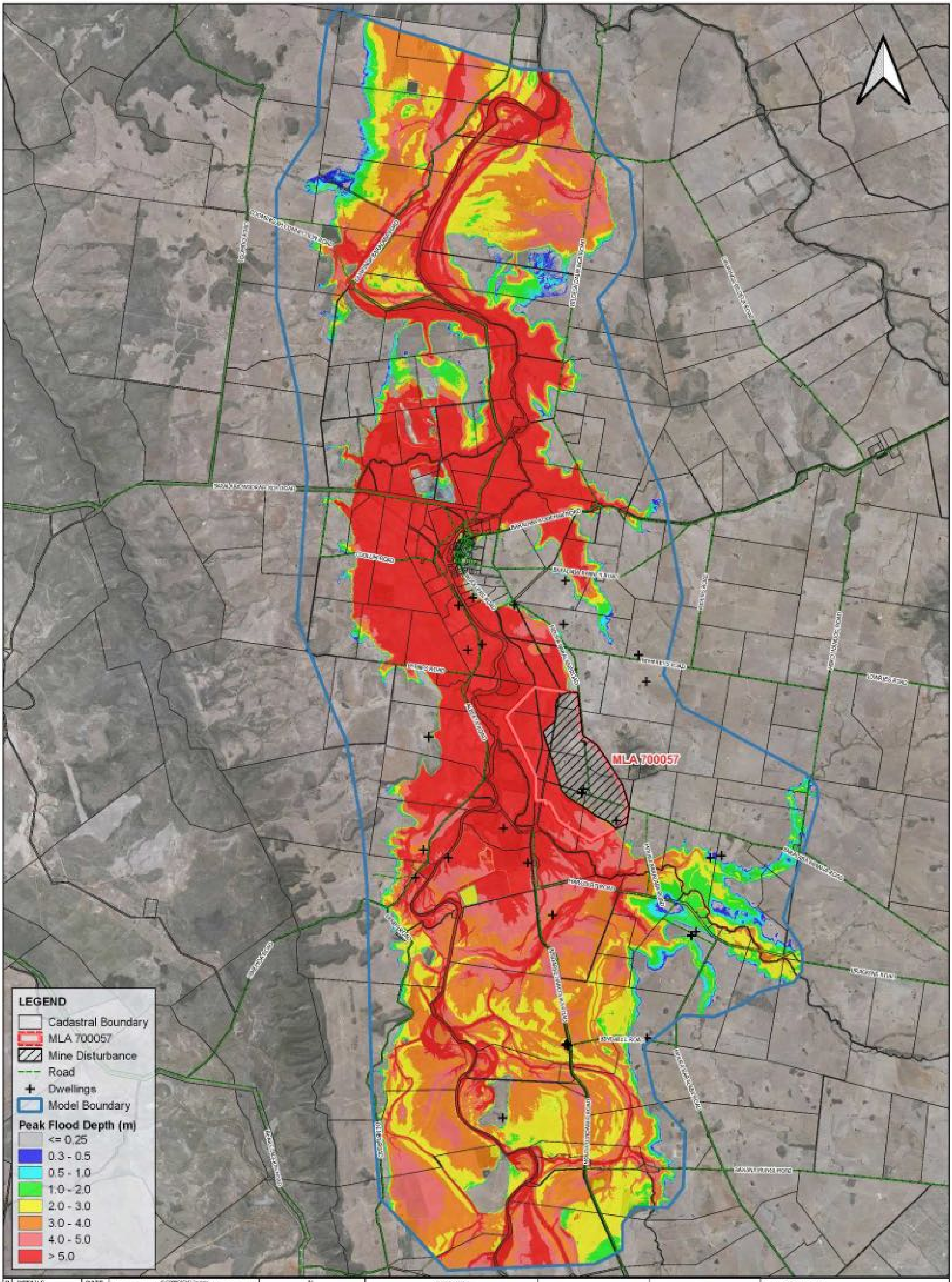
BARALABA SOUTH

Appendix G.5

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
0.1% AEP Flood Depth - Mine Developed Case

Job Number:
[illegible]



R	DETAILS	DATE
0	First Issue	[illegible]

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DRAWN	AK	CHECKED	AR
APPROVED	AV	DATE	[illegible]

NOTES

N
0 0.9 1.8 2.7 km
SCALE @ A3 - 1:150,000
GDA94 / MGA zone 55

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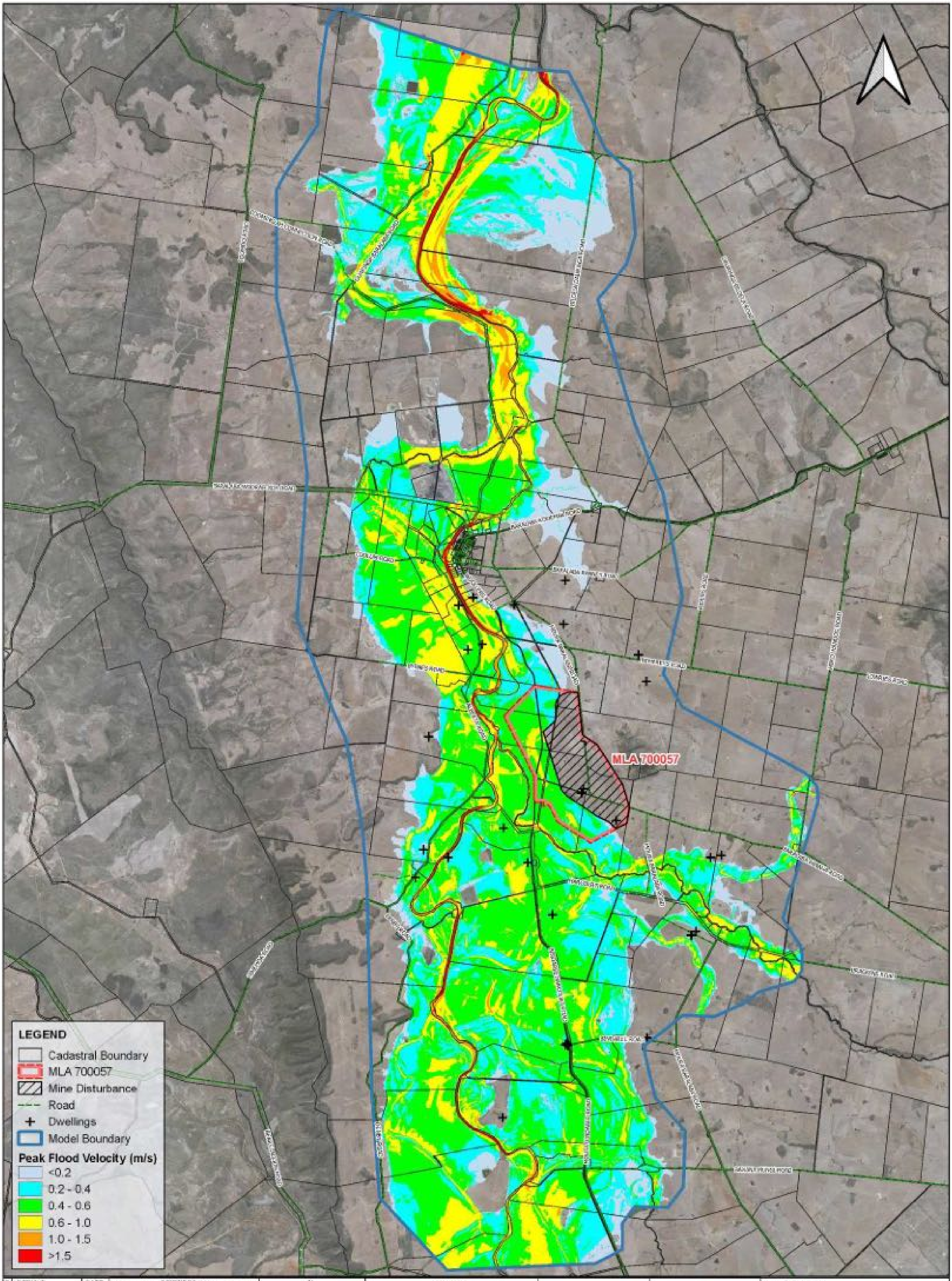
BARALABA SOUTH

Appendix G.6

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
PMF Flood Depth - Mine Developed Case

Job Number:
[illegible]



R	DETAILS	DATE
0	First Issue	[illegible]

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DRAWN	AK	CHECKED	AB
APPROVED	AV	DATE	[illegible]

NOTES

0 0.9 1.8 2.7 km

SCALE @ A3 - 1:150,000

GDA94 / MGA zone 55

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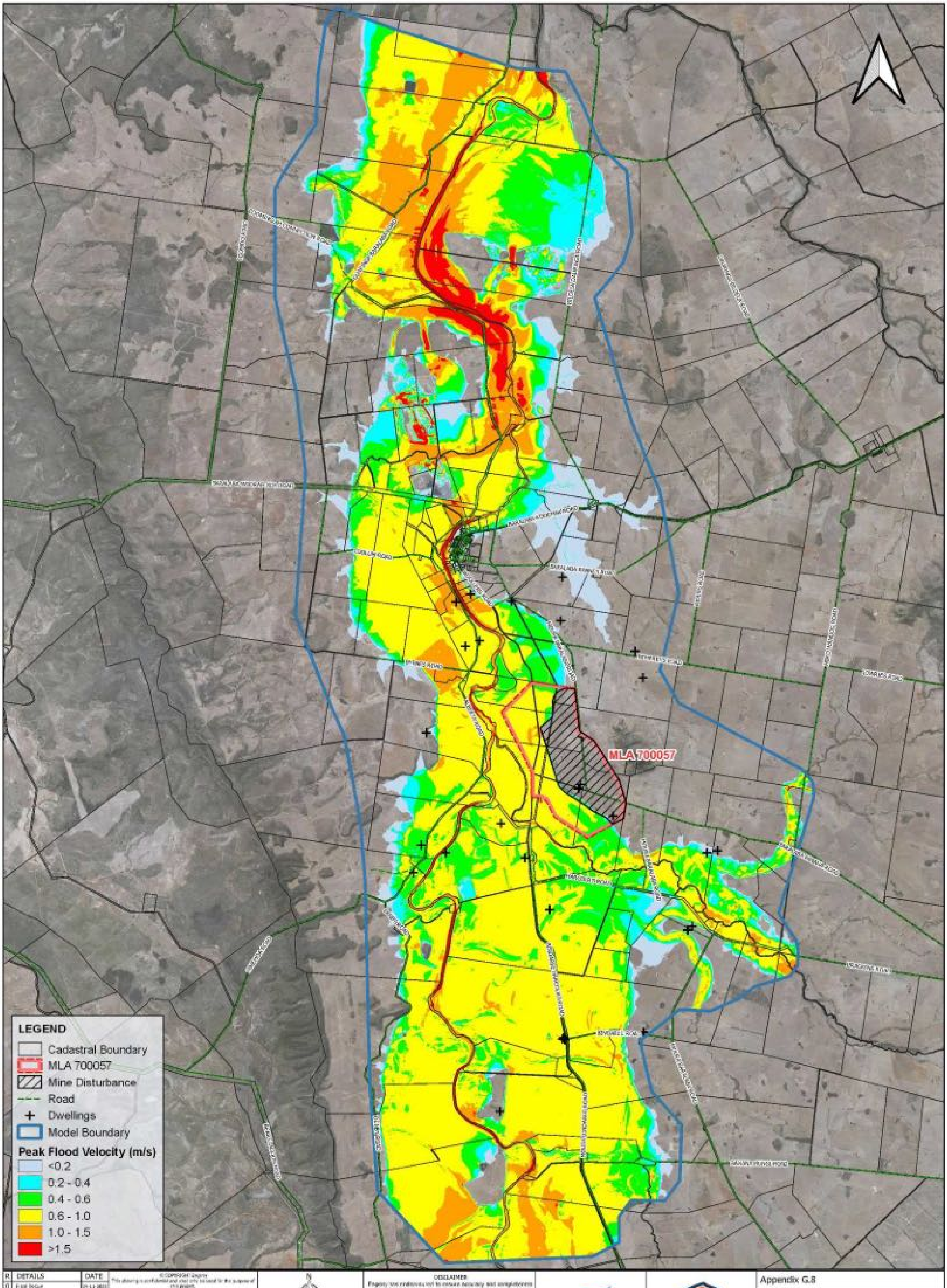
BARALABA SOUTH

Appendix G.7

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
0.1% AEP Flood Velocity - Mine Developed Case

Job Number:
[illegible]



R	DETAILS	DATE
0	First Issue	24-11-2023

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0 0.9 1.8 2.7 km

SCALE @ A3 - 1:150,000

GDA94 / MGA zone 55

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BARALABA SOUTH

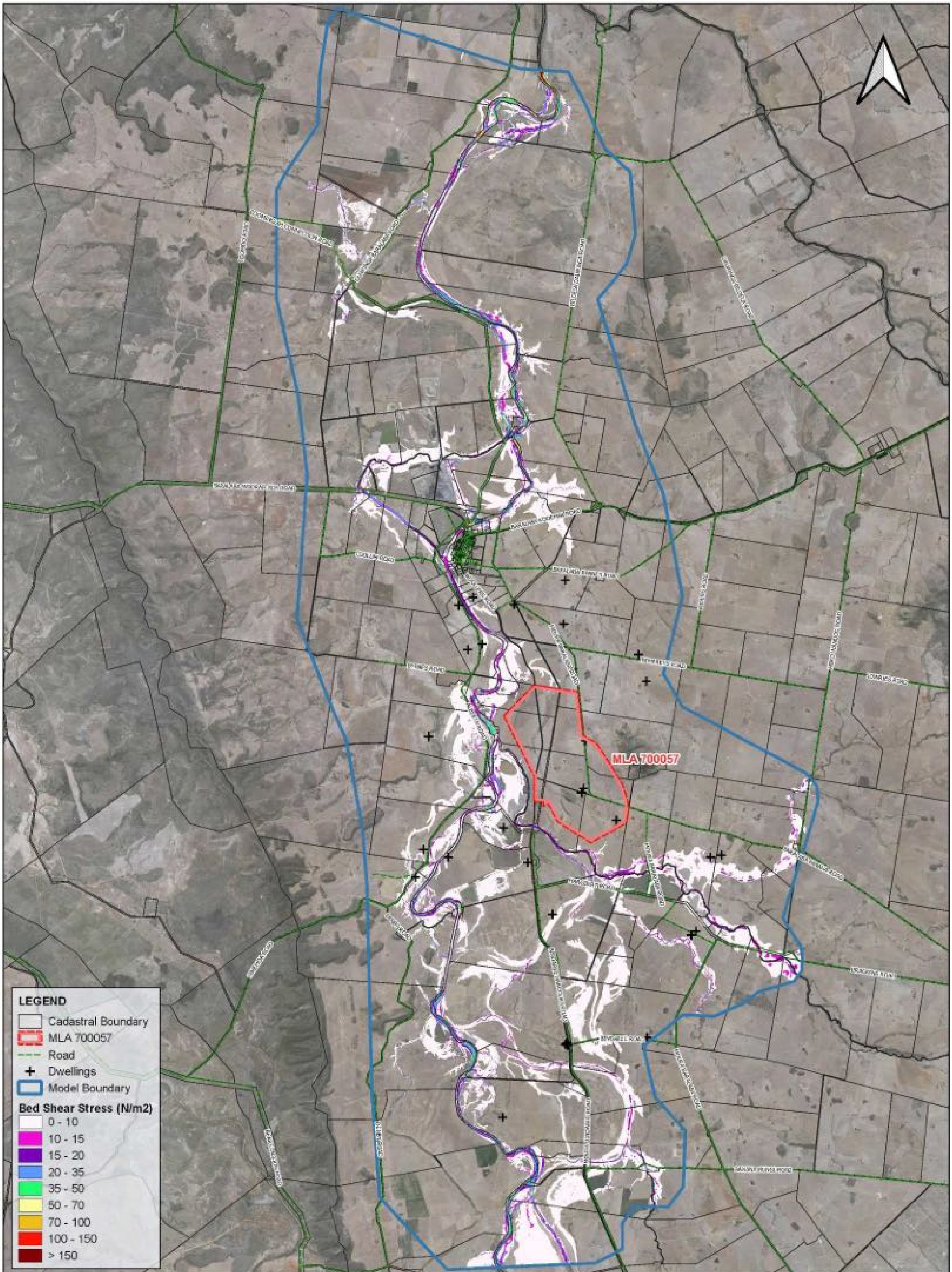
Appendix G.8

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
PMF Flood Velocity - Mine Developed Case

Job Number:
[illegible]

[illegible]

APPENDIX H: STREAM POWER AND BED SHEAR STRESS MAPS



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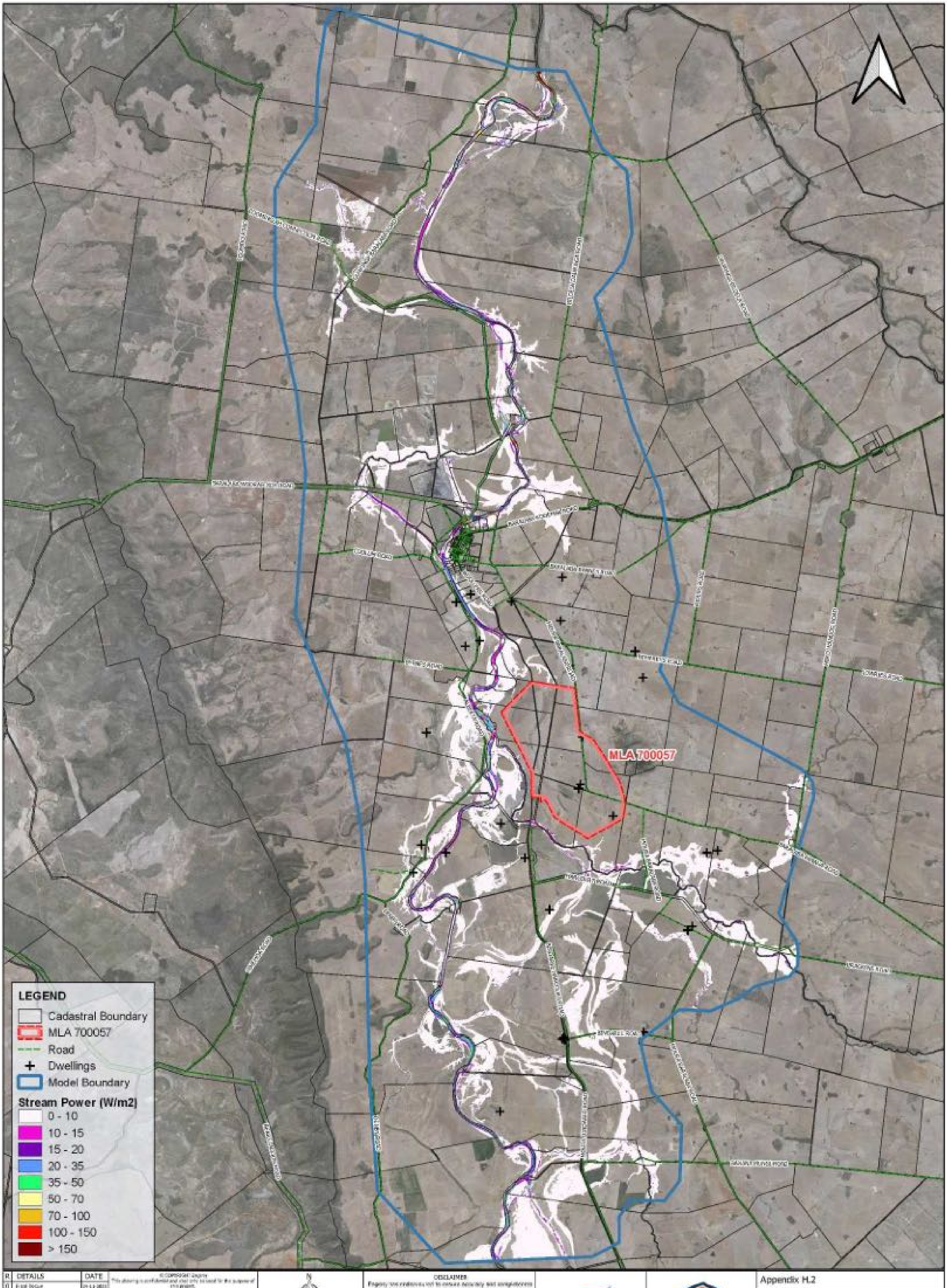
BARALABA SOUTH

