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Scenic Rim Flood Modelling

Bremer River Flood Modelling – Consolidated Final Report

Scenic Rim Regional Council

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1 Introduction

1.1 Study background

Scenic Rim Regional Council (SRRC) is seeking to gain a better understanding of the Region's Natural Hazard (Flood) characteristics. Aurecon has undertaken flood studies across the Scenic Rim Regional Council (SRRC) area for seven major waterway systems including Logan River, Albert River, Bremer River, Teviot Brook, Warrill Creek, Purga Creek and the Upper Coomera River. These studies involved the development of catchment wide models for each of the waterways, covering the majority of creeks and tributaries.

Aurecon were originally commissioned by SRRC to undertake flood modelling of each system to provide SRRC with flood extents, heights, velocities and hazard categories for the 1% AEP event. This modelling focussed on providing information to assist Council with strategic planning objectives.

Council recognised that whilst the 1% AEP event provided important information on large scale flooding across each catchment, understanding the behaviour of more frequent events was also important in particular when looking at risk to properties, access and egress routes during floods and for disaster management planning.

As such, Council commissioned Aurecon to update the flood models for each of its seven major catchments to include assessment of the 2%, 5% and 10% AEP flood events.

This report consolidates and presents the investigation completed for the Bremer River catchment.

1.2 Study area

The Bremer River is part of the Brisbane River Basin and extends north from the Queensland/New South Wales border ranges to the confluence with Brisbane River downstream of Ipswich. The area of interest for this flood study is the upper reaches of the Bremer River from Moorang to Lower Mount Walker. This area of the catchment is predominantly rural. The Scenic Rim Local Government boundary extends to Lower Mount Walker and defines the lower extent of this study.

1.3 Study objectives

The Scenic Rim Flood Hazard Management and Disaster Mitigation Assessment Project for the Bremer River Catchment is a joint initiative of Scenic Rim Regional Council, the Queensland Government and the Australian Government

SRRC initially requested a flood study that was compliant with the current State Planning Policy (and associated guidelines) and the relevant requirements of the Building Act 1975 (Act). The flood study is to provide Council with the ability to designate a flood hazard area under Section 13 of the Act.

The second stage objective was to provide information to assist with Council's disaster management planning and response functions. The following tasks were undertaken as part of this two-stage assessment:

- Hydrologic modelling of the catchment and calibration against selected historical events

- Hydraulic modelling of the Bremer River and joint calibration with the hydrologic model
- Preparation of 1% AEP flood mapping presenting flood inundation extents, flood depths, flow velocities and hazard rating
- Identification of the minimum and maximum flood levels for each property inundated by the 1% AEP event
- Updated hydrologic and hydraulic modelling for the 10%, 5% and 2% AEP events
- Updated definition of minor, moderate and major flood events at each key stream gauge location to enable Council to inform BOM (and to update the current flood gauges)
- Review of the current flood gauge network to ascertain whether there are any further locations where flood gauges could/should be located
- Review of the correlation between gauge height, flooding event and scale of event, and
- Preparation of flood mapping for the additional events presenting flood inundation extents, flood depths, flow velocities and hazard ratings

The work undertaken to achieve the above objectives is documented in the following report.

The Scenic Rim Flood Hazard Management and Disaster Mitigation Assessment Project for the Bremer River catchment is a joint initiative of Scenic Rim Regional Council, the Queensland Government and the Australian Government

2 Study Data

A number of datasets have been collated, reviewed and adopted for use in this project as described below.

2.1 Previous models/reports

A detailed hydrologic URBS model of Bremer River was previously developed for Seqwater as part of the 2013 hydrology study for the Wivenhoe and Somerset Dam Optimisation Study (WSDOS). This model contained calibration data for the 1974, 1991 and 2011 historical events. The URBS hydrologic model was sourced and used as the basis for this hydraulic assessment.

The URBS model was recalibrated by Aurecon as part of the 1% AEP hydraulic assessment work in 2014.

2.2 Survey Data

2.2.1 Aerial LiDAR Survey

SRRC provided 2011 Aerial LiDAR Survey (ALS) data which typically produces levels within an accuracy of ±150 mm and a horizontal accuracy of ±300 mm. Ground survey (2013) of Permanent Survey Marks (PSM) was provided to verify the ALS data and a comparison of the two datasets was undertaken. The ALS data was found to provide elevations within ±300 mm of the ground survey PSM. This is considered a reasonably accurate representation of the topography and confirmed that the LiDAR was suitable for use in the hydraulic model. There are local discrepancies identified between the datasets but it was not expected that these differences would affect the hydraulic modelling outcomes. No regional level variations were noted within the data provided.

No bathymetric data was provided for this study and it was noted in the 1% AEP assessment in 2014 that the river bed definition was limited by the presence standing water. Whilst this limitation was not considered significant for the 2014 1% AEP study due to the high proportion of overbank flow in the major storm event. The bathymetry is considered more significant for the analysis of minor to moderate storm events due to the higher proportion of in-channel flow.

2.2.2 Structures data for 1% AEP event

Structure details for a number of bridges were provided by SRRC. The bridge information was limited with no As-Constructed details available. In 2014 the following simplified assumptions were made regarding bridge structures:

- It has been assumed that the bridge deck has the same level as the adjacent road level
- The thickness of the deck has been assumed to be 900 mm

A blockage factor of 20% was assumed to allow for pier losses.

2.2.3 Field Survey

To assist with providing information for emergency management response critical road crossings were identified within the Bremer River Catchment. This was carried out in consultation with Council.

Detailed field survey was commissioned in 2017 to obtain structure details for incorporation into the hydraulic model. In the Bremer River catchment, the following crossings were surveyed:

- Rosevale Road – South Bridge
- Stokes Crossing

Using this field survey improvements were made to the bathymetric representation within the current model. This is discussed further in Section 6.2.3.2.

2.3 GIS data

The following GIS datasets were provided by SRRC:

- Aerial imagery – High resolution 2013 aerial imagery
- GIS based hydraulic structures data. Details regarding refinements to the modelling of hydraulic structures is provided in Section 6.2.3.2
- Updated DCDB (2017)

These datasets have been utilised for the generation of flood mapping and tabulated flood levels.

2.4 Public databases

Publicly available flood information from the Queensland Department of Natural Resources and Mines (DNRM) via the Queensland Reconstruction Authority (QRA) 'floodcheck' database was utilised to provide an indication of potential flood extents around each of the sites from regional flood events.

2.5 Report terminology

This report adopts the latest approach to design flood terminology as detailed in the updated *Australian Rainfall and Runoff – Book 1 Terminology* (AR&R, National Committee on Water Engineering, 2016). Therefore, all design events are discussed in terms of Annual Exceedance Probability (AEP) using percentage probability (eg 1% AEP design event).

Table 1, an extract of Figure 1.2.1 from Book 1 (AR&R, 2016), details the relationship between Annual Recurrence Interval (ARI) and AEP for a range of design events.

Table 1 Extract from Figure 1.2.1 AR&R adopted terminology

AEP (%)	AEP (1 in x)	Average recurrence interval (ARI)
10.00	10	9.49
5.00	20	20
2.00	50	50
1.00	100	100
0.50	200	200
0.20	500	500

As can be seen from Table 1, the difference between AEP and ARI is minimal for 10 year ARI event and above. This range of events reflects a focus on flooding therefore use of the AEP terminology has been adopted.

3 Hydrologic model

3.1 Background

The previously developed 2013 WSDOS URBS hydrologic model of the Bremer River was considered suitable for use and adopted for this study. URBS is a runoff routing model and an industry standard tool commonly used for hydrologic studies.

3.2 Initial URBS model parameters

The URBS model parameters recommended in the WSDOS study (Seqwater, 2013) are detailed in Table 2. These parameters were adopted as a starting point and modified as part of the joint calibration process as described in Section 5. The final calibration parameters were then used to specify design event parameters for the design events.

Table 2 WSDOS URBS model calibration parameters

Event	Calibration parameters				
	Initial Loss Rate (mm)	Continuing Loss Rate (mm/hr)	Alpha, α	Beta, β	m
1974	65	2.0	0.3	3.0	0.8
1991	65	2.5	0.4	2.5	0.8
2011	30	2.0	0.25	3.0	0.8

URBS uses five key parameters which can be varied to represent hydrological conditions:

- Alpha – channel and storage routing parameter typical range 0.03 to 0.20
- Beta – catchment routing parameter typical range 1 to 9
- m – catchment routing exponent typical range 0.6 to 1.0
- IL – Initial Loss (mm) typical range 0 to 100
- CL – Continuing Loss (mm/hr) typical range 0 to 5

The initial loss parameter is largely event specific relating to the antecedent conditions in the catchment, and as expected varies between calibration events.

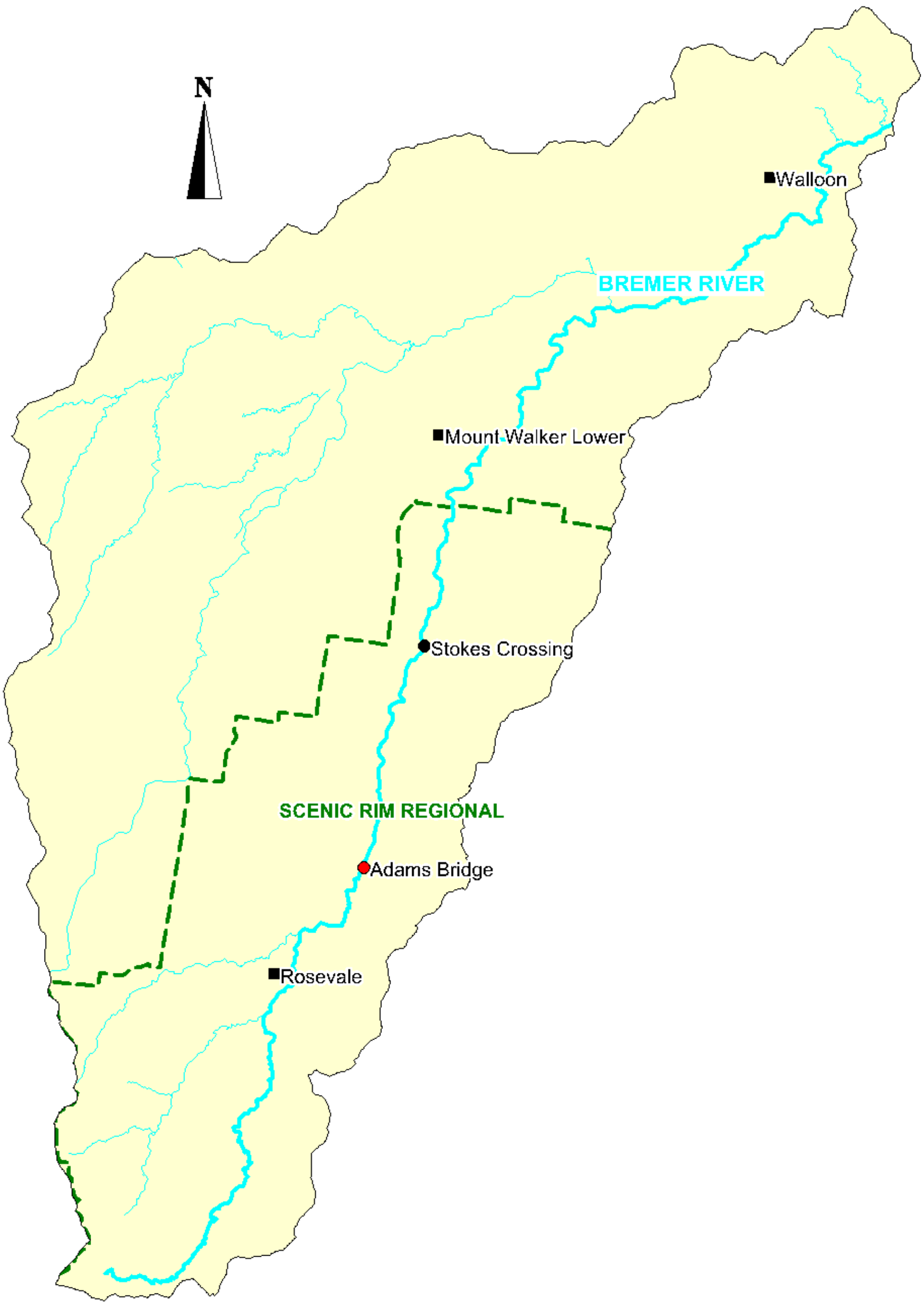

Figure 1 Bremer River catchment

4 Hydraulic model

4.1 Software platform and modelling approach

A 2-dimensional (2D) hydraulic modelling approach was adopted for this study. The Bremer River hydraulic model has been developed to cover the entire floodplain and includes representation of the major hydraulic structures and topographic features that influence flood behaviour. Adoption of the 2D modelling software enabled floodplain and breakout flows to be accurately represented. Modelling has been undertaken using the TUFLOW software (version 2013-12-AC).

4.2 Modelling extents

The extent of the Bremer River system modelled and mapped matches the extents shown on the Queensland Reconstruction Authority (QRA) website as the 2010/11 Interim flood lines for the SRRC area. The model extends from Moorang to Lower Mount Walker and includes an area of approximately 180 km^2.

4.3 Topography

The hydraulic model was based on topographic information sourced from the 2011 LiDAR survey provided by SRRC. The topography is represented in the hydraulic model using a 20 m grid size. This grid size allows sufficient detail for the channel and floodplain representation in the hydraulic model whilst allowing for reasonable model run times. Figure A-1, Appendix A presents the model topography.

4.4 Initial roughness assumptions

Initial surface roughness values used in the hydraulic model are presented in Table 3 and were based on accepted industry values. Land use types were identified for areas using aerial photography provided. Figure A-2, Appendix A presents the model roughness.

Table 3 Adopted roughness/Manning's n values

Land use type	Manning's n
Dense Vegetation	0.090
Medium Vegetation	0.070
Open Fields	0.040
Agricultural areas	0.050
Road Reserve	0.020
River Corridor	0.030

4.5 Hydraulic structures

Three Bremer River bridge crossings were included in the TUFLOW hydraulic model. Details of the existing bridges included are outlined in Table 4.

Table 4 Existing bridges

Name	Description	Bridge Type	Bridge Length (m)
Adams Bridge	Bremer River crossing at Rosevale Road	Timber Bridge	43
Tierneys Bridge	Bremer River crossing at Tierneys Bridge Road	Timber Bridge	23
Rosevale Bridge	Bremer River crossing at Rosevale Road	Concrete Bridge	32

4.6 Boundary conditions

The URBS model outputs were applied as inflows into the TUFLOW model. Total inflows from catchments upstream of the hydraulic model extents were applied at the upstream model boundary and local inflows from areas within the TUFLOW model were applied throughout the model.

A normal depth boundary condition was applied at the downstream boundary. Since the downstream boundary is not a well-defined water level, a stage-discharge relationship was used in TUFLOW to define the boundary condition.

5 Calibration

5.1 Process of calibration

Three events were used in the model calibration process being 1974, 1991 and 2010/11. Inflow hydrographs from the URBS model were incorporated into the TUFLOW hydraulic model at a number of locations within the study area. The hydraulic model was run and the resulting water levels and discharges compared to the Adams Bridge stream gauge data. An iterative joint calibration approach was then undertaken with both hydrologic and hydraulic model parameters adjusted to achieve the best match against the available recorded historical data.

5.2 Calibration targets

Ideally, the following tolerances are indicative of a good calibration:

Table 5 Calibration targets

Water level	Discharge
+/- 0.15m at stream gauges	+/- 10%

5.3 Gauge data

Historical stream gauge data was available at Adams Bridge and Stokes Crossing. At the Adams Bridge stream gauge, data was available for 1974, 1991 and 2011 events. The Stokes Crossing gauge provided historical data for the 2011 event only. During this event, the Stokes Crossing gauge failed and was therefore not considered as a calibration point.

Table 6 Stream gauge used for calibration

Station number	Station name	Period	Gauge zero (m AHD)
143110A	Adams Bridge	1968 to current	75.064

5.4 Calibration results

The following plots present the results from the joint calibration against the recorded gauge data. The Bremer River gauge at Adams Bridge is relatively well rated although the majority of flow gauging's are for very small discharges. The highest recorded gauging is 4.18 m gauge height corresponding to 173 m³/s. Higher values have to be reviewed with caution. As there is only limited data available, the focus of the calibration exercise was to match peak water levels and to match the rising limb of the hydrograph as well as possible.