Appendix H.1

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
10% AEP Bed Shear Stress - Existing Case

Job Number:
QC1018_004985-H0.1



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BARALABA SOUTH

Appendix H.2

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
10% AEP Stream Power - Existing Case

Job Number:
QC1018_004985-14C-0

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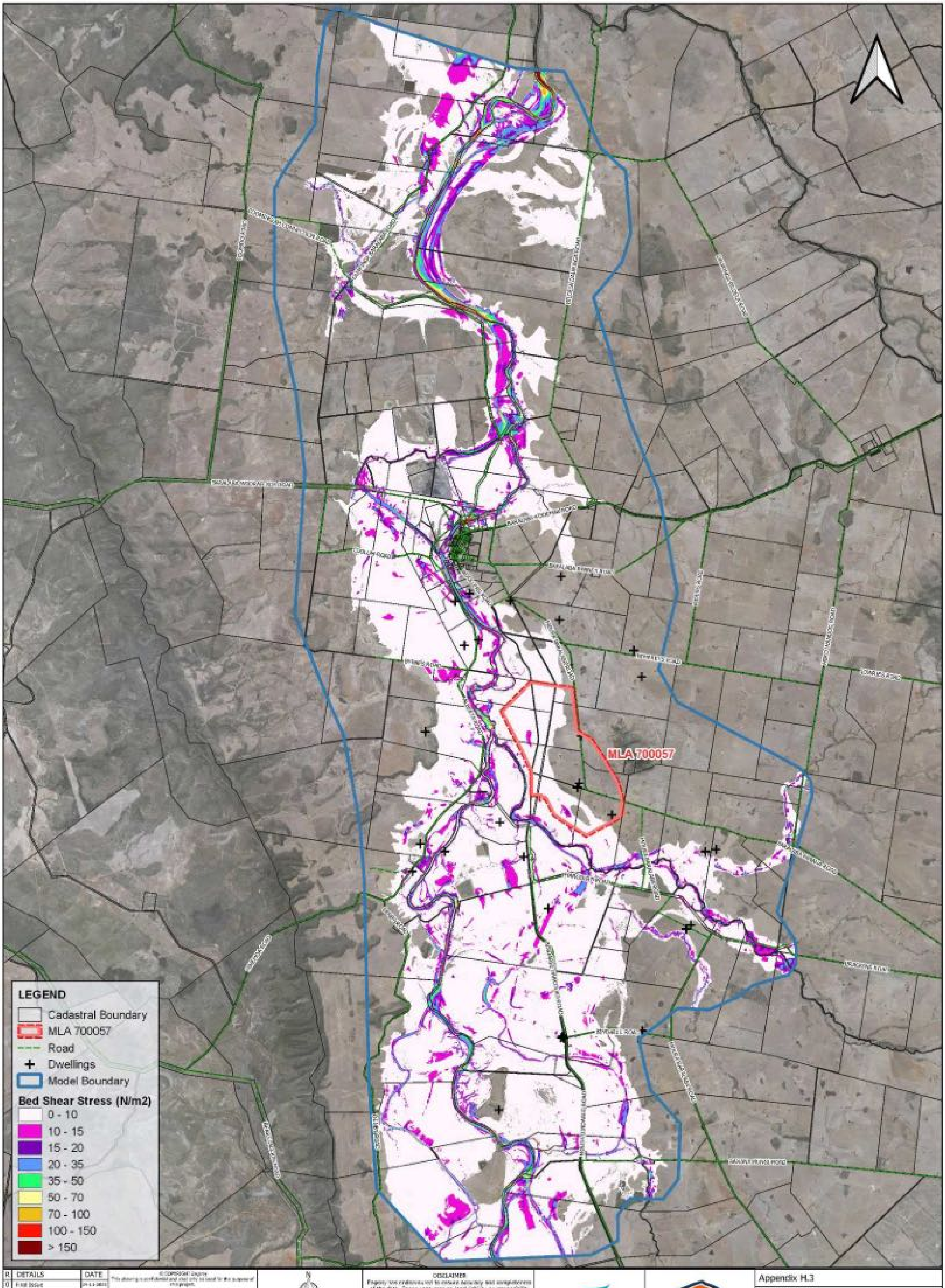

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0 0.8 1.6 2.7 km

SCALE @ A3 - 1:150,000

GDA94 / MGA zone 55

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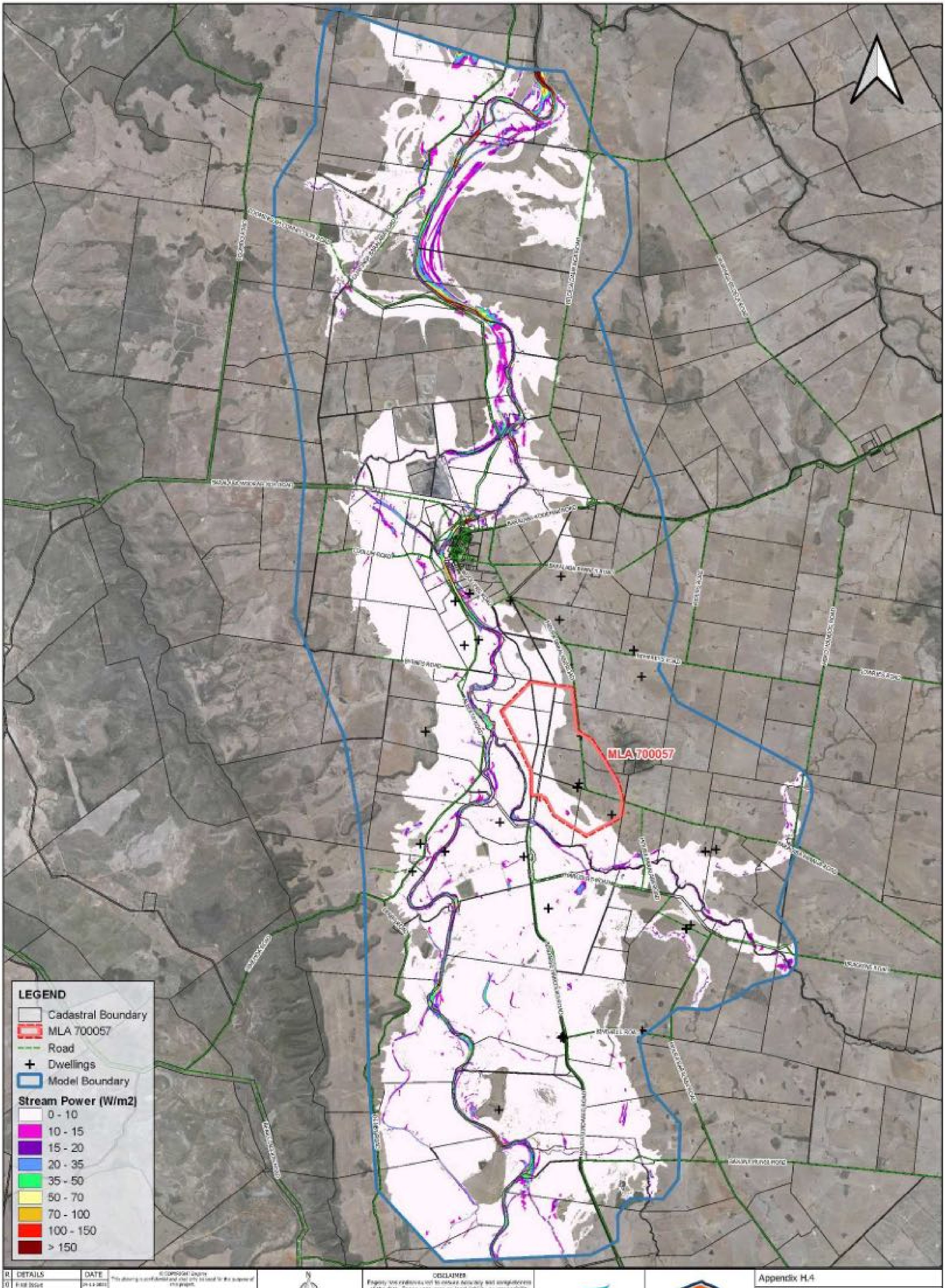
BARALABA SOUTH

Appendix H.3

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
1% AEP Bed Shear Stress - Existing Case

Job Number:



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NOTES

N

0 0.9 1.8 2.7 km

SCALE @ A3 - 1:150,000

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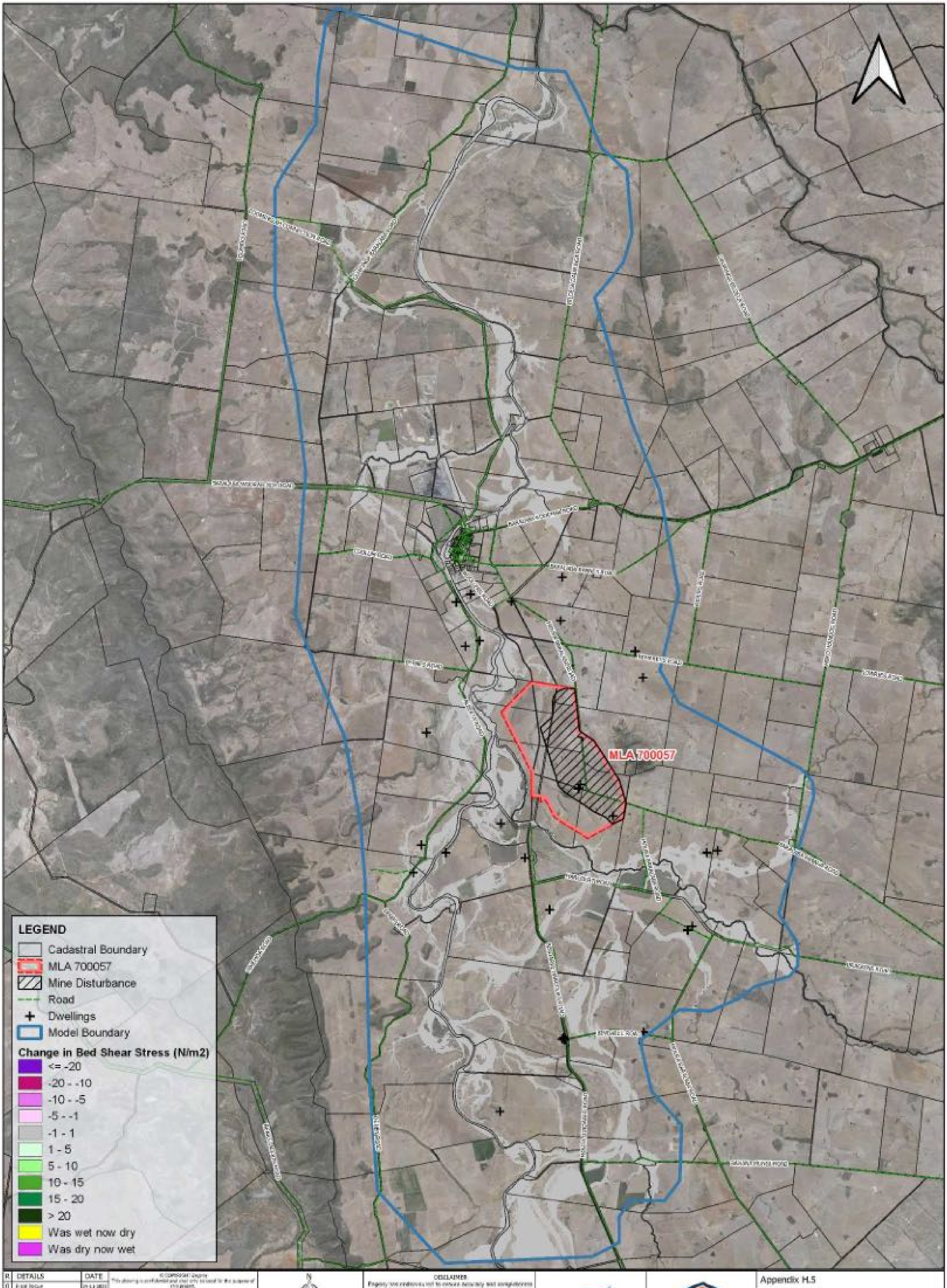
BARALABA SOUTH

Appendix H.4

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
1% AEP Stream Power - Existing Case

Job Number:
[illegible]

[illegible]



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APPROVED	AV	DATE	[illegible]

0 0.8 1.6 2.7 km

SCALE @ A3 - 1:150,000

GDA94 / MGA zone 55

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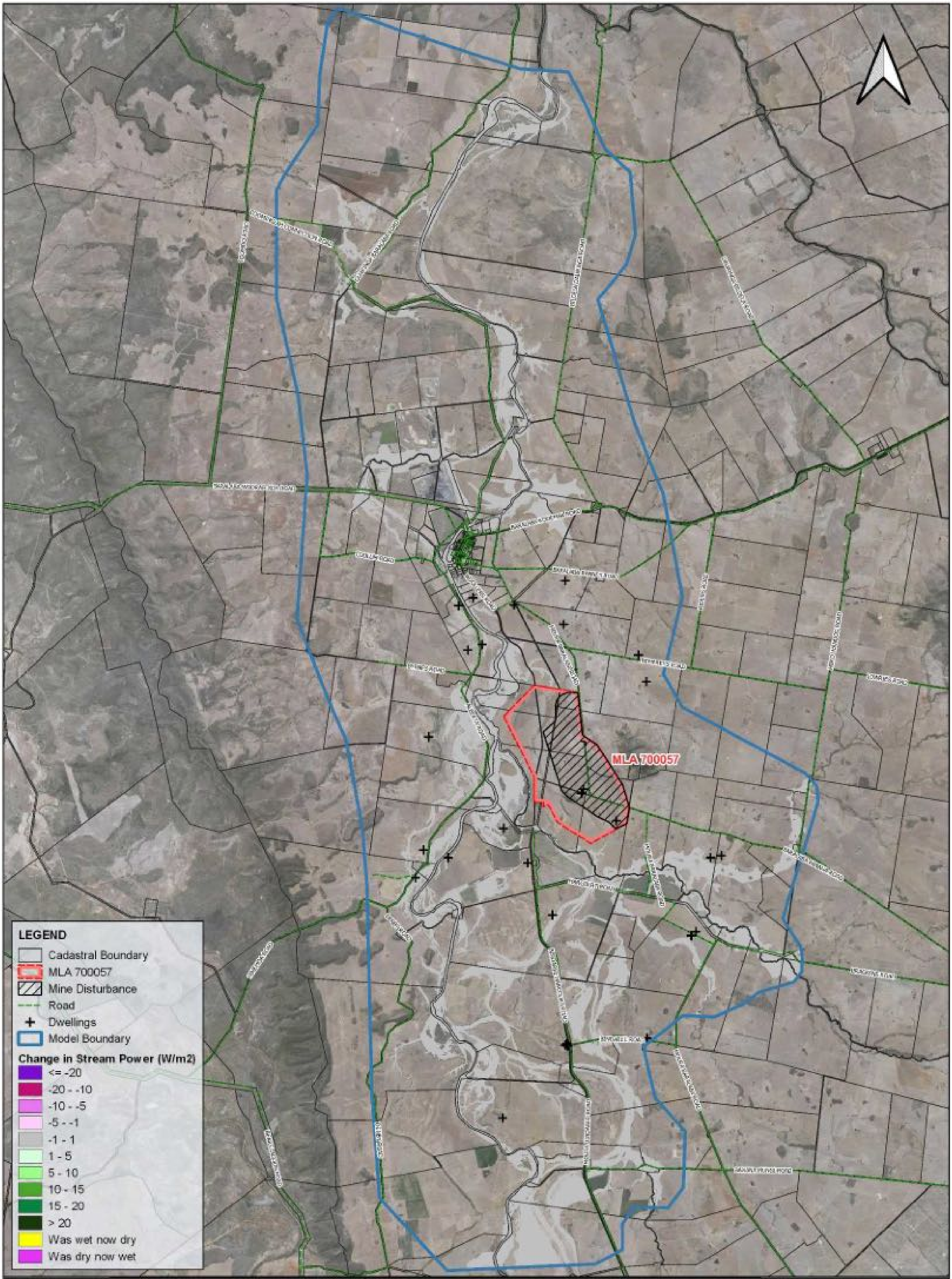
BARALABA SOUTH

Appendix H.5

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
10% AEP Change In Bed Shear Stress (Mine Developed Case - Existing Case)

Job Number:
[illegible]



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NOTES

0 0.9 1.8 2.7 km

SCALE @ A3 - 1:150,000

GDA94 / MGA zone 55

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BARALABA SOUTH

Appendix H.6

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
10% AEP Change In Stream Power (Mine Developed Case - Existing Case)

Job Number:
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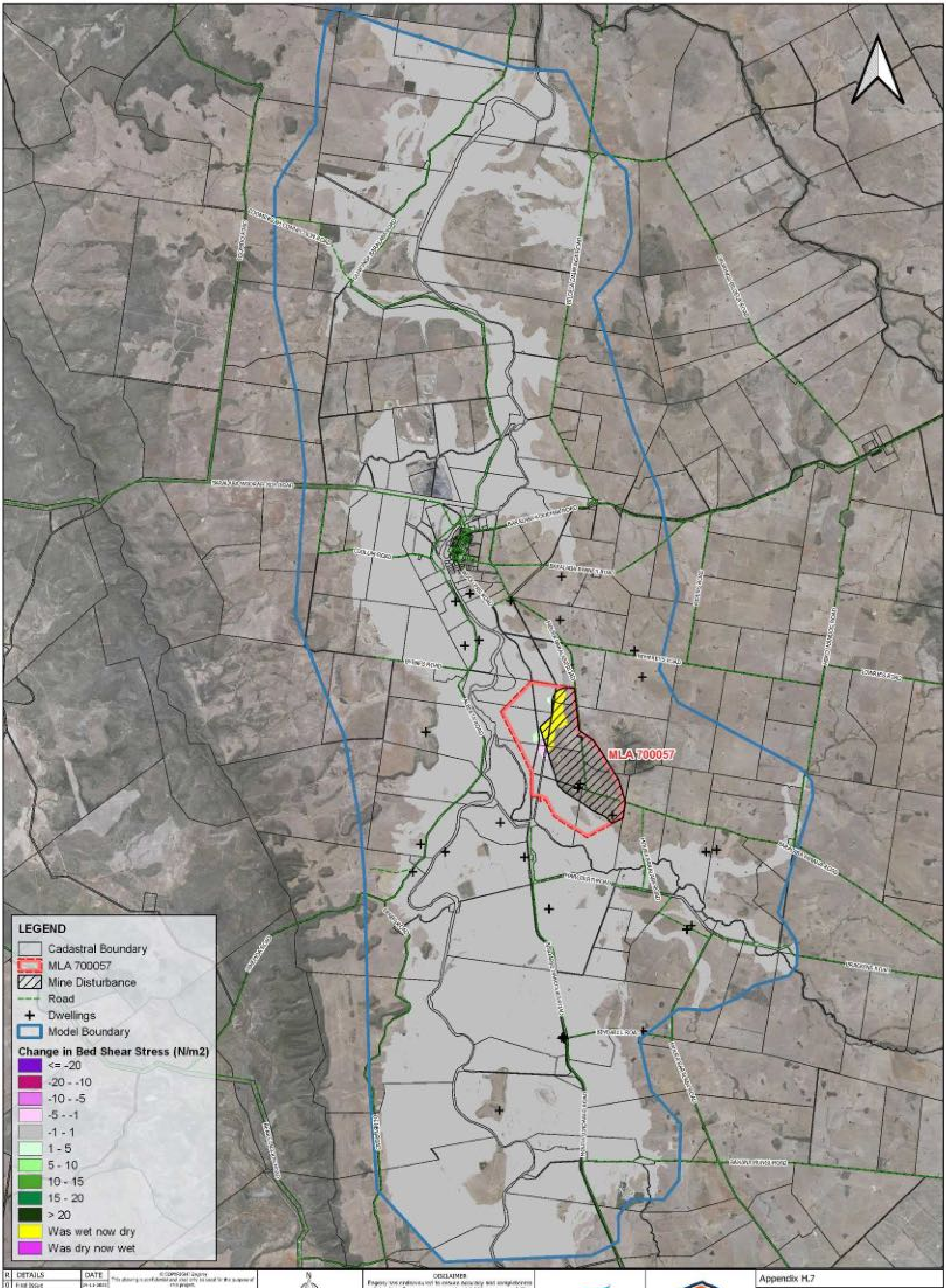
[illegible]



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NOTES

N

0 0.9 1.8 2.7 km

SCALE @ A3 - 1:150,000

GDA94 / MGA zone 55

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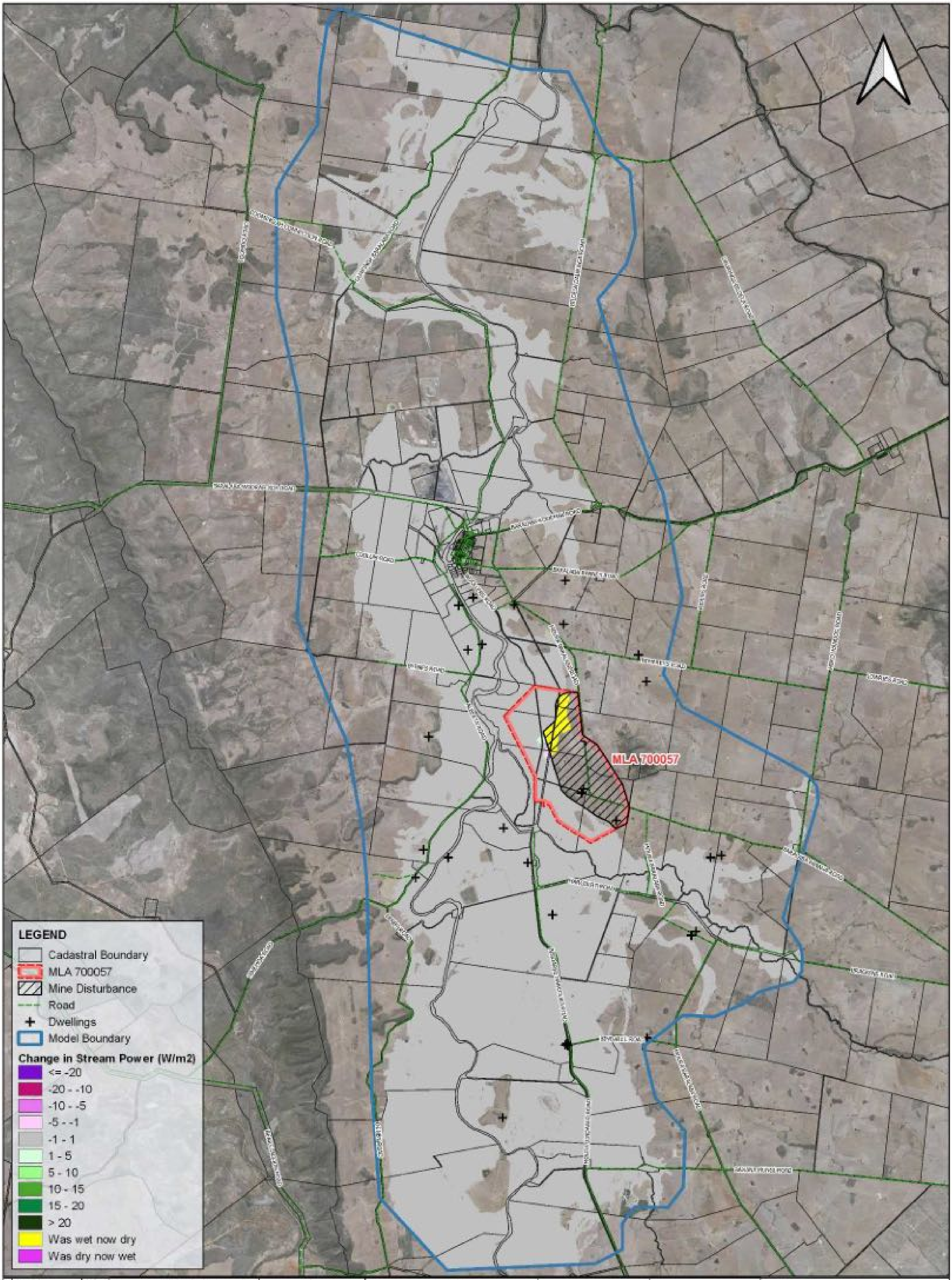
BARALABA SOUTH

Appendix H.7

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
1% AEP Change in Bed Shear Stress (Mine Developed Case - Existing Case)

Job Number:
[illegible]

[illegible]



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APPROVED	AV	DATE	24-11-2023

0 0.9 1.8 2.7 km
SCALE @ A3 - 1:150,000
GDA94 / MGA zone 55

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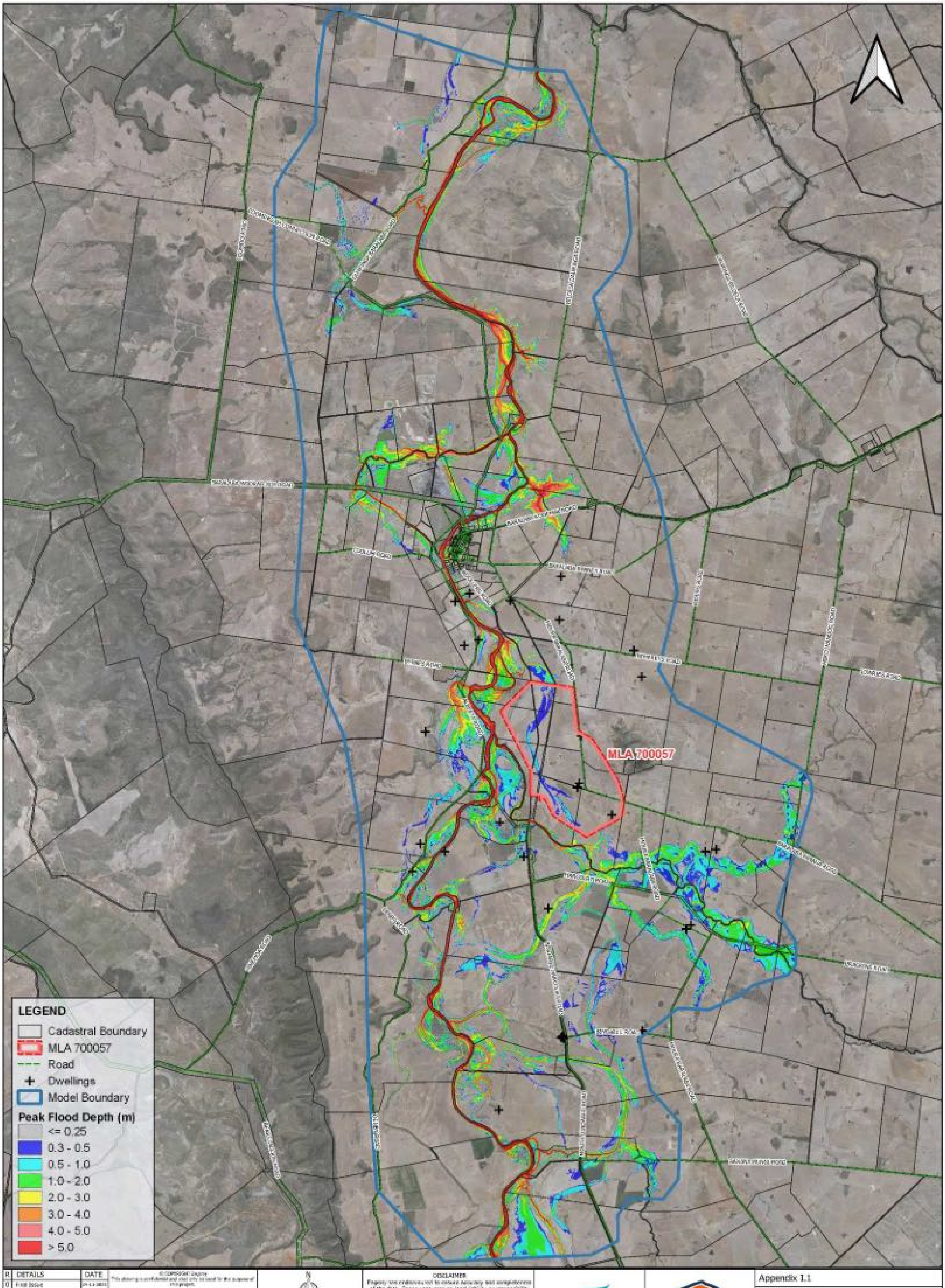
BARALABA SOUTH

Appendix H.8

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
1% AEP Change in Stream Power (Mine Developed Case - Existing Case)

Job Number:
QC1018_[illegible]

APPENDIX I: BANANA CREEK DOMINATED FLOODING MAPS



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NOTES

0 0.9 1.8 2.7 km

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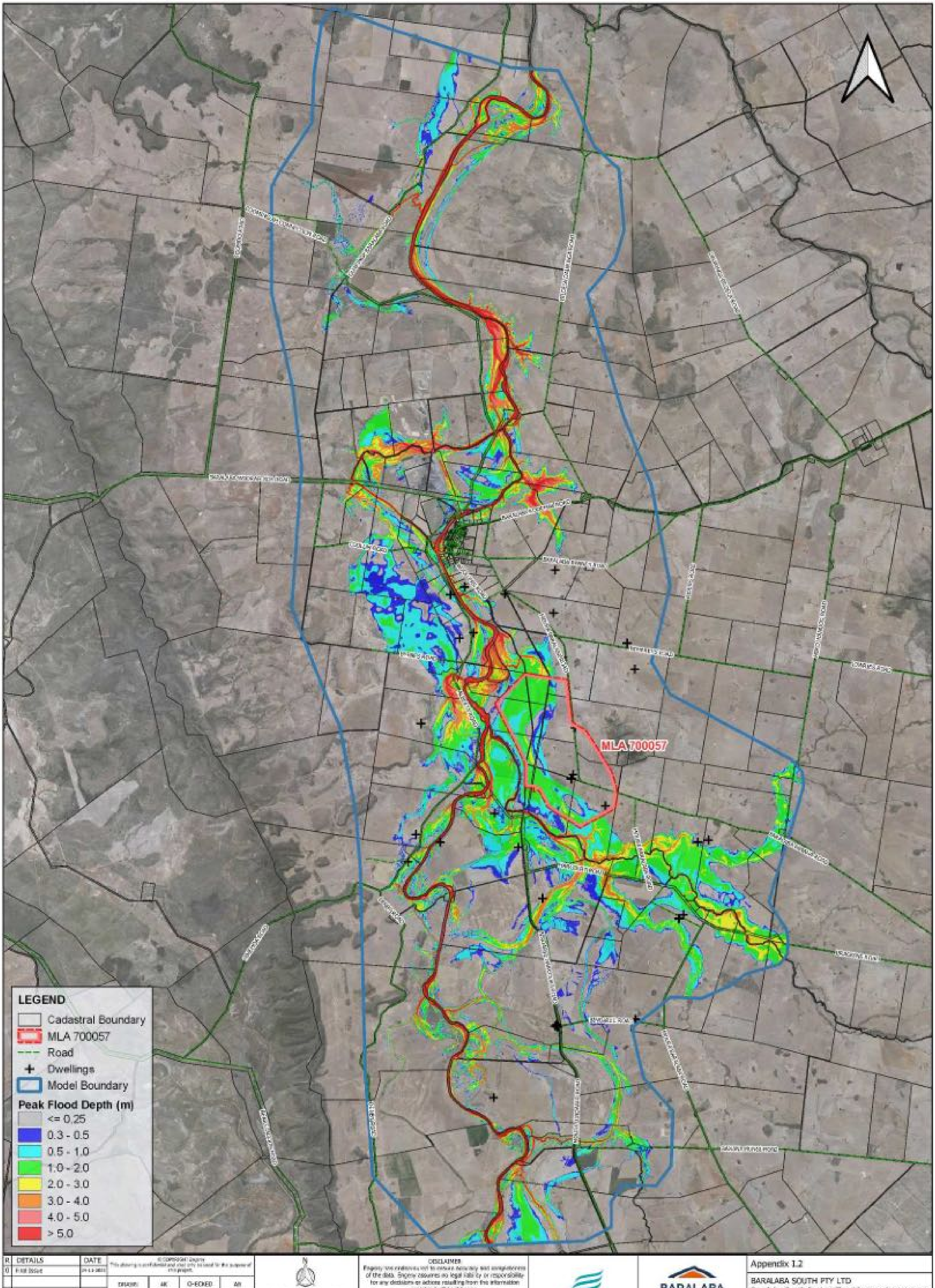
BARALABA SOUTH

Appendix 1.1

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
Banana Creek 10% AEP Flood Depth - Existing Case

Job Number:
[illegible]

[illegible]



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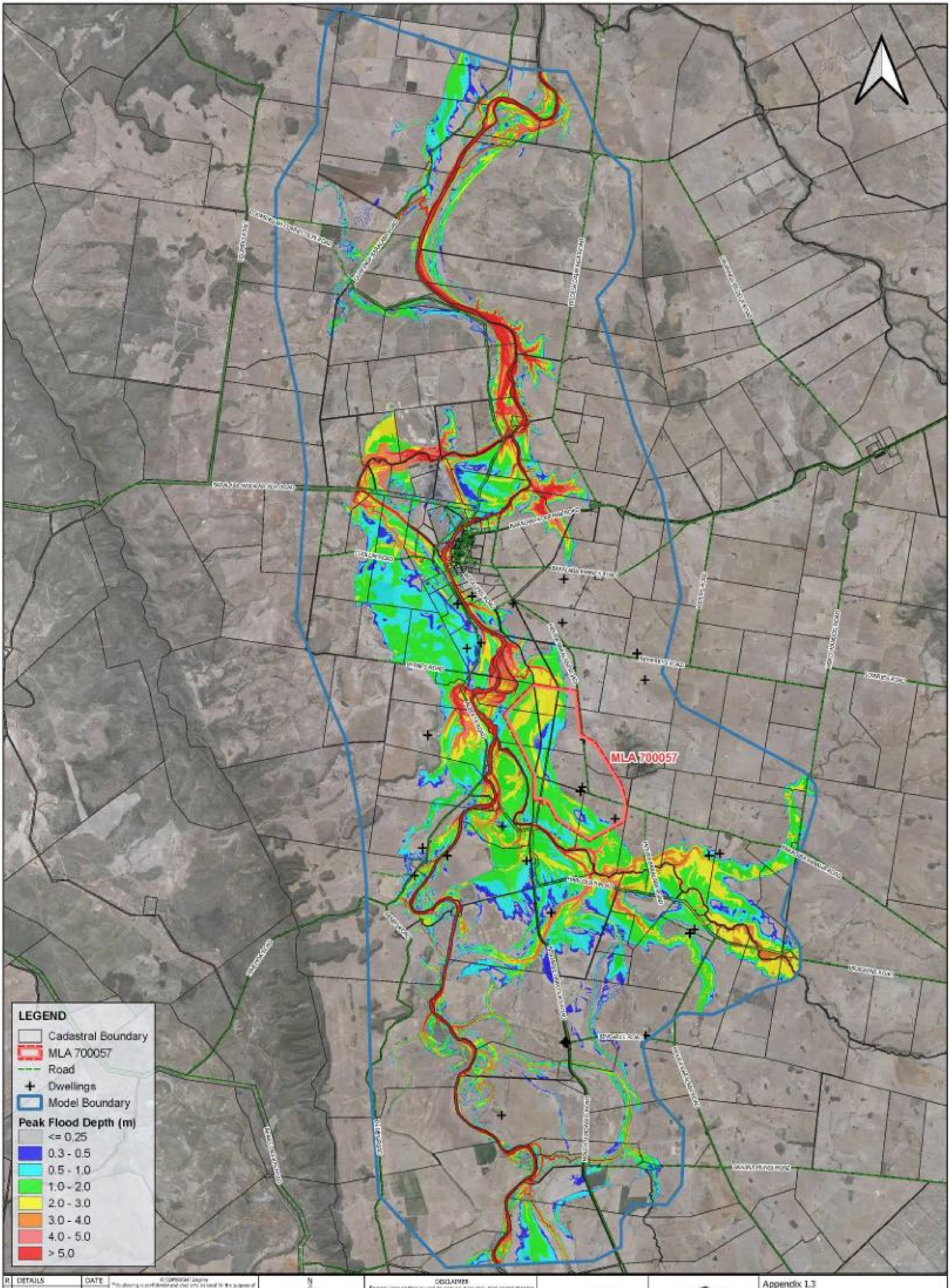
Appendix 1.2