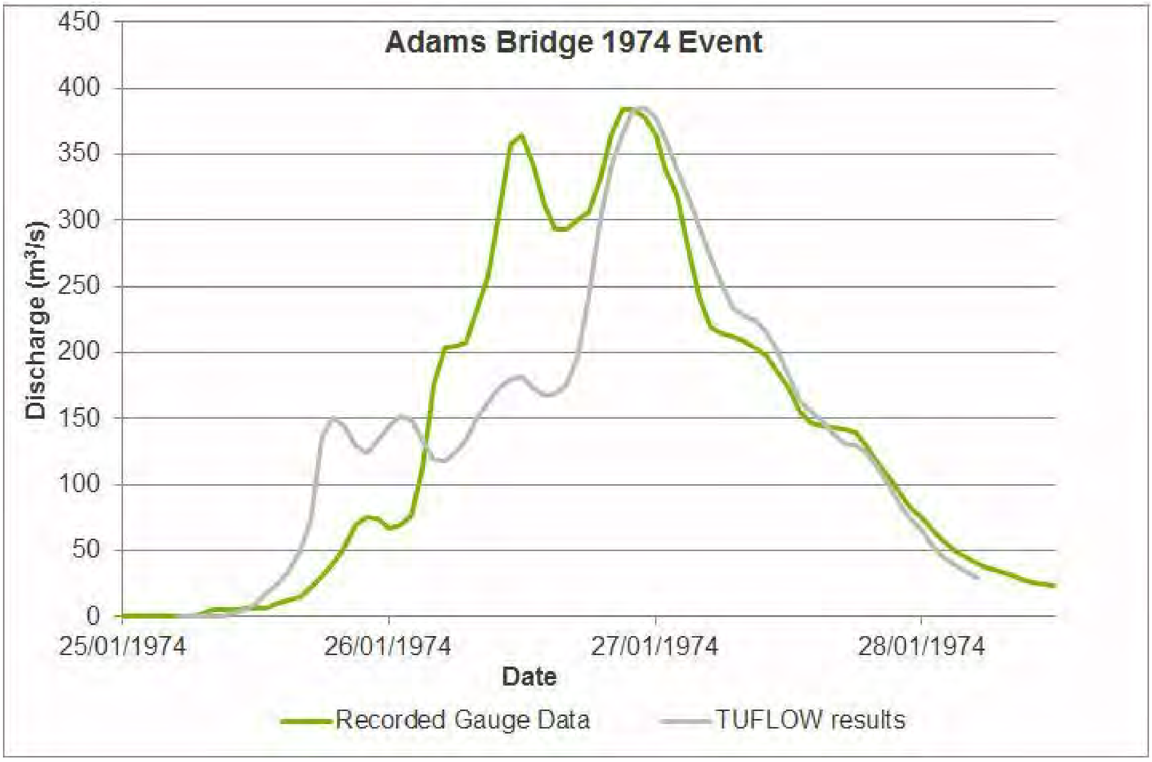

Figure 2 Adams Bridge flow comparison 1974 event

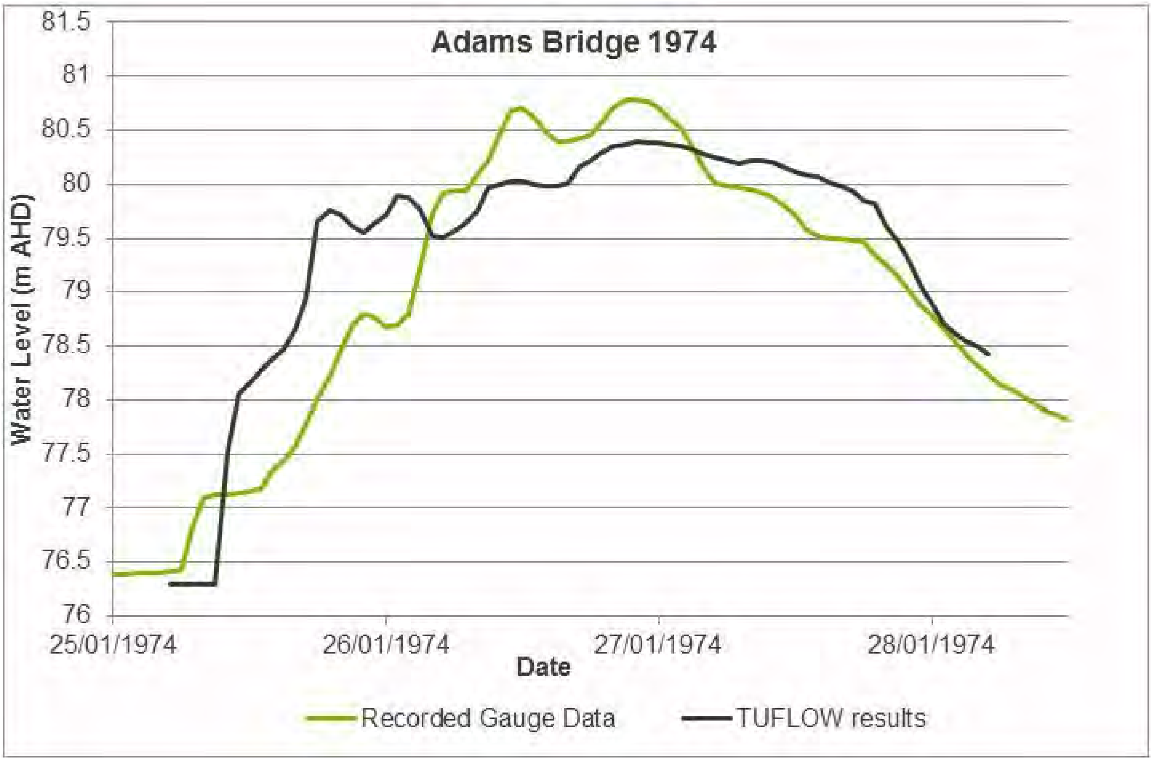

Figure 3 Adams Bridge water level comparison 1974 event

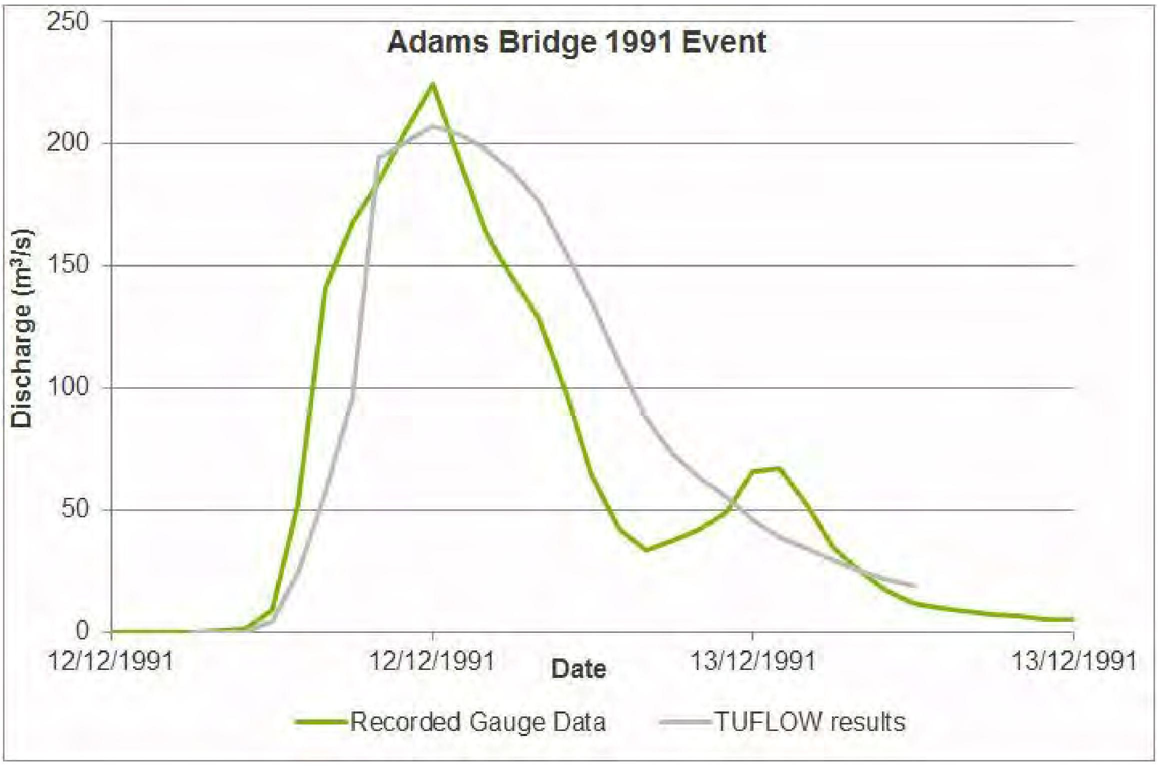

Figure 4 Adams Bridge flow comparison 1991 event

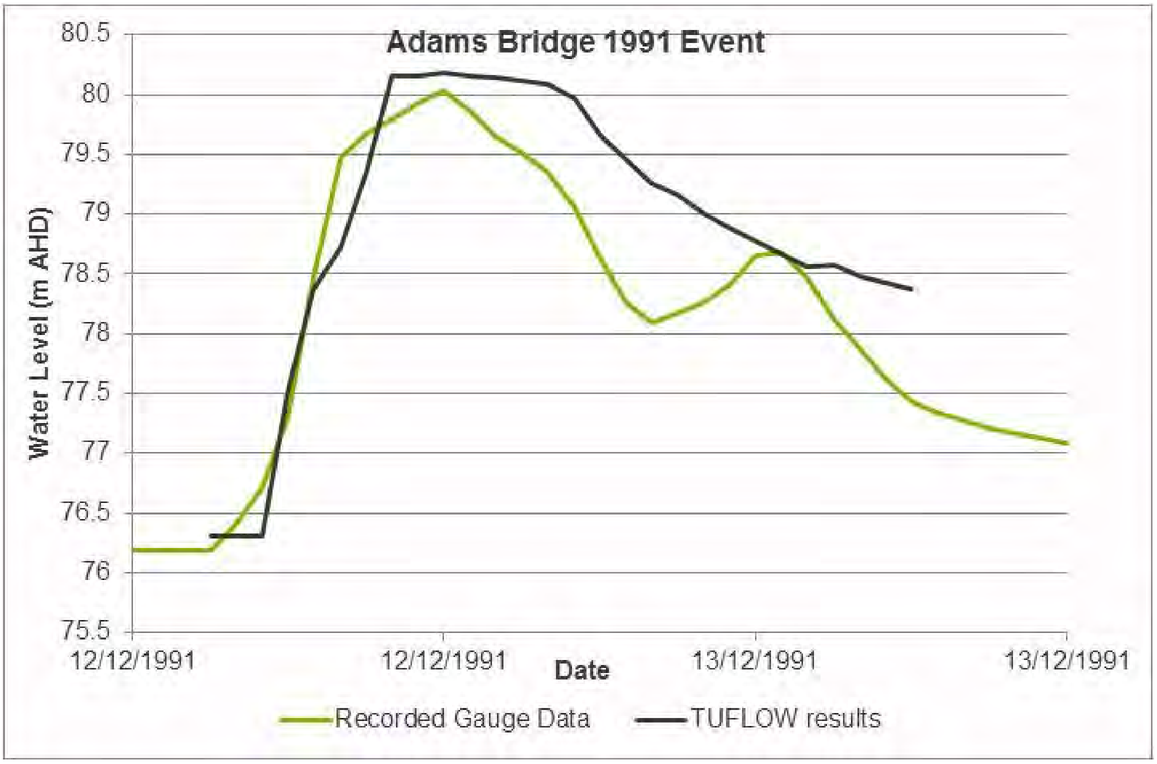

Figure 5 Adams Bridge water level comparison 1991 event

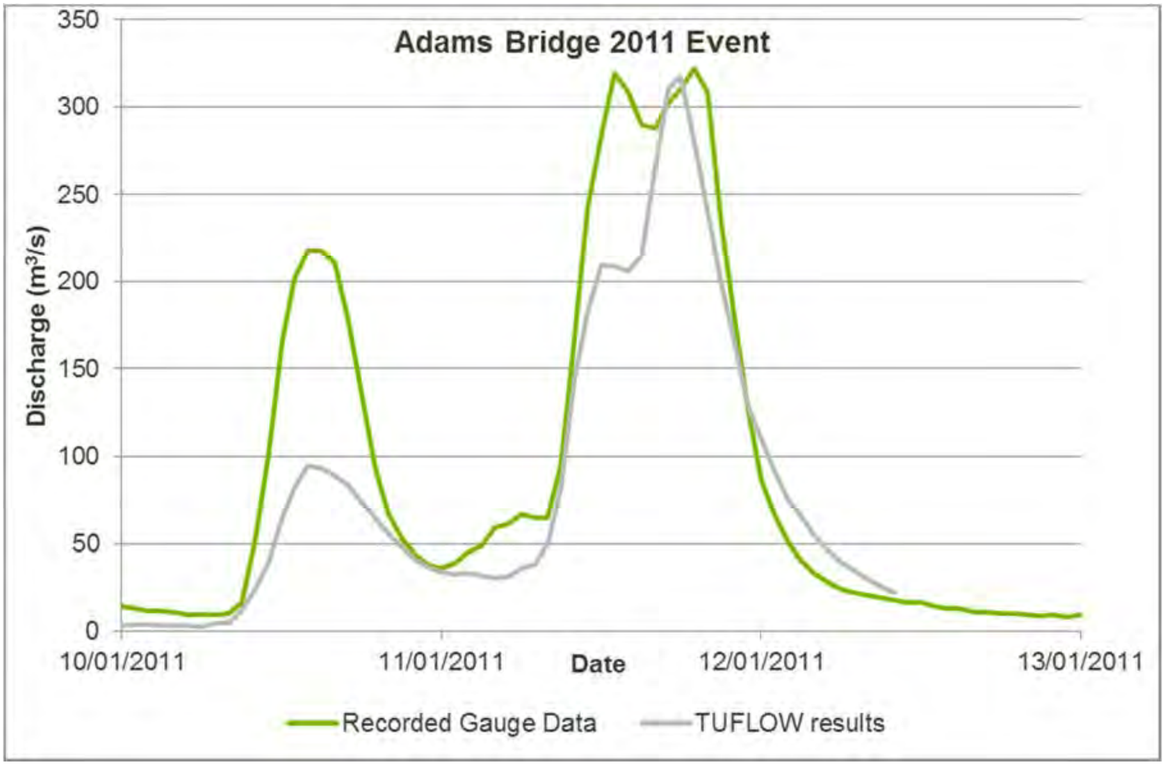

Figure 6 Adams Bridge flow comparison 2011 event

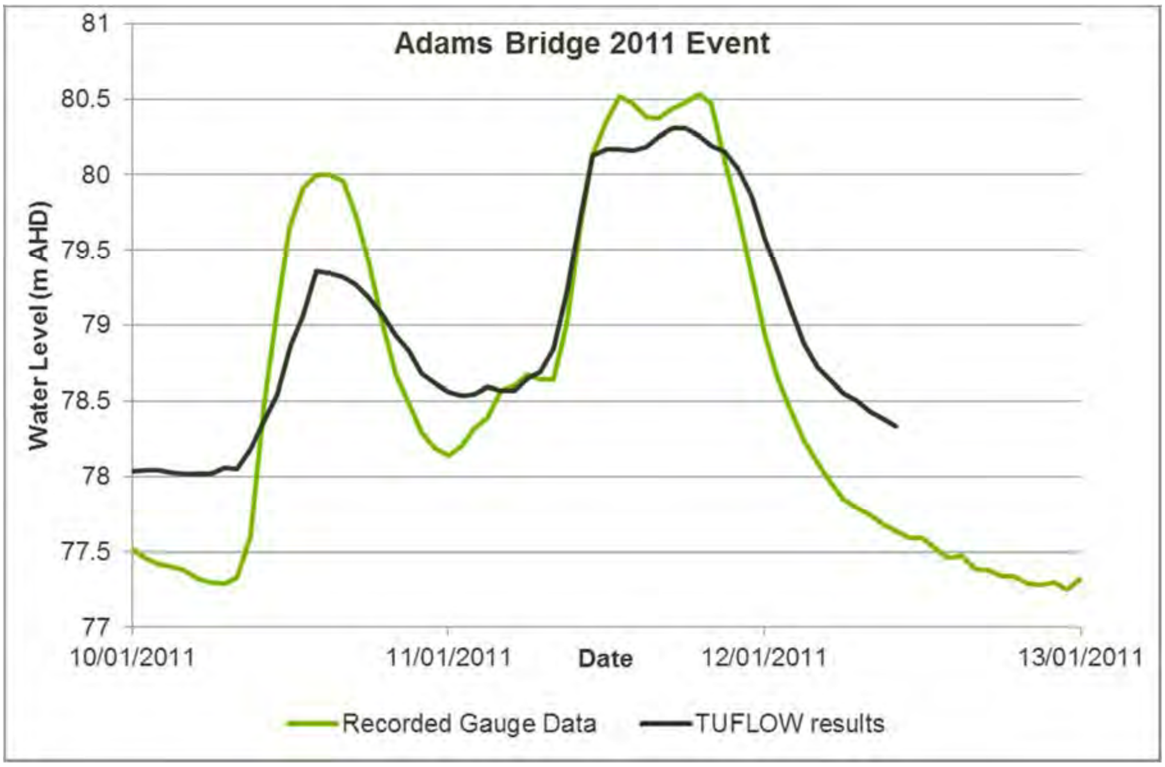

Figure 7 Adams Bridge water level comparison 2011 event

Table 7 presents the calibration outcomes achieved at the Adams Bridge gauge for the 1974, 1991 and 2011 events.

Table 7 Observed vs modelled level and discharge at the Adams Bridge stream gauge

Result	1974 Event		1991 Event		2011 Event	
	Recorded	Modelled	Recorded	Modelled	Recorded	Modelled
Peak water level (m AHD)	80.78	80.39 (-0.39)	80.04	80.18 (+0.14)	80.53	80.34 (-0.19)
Peak discharge (m^3/s)	383	385 (+0.5%)	230	207 (-10%)	322	334 (+4%)

5.5 Discussion

Overall, a reasonable calibration has been achieved based on the available information and suitability for the objectives of this study. The findings for each calibration event are described in the following sections.

5.5.1 1974 event

Whilst not being within +/-0.15 m, the 1974 event is considered to have achieved a good calibration based on the results at the gauge only. The shape of the flow hydrograph matches the recorded data very well for the second peak and the timing of the hydrograph peaks is within one hour which is also considered to be good.

5.5.2 1991 event

The results of the 1991 event are within the tolerances and therefore the calibration is regarded as good. The timing of the hydrograph peaks is within one hour which is also considered to be good.

5.5.3 2011 event

Whilst just being outside +/-0.15 m, the 2011 event is considered to have achieved a good calibration, based on the results at the gauge only. The timing of the hydrograph peaks is within one hour which is also considered to be good.

5.6 Adopted URBS model calibration parameters

As detailed above, a joint calibration exercise was undertaken and the following parameters were adopted for the URBS model for each historical event:

Table 8 URBS model calibration parameters

Event	Calibration parameters				
	IL (mm)	CL (mm/hr)	α	β	m
1974	35	2.0	0.8	2.8	0.8
1991	0	6.5	0.8	2.8	0.8
2011	10	2.5	0.8	2.8	0.8

The values of these parameters vary from those adopted in the WSDOS study for two key reasons:

- The current study has included the development of a hydraulic model which has enabled direct calibration against recorded flood levels rather than relying on the use of rating curves
- The current study is focussed on the upper part of the Bremer River catchment (ie that within SRRC boundaries) and therefore the best match against the Adams Bridge stream gauge has been sought

5.7 Adopted roughness values

Aerial photography was used to define the land use within the study area and industry accepted values of Manning's 'n' roughness were applied. Calibration of the hydraulic model was then used to refine the values. The adopted roughness values are presented in Table 9.

Table 9 Post-calibration Manning's 'n' roughness values

Land use type	Manning's n
Low Density Residential	0.090
Dense Vegetation	0.090
Medium Vegetation	0.070
Low Vegetation	0.045
Agricultural areas	0.050
Road Reserve	0.020
River Corridor	0.050

6 Design event modelling

6.1 1% AEP event

Model calibration parameters for each historical event were established through the joint calibration process. The parameters adopted for calibration and the results of the flood frequency analysis were used to formulate design event parameters for the 1% AEP. The adopted 1% AEP design event parameters are detailed in Table 10.

Table 10 1% AEP design event parameters

Design Event	Calibration parameters				
	Initial Loss Rate (mm)	Continuing Loss Rate (mm/hr)	Alpha, α	Beta, β	m
1% AEP	0	2.5	0.8	2.8	0.8

Using the calibrated hydrologic and hydraulic models, modelling of the 1% AEP event was undertaken. The 1987 rainfall (IFD) and temporal patterns were adopted from Australian Rainfall and Runoff (AR&R).

6.1.1 Flood frequency analysis

A flood frequency analysis (FFA) using the available stream gauge data at Adams Bridge was undertaken to estimate the peak flow for the 1% AEP design event. This was then used to develop the design event calibration parameters.

The FFA is limited by the historical data available at Adams Bridge. The gauge is well rated to flows up to 173 m^3/s but relies on extrapolation of the rating curve for higher flows as shown in Figure 8. The predicted 1% AEP flow at Adams Bridge is 466 m^3/s, which exceeds the highest gauge record for this location. However, despite the limitations of the historical data, the FFA provides an appropriate reference point against which to compare the design event results and refine parameters.

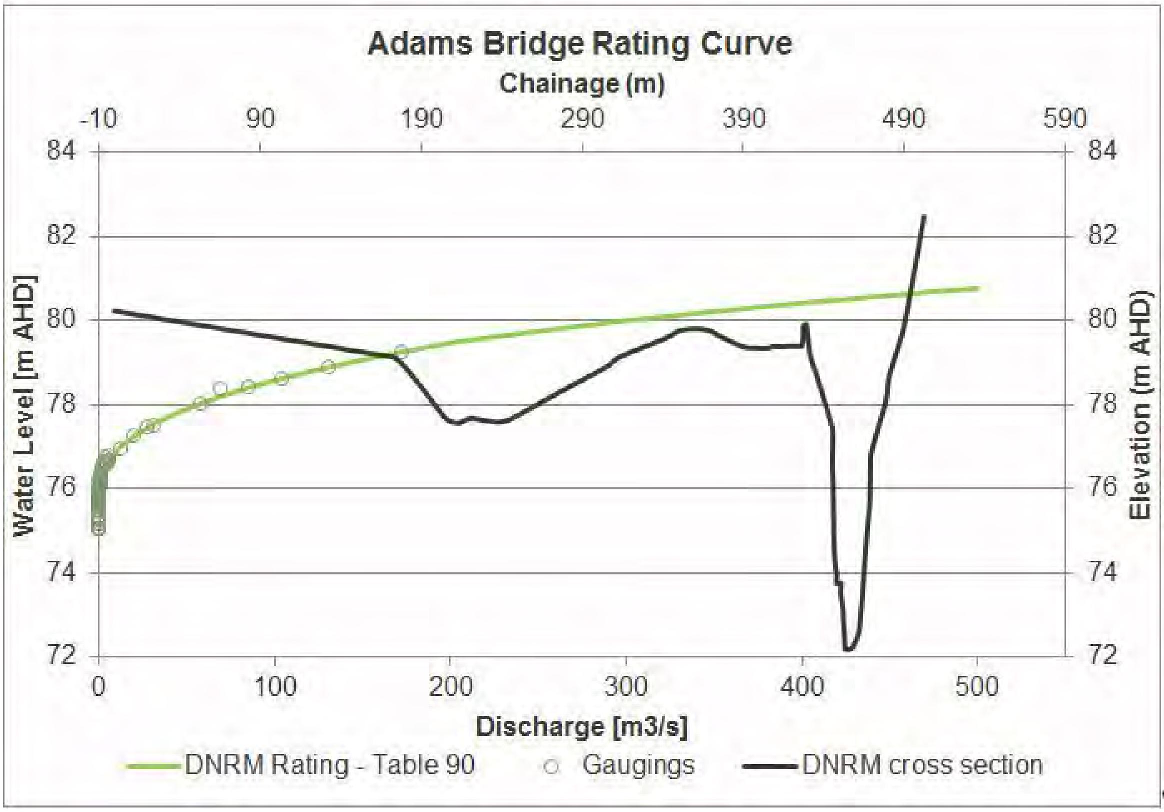

Figure 8 Adams Bridge stream gauge rating

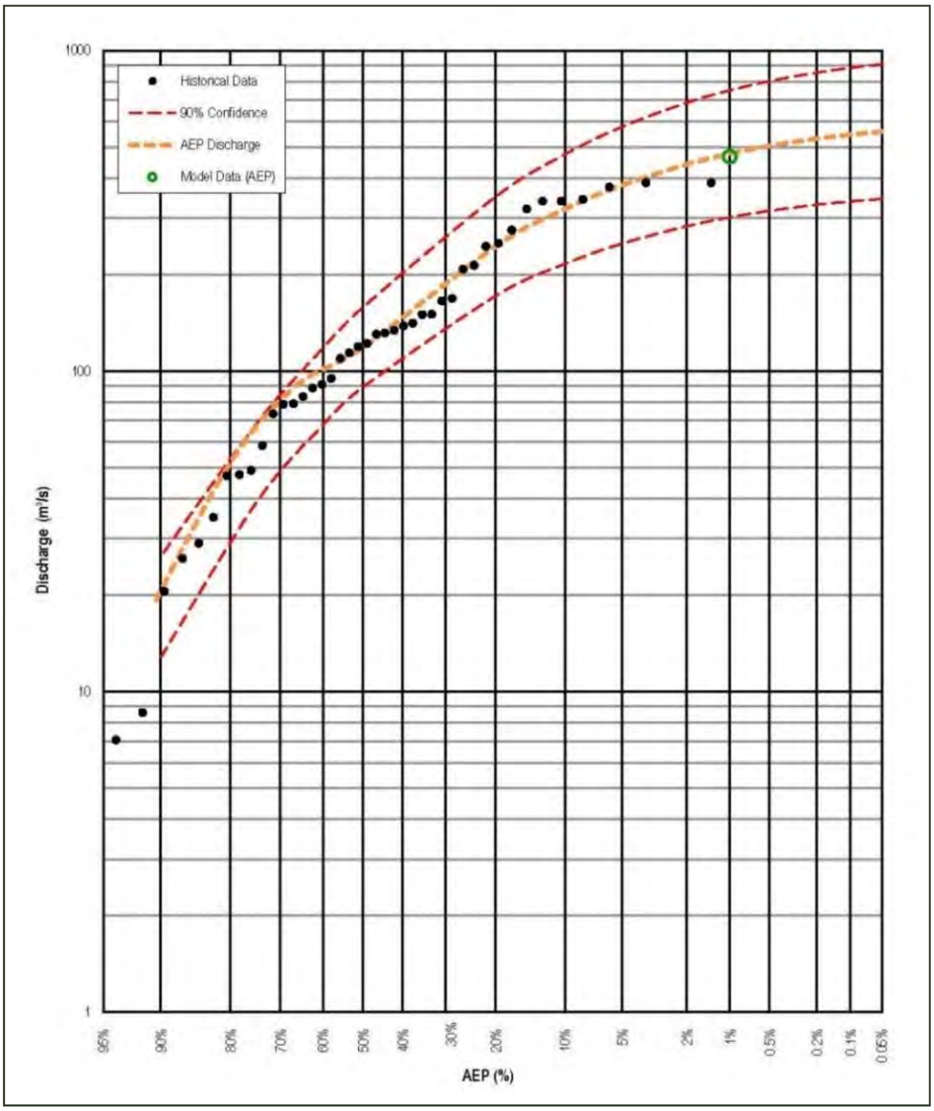

Figure 9 Flood frequency analysis at Adams Bridge

6.1.2 IFD sensitivity testing

In 2014 Australian Rainfall and Runoff (AR&R) was undergoing a significant update. Revised Intensity-Frequency-Duration (IFD) curves were derived and available for sensitivity testing for new flood studies. Whilst they were not yet published for use on flood studies, it was important to be aware of the potential changes and the implications for peak flood level estimation.

A sensitivity run was undertaken adopting the 2013 rainfall (IFD) data in the URBS hydrologic model. The results were assessed against the design event modelling prepared using the 1987 IFD.

The peak water surface levels across the catchment generally show an increase of less than 100 mm using the 2013 IFD data. At Adams Bridge a flow increase of approximately 10% was predicted using the 2013 IFD data. These results are presented in Figure A7.

6.2 10%, 5% and 2% AEP events

The calibrated TUFLOW model developed as part of the 2014 study which investigated 1% AEP flooding behaviour within the Bremer River catchment was used to assess the 10%, 5% and 2% AEP events. The original model was developed using a 20m grid resolution and was intended for investigation of the rare flooding events during which a significant proportion of flooding occurs as overland flow outside of defined watercourse banks.

6.2.1 Software platform and modelling approach

The 2-dimensional (2D) TUFLOW modelling approach used for the 2014 Bremer River Flood study was retained for updated modelling. The 2013 study used TUFLOW version 2013-12-AC which has since been updated. TUFLOW version 2016-03-AD was tested and adopted for this study.
A comparison of results using both versions showed primarily similar results with localised differences of +/- 5cm, overall the differences were negligible.

Key component datasets such as the Manning's n roughness layer and the topographic dataset were retained as per the previous model.

6.2.2 Inflow boundary conditions

The URBS model outputs were applied as inflows into the TUFLOW model in the same locations as used for the 1% AEP model. Local inflows were applied throughout the model domain.

Parameterisation of the URBS model for the 10%, 5% and 2% AEP events was based on the calibrated 1% model developed for the 2014 Bremer River Study. The event independent Alpha, Beta and m parameters were retained as per the calibrated 1% AEP event Bremer River URBS model.

Initial and continuing loss rates are typically adjusted across the range of design events to reflect the likelihood of lower levels of catchment saturation antecedent to more minor events. Adopted URBS model parameters are shown in Table 11.

Table 11 Bremer River URBS model design event parameters

Design Event	Calibration parameters				
	Initial Loss Rate (mm)	Continuing Loss Rate (mm/hr)	Alpha, α	Beta, β	m
2% AEP	8	2.5	0.8	2.8	0.8
5% AEP	16	2.5	0.8	2.8	0.8
10% AEP	24	2.5	0.8	2.8	0.8

6.2.3 Model refinements

6.2.3.1 Initial indicative low flow modelling

As an initial step, inflow hydrographs for the 1% AEP were scaled down to represent a minor/moderate storm scenario. The results from this simulation were used to inform assess which hydraulic structures should be included in the hydraulic model refinement and to review locations where additional bathymetric data may be required. This simulation was only used to guide model development and the results of this simulation are not presented in this report.

6.2.3.2 Hydraulic structures

Improvements to the representation of hydraulic structures details and watercourse bathymetry has been achieved using new ground survey undertaken by Aurecon in May 2017. Locations for ground survey were decided based on review of the initial modelling and discussions between Council and Aurecon. Waterway crossings were identified that were of significance in terms of understanding flooding impacts on access through the Bremer River catchment during flood events. The following aspects were considered in the selection of locations for survey and model refinement:

- Consequence of overtopping in terms of population affected by inundation and loss of access
- Likelihood of overtopping in minor/moderate storm events
- Degree of inundation in minor/moderate storm events

In light of the above, Table 12 details the Bremer River crossing locations selected for survey. These structures have been included in the refined hydraulic model.

Table 12 Surveyed Bremer River crossings

Locality	Structure Type	Key structure dimensions (m)	Deck/Road Level (m AHD)
Rosevale Road South Culvert	Concrete box culvert east of Bridge	3/2.15(w) x 0.9 (h) RCBC	97.52
Rosevale Road South Bridge	Concrete Bridge	32.2 (l) x 8.0 (w)	96.68
Adams Bridge	Concrete Bridge	39.5 (l) x 5.0 (w)	80.91
Stokes Crossing	Concrete box culvert	3/3.0 (w) x 1.5 (h) RCBC	58.43

Note that Adams Bridge is currently being upgraded and under construction. The structure was modelled using information obtained from Design drawings.

6.2.3.3 Bathymetry

Improvements to the hydraulic model bathymetry have been made in the vicinity of each of the surveyed waterway crossings and populated areas. In addition to the actual bridge and culvert structures, survey of the watercourse was undertaken both upstream and downstream at each location. This has enabled an improved representation of the conveyance area at each crossing structure and to improved delineation between in and out of bank flow conditions.

6.2.3.4 Grid resolution

The 1% AEP model was developed using a 20m square grid resolution which was appropriate for the assessment of major flooding during which a large portion of the flood is typically conveyed outside of the watercourse. However, for the 10% to 2% AEP events, a greater portion of catchment discharge flows within the banks of the watercourse. As the upper reaches of Bremer River are less than 10m wide in a number of locations, the model resolution was increased to 10m. By increasing the grid resolution, better definition of watercourse bathymetry is achieved allowing an improved representation of bed and bank levels and overall cross-section conveyance area.

To complement the smaller grid size, a Z-Shape utilising elevations from the DEM traced the major channel to enforce a flow path. This flow path better represents the channel and therefore more accurately represents the flow conditions.

7 Modelling results

7.1 Climate Change

There are several aspects of design flood estimation that are likely to be impacted by climate change. These include:

- Rainfall Intensity-Frequency-Duration (IFD) relationships
- Rainfall temporal patterns
- Continuous rainfall sequences
- Antecedent conditions and baseflow regimes
- Compound extremes (eg riverine flooding combined with storm surge inundation)

Typically, the approach to addressing climate change in flood studies is through consideration of sea-level rise (SLR) and/or increased rainfall intensities. SRRC is located in the upper reaches of the Bremer River drainage basin and therefore is unlikely to be influenced by sea-level rise. The effect of climate change on the Bremer River flood levels was therefore assessed for increased rainfall intensity predictions only.

The latest AR&R (2016) recommendations on climate change consider two Representative Concentration Pathways (RCPs) for greenhouse gas and aerosol concentrations driving climate change for the East Coast Cluster – RCP4.5 & RCP8.5. AR&R (2016) recommends using RCP4.5 as the minimum design basis but notes RCP8.5 should be considered where *'additional expense can be justified on socioeconomic and environmental grounds'*. This guideline recommends an increase in rainfall intensity of 12% for RCP4.5 and 22% for RCP8.5 to the 2090 planning horizon.

Table 13 Predicted increased rainfall intensity (AR&R, 2016)

Representative Concentration Pathway	Temperature increase (°C) at 2090 horizon	Increase in rainfall intensity (%)
4.5	2.25	12
8.5	4.10	22

For the 1% AEP event both Scenarios RCP4.5 and RCP8.5 were assessed and the results are presented on the figures in Appendix A. This includes afflux maps representing the difference in peak flood levels between the climate change and no-climate change scenarios.

SRRC have adopted the 1% AEP event with the RCP4.5 scenario for their Planning Scheme. This event has been used to set levels for development across the region.

For the 10% to 2% AEP events, the climate change investigation is based on RCP 4.5 only.

7.2 Mapping

The TUFLOW model results were analysed and a series of maps (refer Appendix A) were developed to present the results for each modelled return period. Four sets of maps were produced to display:

- Inundation extents with peak water surface levels – these maps present 1 m contours of the peak water surface levels
- Peak depths – these maps present peak depth contours in 0.5 m bands up to a depth of 5 m, with the lower band separated into two bands covering 0 to 0.3 m and 0.3 to 0.5 m
- Peak velocities – these maps present peak velocity contours in 0.5 m bands up to a velocity of 5 m/s
- Hazard maps – Revised guidelines for presentation of flood mapping are now provided in the Australian Emergency Management Handbook Series (2013) produced by Emergency Management Australia (EMA). This handbook and its supporting flood risk management guidelines are intended to replace the SCARM guidelines under which the previous mapping was prepared. The revised guidelines include a revised categorisation for flood hazard which is shown below in Figure 10. The hazard maps have used a simplified version of this classification, where only 3 levels are outlined (Low, Medium and High Hazard). Each of these simplified bands represent 2 bands within the EMA classification

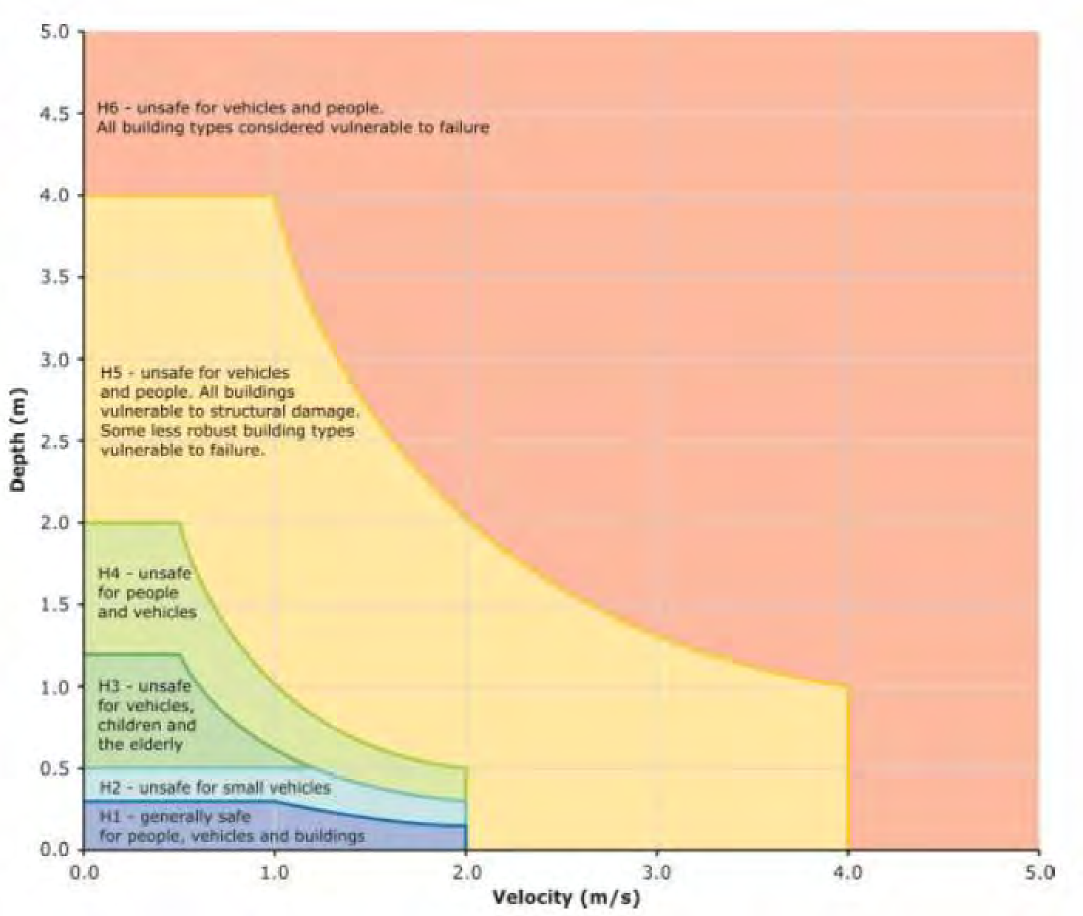

Figure 10 EMA revised flood hazard classification. ***Source: Australian Emergency Management Handbook Series (2013) - Technical flood risk management guideline: Flood hazard***

The flood maps accompanying this report provide a regional overview of the modelling results and are supplemented by GIS data to be supplied to SRRC which can be interrogated to provide further detail. A list of the figures and the full set of maps is presented in Appendix A.

7.3 Property flood levels

Peak water levels at properties affected by each of the design events were determined from the flood modelling results. The results are tabulated by property and will be provided to Council in spreadsheet format.

7.4 Design event discharges

Peak design event discharges are shown below in Table 14. The table shows the increasing in peak discharge both with severity of the event and increasing distance travelled downstream through the catchment.

Table 14 Design event (AEP) peak discharges at key locations

Location	Peak Discharge (m^3/s)		
	10% AEP	5% AEP	2% AEP
Rosevale Road South (Bridge & Culvert)	99	154	207
Adams Bridge	186	266	371
Stokes Crossing	243	344	472

7.5 Road closures

Management of flooding related road closure risk and timing is key to effective emergency planning and response functions. An understanding of the timing and location of road closures will enable emergency services to forewarn residents of impending loss of access prior to the arrival of the flood. Closure of key road crossings have been reviewed for the 10%, 5% and 2% AEP design events. Road closure risk findings are discussed further below.

7.5.1 Design event road closures

Closure of key road crossings has been reviewed for the 10%, 5%, 2% and 1% AEP design events. Figure F has been prepared and presents the estimated flooded width for each AEP for each key crossing within the Bremer River catchment. In addition, peak flood levels for each AEP have been presented for each stream gauge within the catchment. Historical flood levels at the stream gauge are also presented.

This mapping can be used in conjunction with predicted gauge levels that the BoM issue during events to give Council's response team an understanding of the likely crossings that will be inundated and to assist in guiding response measures.

7.6 Gauge rating review

A network of stream alert gauges is owned and operated by various agencies which are used to provide early warning of flooding and for flood forecasting operations by the Bureau of Meteorology (BoM). The stream alert gauges provide classifications for flood severity corresponding to various gauge depths. The descriptors for these classifications as provided by the BoM are as follows:

- **Minor Flooding:** This causes inconvenience such as closing of minor roads and the submergence of low level bridges and makes the removal of pumps located adjacent to the river necessary
- **Moderate Flooding:** This causes the inundation of low lying areas requiring the removal of stock and/or the evacuation of some houses. Main traffic bridges may be closed by flood waters
- **Major Flooding:** This causes inundation of large areas, isolating towns and cities. Major disruptions occur to road and rail links. Evacuation of many houses and business premises may be required. In rural areas, widespread flooding of farmland is likely

It is understood that the gauge flood classification levels may not be reflective of the actual flood severity at some locations. A review the gauge level flood classifications has therefore been undertaken as detailed in the following sections.

7.6.1 Adams Bridge alert gauge

The Adams Bridge stream gauge is located immediately downstream of the Rosevale Road crossing of Bremer River. Adams Bridge is in a rural area surrounded primarily by pasture and grazing land. The current flood classification gauge levels for the Adams Bridge gauge are shown in Table 15.

Table 15 Existing BoM flood classifications – Adams Bridge gauge

Flood height (m)		
Minor	**Moderate**	**Major**
Adams Bridge Alert (Station #540157)		
4.0	5.0	6.0

A review of flood classification levels in light of modelled flooding conditions is provided below in Table 16. The review indicates that the current flood classifications at the Adams Bridge gauge are adequate.

Table 16 Adams Bridge gauge analysis

Water level (m AHD)	Gauge Level (m)	Flood condition description	Flood classification
79.06	**4.0**	▪ Peak flood waters overtop the banks of the Bremer River main channel upstream of the gauge ▪ Minor roads/tracks in the surrounding area are starting to overtop ▪ Rosevale Road is overtopped at Gauge Level **0.75m** ▪ The pasture land upstream of the gauge is partially flooded directly adjacent to the river	Minor
80.06	**5.0**	▪ As per the figure below, access is cut to Properties B ▪ A number of properties at Properties B have become inundated ▪ The inundation of the pasture land upstream of the gauge is more extensive	Moderate
90.06	**6.0**	▪ Widespread inundation of the pasture land upstream of the gauge ▪ Widespread inundation of the pasture land downstream of the gauge ▪ As per the figure below, access is cut to Properties A ▪ Additional properties at Properties B have become inundated	Major

The following figure outlines the area around the Adams Bridge Gauge.

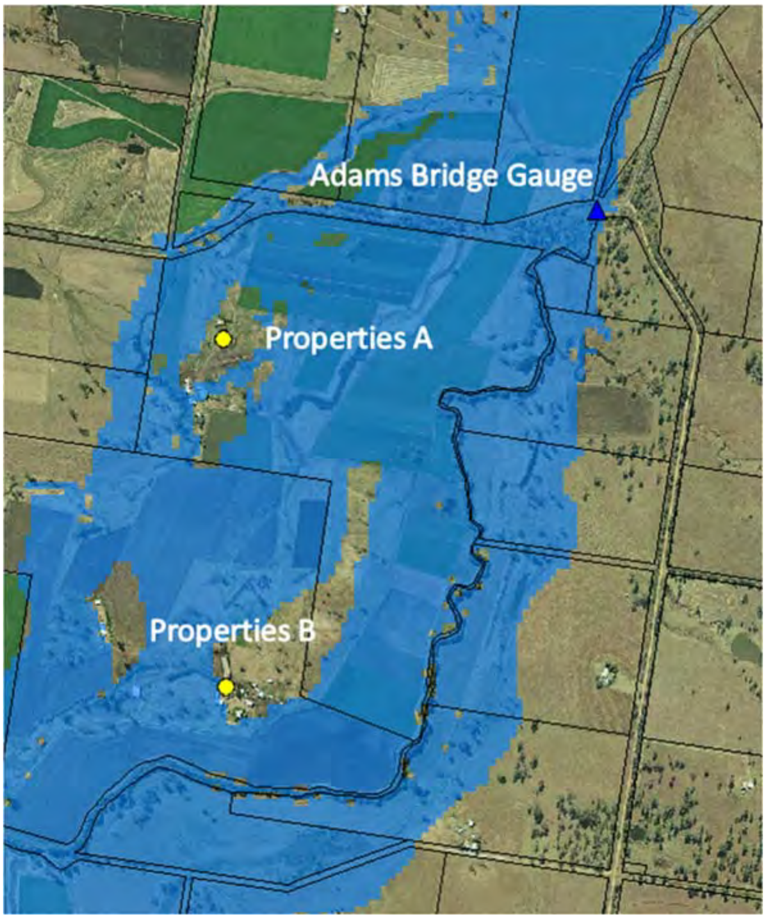

Figure 11 Adams Bridge Gauge Location

7.6.2 Stokes Crossing alert gauge

The Stokes Crossing stream gauge is located immediately downstream of the Stokes Crossing-Mt Mort Road crossing of Bremer River. Stokes Crossing is a rural area surrounded primarily by pasture and grazing land. The current flood classification gauge levels for the Stokes Crossing gauge are shown in Table 17.

Table 17 Existing BoM flood classifications – Stokes Crossing gauge

Flood height (m)		
Minor	**Moderate**	**Major**
Stokes Crossing (Station #040702)		
4.0	5.0	6.0

A review of flood classification levels in light of modelled flooding conditions is provided below in Table 18. The review indicates that the current flood classifications at Stokes Crossing are overstated with respect to their respective gauge levels.

Table 18 Stokes Crossing gauge analysis

Water level (m AHD)	Gauge Level (m)	Flood condition description	Suggested flood classification
60.67	**4.0**	■ At the upper limit of this range, peak flood waters overtop the banks of the Bremer River main channel around the gauge. ■ Stokes Crossing-Mt Mord Road is overtopped and access is lost. First overtopping occurs at Gauge Level **1.0m**.	Minor
61.15	**4.5**	■ There are large areas of pasture land inundated both north and south of the gauge. ■ Stokes Crossing-Mt Mord Road becomes further inundated. ■ No inundation of dwellings or habitable buildings.	Moderate
61.38	**4.7**	■ Widespread inundation of the pasture land to both the north and south of the gauge. ■ Stokes Crossing-Mt Mord Road becomes further inundated. ■ No inundation of dwellings or habitable buildings.	Major

7.6.3 Opportunities for additional alert gauges

Due to the relatively rural nature of the Bremer River catchment, low population and low risk of the access being lost along the major arterial connection, no specific additional alert gauging locations are recommended.

8 Conclusions

Scenic Rim Regional Council (SRRC) has undertaken work to gain a better understanding of the region's Natural Hazard (Flood) characteristics for a range of events from relatively frequent (10% AEP) to rare (1% AEP). This flood study has been undertaken for the Bremer River catchment within Council's boundaries to provide Council with detailed flood information across the catchment.

Hydrologic modelling has been carried out using an established URBS model. Hydraulic modelling of the main floodplain areas has been carried out through the development of a 2D TUFLOW hydraulic model. Refinement of modelling parameters was carried out through a joint calibration of the hydrologic and hydraulic models. Calibration of the models was undertaken against stream gauge records for historical flood events.

Design event modelling for the 1%, 2%, 5% and 10% AEP events was undertaken. Mapping of the modelling results has been prepared and includes flood inundation extents, peak water levels, depths, velocities and hazard zoning in accordance with current guidelines.

Two climate change scenarios were assessed for the 1% AEP flood event to the 2090 planning horizon. Allowances for climate change considered 12% and 22% increases in rainfall intensities as recommended in AR&R (2016).

The RCP 4.5 climate change scenario was assessed for the additional flood events to the 2090 planning horizon. Allowances for climate change for the 10%, 5% and 2% AEP events considered 12% increases in rainfall intensities as recommended in AR&R (2016).

For planning purposes, a tabulation of peak water levels for each design event at properties within the catchment has been prepared. This information and the GIS mapping will be provided in digital format to Council.

9 Assumptions, limitations and recommendations

The following limitations relate to this study:

- Calibration
  - The calibration and verification exercise was undertaken for four events. Although the calibration was successful there were limitations due to the accuracy of the available information.
  - The hydrologic model assumes existing development conditions
  - The available calibration events for the hydraulic model was limited due to limited historic level data within the study area
- 1% AEP event
  - The hydraulic structures modelled in the 1% event are limited to the detail available at the time of analysis
  - The hydraulic modelling for the 1% AEP event adopted a 20 m grid hydraulic model. This model resolution may not be representative of features such as small local drainage channels.
- 2%, 5% and 10% AEP events
  - The hydraulic structures modelled are limited to the detail provided except where survey has been undertaken at agreed locations
  - The hydraulic modelling presented for these events adopted a 10 m grid hydraulic model. This model resolution may not be representative of features such as small local drainage channels.
- General
  - Hydraulic models are influenced by the boundary conditions. Areas of flooding in proximity of the downstream boundary condition should be investigated with caution. Note that the downstream boundary is outside of the Scenic Rim Regional Council boundary.
  - Information presented in this report is indicative only and may vary, depending upon the level of catchment and floodplain development. Filling of land or excavation and levelling may alter the ground levels locally at any time, whilst errors may occur from place to place in local ground elevation data from which the model has been developed.

10 References

Aurecon 2014, Bremer River Flood Study – Final Report

BMT WBM, 2010, TUFLOW User Manual

Bureau of Meteorology, 2013, Intensity-Frequency-Duration data

Carroll, DG, 2009, URBS Manual – A Rainfall Runoff Routing Model for Flood Forecasting and Design

CSIRO, 2000, Floodplain Management in Australia: Best Practice Principles and Guidelines, SCARM Report

Emergency Management Australia, 2013, Managing the floodplain: a guide to best practice in flood risk management in Australia – Handbook 7

Institution of Engineers Australia, 1998, Australian Rainfall & Runoff: A guide to Flood Estimation

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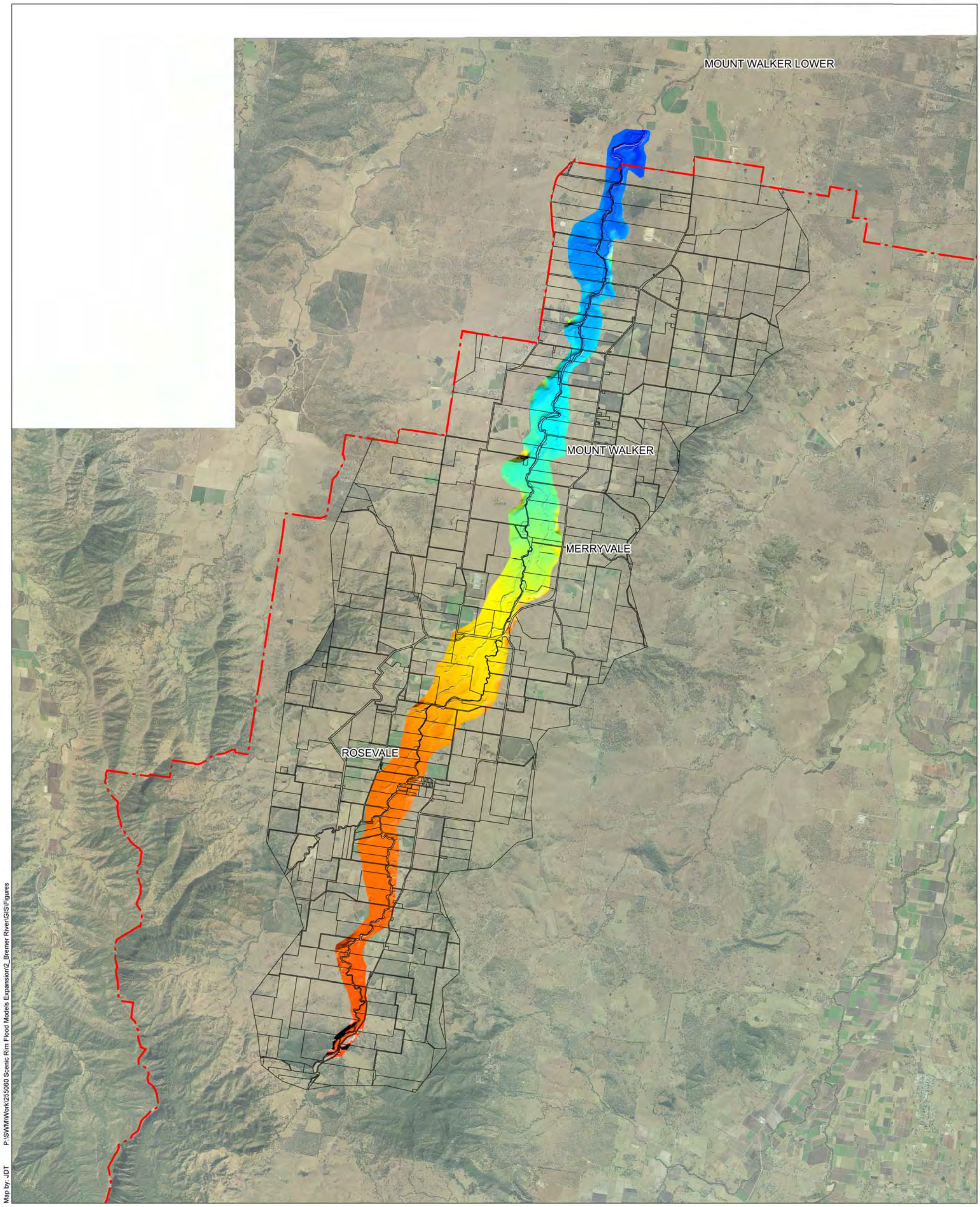
Queensland Government, 2015, Building Act 1975

Appendices

Appendix A
Figures

Figure	Description
Figure A-1	Topography
Figure A-2	Roughness Values
Figure A-7	2013 IFD Difference Map
Figure B1	1% AEP Event – Inundation Extent Map
Figure B2-a	1% AEP Event – 4.5 Climate Change Scenario – Afflux Map
Figure B2-b	1% AEP Event – 8.5 Climate Change Scenario – Afflux Map
Figure B3-a	1% AEP Event – Inundation Extent Map with 4.5 Climate Change Scenario
Figure B3-b	1% AEP Event – Inundation Extent Map with 8.5 Climate Change Scenario
Figure B4	1% AEP Event – 4.5 Climate Change Scenario – Inundation Extent Map
Figure B5	1% AEP Event – 4.5 Climate Change Scenario – Peak Velocities Map
Figure B6	1% AEP Event – 4.5 Climate Change Scenario – Peak Depth Map
Figure B7	1% AEP Event – 4.5 Climate Change Scenario – Peak Hazard Map
Figure C1	2% AEP Event – Inundation Extent Map
Figure C2	2% AEP Event – Peak Velocities Map
Figure C3	2% AEP Event – Peak Depth Map
Figure C4	2% AEP Event – Hazard Map
Figure C5-a	2% AEP Event – Inundation Extent Map with 4.5 Climate Change Scenario
Figure C5-b	2% AEP Event – 4.5 Climate Change Scenario – Afflux Map
Figure D1	5% AEP Event – Inundation Extent Map
Figure D2	5% AEP Event – Peak Velocities Map
Figure D3	5% AEP Event – Peak Depth Map
Figure D4	5% AEP Event – Hazard Map
Figure D5-a	5% AEP Event – Inundation Extent Map with 4.5 Climate Change Scenario
Figure D5-b	5% AEP Event – 4.5 Climate Change Scenario – Afflux Map
Figure E1	10% AEP Event – Inundation Extent Map
Figure E2	10% AEP Event – Peak Velocities Map
Figure E3	10% AEP Event – Peak Depth Map
Figure E4	10% AEP Event – Hazard Map
Figure E5-a	10% AEP Event – Inundation Extent Map with 4.5 Climate Change Scenario
Figure E5-b	10% AEP Event – 4.5 Climate Change Scenario – Afflux Map



Legend

SRRC Boundary

Cadastral Boundaries

Notes:

A3 scale 1:100,000

0 2,500 m 5,000 m

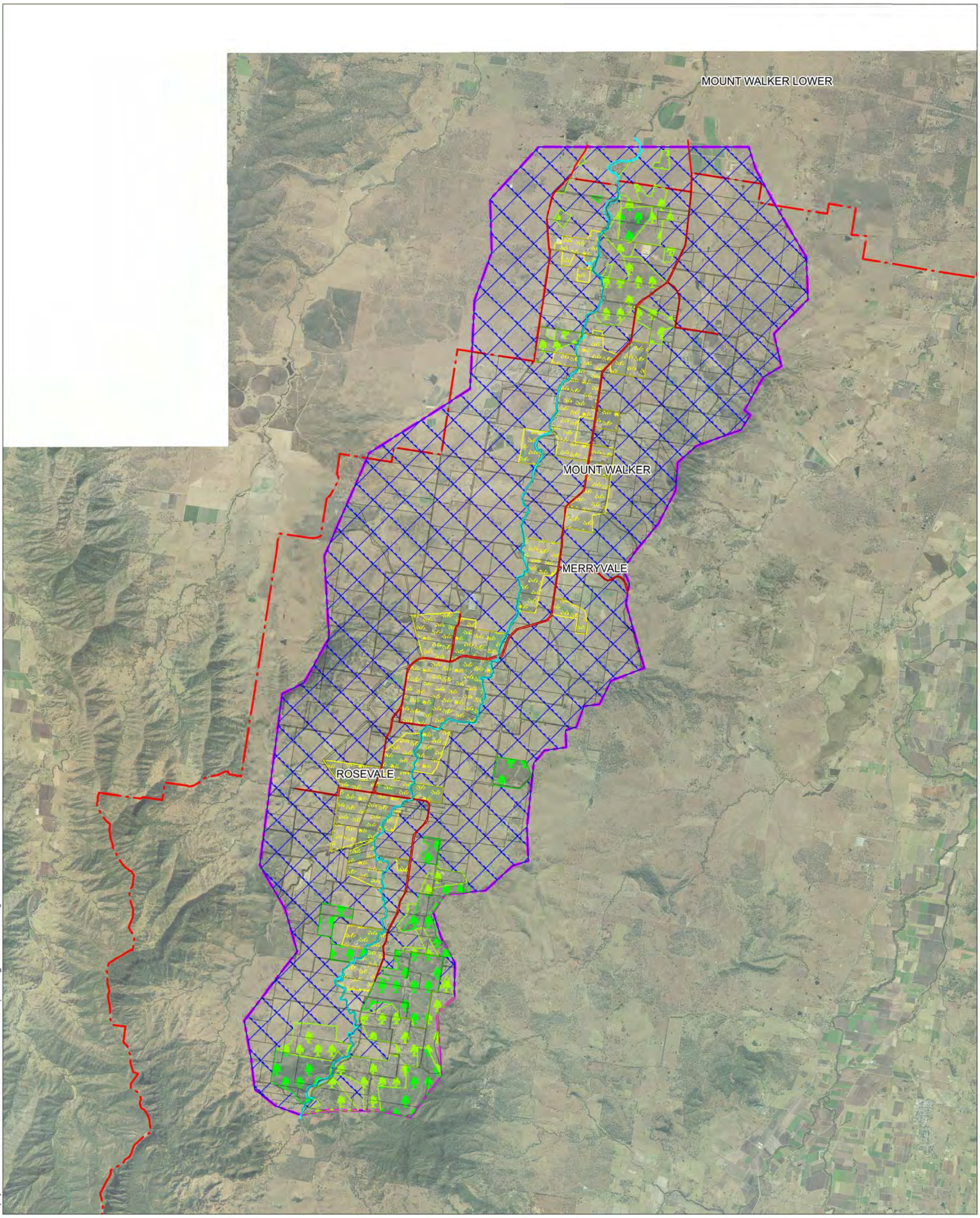
Date: 23/06/2017 Version: 2 Job No: 242281

Projection: MGA Zone 56

Bremer River Flood Study **Figure A-1**

Topography

aurecon



Legend

- River
- Crop Fields
- Roads
- Dense Vegetation
- Medium Vegetation
- Open Space
- SRRC Boundary
- Model Extent
- Cadastral Boundary

Notes:

A3 scale 1:100,000

0 2,500 m 5,000 m

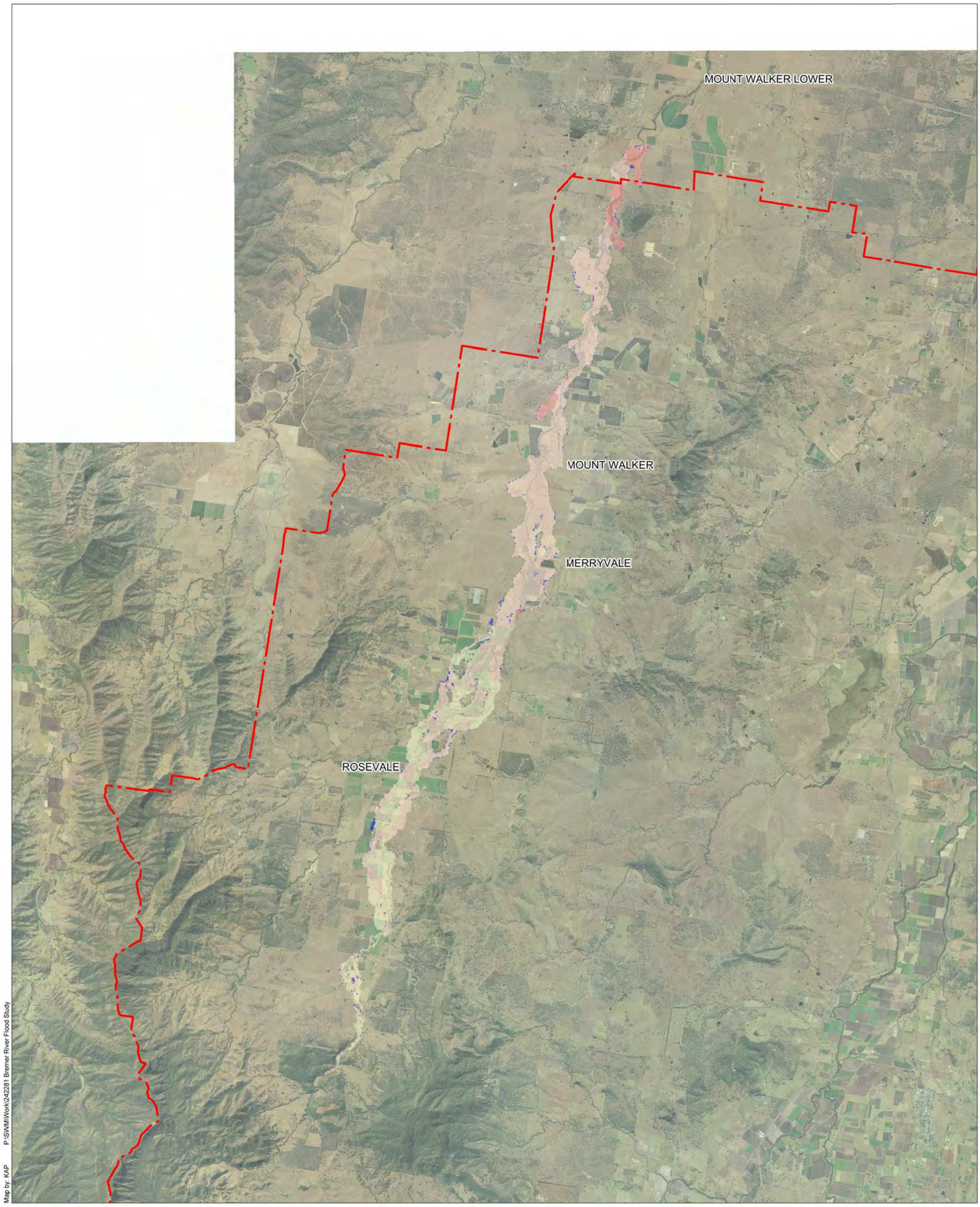
Date: 23/06/2017 Version: 2 Job No: 242281

Projection: MGA Zone 56

Bremer River Flood Study Figure A-2

Roughness Values

aurecon



Legend

SRRC Boundary

Afflux (m)

- < -0.40
- -0.40 to -0.30
- -0.30 to -0.20
- -0.20 to -0.10
- -0.10 to -0.03
- -0.03 to 0.03
- 0.03 to 0.10
- 0.10 to 0.20
- 0.20 to 0.30
- 0.30 to 0.40
- > 0.40
- Was Dry Now Wet
- Was Wet Now Dry

Notes:

A3 scale 1:100,000

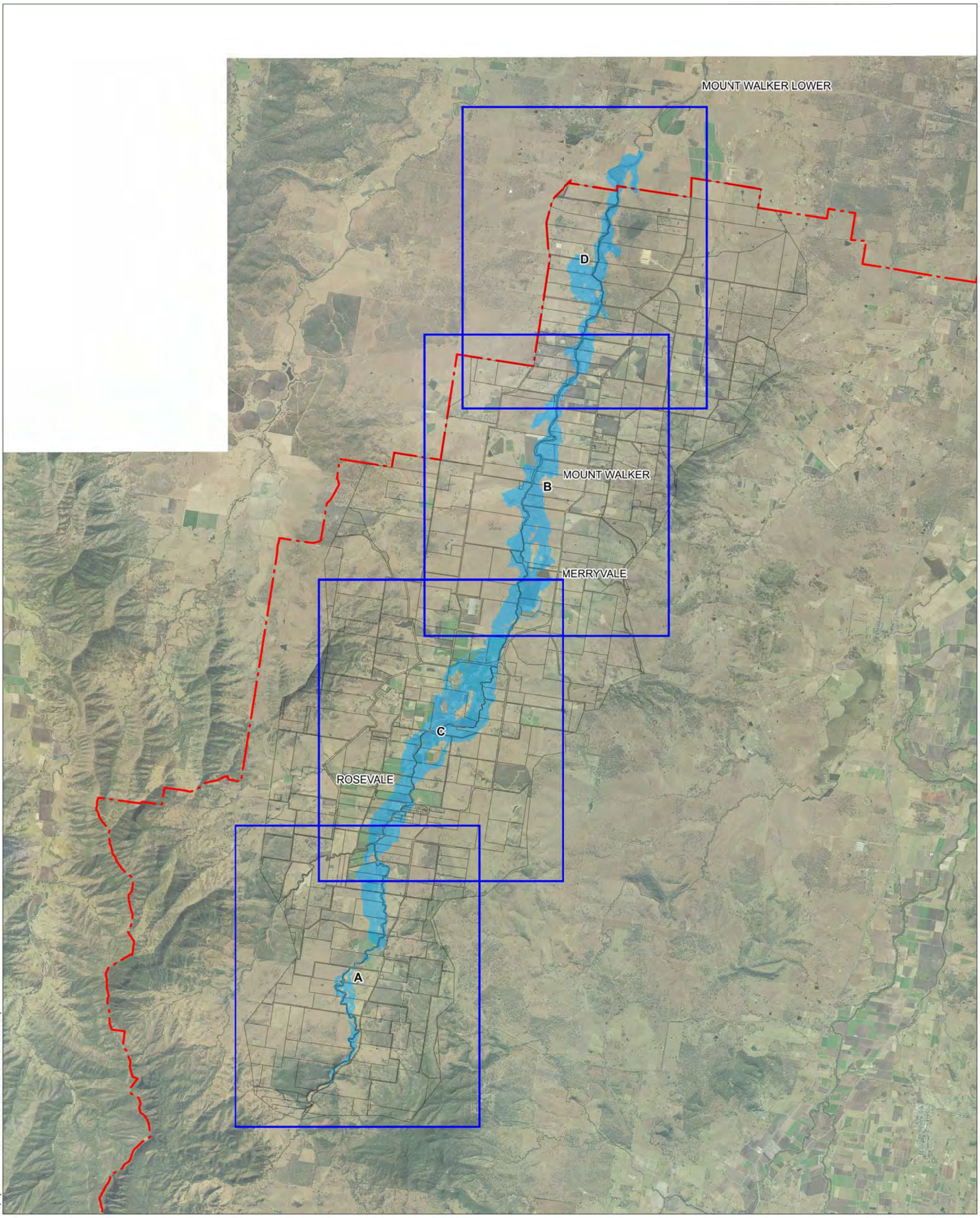
0 2,500 m 5,000 m

Date: 24/10/2014 Version: 2 Job No: 242281

Projection: MGA Zone 56

Bremer River Flood Study Figure A-7

2013 IFD Difference Map



Legend

SRRC Boundary
Cadastral Boundary
Peak Water Level Contour [m AHD]
Inundation Extents

Notes:

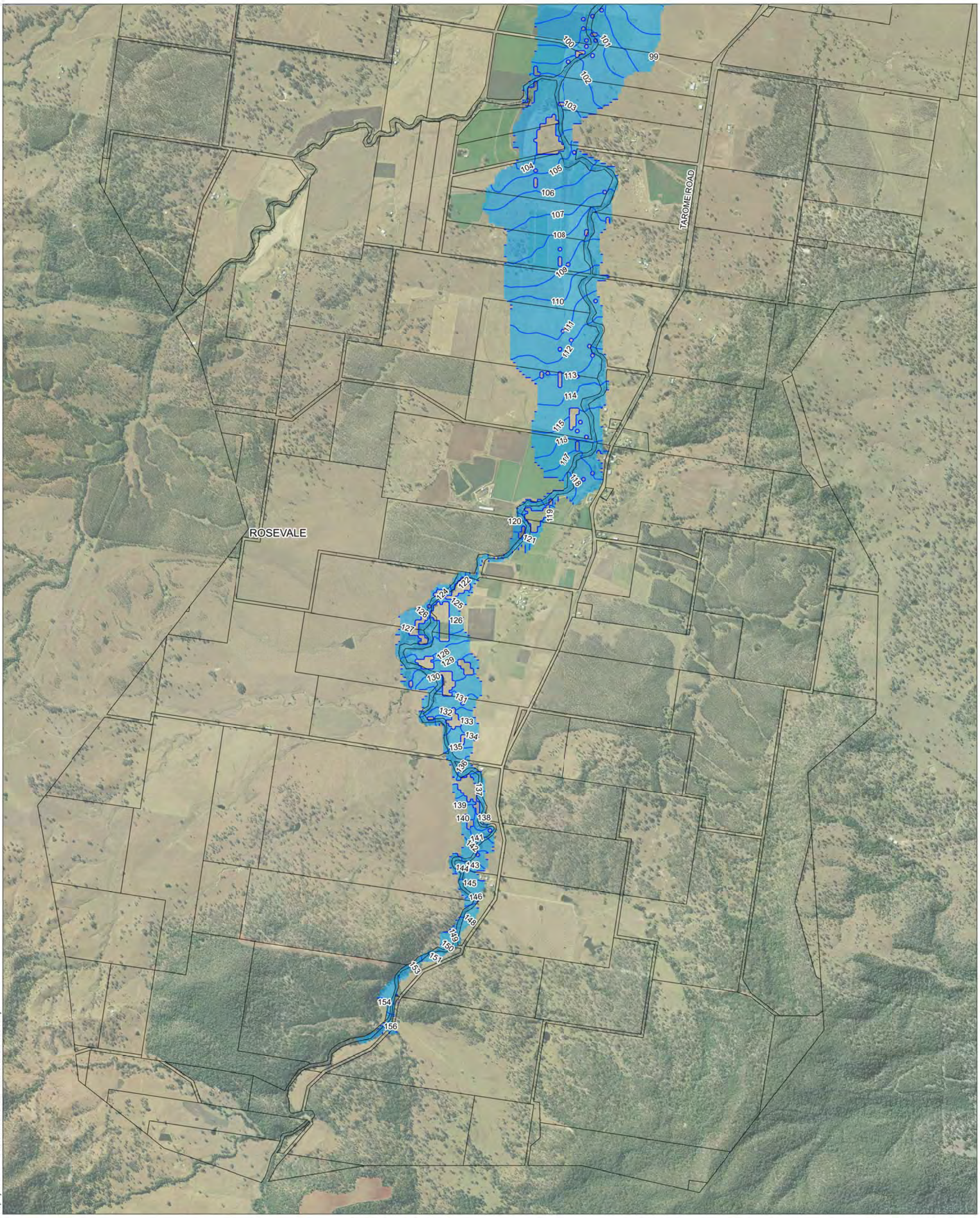
A3 scale 1:100,000
0 2,500 m 5,000 m

Date: 24/10/2014 Version: 2 Job No: 242281
Projection: MGA Zone 56

Bremer River Flood Study Figure B1

1% AEP Event - Inundation Extent & Peak Water Levels

aurecon



Map by: KAP P:\SWM\Work\242281 Bremer River Flood Study

Legend

SRRC Boundary

Cadastral Boundary

Inundation Extents

Peak Water Level Contour [m AHD]

Notes:

A3 scale 1:25,000

0 625 m 1,250 m

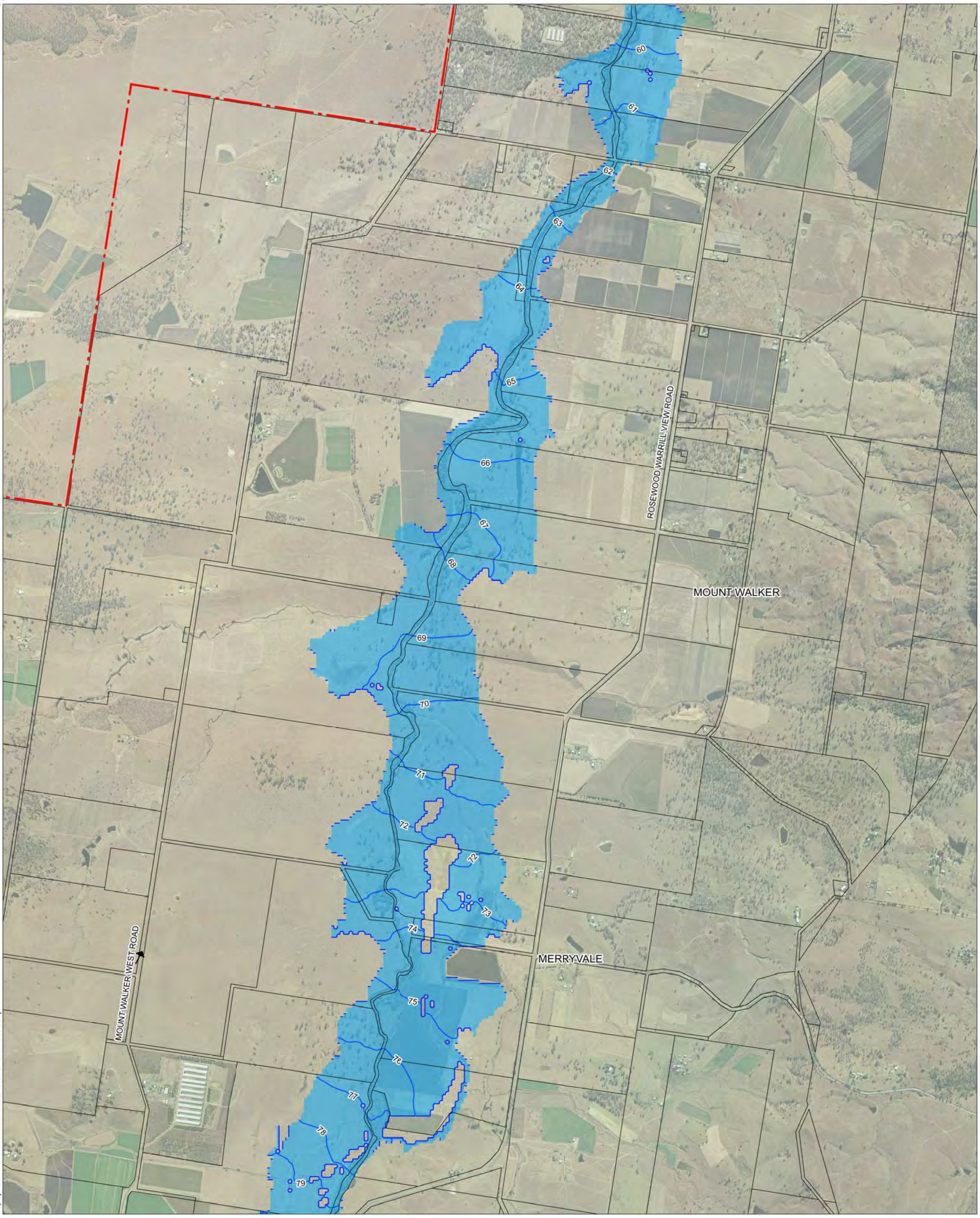
Date: 24/10/2014 Version: 2 Job No: 242281

Projection: MGA Zone 56

Bremer River Flood Study Figure B1-a

1% AEP Event - Inundation Extent & Peak Water Levels

aurecon



Map by: KAP P:\SWM\Work\242281 Bremer River Flood Study

Legend

- SRRC Boundary
- Inundation Extents
- Cadastral Boundary
- Peak Water Level Contour [m AHD]

Notes:

A3 scale 1:25,000

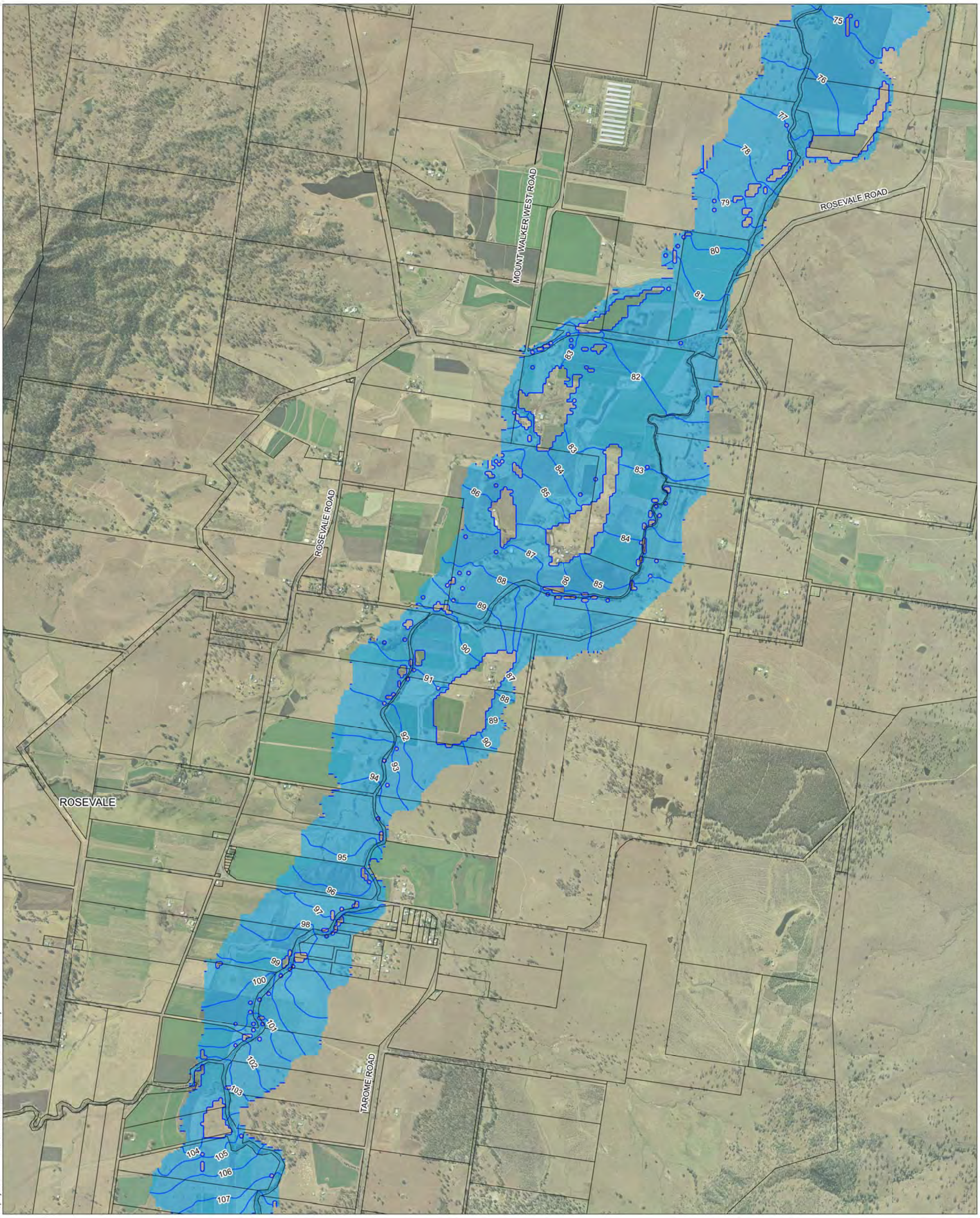
0 625 m 1,250 m

Date: 24/10/2014 Version: 2 Job No: 242281

Projection: MGA Zone 56

Bremer River Flood Study Figure B1-b

1% AEP Event - Inundation Extent & Peak Water Levels



Legend

SRRC Boundary	Cadastral Boundary
Inundation Extents	Peak Water Level Contour [m AHD]

Notes:

A3 scale 1:25,000

0 625 m 1,250 m

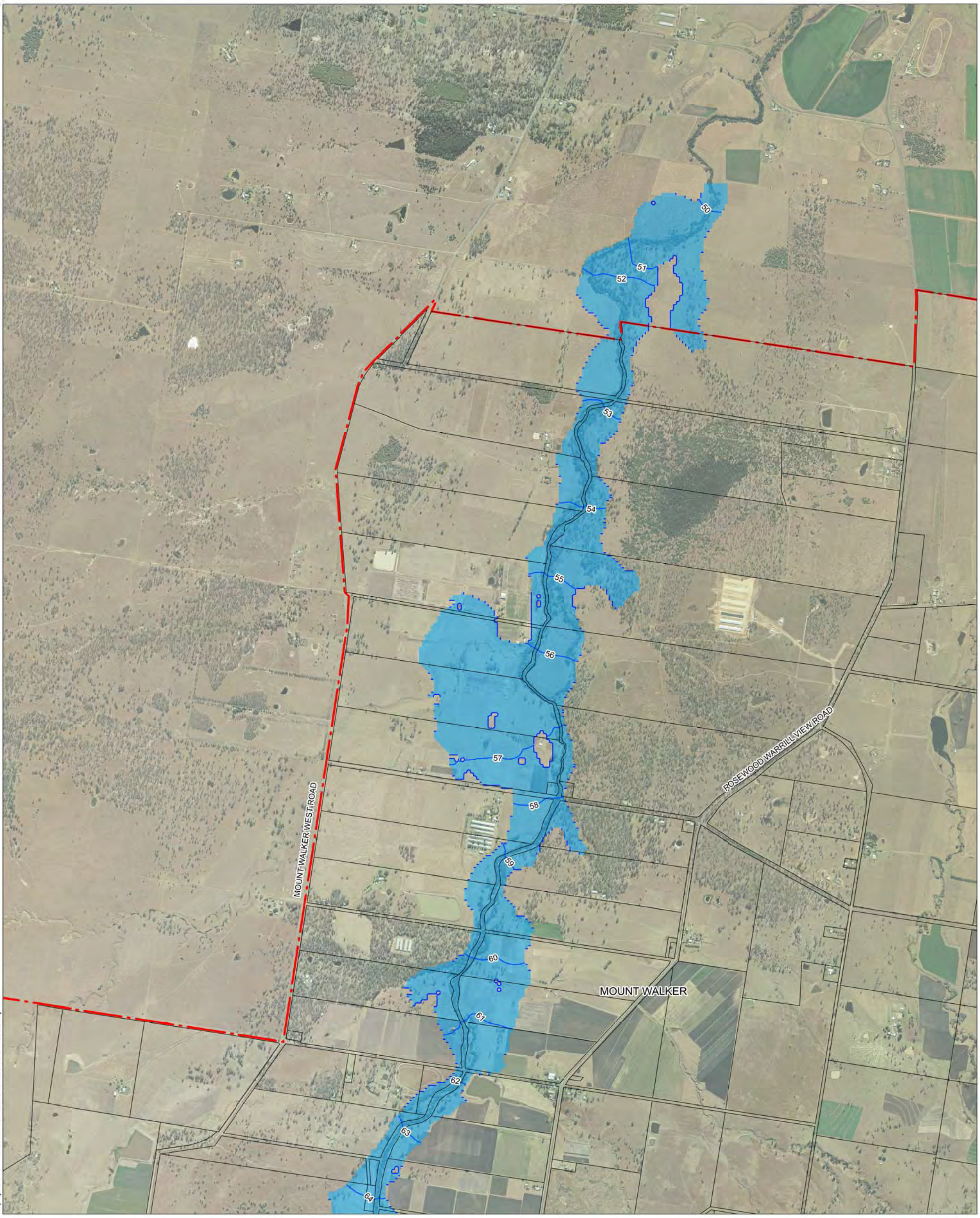
Date: 24/10/2014 Version: 2 Job No: 242281

Projection: MGA Zone 56

Bremer River Flood Study **Figure B1-c**

1% AEP Event - Inundation Extent & Peak Water Levels

aurecon



Map by: KAP P:\SWM\Work\242281 Bremer River Flood Study

Legend

- SRRC Boundary
- Inundation Extents
- Cadastral Boundary
- Peak Water Level Contours [m AHD]

Notes:

A3 scale 1:25,000

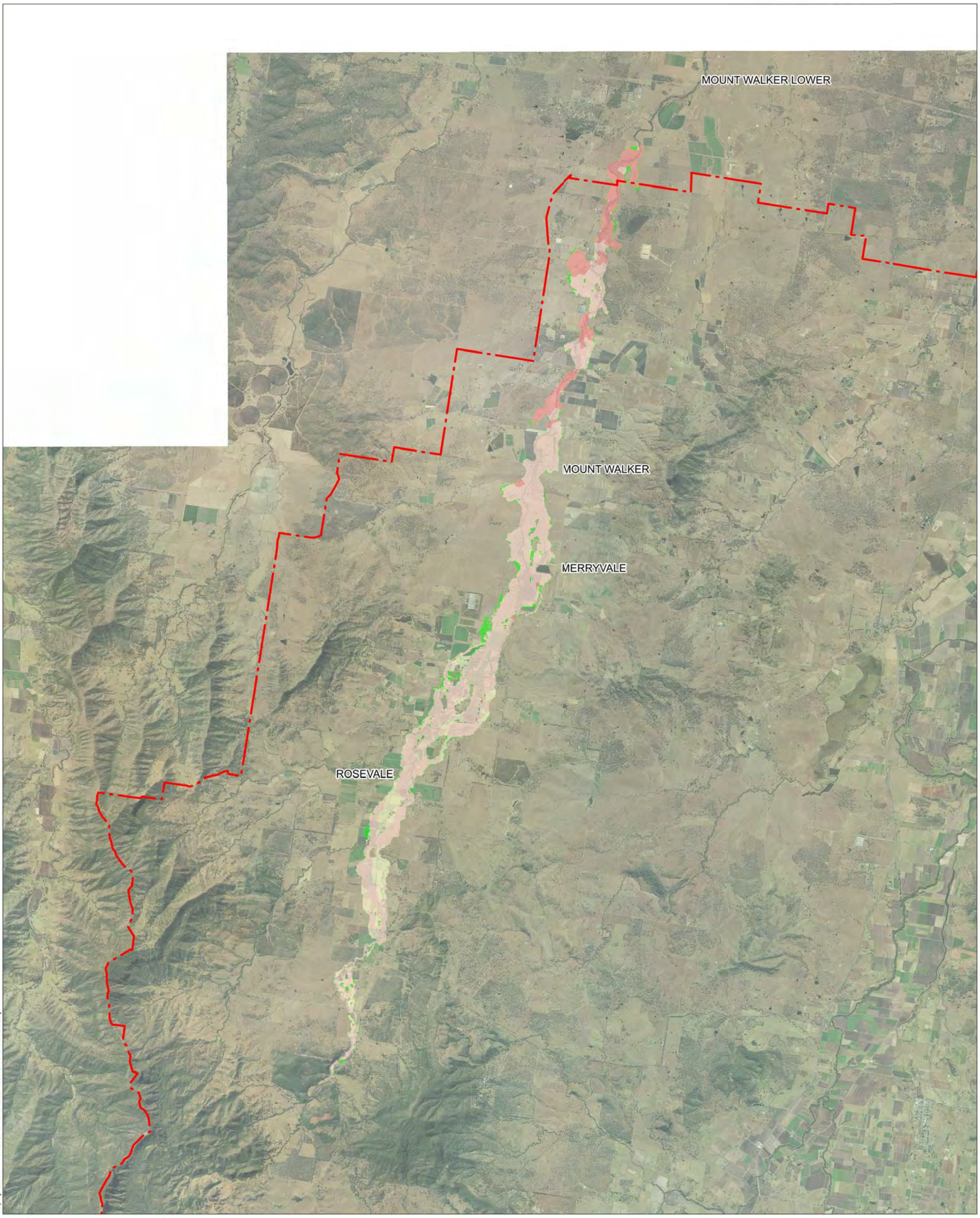
0 625 m 1,250 m

Date: 24/10/2014 Version: 2 Job No: 242281

Projection: MGA Zone 56

Bremer River Flood Study Figure B1-d

1% AEP Event - Inundation Extent & Peak Water Levels



Legend

SRRC Boundary

Afflux (m)
- < -0.80
- -0.80 to -0.60
- -0.60 to -0.40
- -0.40 to -0.20
- -0.20 to -0.03
- -0.03 to 0.03
- 0.03 to 0.20
- 0.20 to 0.40
- 0.40 to 0.60
- 0.60 to 0.80
- > 0.80
- Was Dry Now Wet
- Was Wet Now Dry

Notes:

A3 scale 1:100,000

0 2,500 m 5,000 m

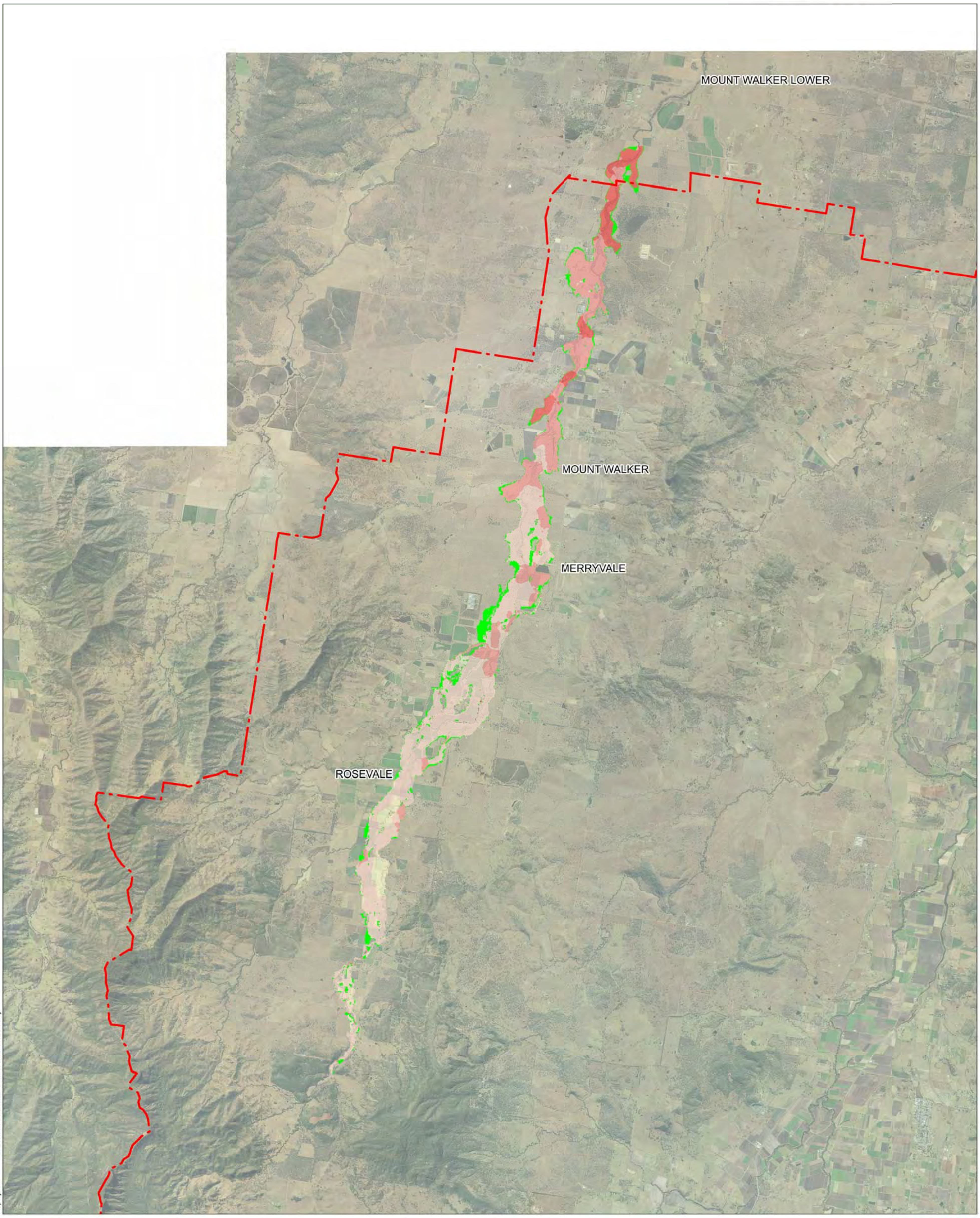
Date: 07/04/2016 Version: 2 Job No: 242281