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
Banana Creek 1% AEP Flood Depth - Existing Case

Job Number:
[illegible]

[illegible]



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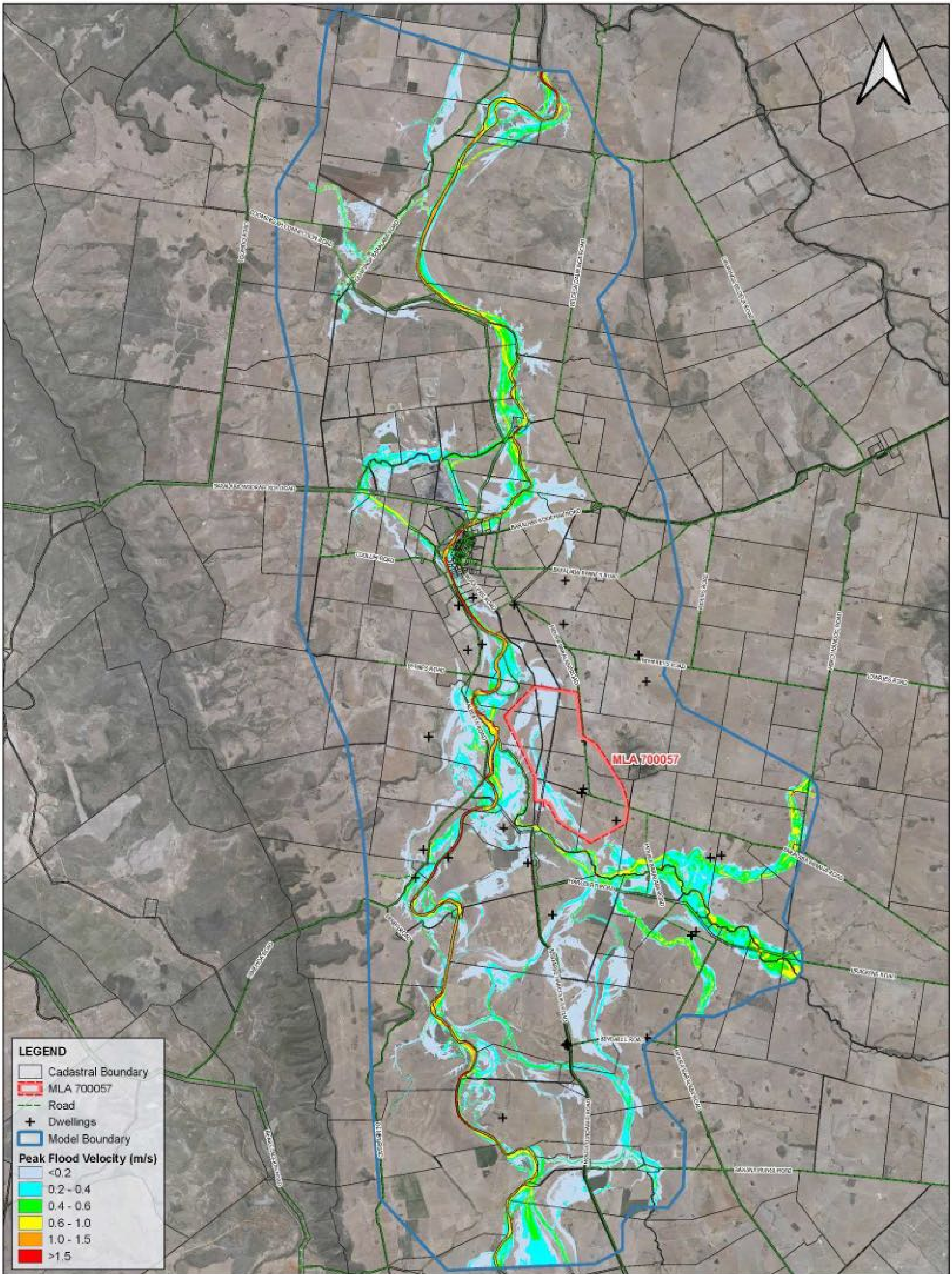
BARALABA SOUTH

Appendix 1.3

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
Banana Creek 0.1% AEP Flood Depth - Existing Case

Job Number:
[illegible]

[illegible]



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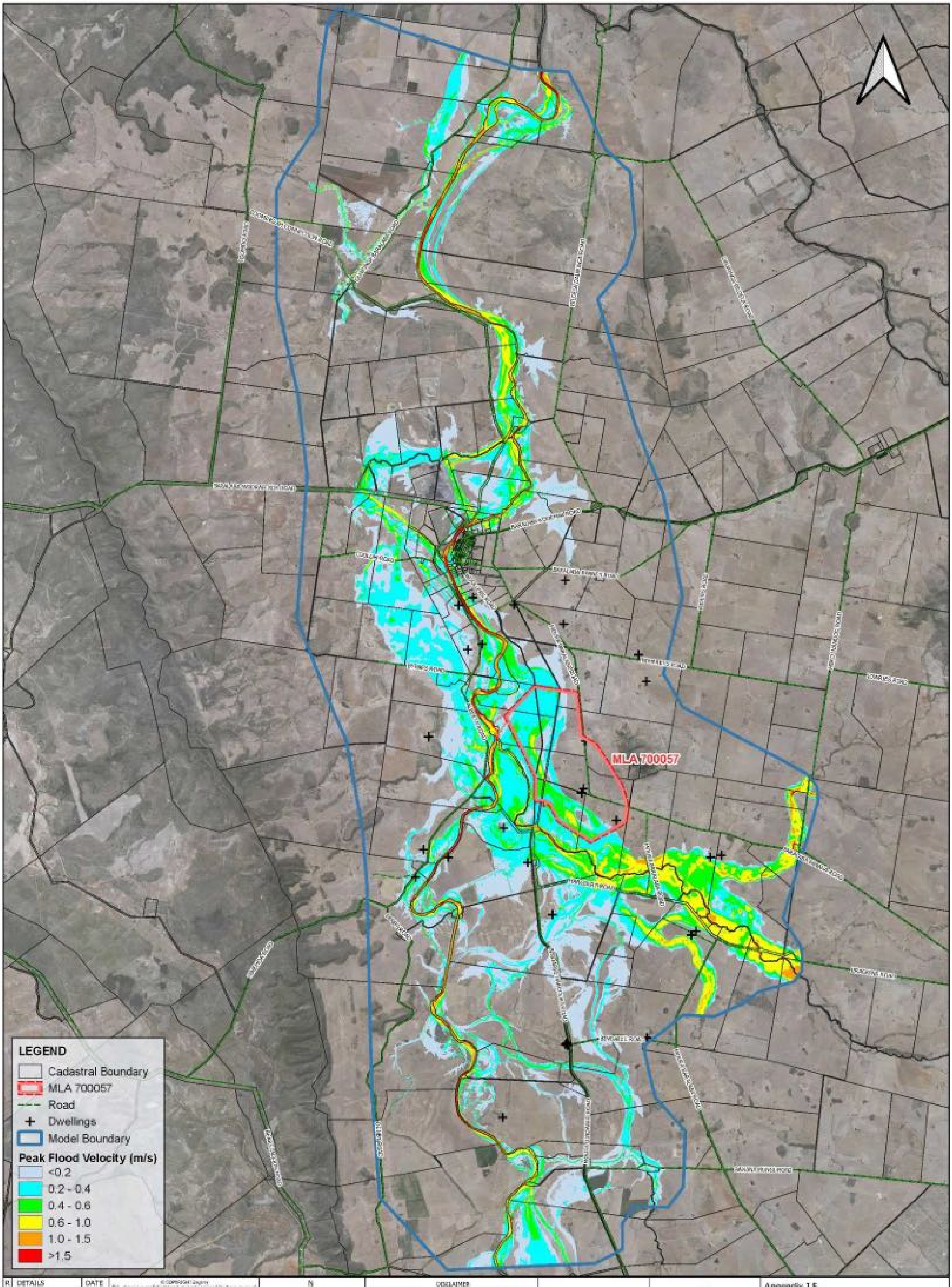
BARALABA SOUTH

Appendix 1.4

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
Banana Creek 10% AEP Flood Velocity - Existing Case

Job Number:
QC1018_004986-12-0



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SCALE @ A3 - 1:150,000

GDA94 / MGA zone 55

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BARALABA SOUTH

Appendix 1.5

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
Banana Creek 1% AEP Flood Velocity - Existing Case

Job Number:
QC1018_004986-152-1

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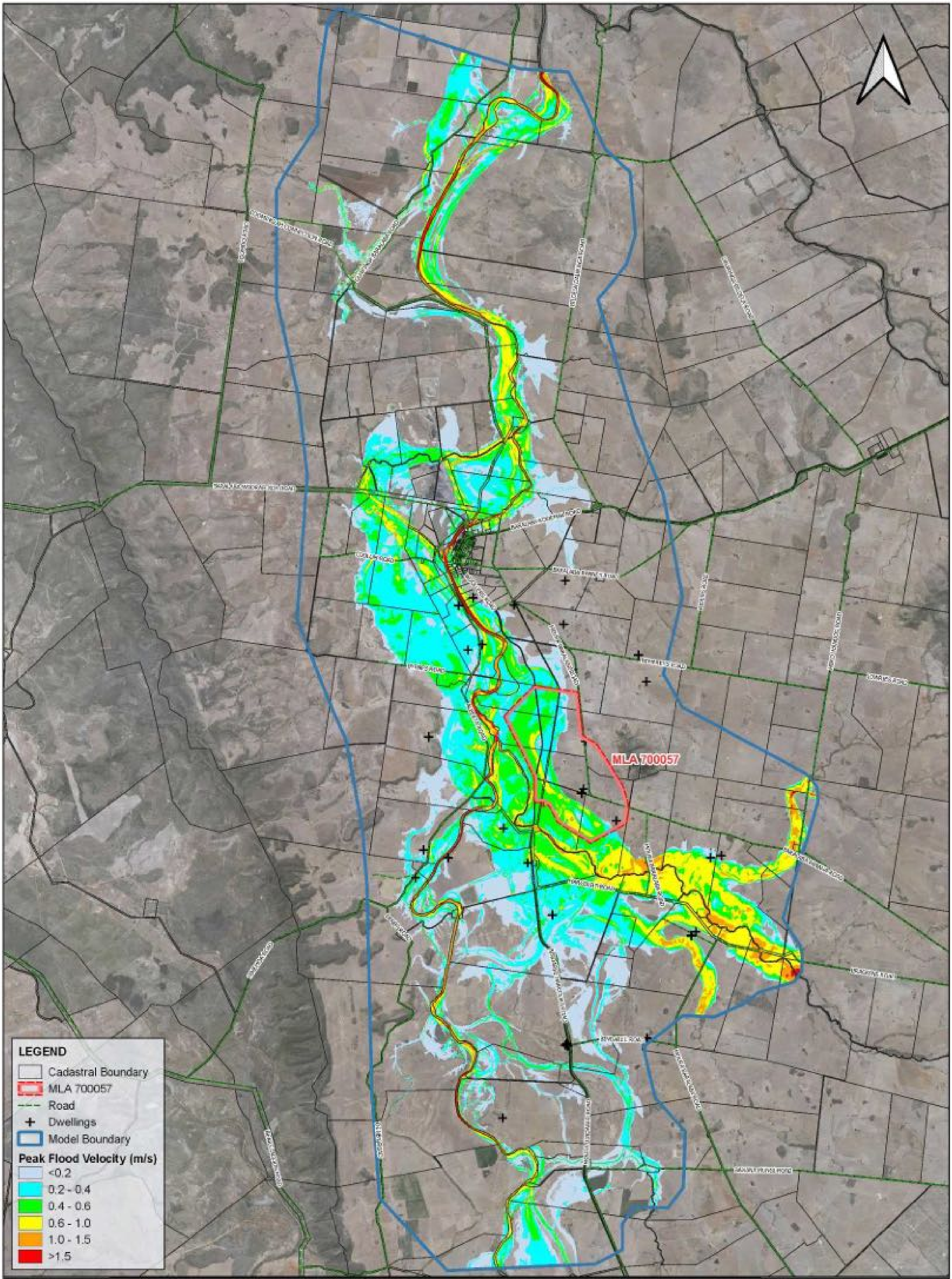

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0 0.8 1.6 2.7 km

SCALE @ A3 - 1:150,000

GDA94 / MGA zone 55

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BARALABA SOUTH

Appendix 1.6

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
Banana Creek 0.1% AEP Flood Velocity - Existing Case

Job Number:
QC1018_004986-12-1

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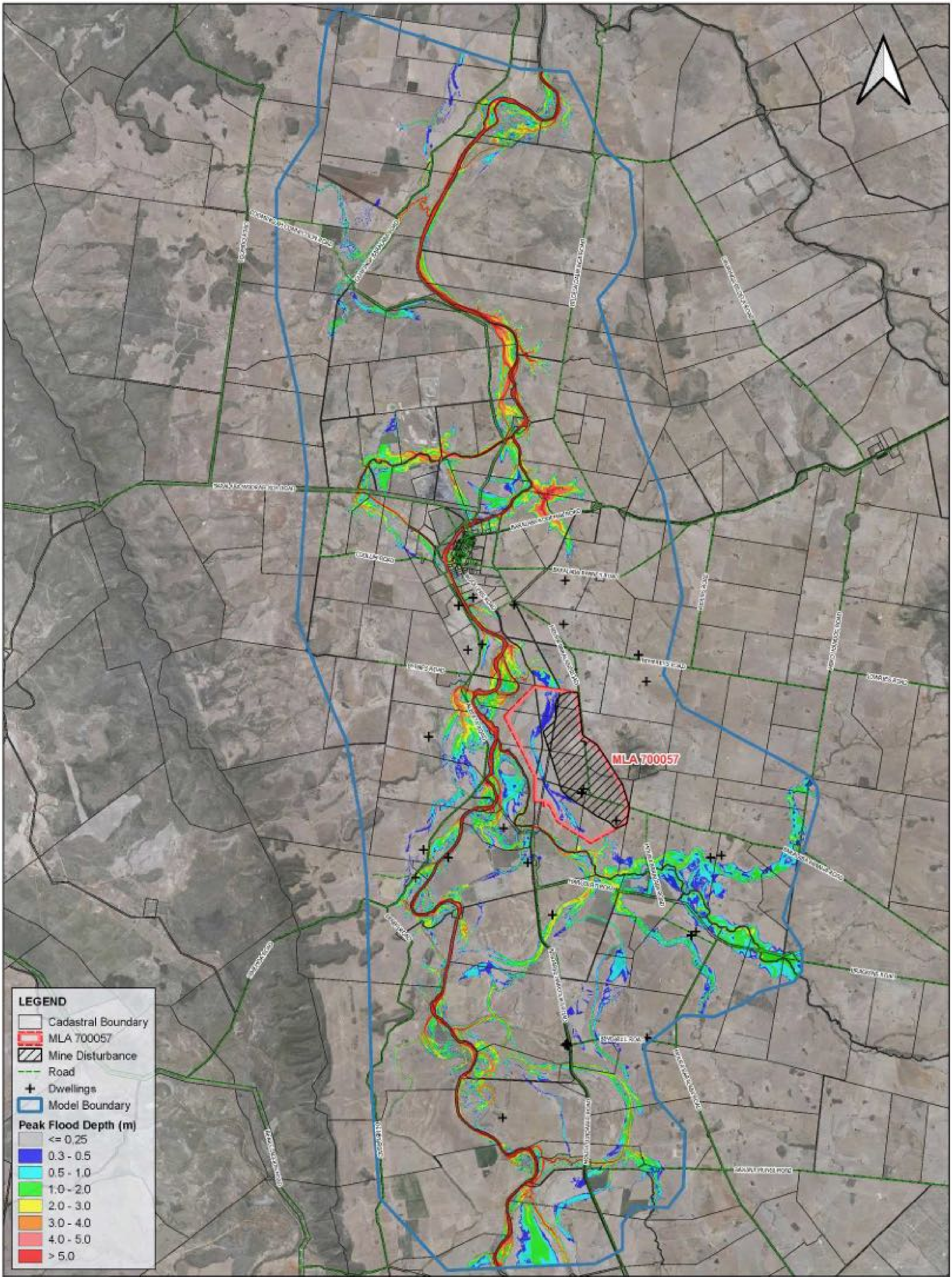

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NOTES

N

0 0.9 1.8 2.7 km

SCALE @ A3 - 1:150,000

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BARALABA SOUTH

Appendix 1.7

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
Banana Creek 10% AEP Flood Depth - Mine Developed Case

Job Number:
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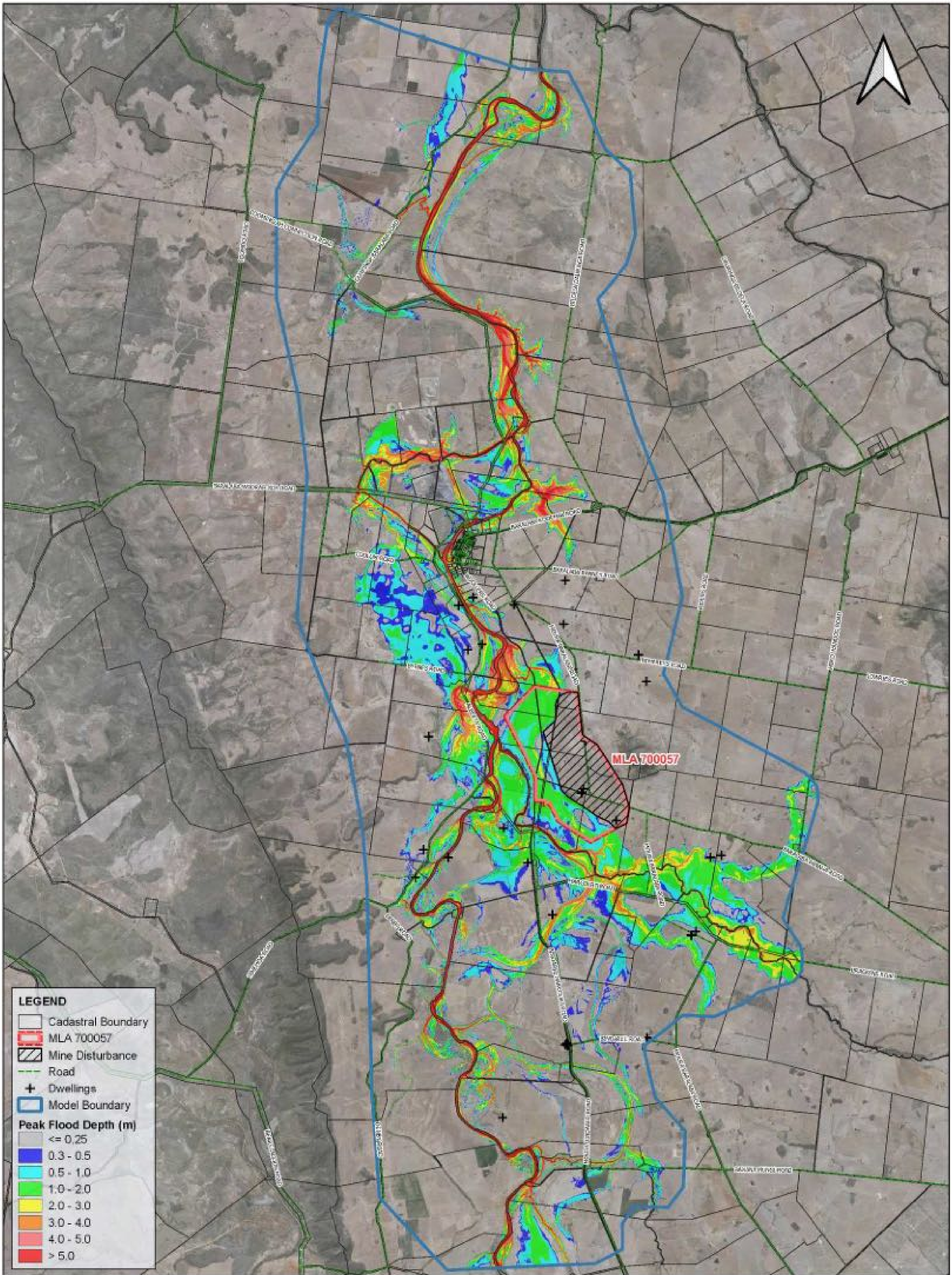
[illegible]