Projection: MGA Zone 56

Bremer River Flood Study Figure B2-a

Climate Change Scenario 4.5 - 1% Afflux Map

aurecon



Legend

Afflux (m)

- < -0.80
- -0.80 to -0.60
- -0.60 to -0.40
- -0.40 to -0.20
- -0.20 to -0.03
- -0.03 to 0.03
- 0.03 to 0.20
- 0.20 to 0.40
- 0.40 to 0.60
- 0.60 to 0.80
- > 0.80
- Was Dry Now Wet
- Was Wet Now Dry

Notes:

A3 scale 1:100,000

0 2,500 m 5,000 m

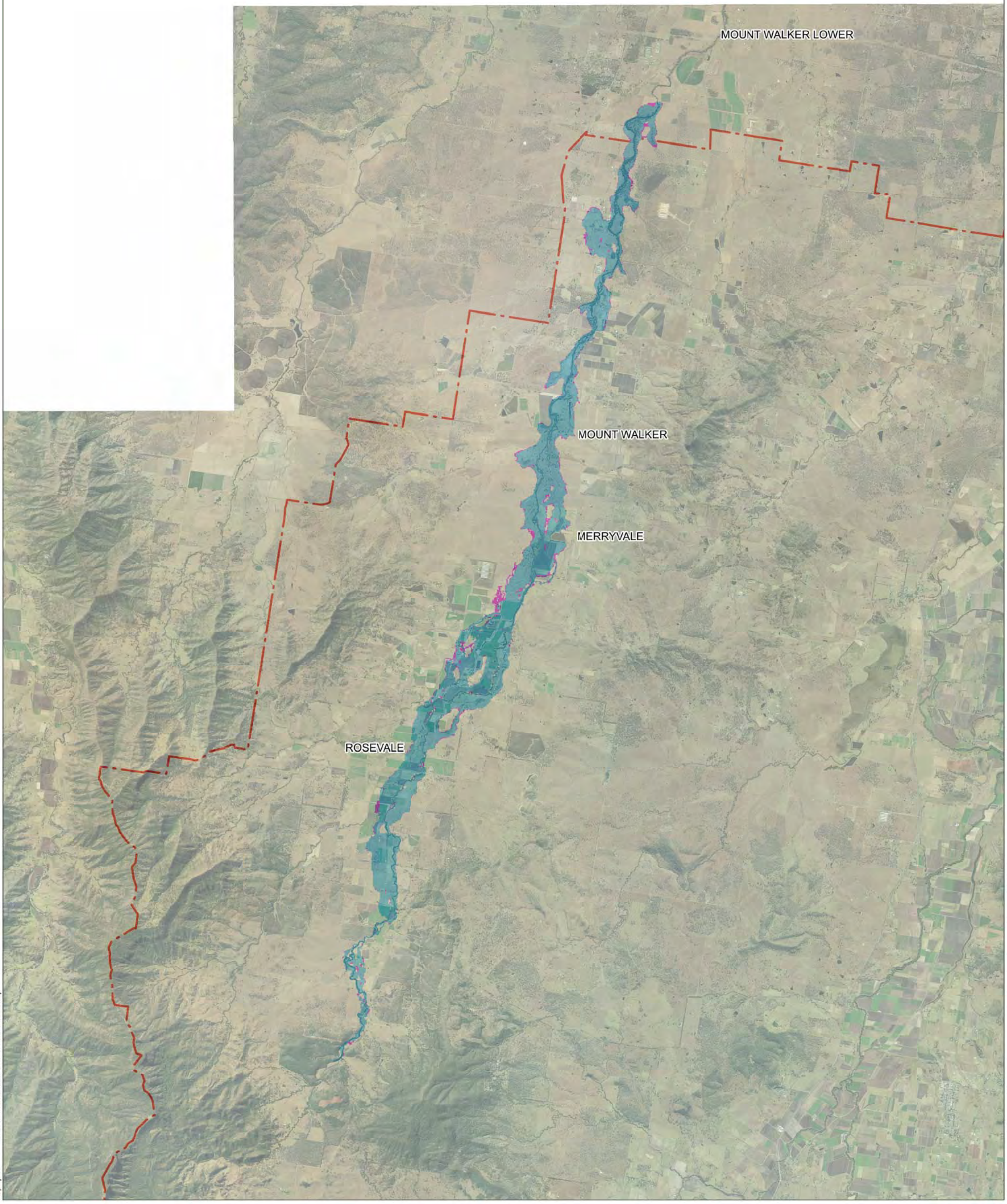
Date: 07/04/2016 Version: 2 Job No: 242281

Projection: MGA Zone 56

Bremer River Flood Study Figure B2-b

Climate Change Scenario 8.5 - 1% Afflux Map

aurecon



P:\SWM\Work\242281 Bremer River Flood Study

Map by: JD

Legend

SRRC Boundary

Climate Change Scenario 4.5

Existing Scenario

Notes:

A3 scale 1:100,000

0 2,500 m 5,000 m

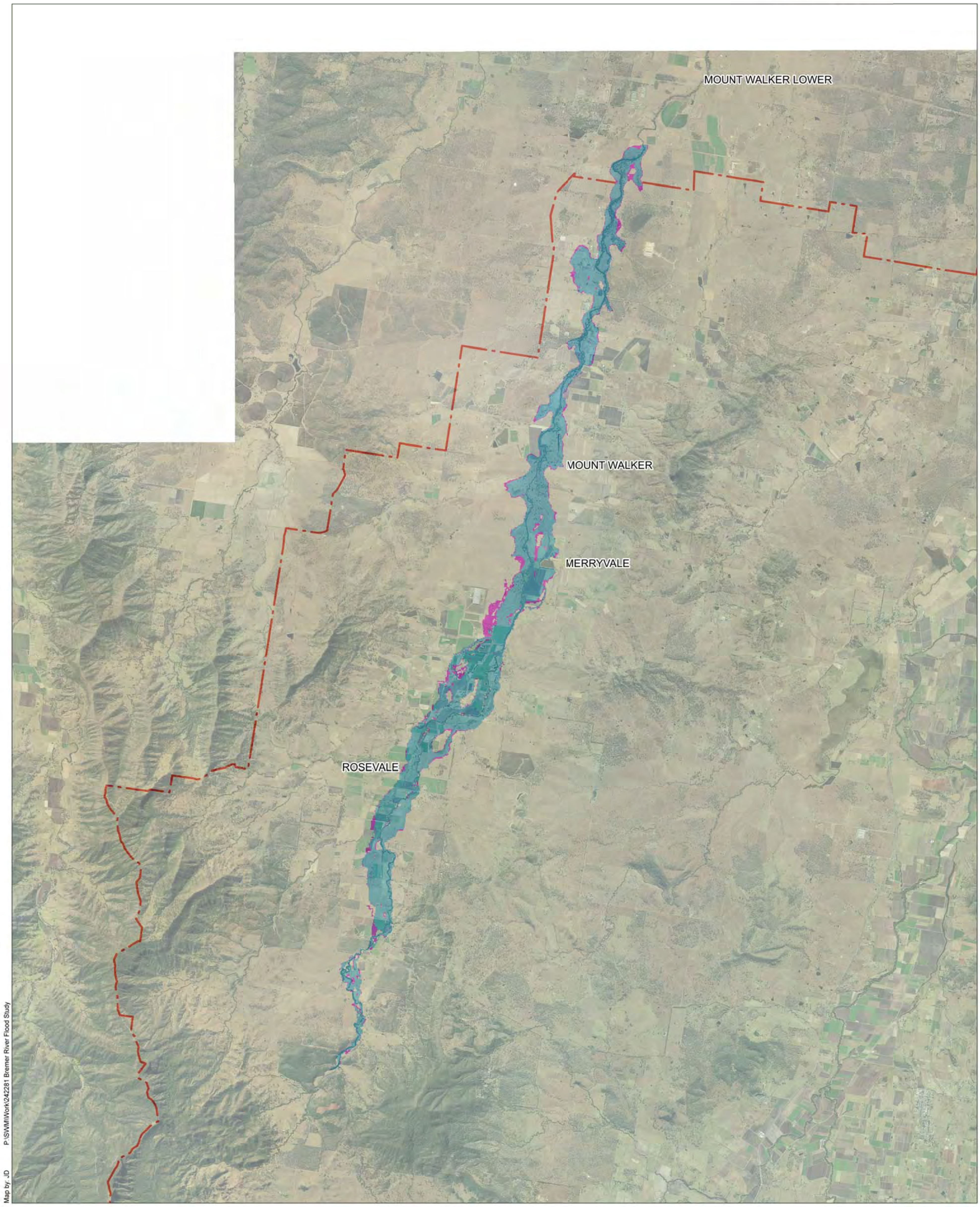
Date: 07/04/2016 Version: 2 Job No: 242281

Projection: MGA Zone 56

Bremer River Flood Study **Figure B3-a**

Climate Change Scenario 4.5 - 1% Inundation Extent

aurecon



Legend

- SRRC Boundary
- Climate Change Scenario 8.5
- Existing Scenario

Notes:

A3 scale 1:100,000

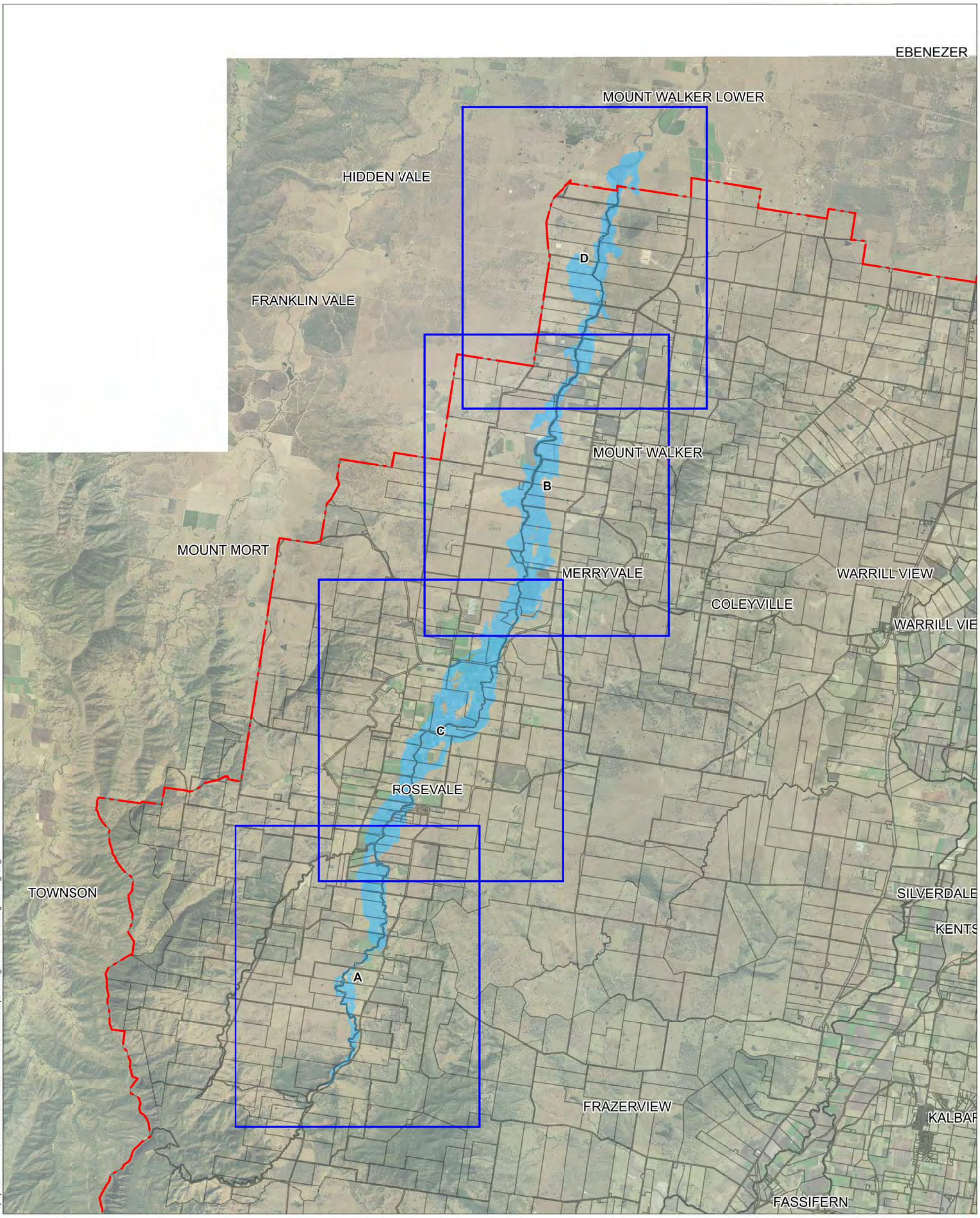
0 2,500 m 5,000 m

Date: 07/04/2016 Version: 2 Job No: 242281

Projection: MGA Zone 56

Bremer River Flood Study **Figure B3-b**

Climate Change Scenario 8.5 - 1% Inundation Extent



Legend

SRRC Boundary

Cadastral Boundary

Inundation Extent

Peak Water level Contour (mAHD)

Notes:

1:100,000

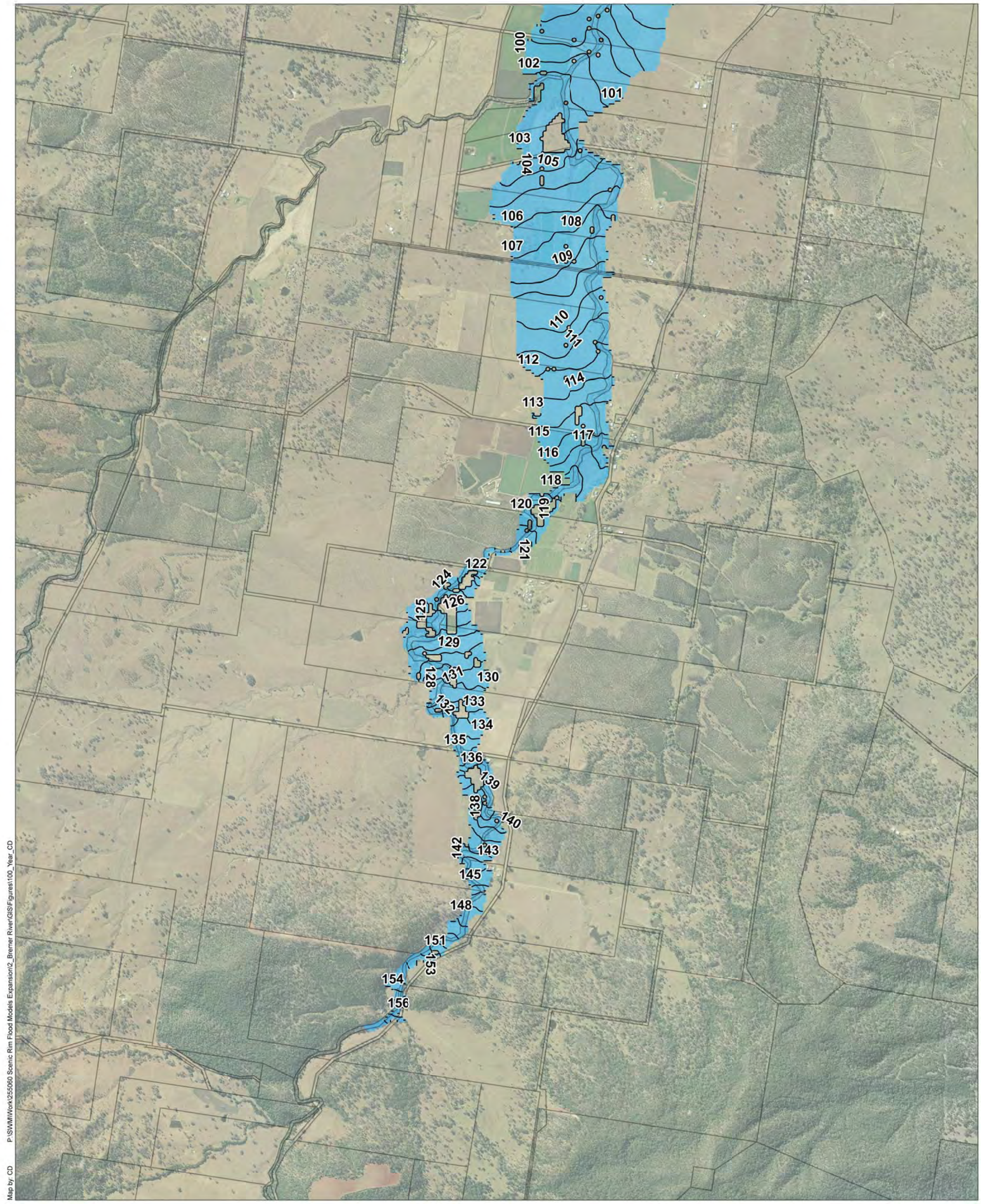
0 2,500 m 5,000 m

Date:01/08/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure B4**

1% AEP Event Climate Change Scenario 4.5 - Inundation Extent



Legend

SRRC Boundary

Cadastral Boundary

Inundation Extent

Peak Water level Contour (mAHD)

Notes:

1:25,000

0 625 m 1,250 m

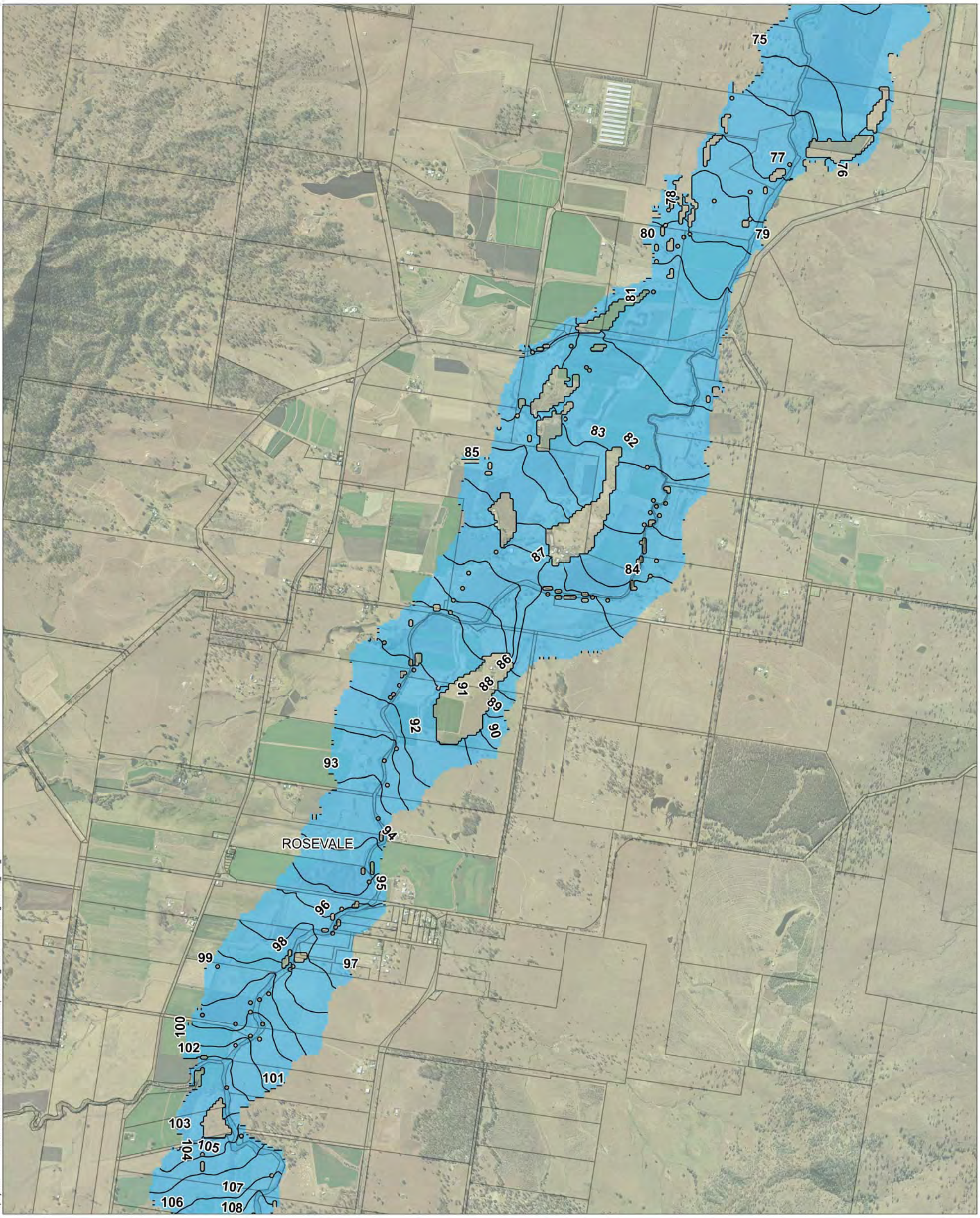
Date:01/08/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure B4-a**

1% AEP Event Climate Change Scenario 4.5 - Inundation Extent

aurecon



Legend

SRRC Boundary

Cadastral Boundary

Inundation Extent

Peak Water level Contour (mAHD)

Notes:

1:25,000

0 625 m 1,250 m

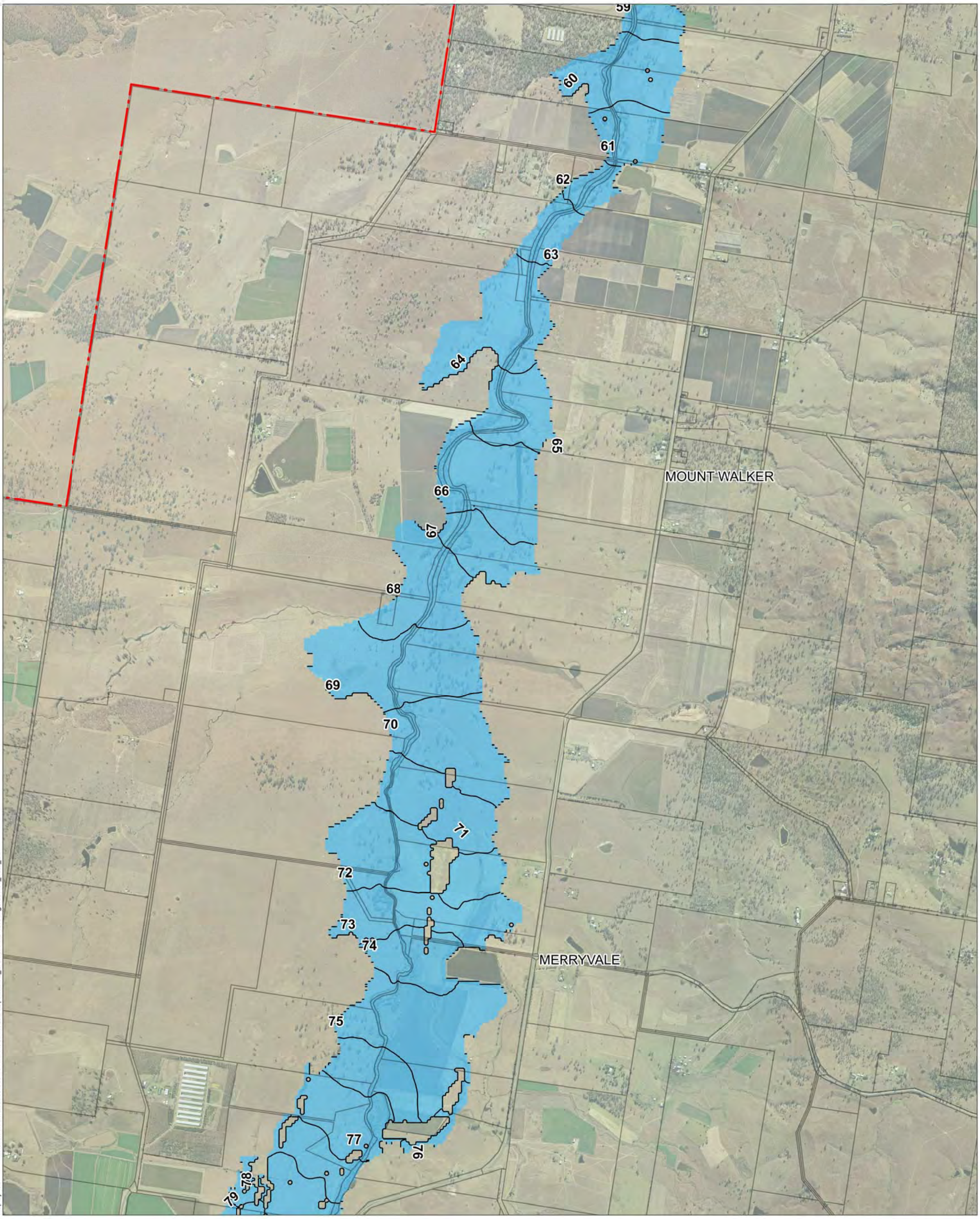
Date:01/08/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure B4-b**

1% AEP Event Climate Change Scenario 4.5 - Inundation Extent

aurecon



Legend

SRRC Boundary

Cadastral Boundary

Inundation Extent

Peak Water level Contour (mAHD)

Notes:

1:25,000

0 625 m 1,250 m

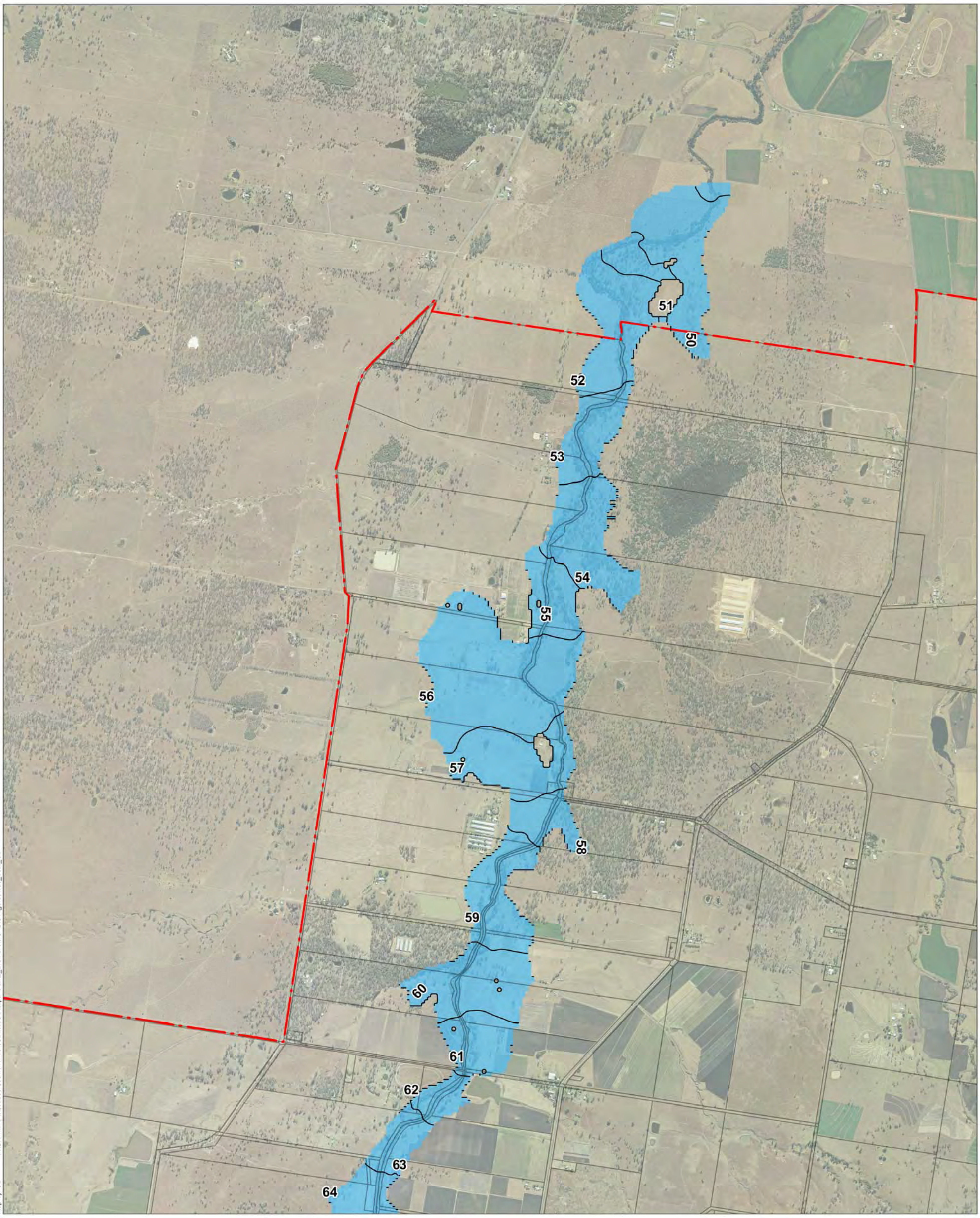
Date: 01/08/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure B4-c**

1% AEP Event Climate Change Scenario 4.5 - Inundation Extent

aurecon



Map by: CD P:\SWM\Work\255060 Scenic Rim Flood Models Expansion\2_Bremer River\GIS\Figures\100_Year_CD

Legend

SRRC Boundary

Cadastral Boundary

Inundation Extent

Peak Water level Contour (mAHD)

Notes:

1:25,000

0 625 m 1,250 m

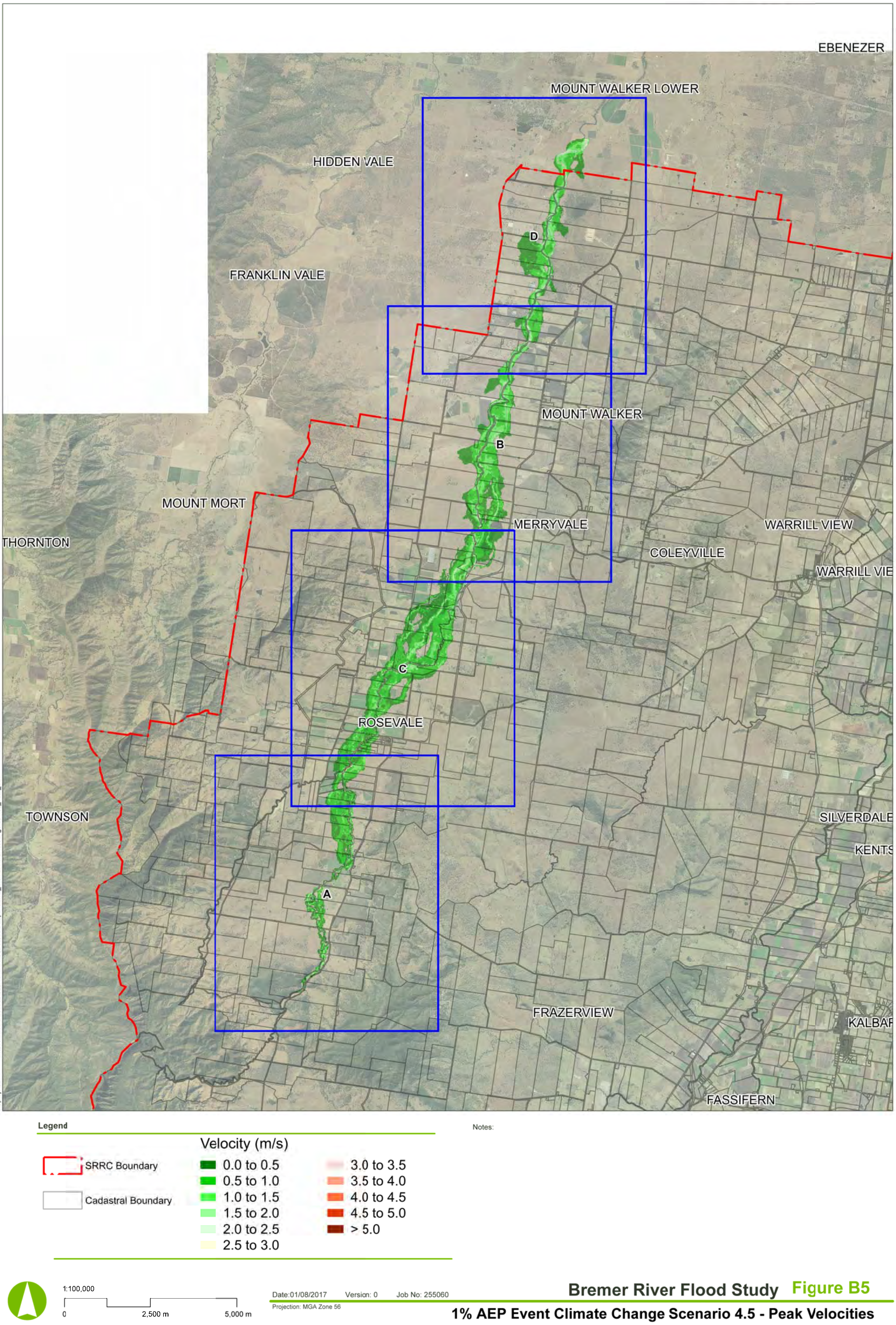
Date:01/08/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure B4-d**

1% AEP Event Climate Change Scenario 4.5 - Inundation Extent

aurecon



Map by: CD P:\SWM\Work\255060 Scenic Rim Flood Models Expansion\2_Bremer River\GIS\Figures\100_Year_CD

Notes:

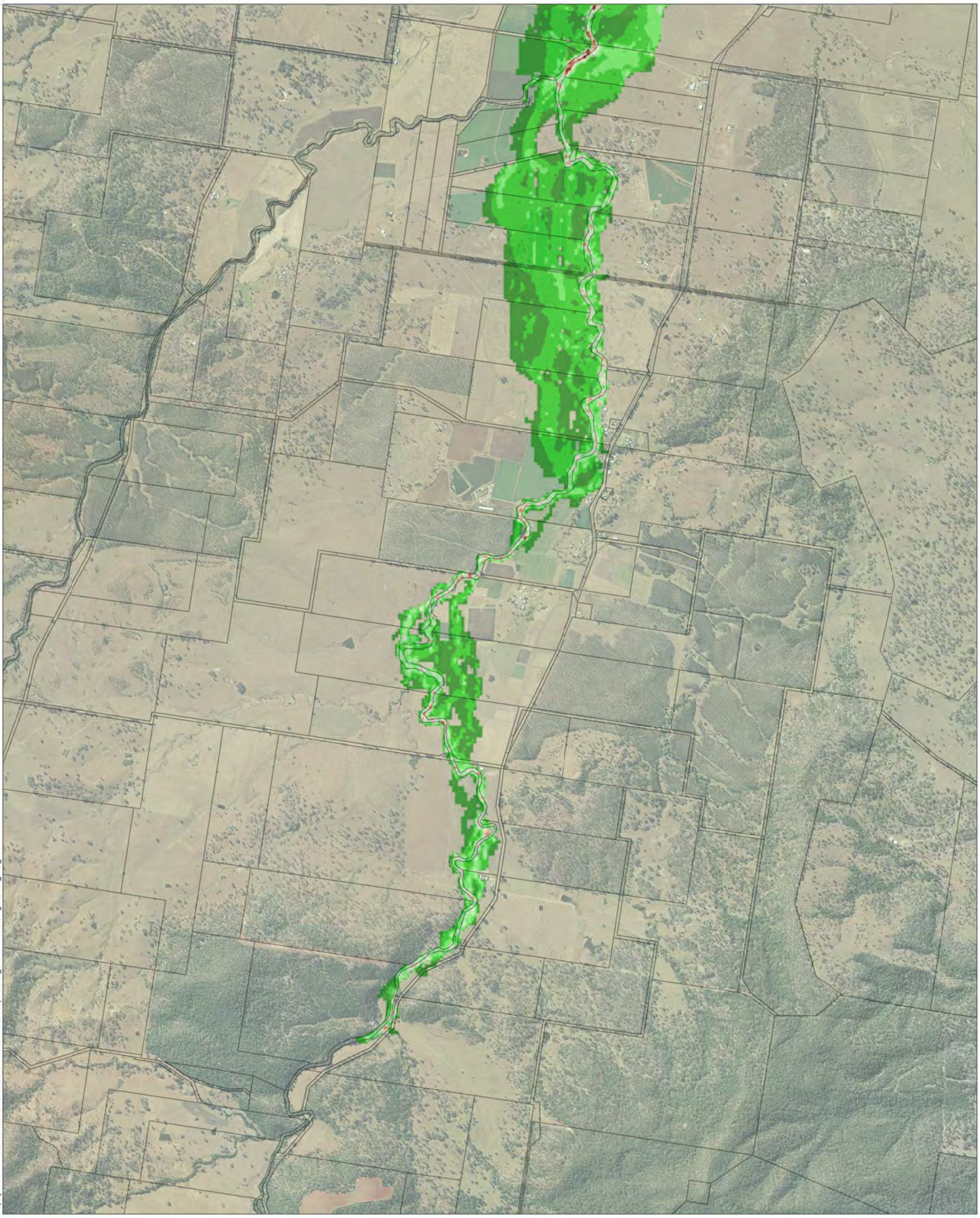
Date:01/08/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure B5**

1% AEP Event Climate Change Scenario 4.5 - Peak Velocities

aurecon



Map by: CD

P:\SWM\Work\255060 Scenic Rim Flood Models Expansion\2_Bremer River\GIS\Figures\100_Year_CD

Legend

Notes:

	Velocity (m/s)	
SRRC Boundary	0.0 to 0.5	3.0 to 3.5
	0.5 to 1.0	3.5 to 4.0
Cadastral Boundary	1.0 to 1.5	4.0 to 4.5
	1.5 to 2.0	4.5 to 5.0
	2.0 to 2.5	> 5.0
	2.5 to 3.0	

1:25,000

0 625 m 1,250 m

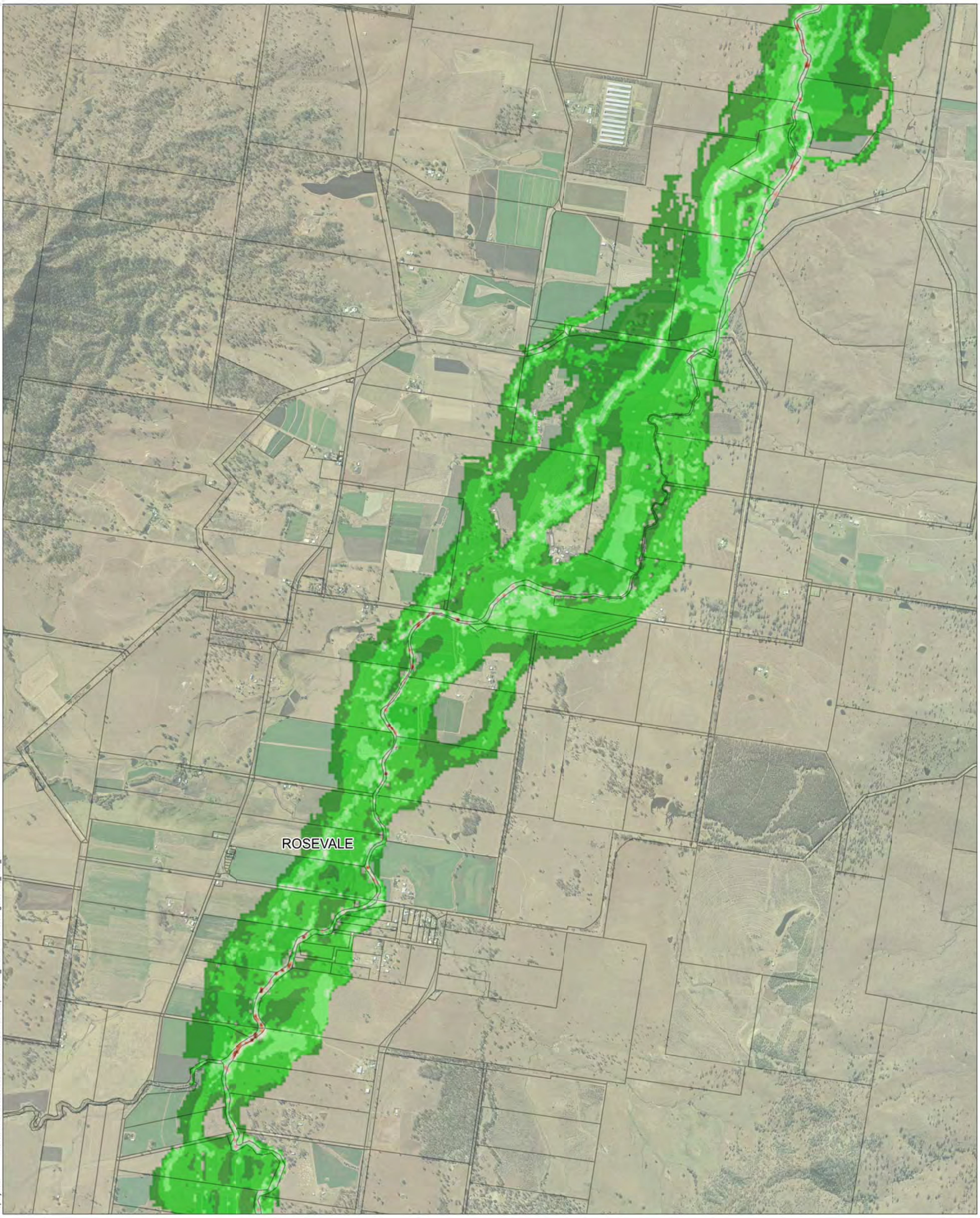
Date:01/08/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure B5-a**

1% AEP Event Climate Change Scenario 4.5 - Peak Velocities

aurecon



Map by: CD

P:\SWM\Work\255060 Scenic Rim Flood Models Expansion\2_Bremer River\GIS\Figures\100_Year_CD

Legend

- SRRC Boundary
- Cadastral Boundary

Velocity (m/s)

- 0.0 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 2.5
- 2.5 to 3.0
- 3.0 to 3.5
- 3.5 to 4.0
- 4.0 to 4.5
- 4.5 to 5.0
- > 5.0

Notes:

1:25,000

0 625 m 1,250 m

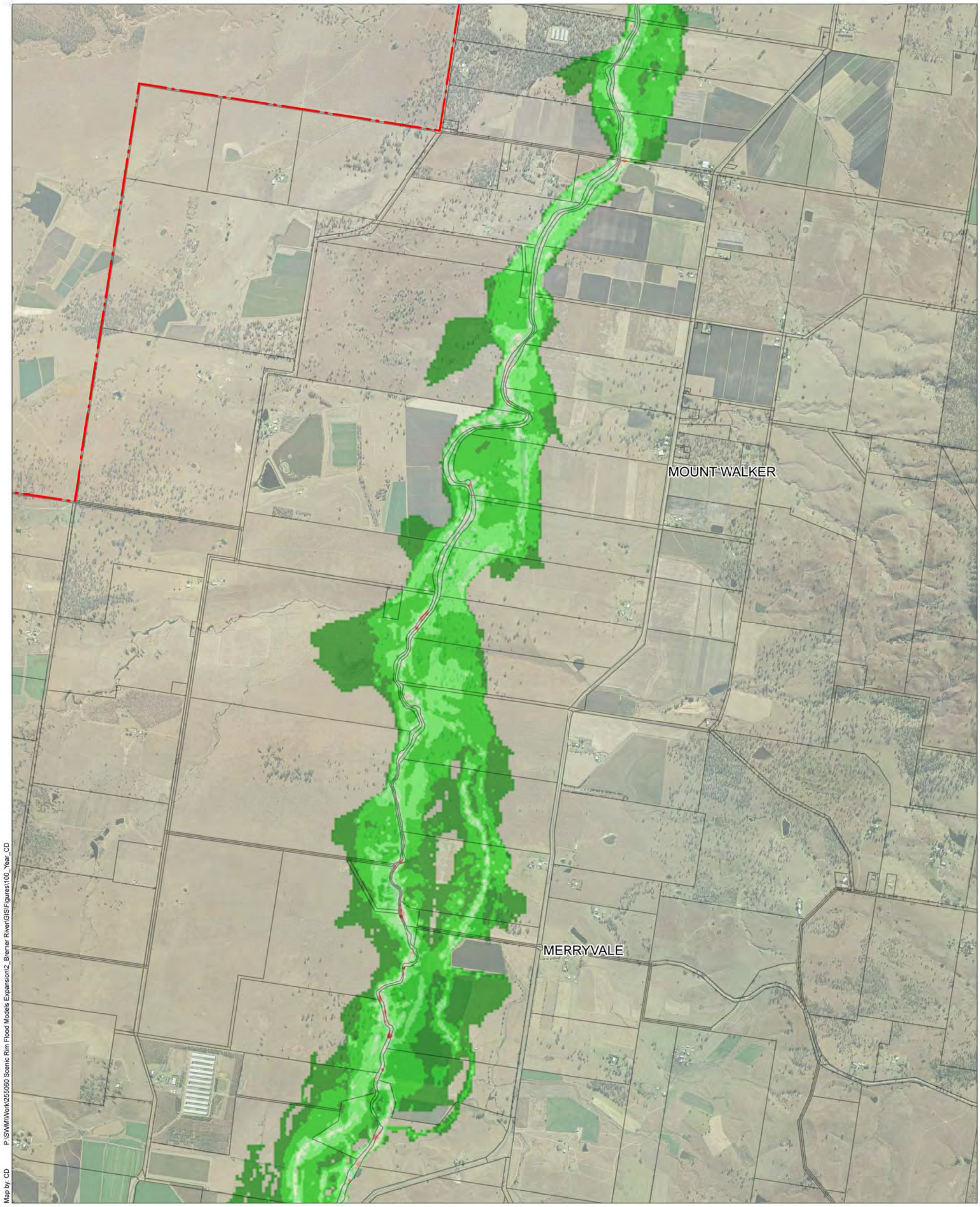
Date:01/08/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure B5-b**

1% AEP Event Climate Change Scenario 4.5 - Peak Velocities

aurecon



Legend

Velocity (m/s)

SRRC Boundary	0.0 to 0.5
Cadastral Boundary	0.5 to 1.0
	1.0 to 1.5
	1.5 to 2.0
	2.0 to 2.5
	2.5 to 3.0
	3.0 to 3.5
	3.5 to 4.0
	4.0 to 4.5
	4.5 to 5.0
	> 5.0

Notes:

1:25,000

0 625 m 1,250 m

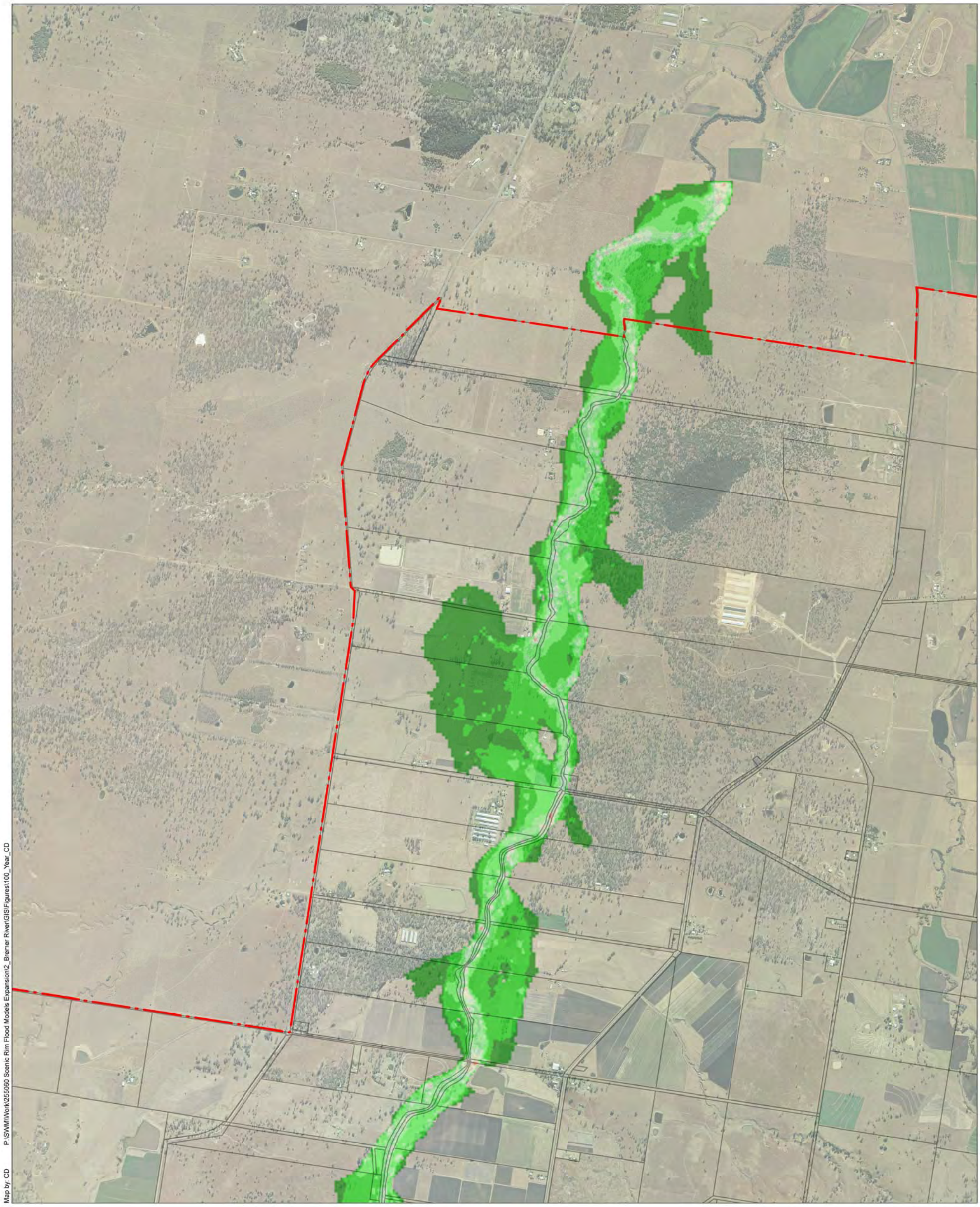
Date:01/08/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure B5-c**

1% AEP Event Climate Change Scenario 4.5 - Peak Velocities

aurecon



Legend

Velocity (m/s)

SRRC Boundary	0.0 to 0.5
Cadastral Boundary	0.5 to 1.0
	1.0 to 1.5
	1.5 to 2.0
	2.0 to 2.5
	2.5 to 3.0
	3.0 to 3.5
	3.5 to 4.0
	4.0 to 4.5
	4.5 to 5.0
	> 5.0

Notes:

1:25,000

0 625 m 1,250 m

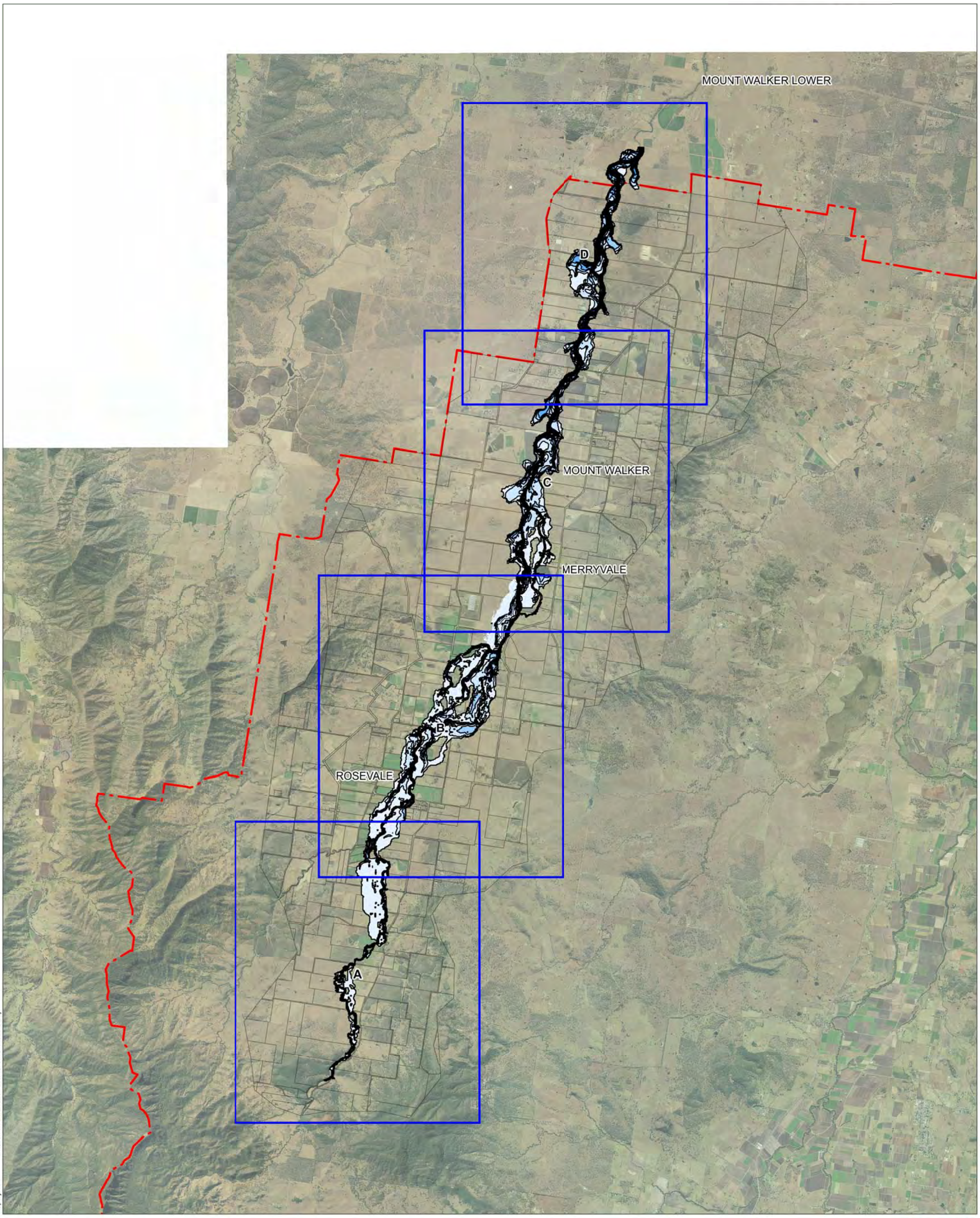
Date:01/08/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure B5-d**