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NOTES

0 0.9 1.8 2.7 km

SCALE @ A3 - 1:150,000

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BARALABA SOUTH

Appendix 1.8

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
Banana Creek 1% AEP Flood Depth - Mine Developed Case

Job Number:
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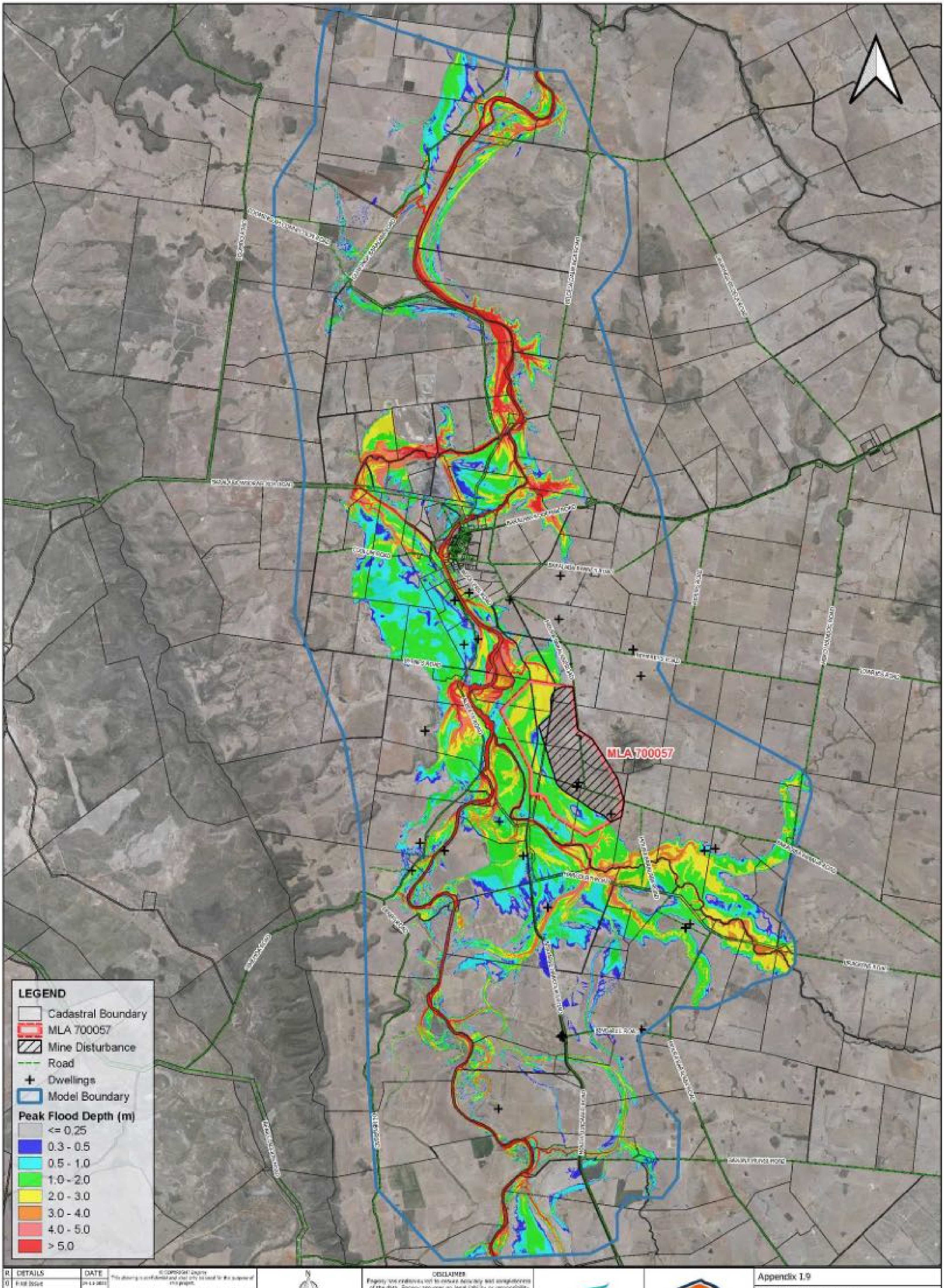

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NOTES

0 0.8 1.6 2.7 km
SCALE @ A3 - 1:150,000
GDA94 / MGA zone 55

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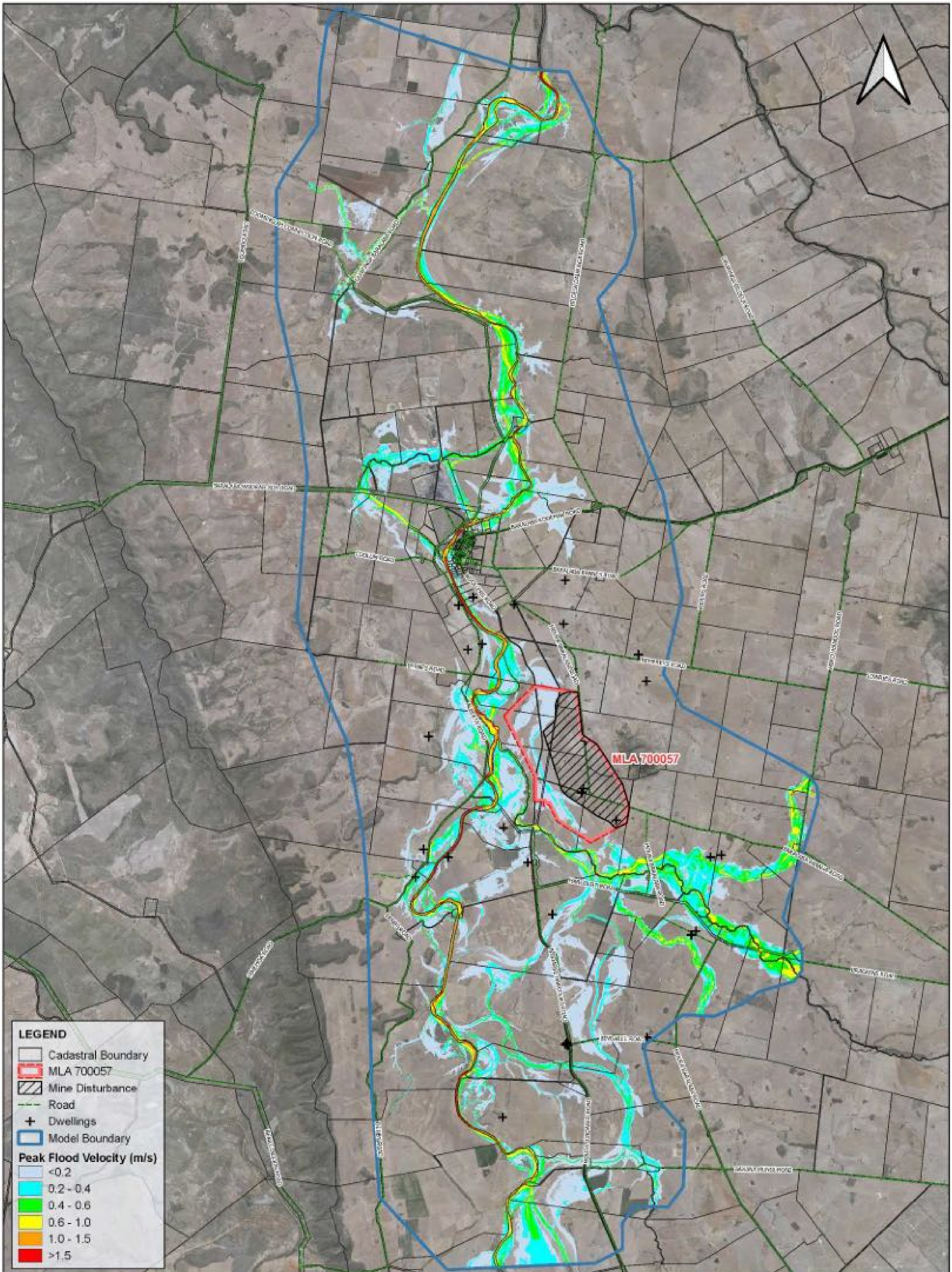
BARALABA SOUTH

Appendix 1.9

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
Banana Creek 0.1% AEP Flood Depth - Mine Developed Case

Job Number:
[illegible]

[illegible]



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NOTES

0 0.9 1.8 2.7 km

SCALE @ A3 - 1:150,000

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BARALABA SOUTH

Appendix 1.10

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
Banana Creek 10% AEP Flood Velocity - Mine Developed Case

Job Number:
QC1018_004986-127-0

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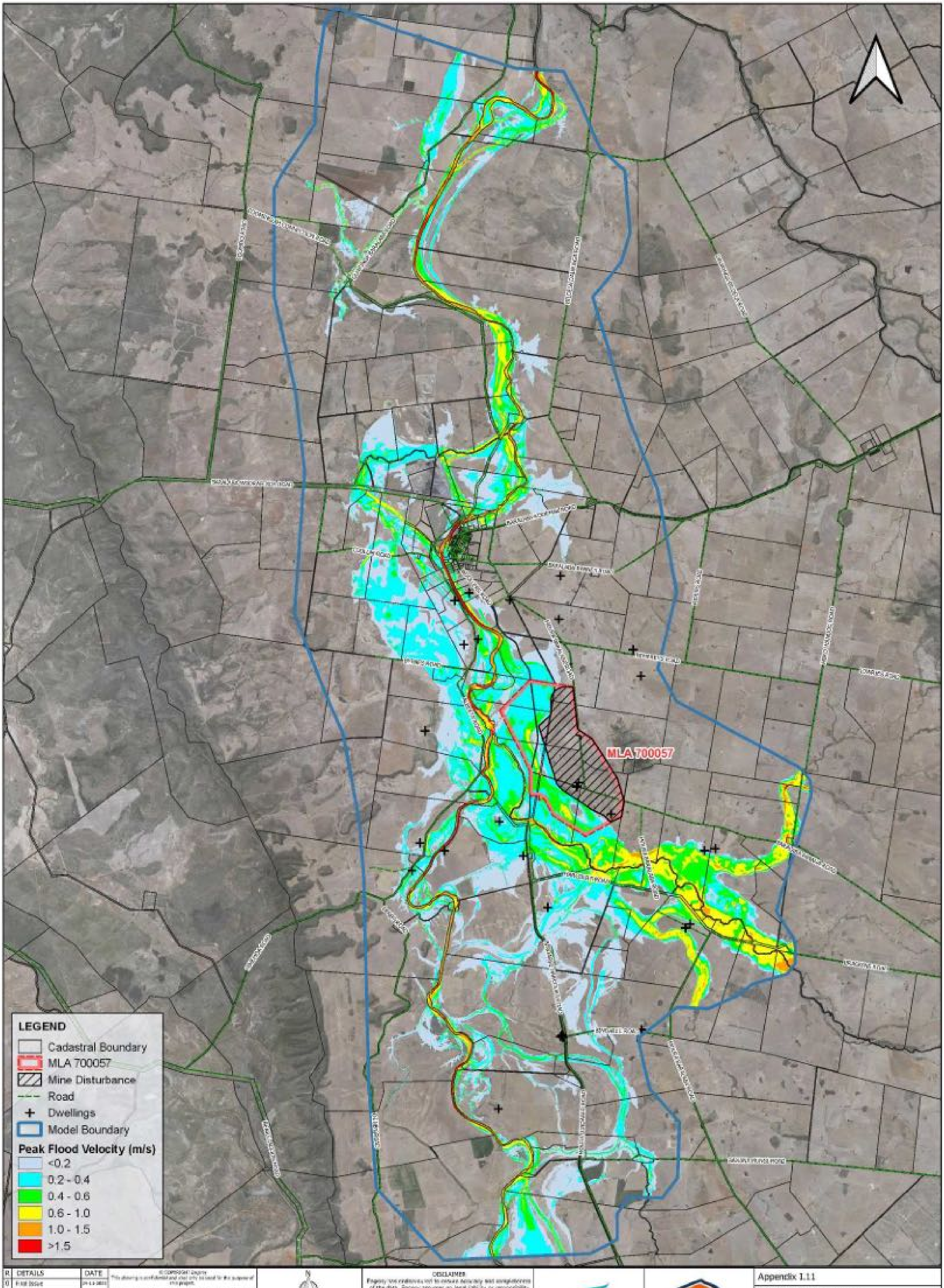

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APPROVED	AV	DATE	[illegible]

NOTES

0 0.9 1.8 2.7 km

SCALE @ A3 - 1:150,000

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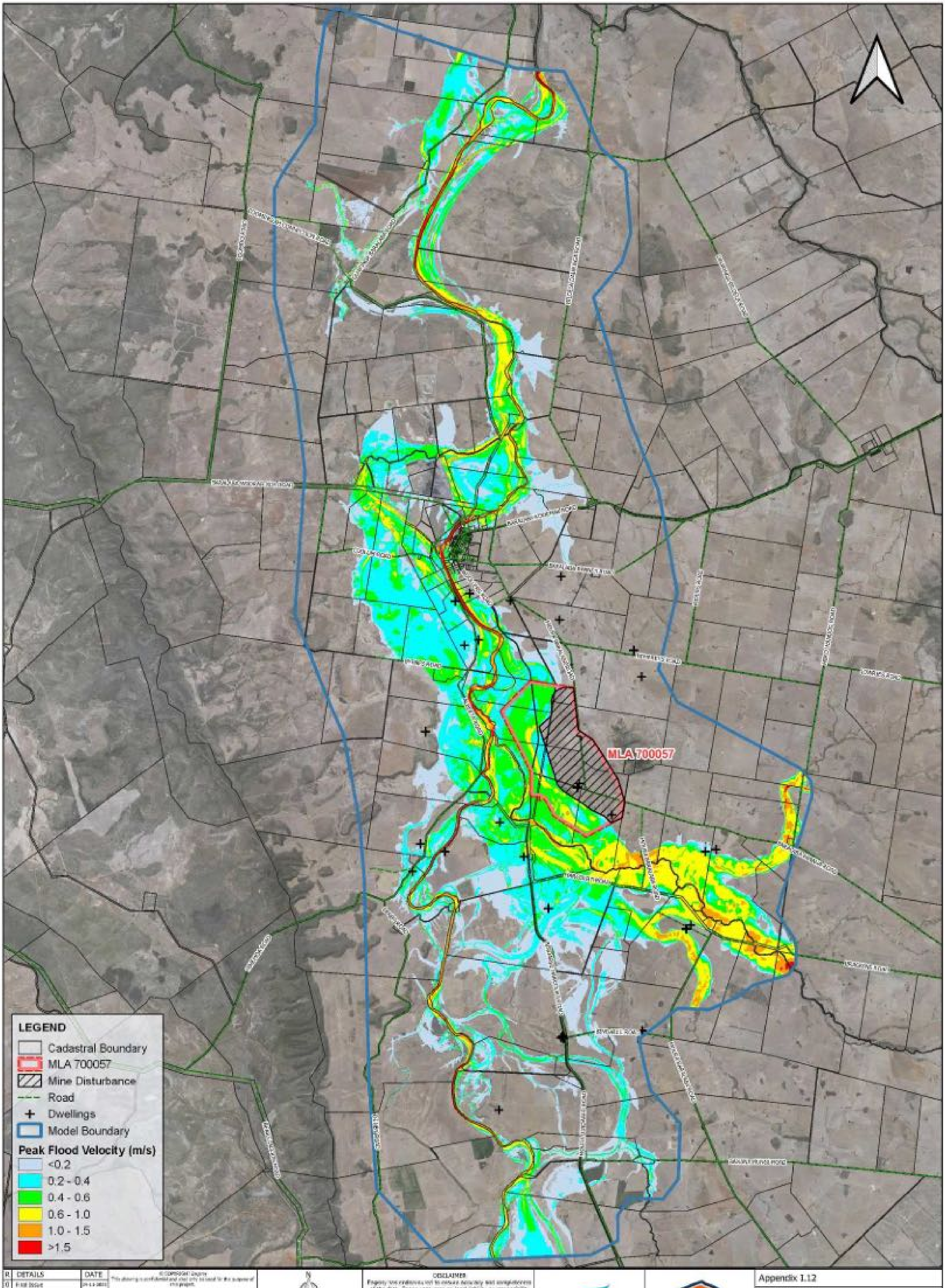
BARALABA SOUTH

Appendix 1.11

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
Banana Creek 1% AEP Flood Velocity - Mine Developed Case

Job Number:
[illegible]

[illegible]



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NOTES

SCALE @ A3 - 1:150,000

GDA94 / MGA zone 55

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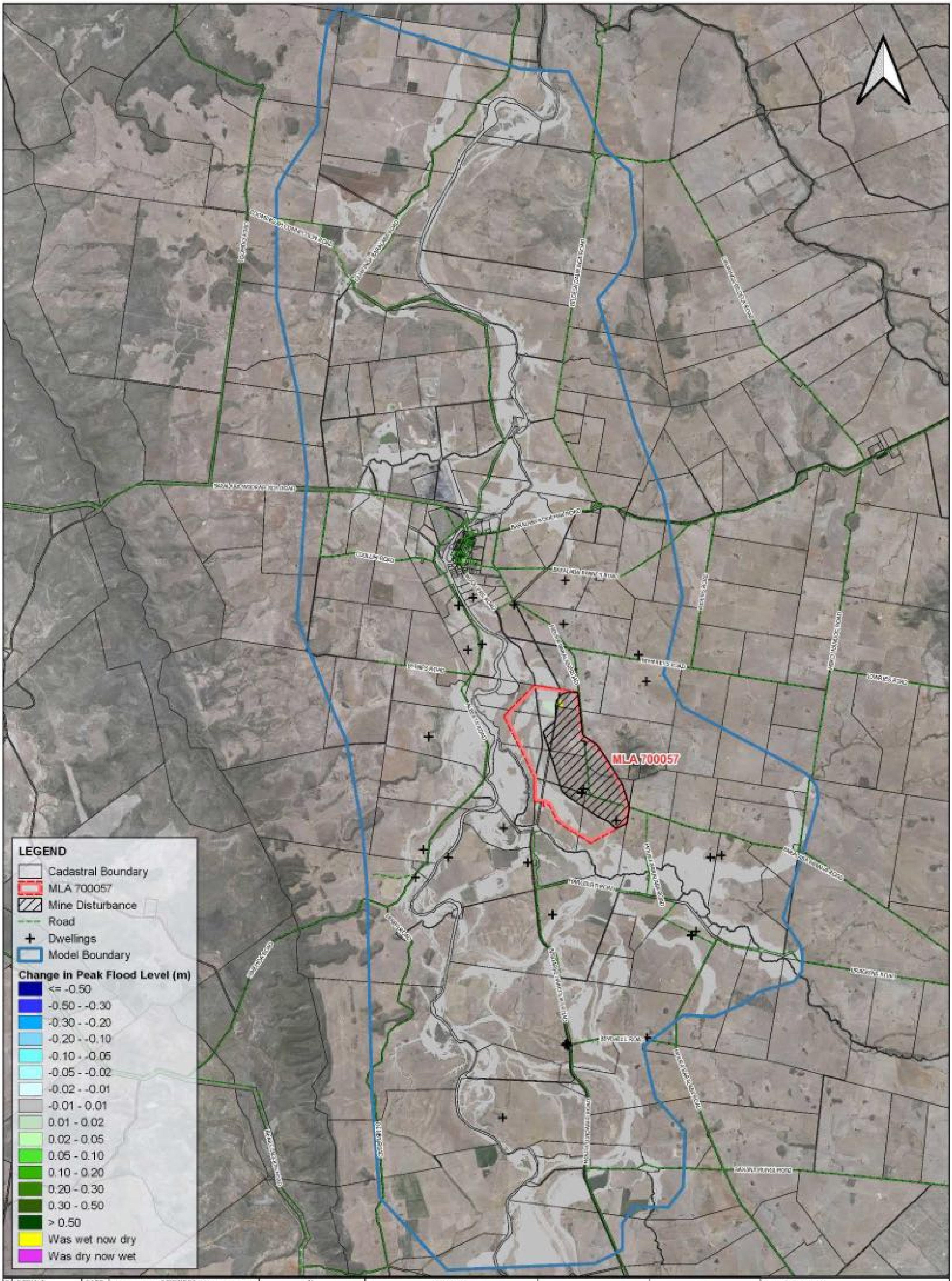
Appendix 1.12

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
Banana Creek 0.1% AEP Flood Velocity - Mine Developed Case

Job Number:
[illegible]

[illegible]



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N

0 0.9 1.8 2.7 km

SCALE @ A3 - 1:150,000

GDA94 / MGA zone 55

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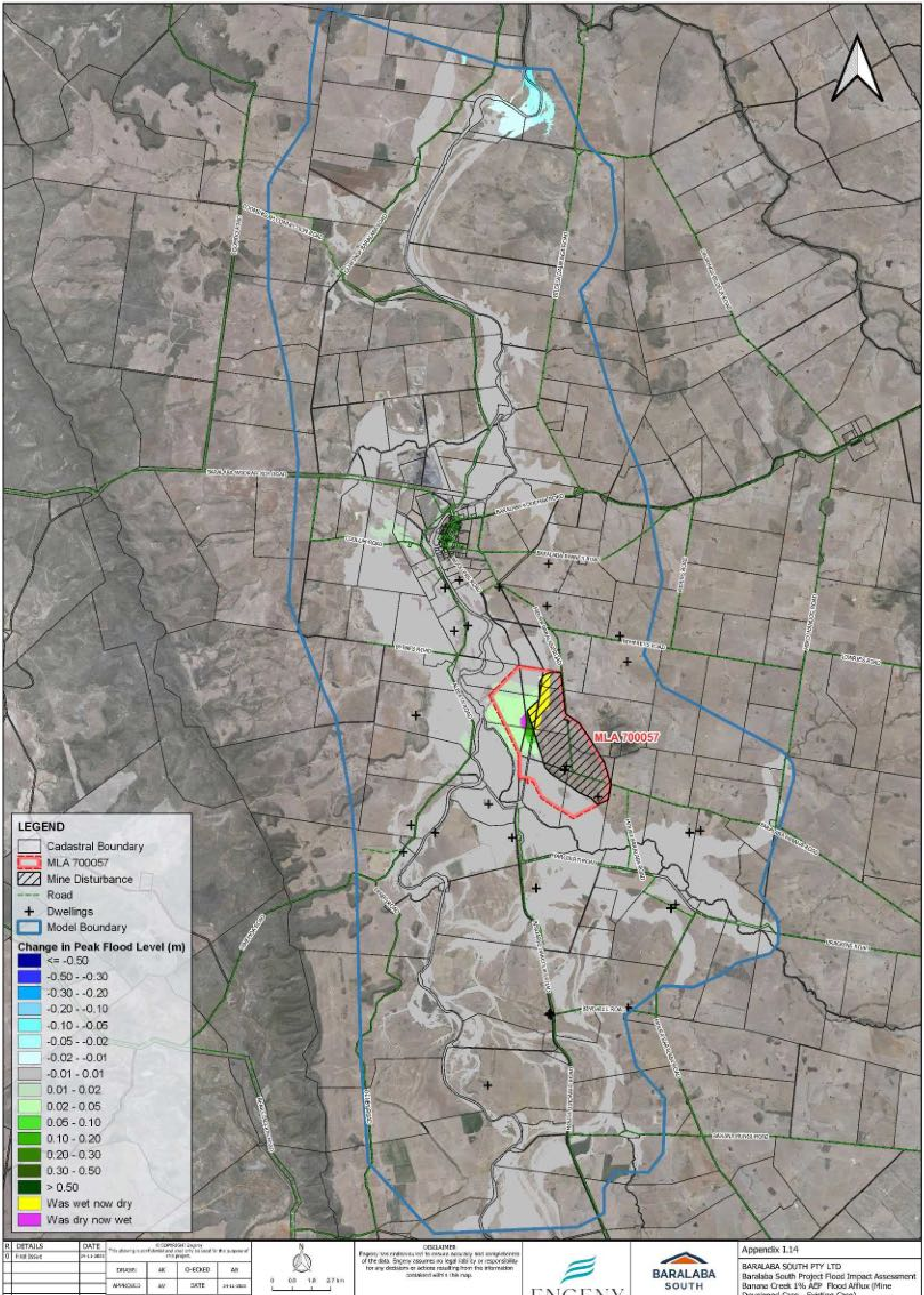
BARALABA
SOUTH

Appendix 1.13

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
Banana Creek 10% AEP Flood Afflux (Mine Developed Case - Existing Case)

Job Number:
[illegible]

[illegible]



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APPROVED	AV	DATE	[illegible]

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SCALE @ A3 - 1:150,000

GDA94 / MGA zone 55

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BARALABA SOUTH

Appendix 1.14

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
Banana Creek 1% AEP Flood Afflux (Mine Developed Case - Existing Case)

Job Number:
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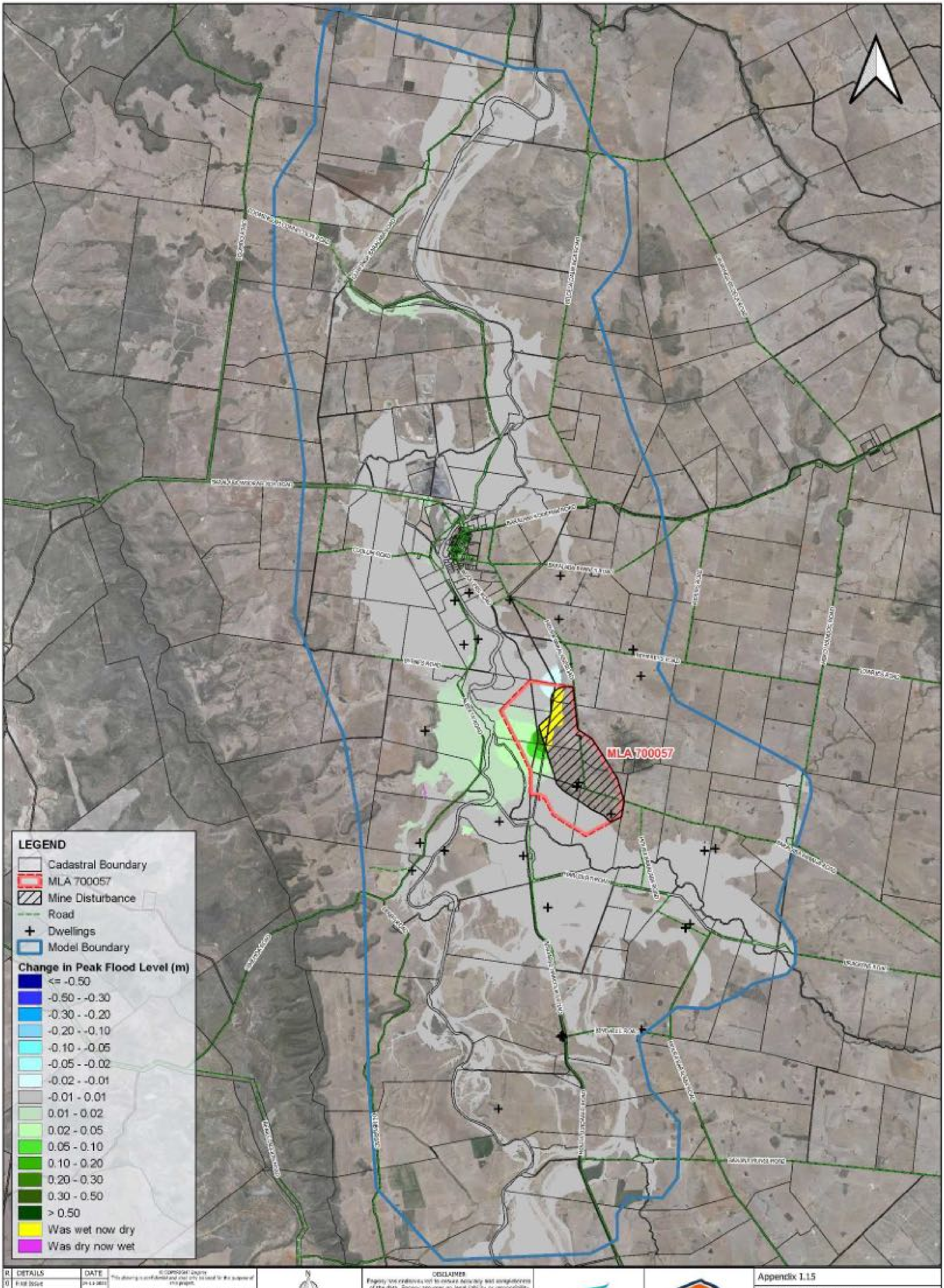

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DRAWN	AK	CHECKED	AB
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NOTES

0 0.9 1.8 2.7 km

SCALE @ A3 - 1:150,000

GDA94 / MGA zone 55

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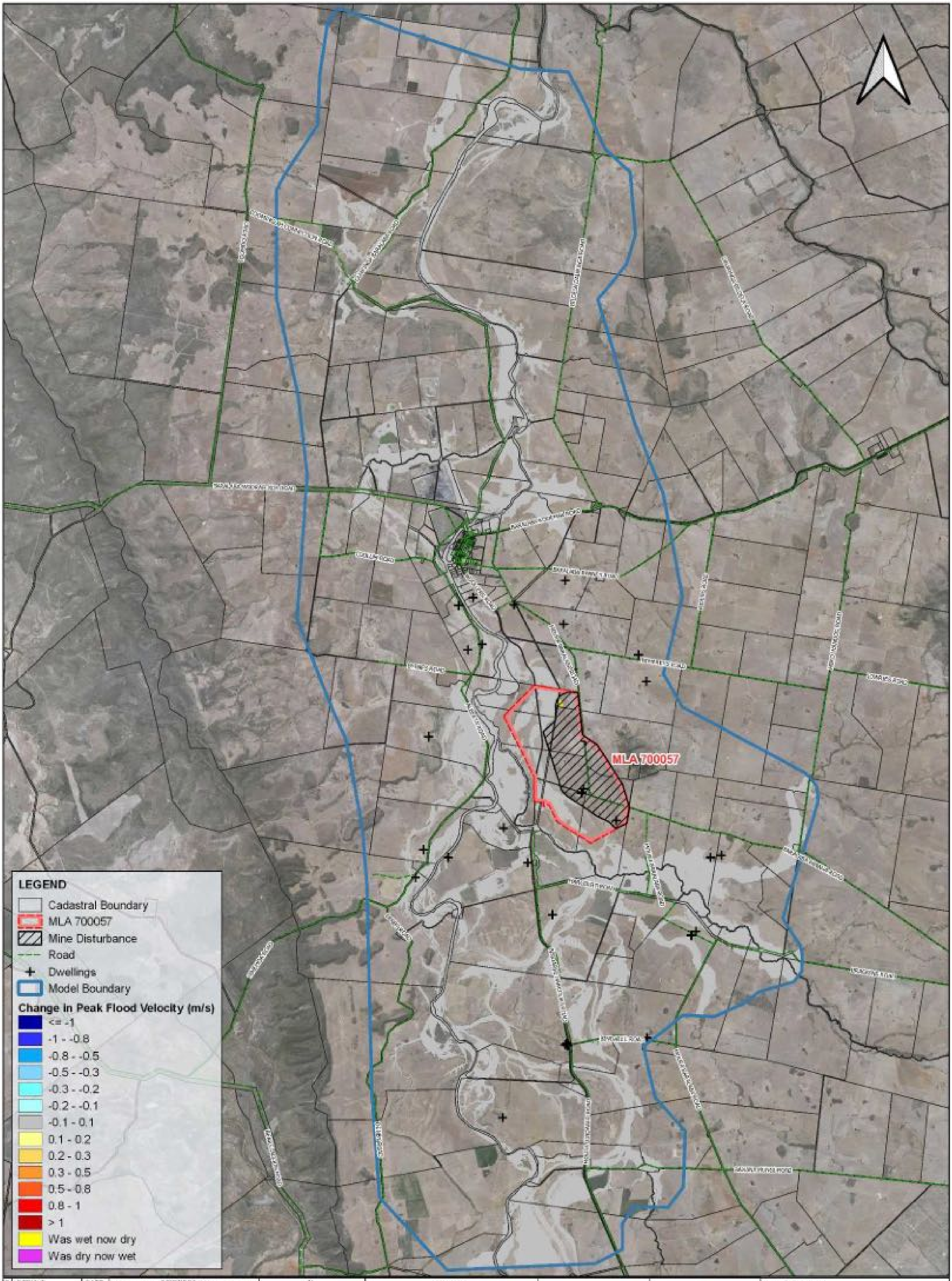
BARALABA SOUTH

Appendix 1.15

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
Banana Creek 0.1% AEP Flood Afflux (Mine Developed Case - Existing Case)

Job Number:
[illegible]

[illegible]



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APPROVED	AV	DATE	24-11-2023

NOTES

0 0.9 1.8 2.7 km

SCALE @ A3 - 1:150,000

GDA94 / MGA zone 55

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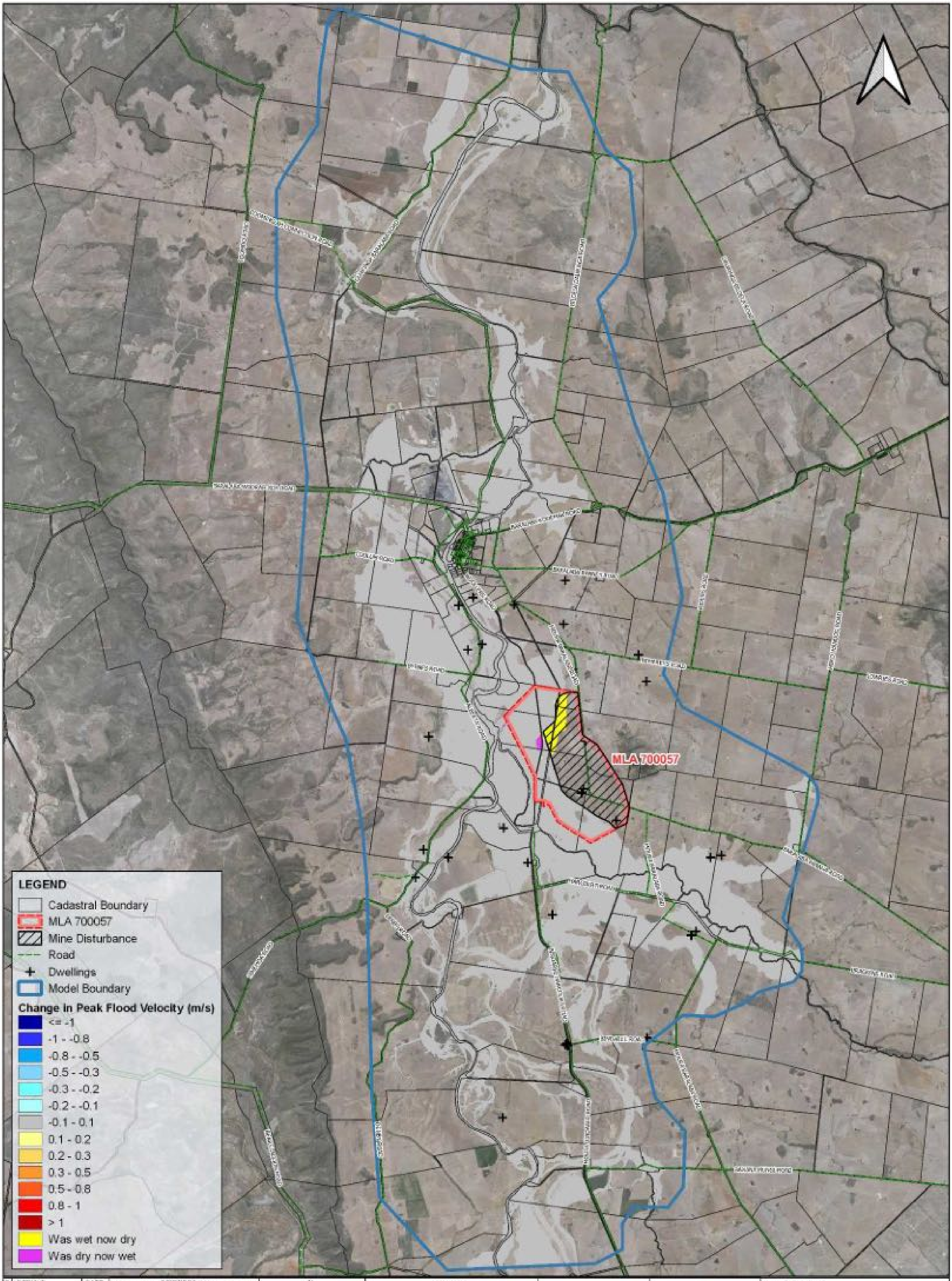
BARALABA SOUTH

Appendix 1.16

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
Banana Creek 10% AEP Change in Peak Flood Velocity (Mine Developed Case - Existing Case)

Job Number:
[illegible]

Q:\Projects\QC1018 Baralaba Coal\QC1018_004 BSP SWTARFIA Revision\05 Design\QGIS\Figures\Flood Figures\QC1018_004-RPT-001-C Flood_Figures.qgz



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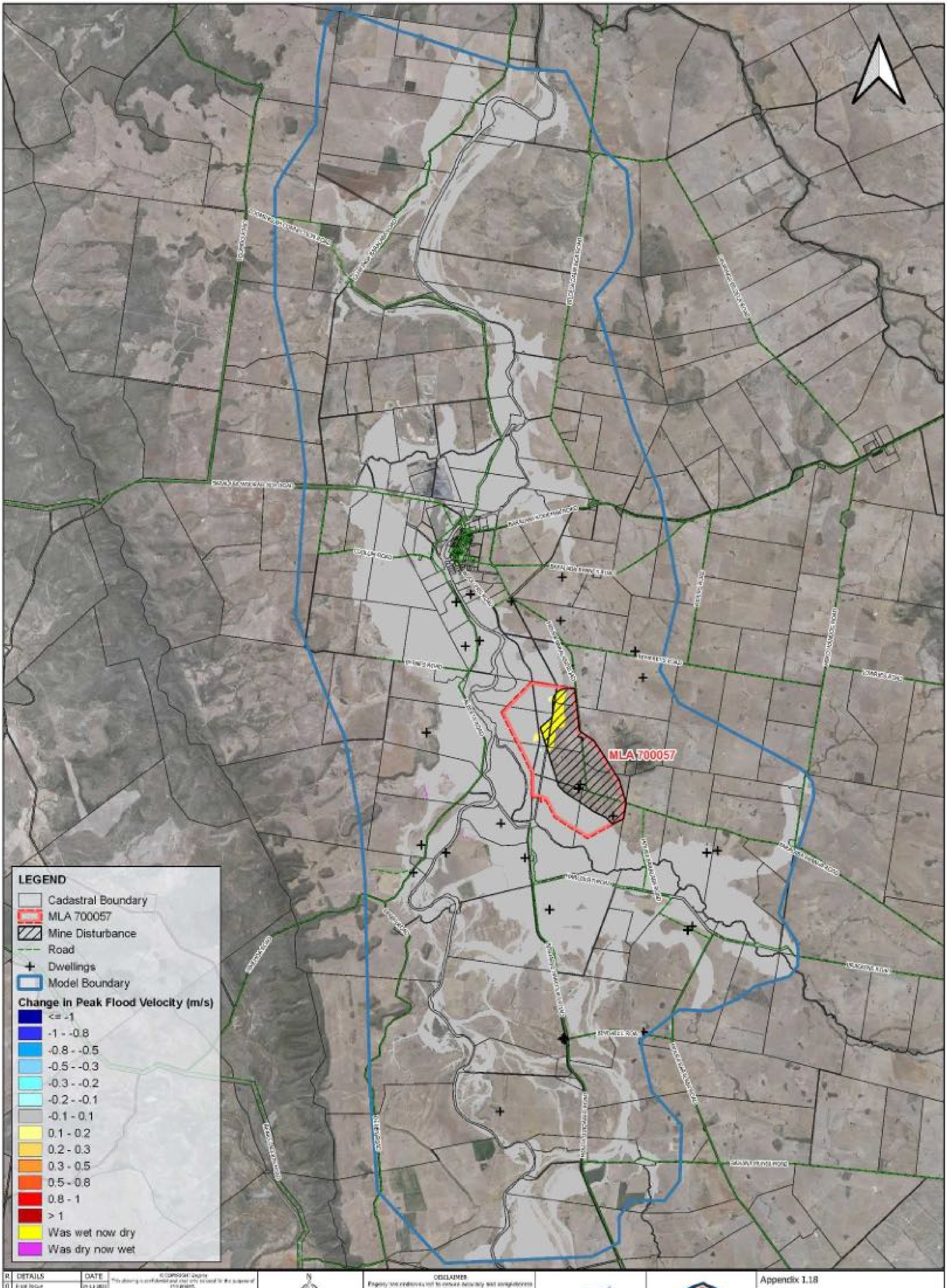
BARALABA SOUTH

Appendix 1.17

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
Banana Creek 1% AEP Change in Peak Flood Velocity (Mine Developed Case - Existing Case)

Job Number:
QC1018_004986-164-2



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SCALE @ A3 - 1:150,000

GDA94 / MGA zone 55

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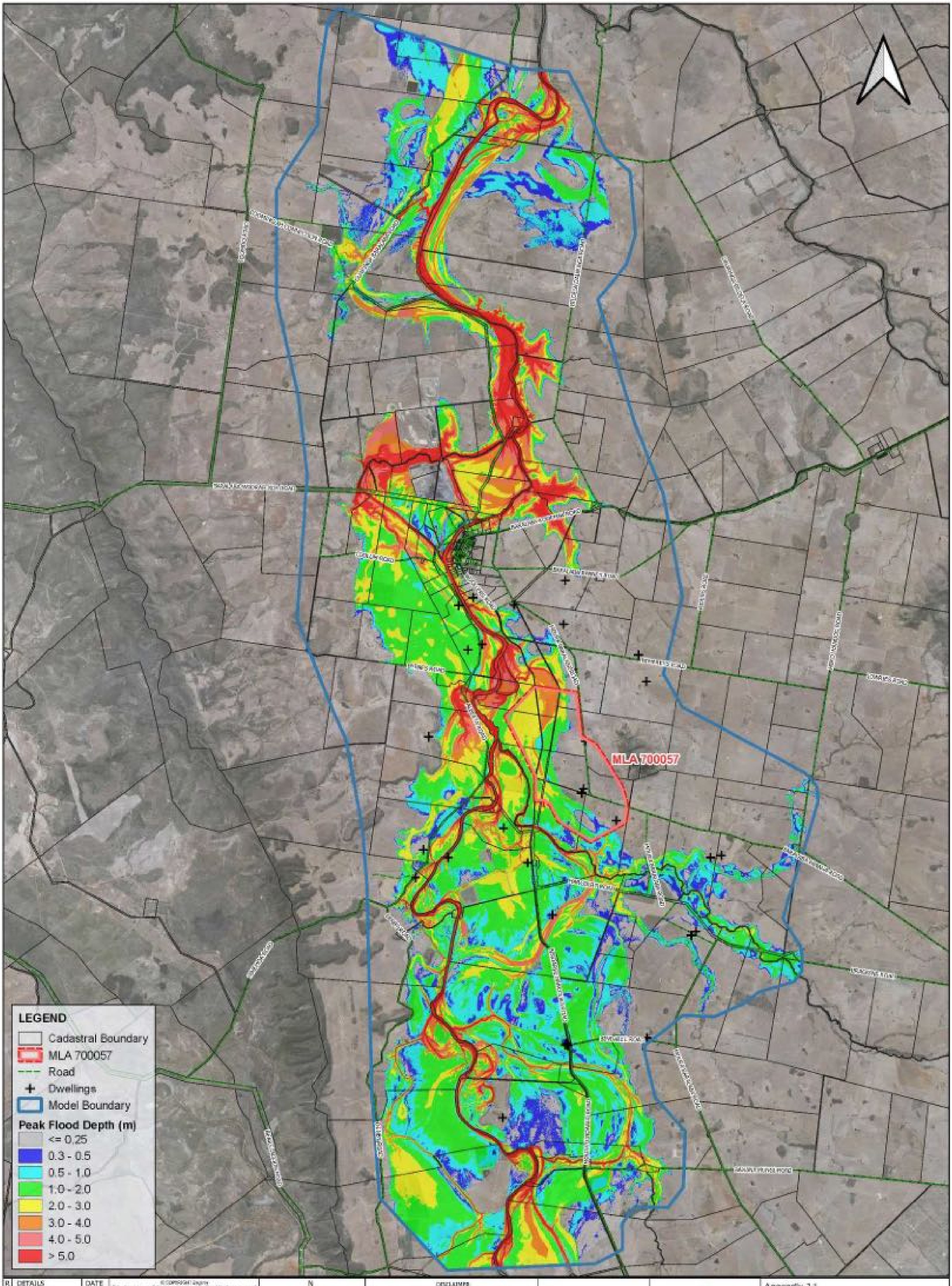
BARALABA SOUTH

Appendix 1.18

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
Banana Creek 0.1% AEP Change in Peak Flood Velocity (Mine Developed Case - Existing Case)

Job Number:
[illegible]

APPENDIX J: SENSITIVITY SCENARIO FLOOD DEPTH AND AFFLUX



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0 0.8 1.6 2.7 km

SCALE @ A3 - 1:150,000

GDA94 / MGA zone 55

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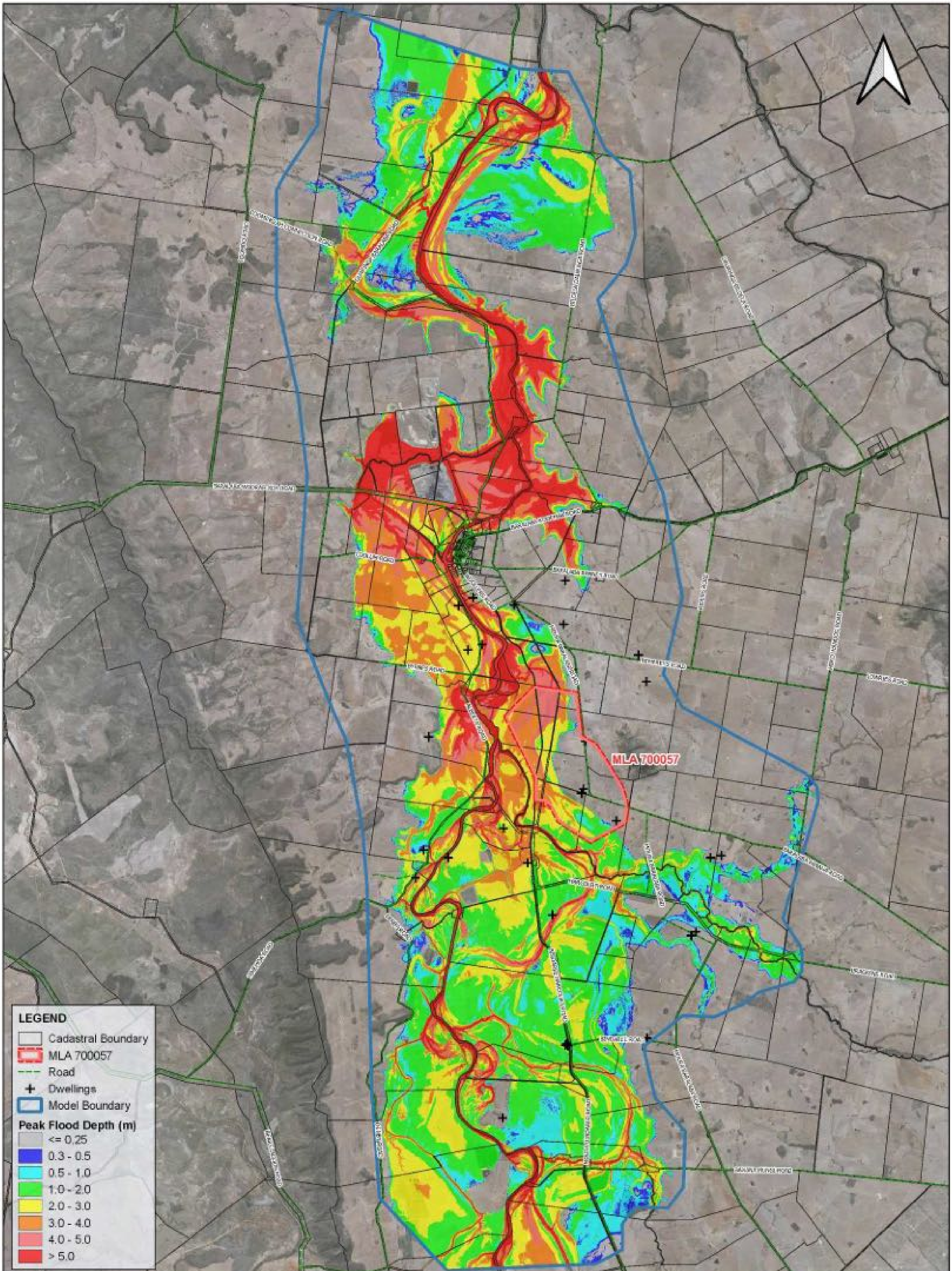
BARALABA SOUTH

Appendix 3.1

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
Climate Change 1% AEP Flood Depth - Existing Case

Job Number.



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APPROVED	AV	DATE	[illegible]

0 0.8 1.6 2.7 km

SCALE @ A3 - 1:150,000

GDA94 / MGA zone 55

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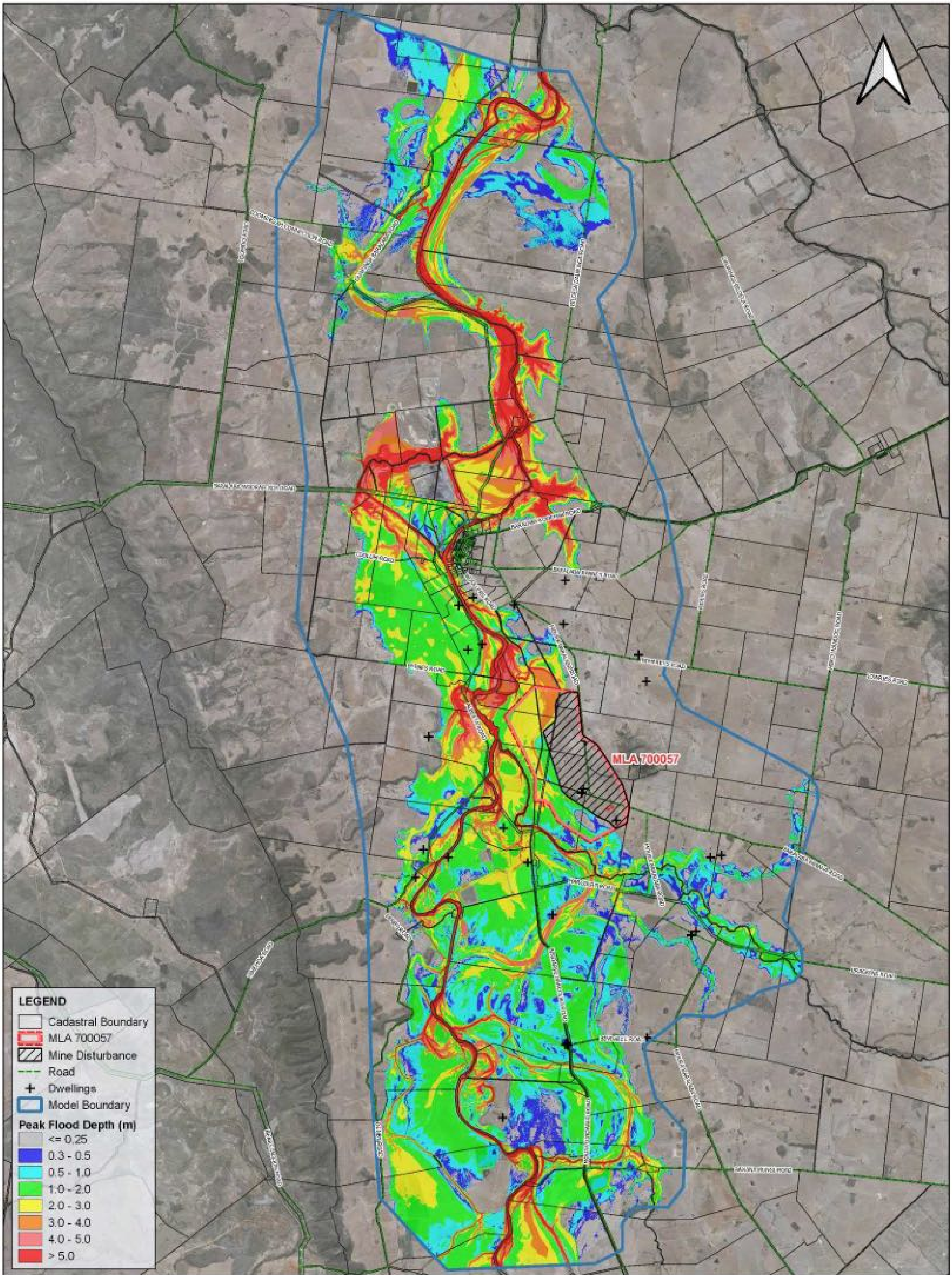
BARALABA SOUTH

Appendix 3.2

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
Climate Change 0.1% AEP Flood Depth - Existing Case

Job Number:
[illegible]



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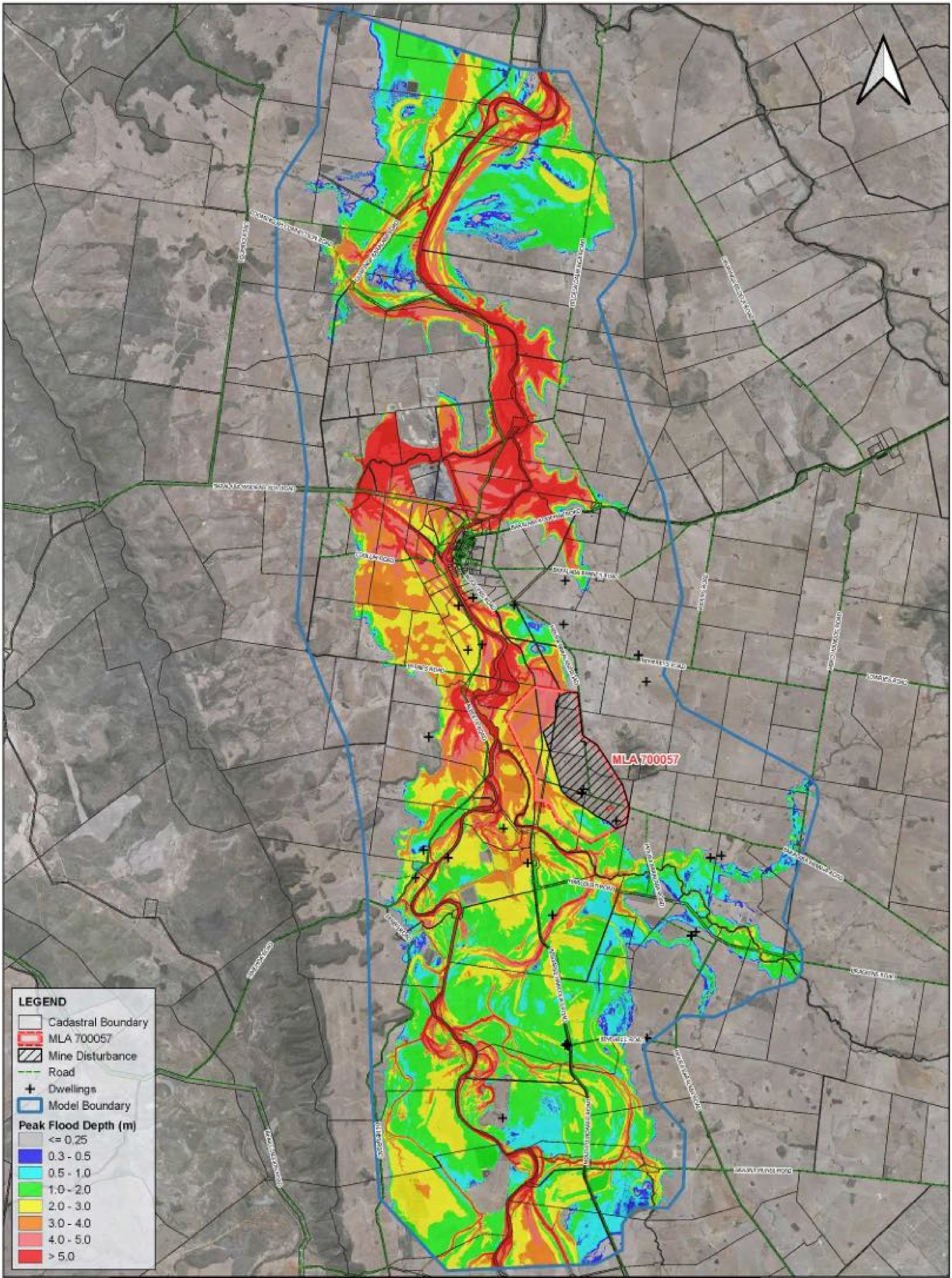
BARALABA SOUTH

Appendix 3.3

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
Climate Change 1% AEP Flood Depth - Mine Developed Case

Job Number:



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NOTES

0 0.9 1.8 2.7 km

SCALE @ A3 - 1:150,000

GDA94 / MGA zone 55

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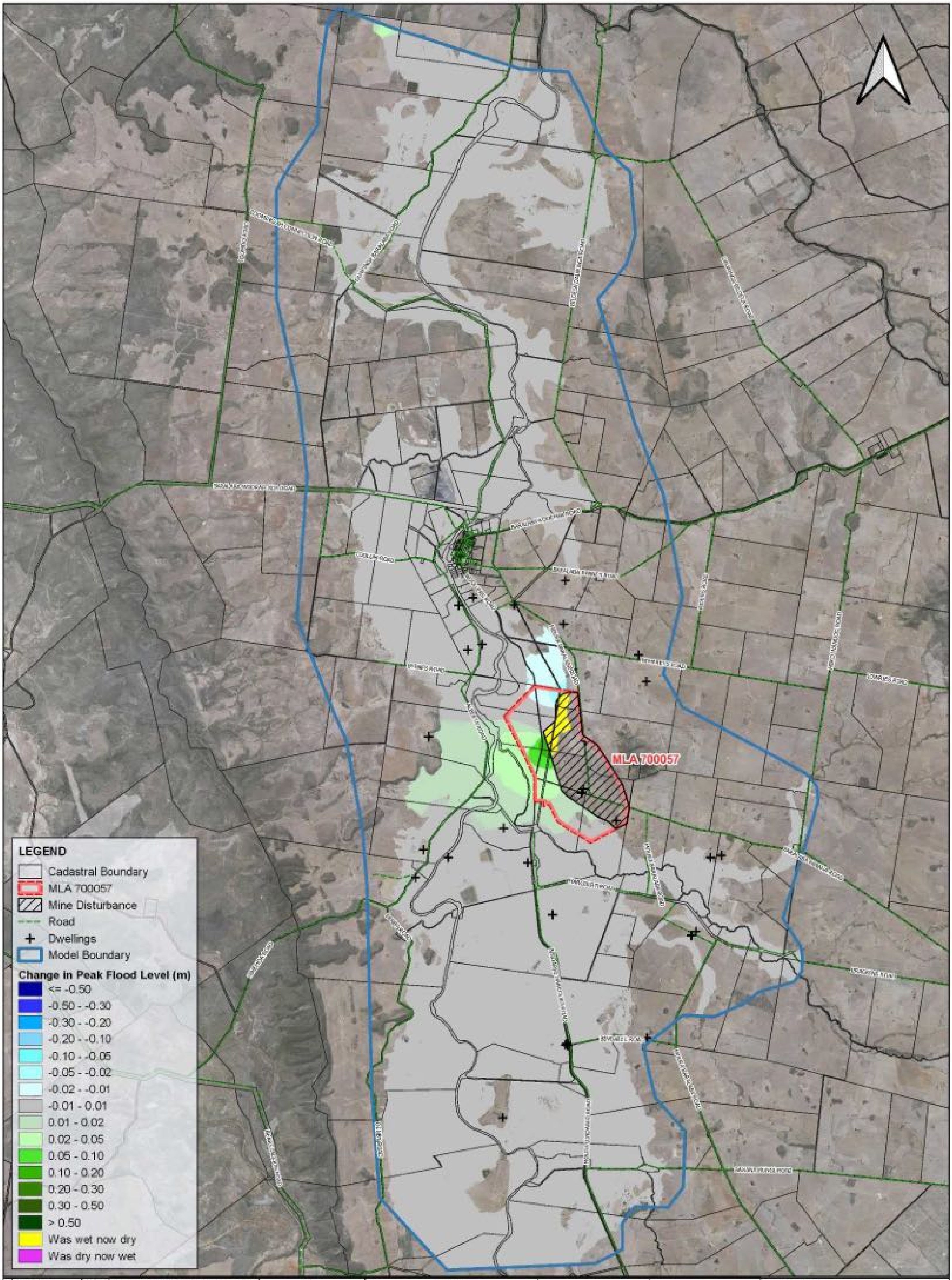
BARALABA SOUTH

Appendix J.4

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
Climate Change 0.1% AEP Flood Depth - Mine Developed Case

Job Number:
QC1018_004986-16-1

Q:\Projects\QC1018 Baralaba Coal\QC1018_004986P SWTASFIA Revision\05 Design\QGIS\Figures\Flood Figures\QC1018_004986R-001-0 Flood_Figures.qgz



R	DETAILS	DATE
0	First Issue	[illegible]

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APPROVED	AV	DATE	[illegible]

SCALE @ A3 - 1:150,000

GDA94 / MGA zone 55

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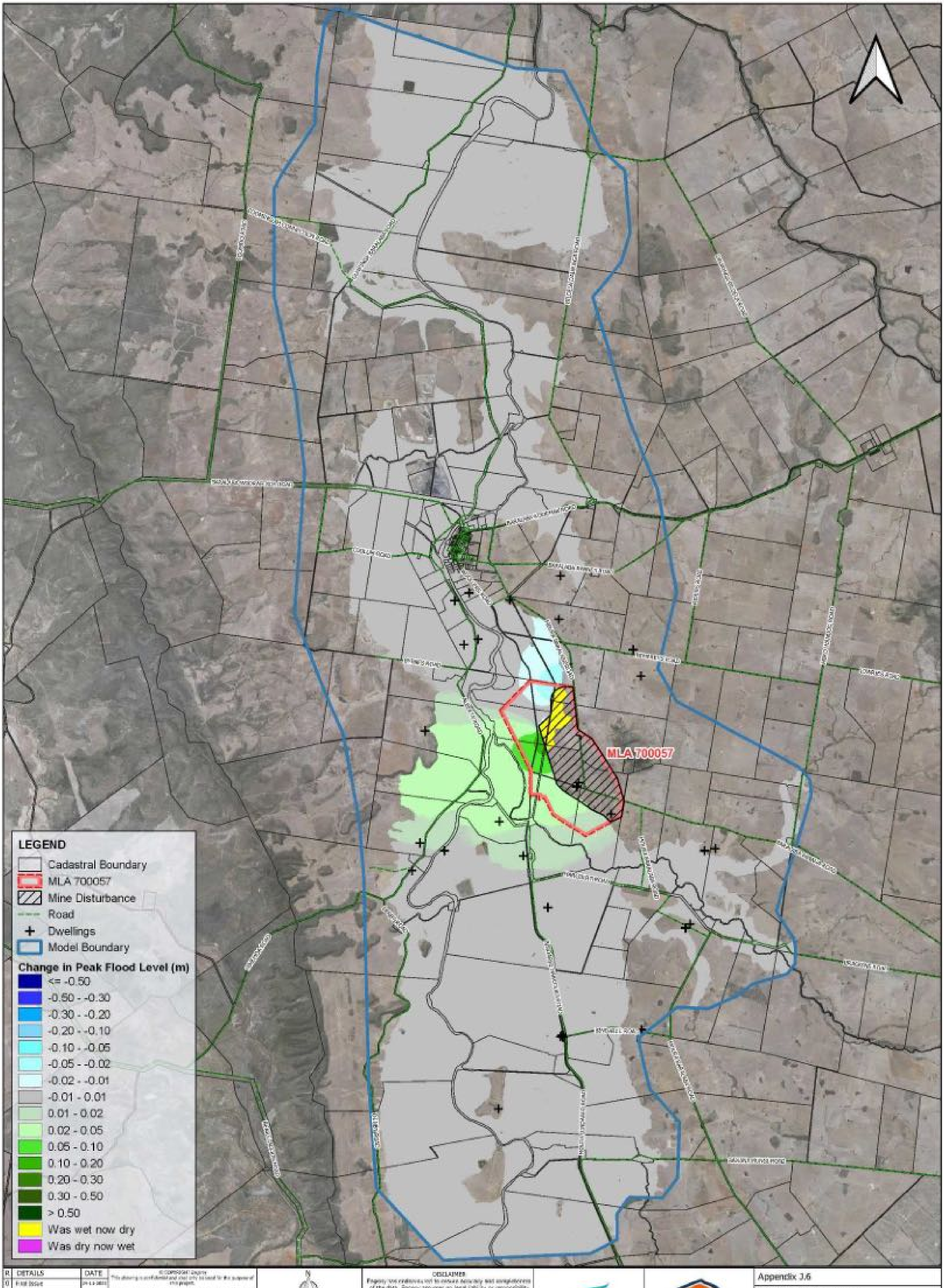
BARALABA SOUTH

Appendix 3.5

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
Climate Change 1% AEP Flood Afflux (Mine Developed Case - Existing Case)

Job Number:
[illegible]



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0 0.9 1.8 2.7 km

SCALE @ A3 - 1:150,000

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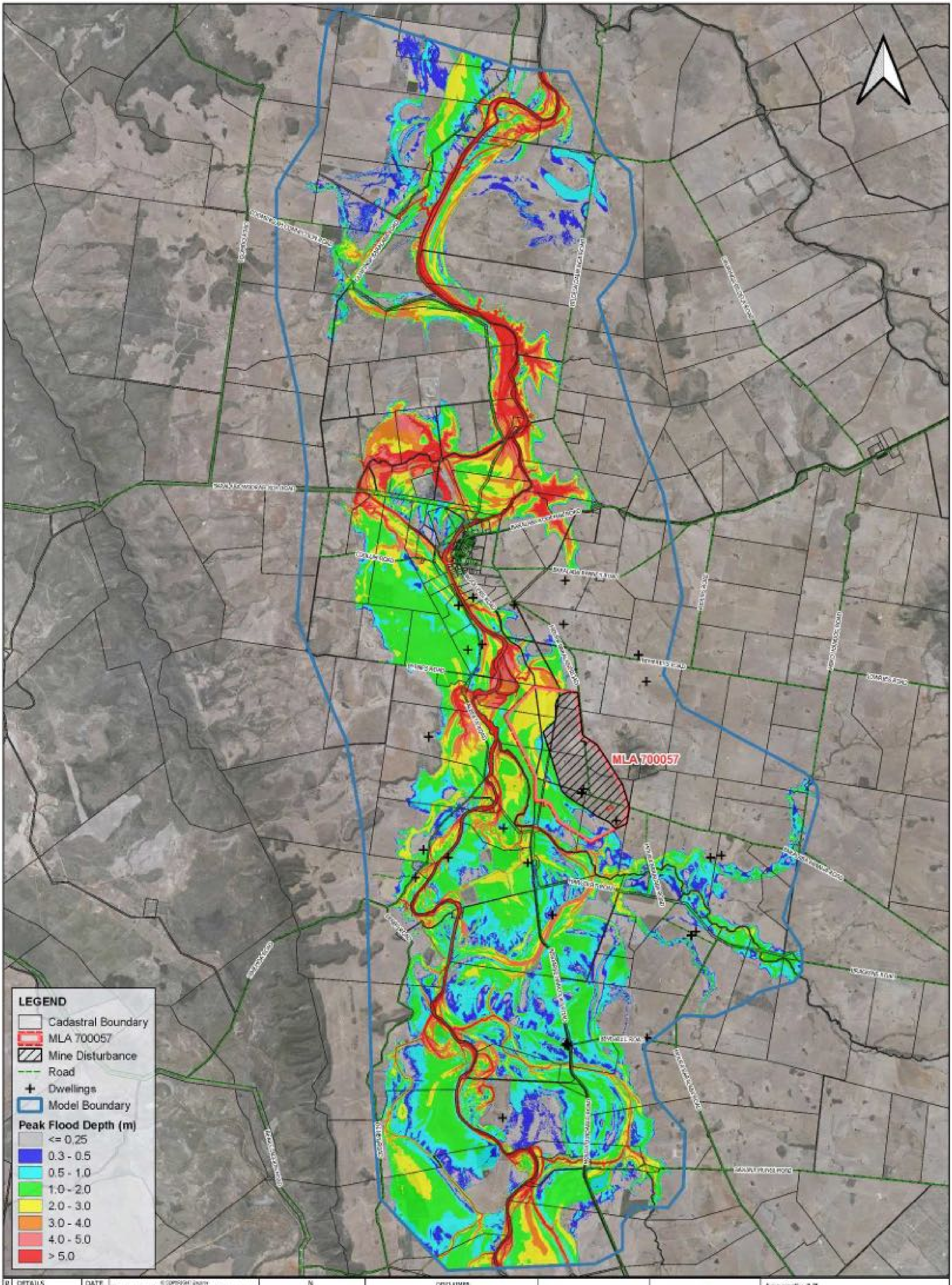
BARALABA SOUTH

Appendix J.6

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
Climate Chane 0.1% AEP Flood Afflux (Mine Developed Case - Existing Case)

Job Number.



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0 0.9 1.8 2.7 km
SCALE @ A3 - 1:150,000
GDA94 / MGA zone 55

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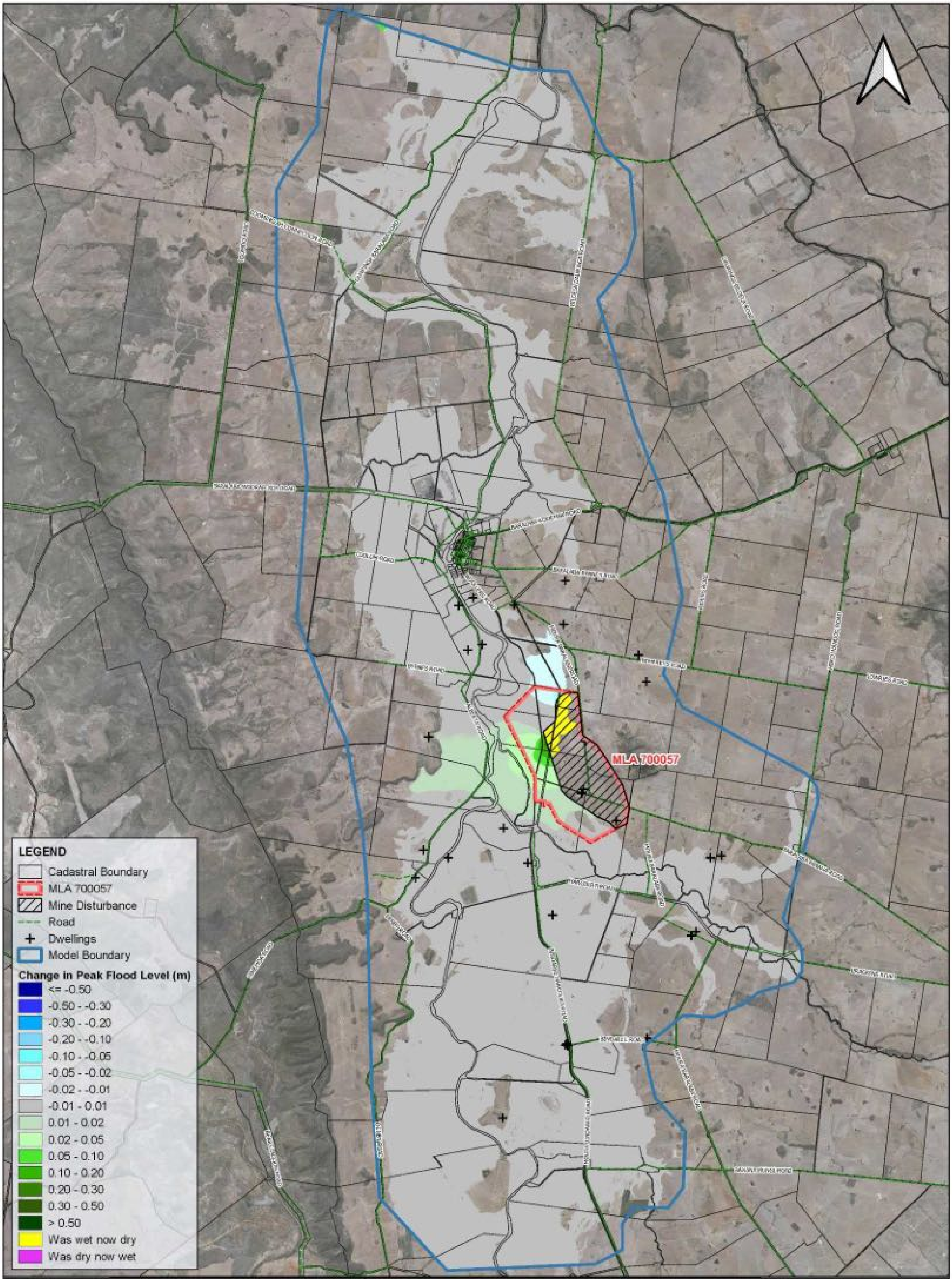
BARALABA SOUTH

Appendix 3.7

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
2010 Event Sensitivity Flood Depth - Mine Developed Case

Job Number:



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0	First Issue	24-11-2023

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NOTES

0 0.9 1.8 2.7 km

SCALE @ A3 - 1:150,000

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BARALABA SOUTH

Appendix J.8

BARALABA SOUTH PTY LTD
Baralaba South Project Flood Impact Assessment
2010 Event Sensitivity Flood Afflux (Mine Developed Case - Existing Case)

Job Number:
QC1018_004986-17 [illegible]

[illegible]