1% AEP Event Climate Change Scenario 4.5 - Peak Velocities

aurecon



Legend

Cadastral Boundary

SRRC Boundary

Velocity (m/s)

0.0 to 0.5	3.0 to 3.5
0.5 to 1.0	3.5 to 4.0
1.0 to 1.5	4.0 to 4.5
1.5 to 2.0	4.5 to 5.0
2.0 to 2.5	> 5.0
2.5 to 3.0	

Notes:

A3 scale 1:100,000

0 2,500 m 5,000 m

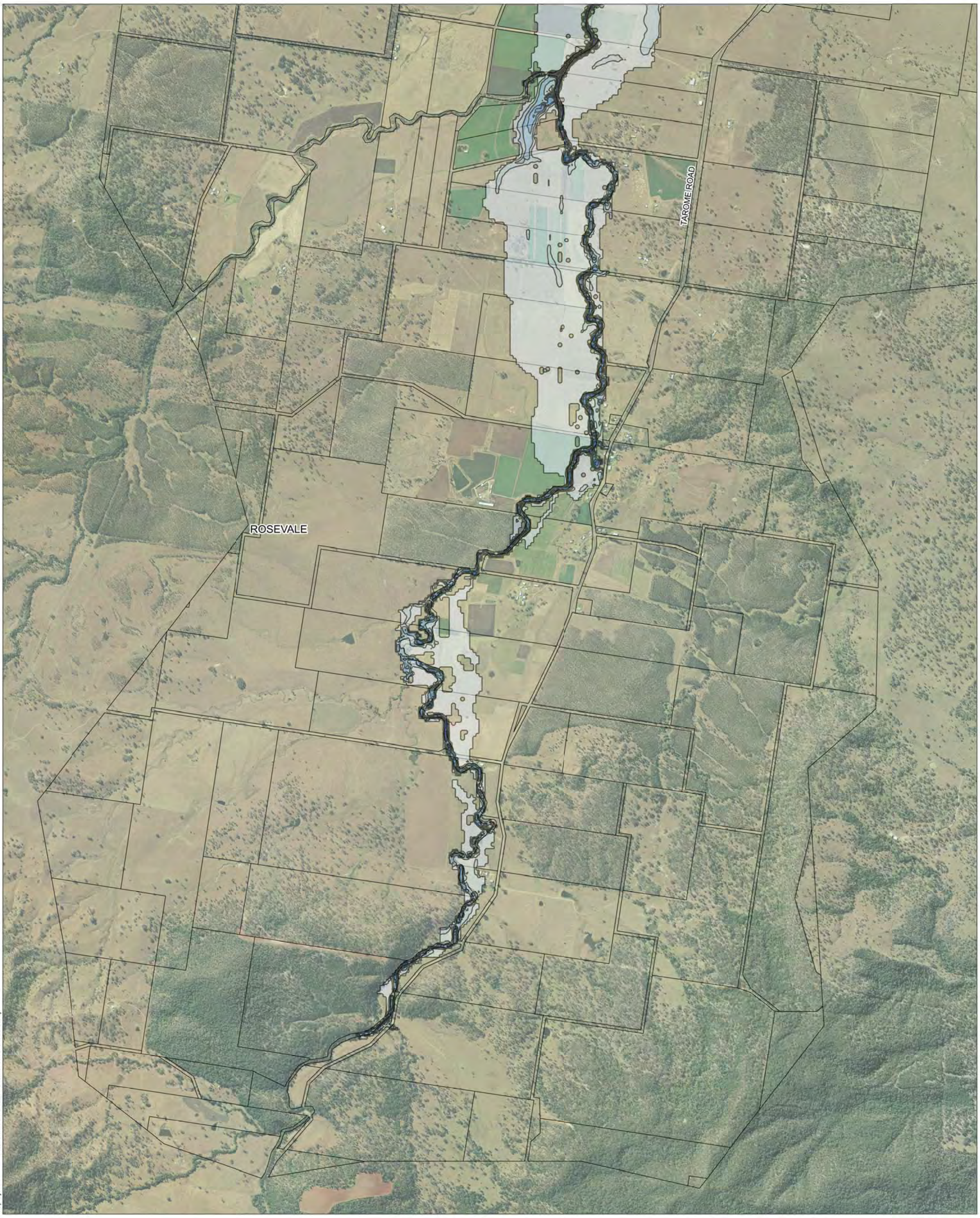
Date: 24/10/2014 Version: 2 Job No: 242281

Projection: MGA Zone 56

Bremer River Flood Study **Figure B6**

1% AEP Event - Peak Depths

aurecon



Legend

- SRRC Boundary
- Cadastral Boundary

Peak Water Depths (m)

- 0.0 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 2.5
- 2.5 to 3.0
- 3.0 to 3.5
- 3.5 to 4.0
- 4.0 to 4.5
- 4.5 to 5.0
- > 5.0

Notes:

A3 scale 1:25,000

0 625 m 1,250 m

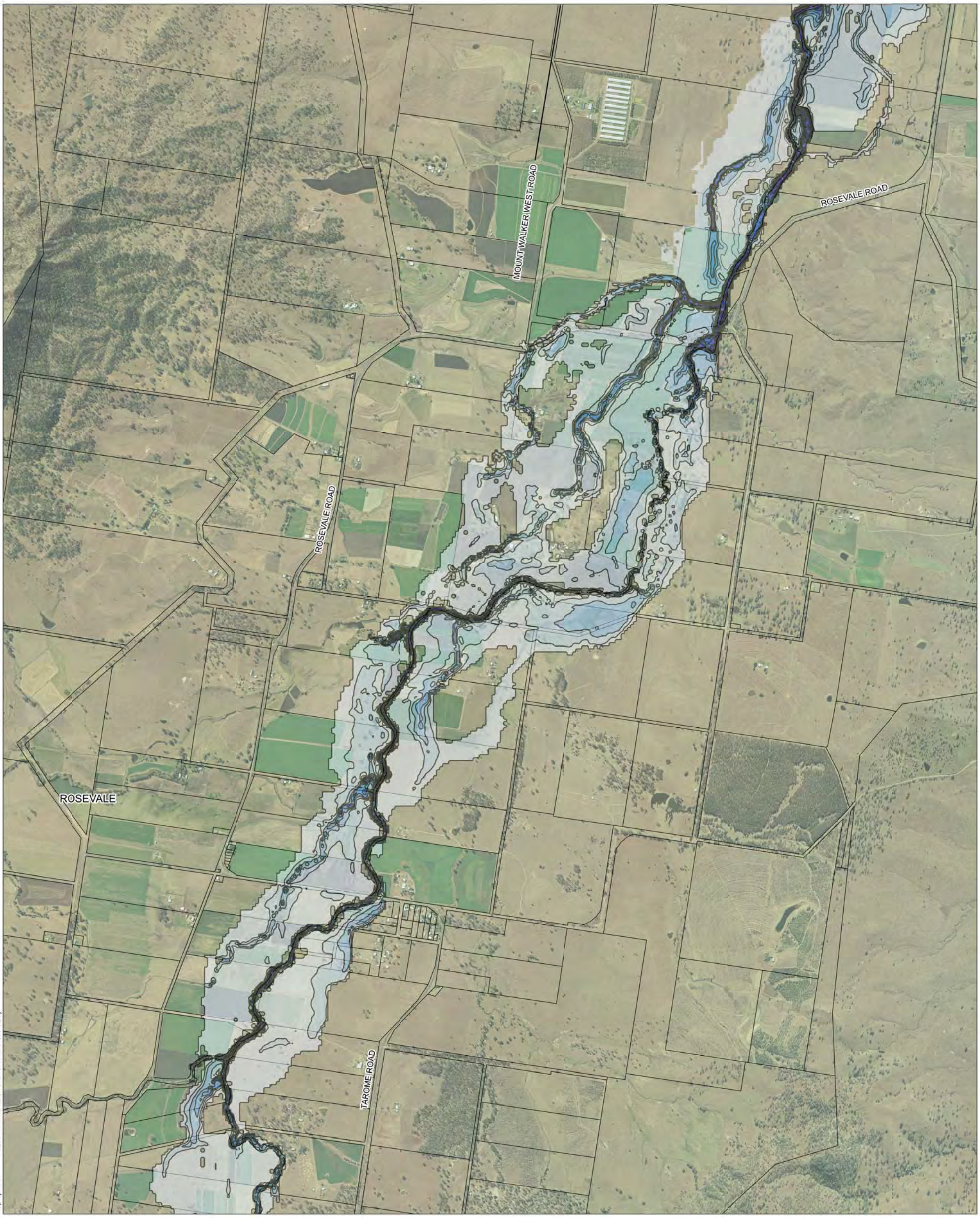
Date: 24/10/2014 Version: 2 Job No: 242281

Projection: MGA Zone 56

Bremer River Flood Study **Figure B6-a**

1% AEP Event - Peak Depths

aurecon



Legend

SRRC Boundary

Cadastral Boundary

Peak Water Depths (m)

- 0.0 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 2.5
- 2.5 to 3.0
- 3.0 to 3.5
- 3.5 to 4.0
- 4.0 to 4.5
- 4.5 to 5.0
- > 5.0

Notes:

A3 scale 1:25,000

0 625 m 1,250 m

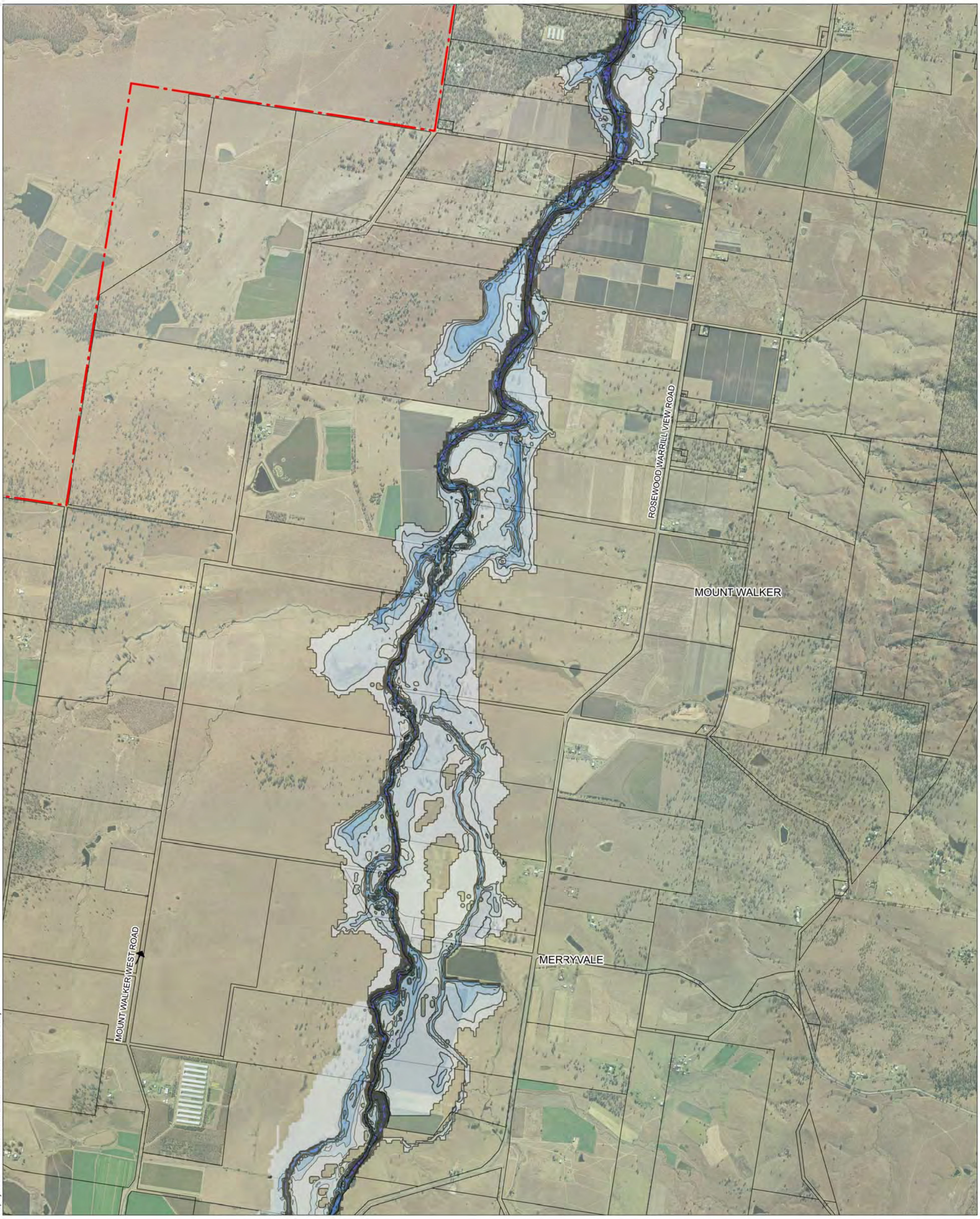
Date: 24/10/2014 Version: 2 Job No: 242281

Projection: MGA Zone 56

Bremer River Flood Study **Figure B6-b**

1% AEP Event - Peak Depths

aurecon



Legend

SRRC Boundary

Cadastral Boundary

Peak Water Depths (m)

- 0.0 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 2.5
- 2.5 to 3.0
- 3.0 to 3.5
- 3.5 to 4.0
- 4.0 to 4.5
- 4.5 to 5.0
- > 5.0

Notes:

A3 scale 1:25,000

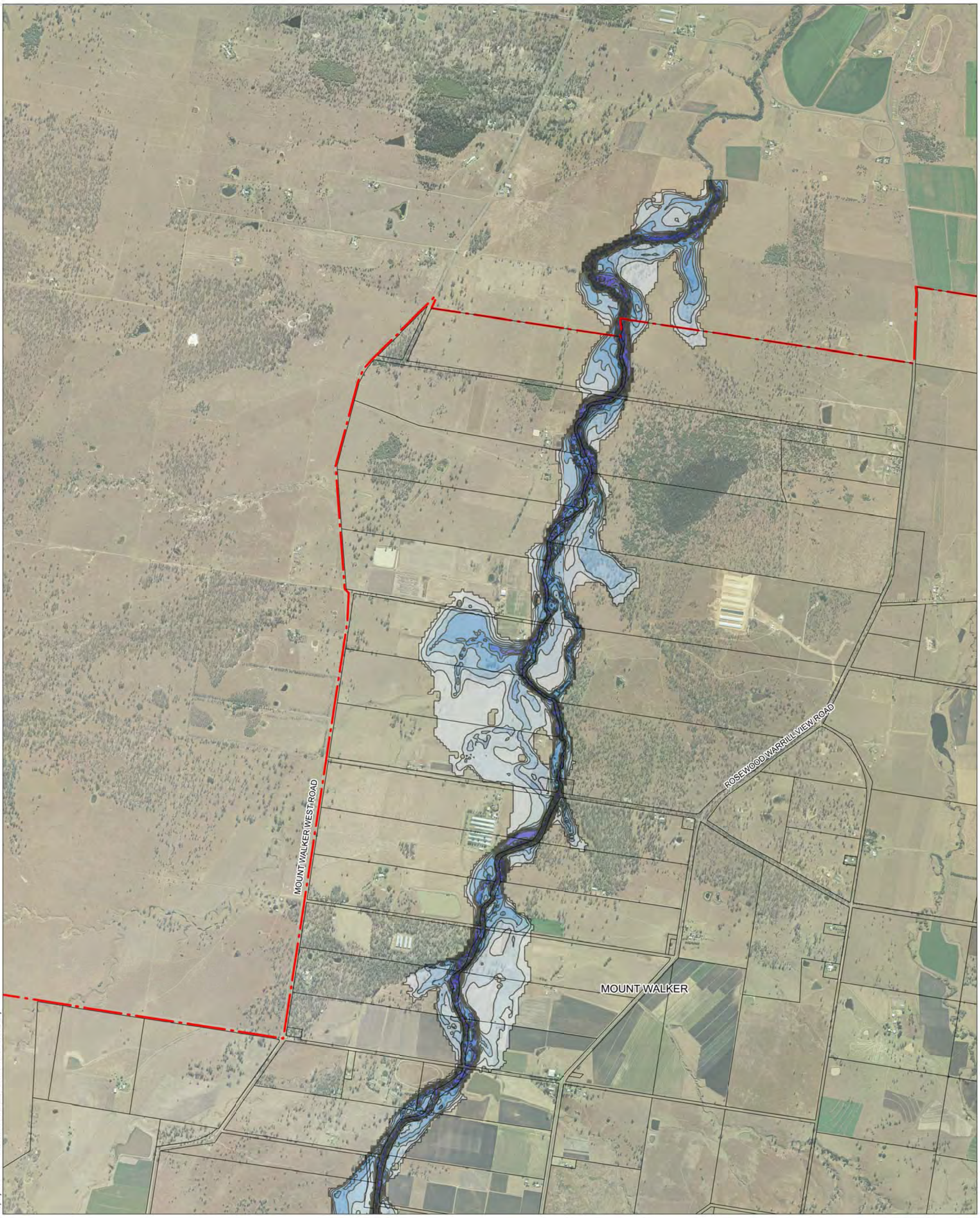
0 625 m 1,250 m

Date: 24/10/2014 Version: 2 Job No: 242281

Projection: MGA Zone 56

Bremer River Flood Study Figure B6-c

1% AEP Event - Peak Depths



Map by: KAP P:\SWM\Work\242281 Bremer River Flood Study

Legend

SRRC Boundary
Cadastral Boundary

Peak Water Depths (m)

- 0.0 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 2.5
- 2.5 to 3.0
- 3.0 to 3.5
- 3.5 to 4.0
- 4.0 to 4.5
- 4.5 to 5.0
- > 5.0

Notes:

A3 scale 1:25,000

0 625 m 1,250 m

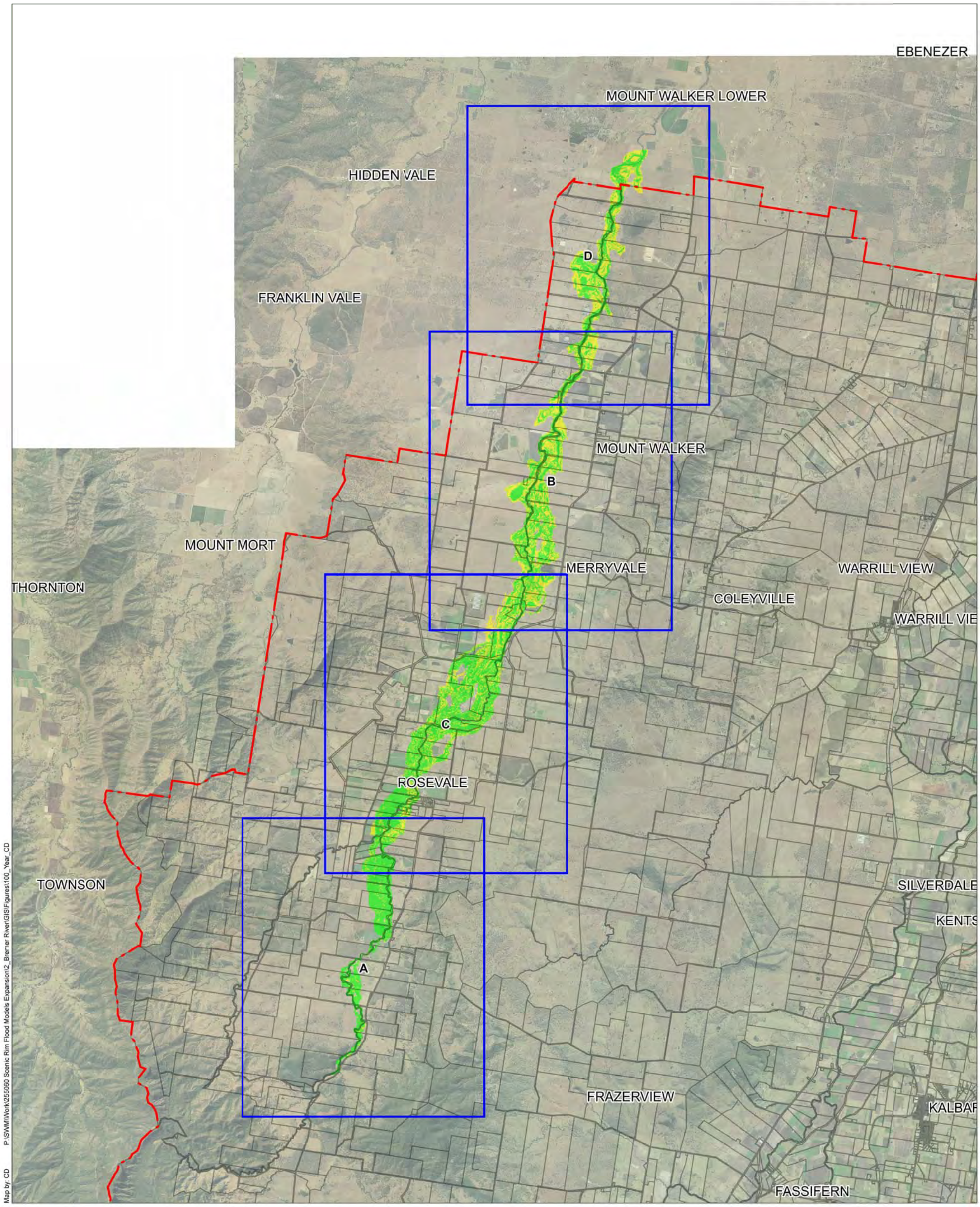
Date: 24/10/2014 Version: 2 Job No: 242281

Projection: MGA Zone 56

Bremer River Flood Study **Figure B6-d**

1% AEP Event - Peak Depths

aurecon



Legend

SRRC Boundary
Cadastral Boundary
Low Hazard
Medium Hazard
High Hazard

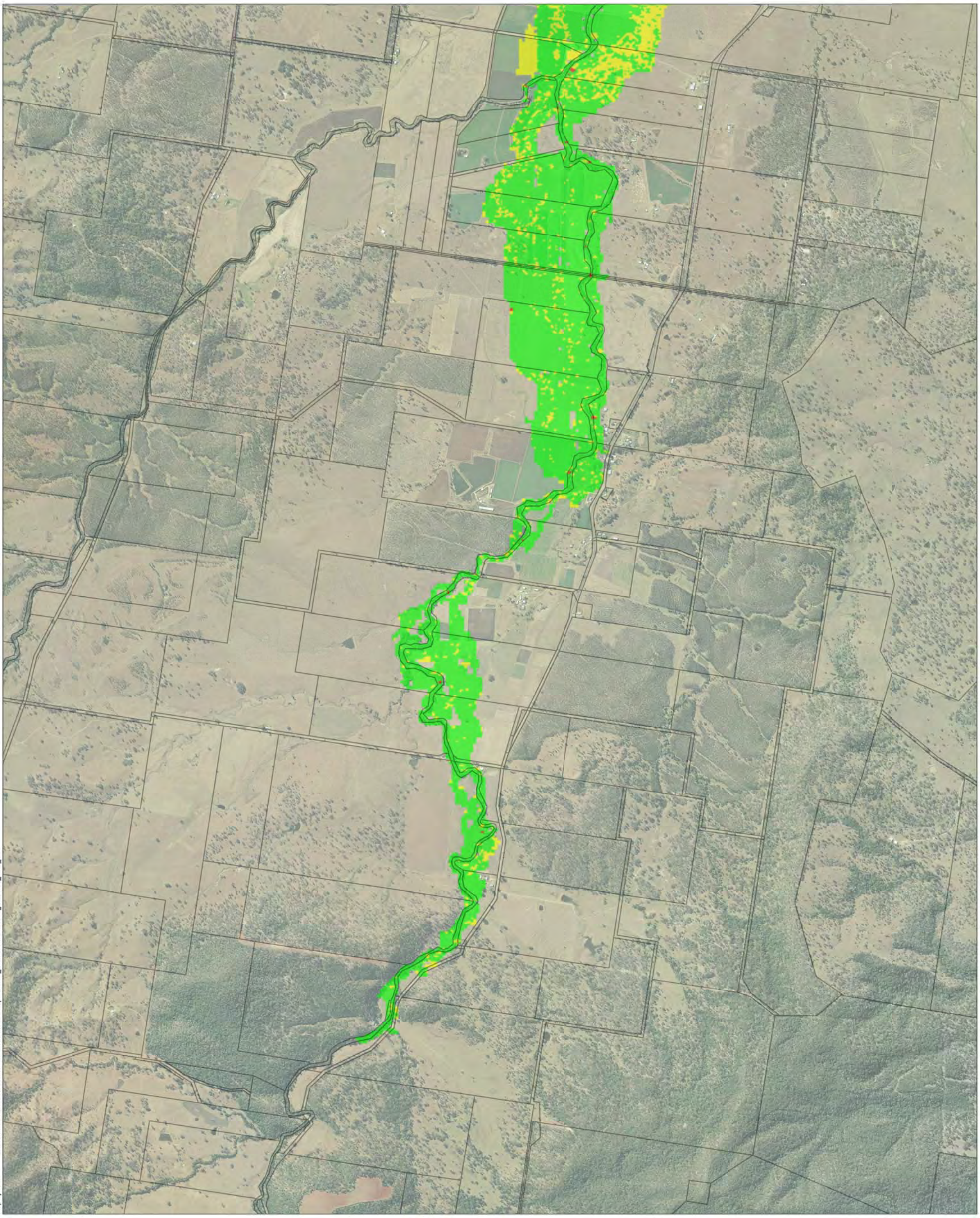
Notes:

1:100,000
0 2,500 m 5,000 m

Date:01/08/2017 Version: 0 Job No: 255060
Projection: MGA Zone 56

Bremer River Flood Study **Figure B7**

1% AEP Event Climate Change Scenario 4.5 - Peak Hazard Map



Legend

SRRC Boundary
Cadastral Boundary
Low Hazard
Medium Hazard
High Hazard

Notes:

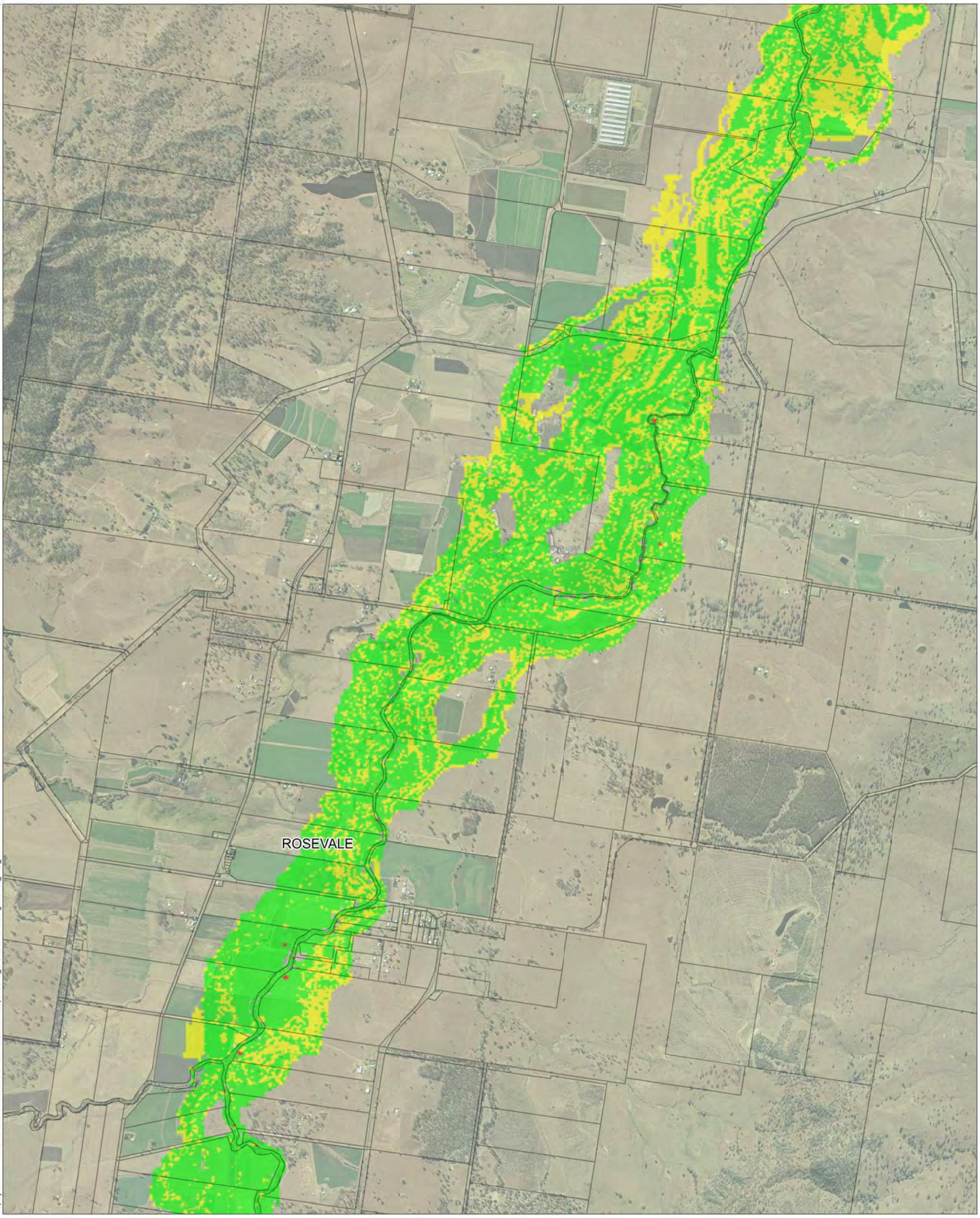
1:25,000
0 625 m 1,250 m

Date:01/08/2017 Version: 0 Job No: 255060
Projection: MGA Zone 56

Bremer River Flood Study **Figure B7-a**

1% AEP Event Climate Change Scenario 4.5 - Peak Hazard Map

aurecon



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Map by: CD

Legend

SRRC Boundary

Cadastral Boundary

Low Hazard

Medium Hazard

High Hazard

Notes:

1:25,000

0 625 m 1,250 m

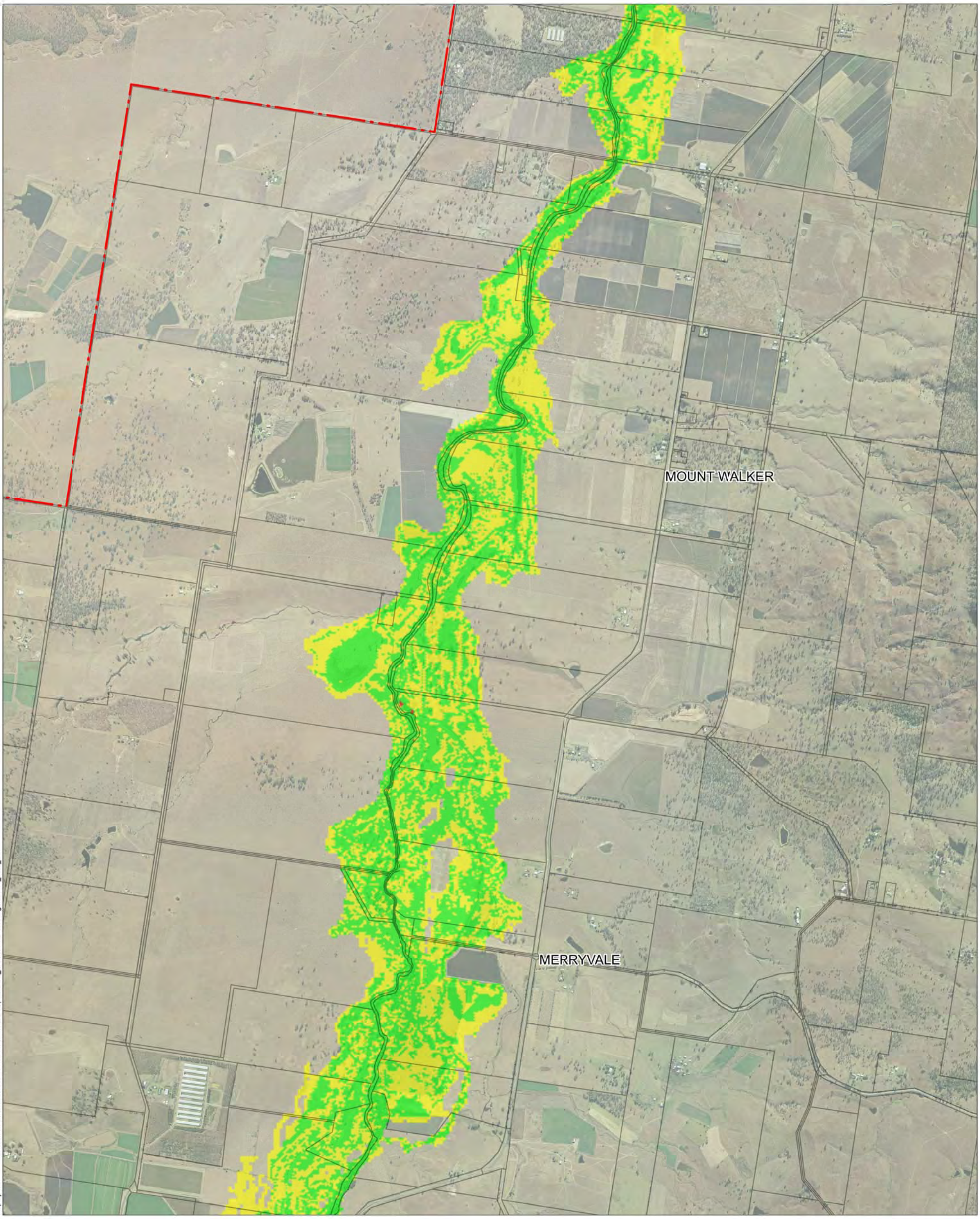
Date:01/08/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure B7-b**

1% AEP Event Climate Change Scenario 4.5 - Peak Hazard Map

aurecon



Legend

SRRC Boundary
Cadastral Boundary
Low Hazard
Medium Hazard
High Hazard

Notes:

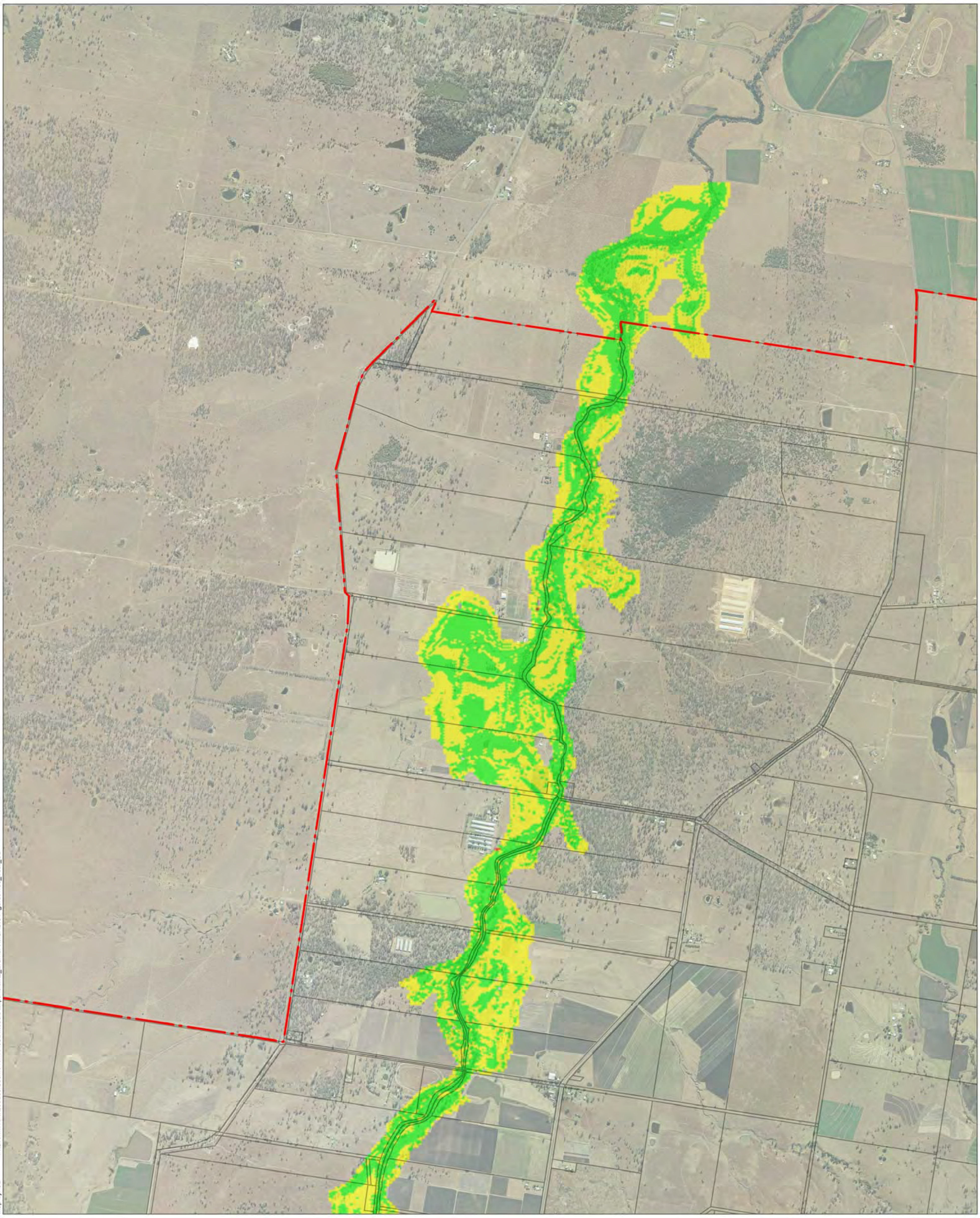
1:25,000
0 625 m 1,250 m

Date:01/08/2017 Version: 0 Job No: 255060
Projection: MGA Zone 56

Bremer River Flood Study **Figure B7-c**

1% AEP Event Climate Change Scenario 4.5 - Peak Hazard Map

aurecon



Map by: CD

P:\SWM\Work\255060 Scenic Rim Flood Models Expansion\2_Bremer River\GIS\Figures\100_Year_CD

Legend

SRRC Boundary

Cadastral Boundary

Low Hazard

Medium Hazard

High Hazard

Notes:

1:25,000

0 625 m 1,250 m

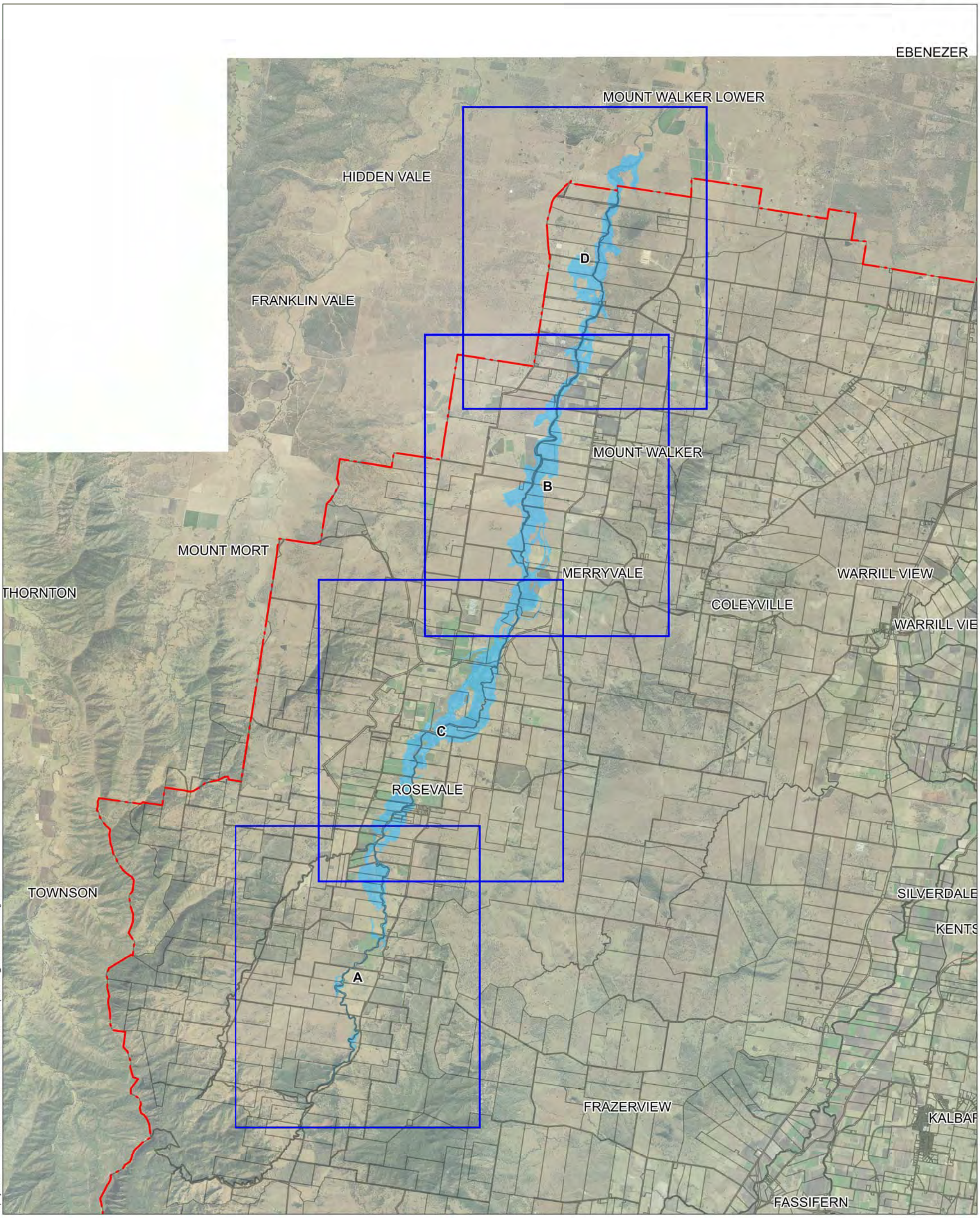
Date:01/08/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure B7-d**

1% AEP Event Climate Change Scenario 4.5 - Peak Hazard Map

Document Set ID: 10154451
Version: 1, Version Date: 21/12/2017



Map by: JDT P:\SWM\Work\255060 Scenic Rim Flood Models Expansion\2_Bremer River\GIS\Figures\

Legend

SRRC Boundary

Cadastral Boundary

Inundation Extent

Peak Water level Contour (mAHD)

Notes:

1:100,000

0 2,500 m 5,000 m

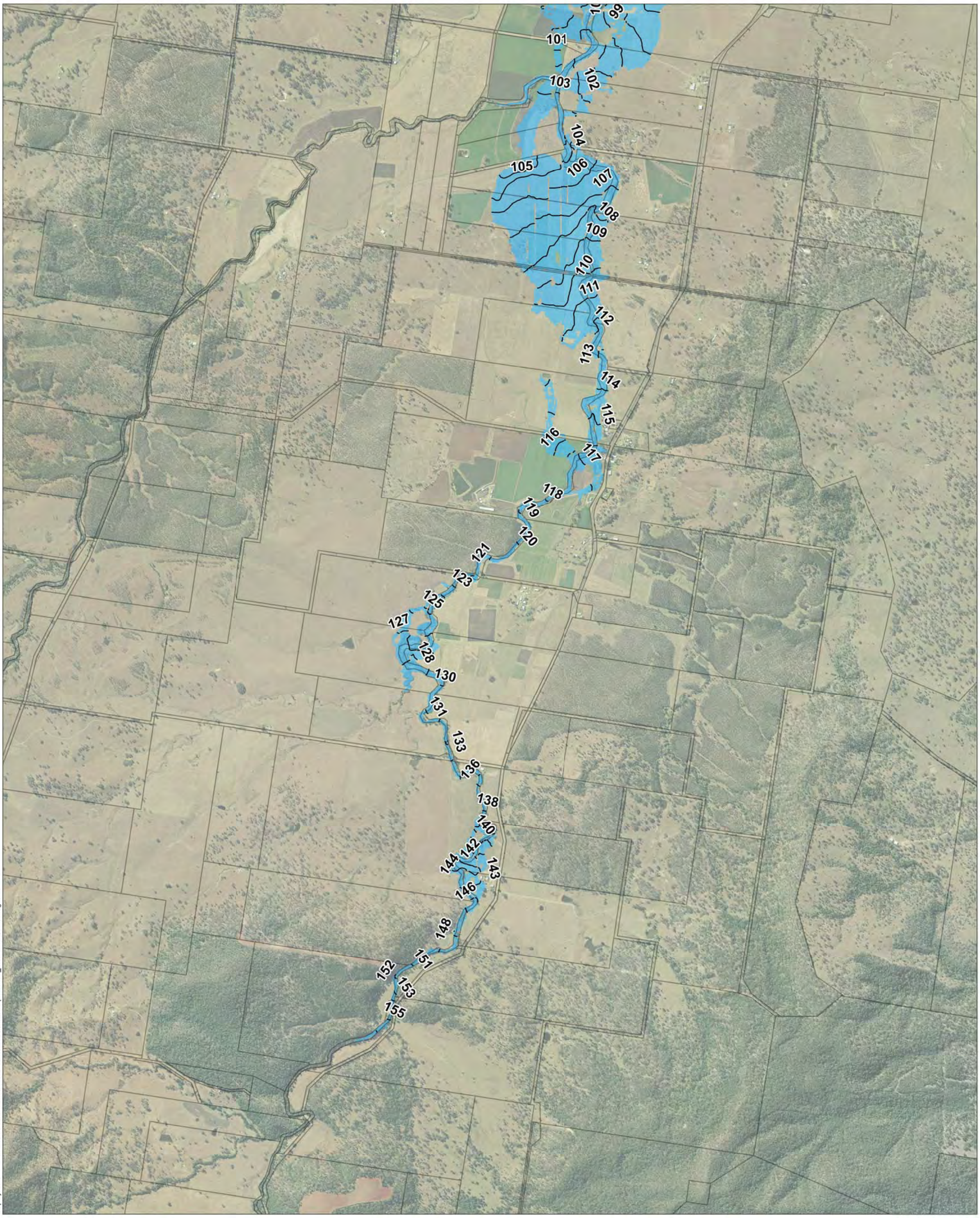
Date: 22/06/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure C1**

2% AEP Event - Inundation Extent

aurecon



Legend

SRRC Boundary

Cadastral Boundary

Inundation Extent

Peak Water level Contour (mAHD)

Notes:

1:25,000

0 625 m 1,250 m

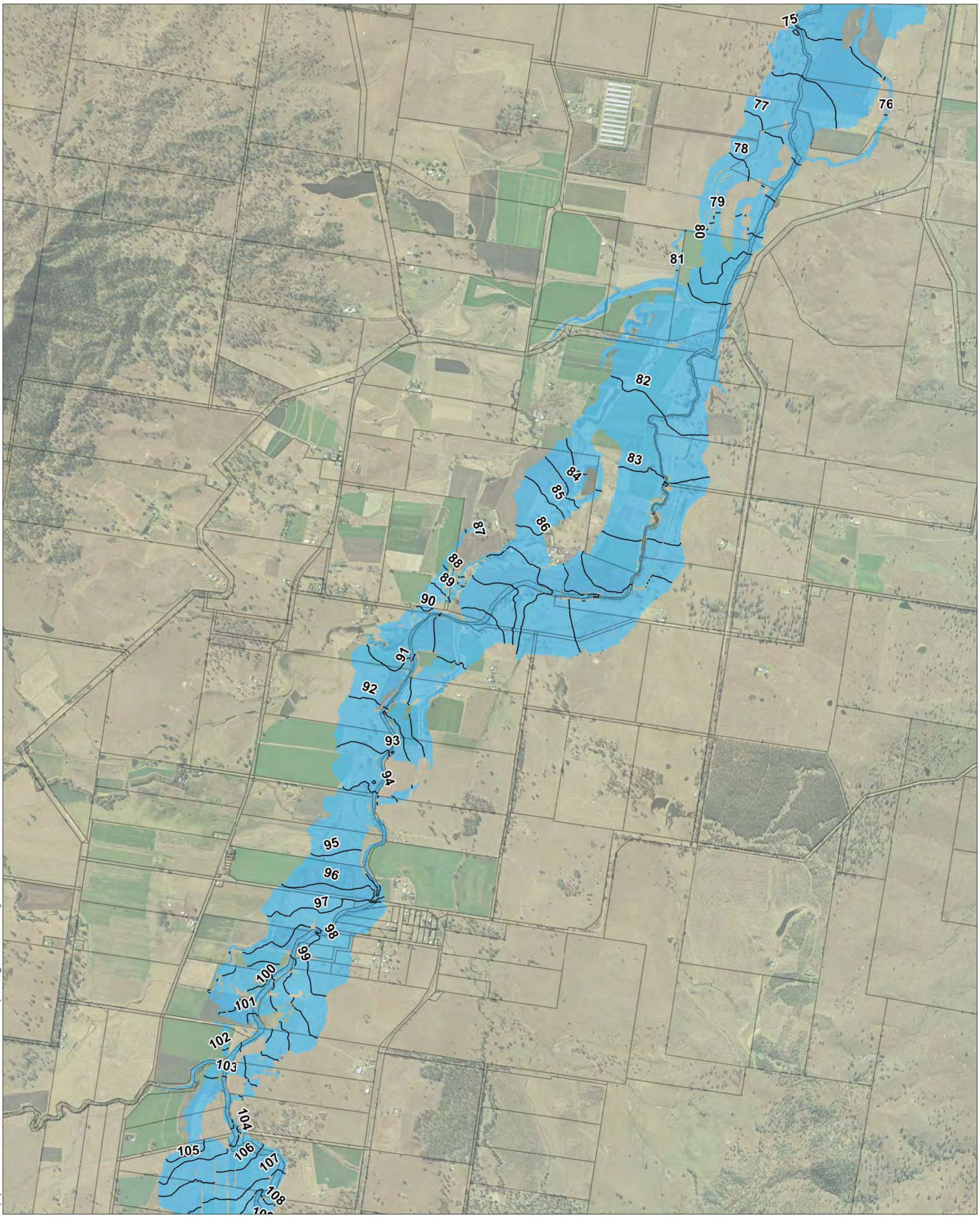
Date: 22/06/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure C1-a**

2% AEP Event - Inundation Extent

aurecon



Map by: JDT   P:\SWM\Work\255060 Scenic Rim Flood Models Expansion\2_Bremer River\GIS\Figures\

Legend

SRRC Boundary

Cadastral Boundary

Inundation Extent

Peak Water level Contour (mAHD)

Notes:

1:25,000

0   625 m   1,250 m

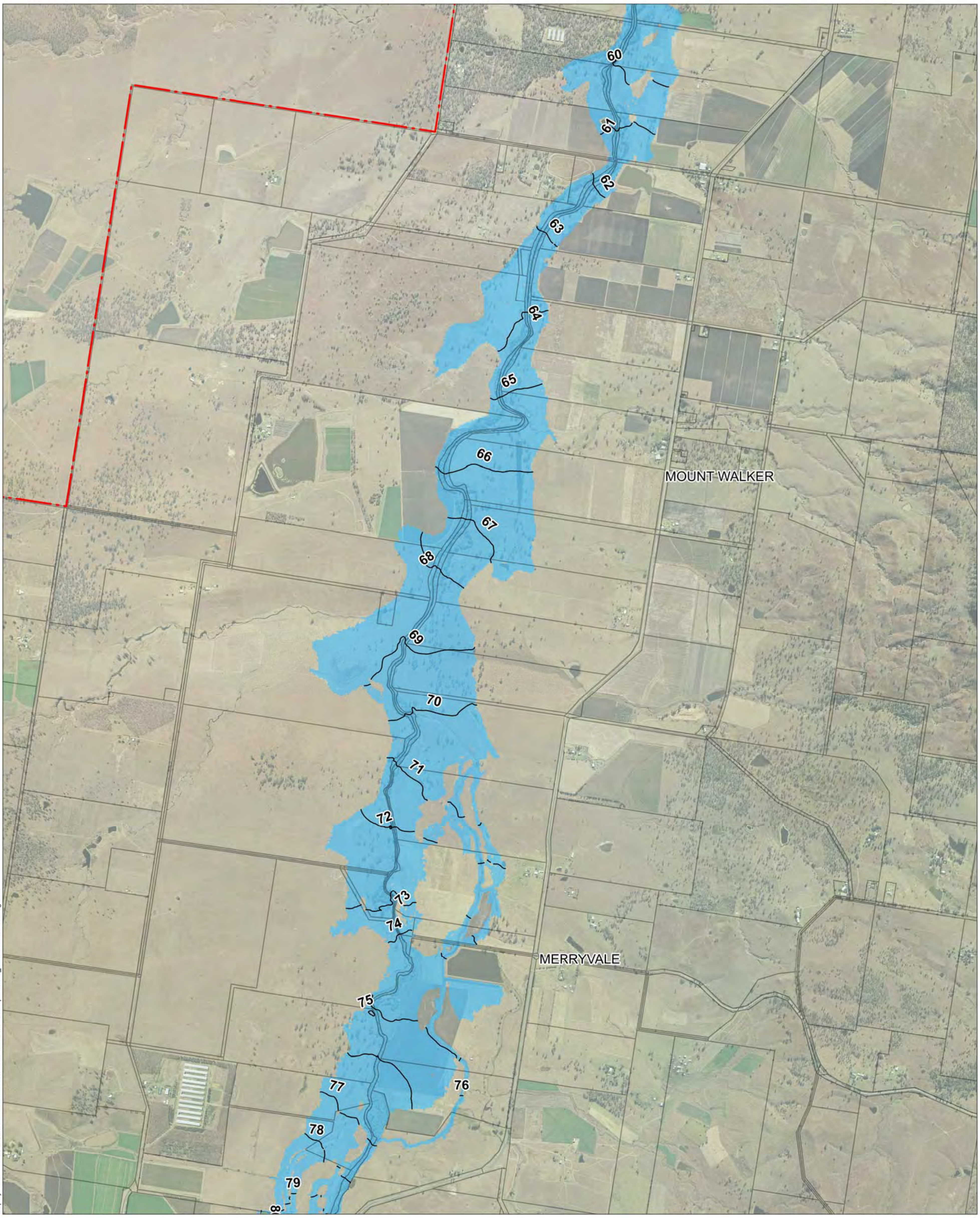
Date: 22/06/2017   Version: 0   Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure C1-b**

2% AEP Event - Inundation Extent

aurecon



Map by: JDT P:\SWM\Work\255060 Scenic Rim Flood Models Expansion\2_Bremer River\GIS\Figures\

Legend

SRRC Boundary

Cadastral Boundary

Inundation Extent

Peak Water level Contour (mAHD)

Notes:

1:25,000

0 625 m 1,250 m

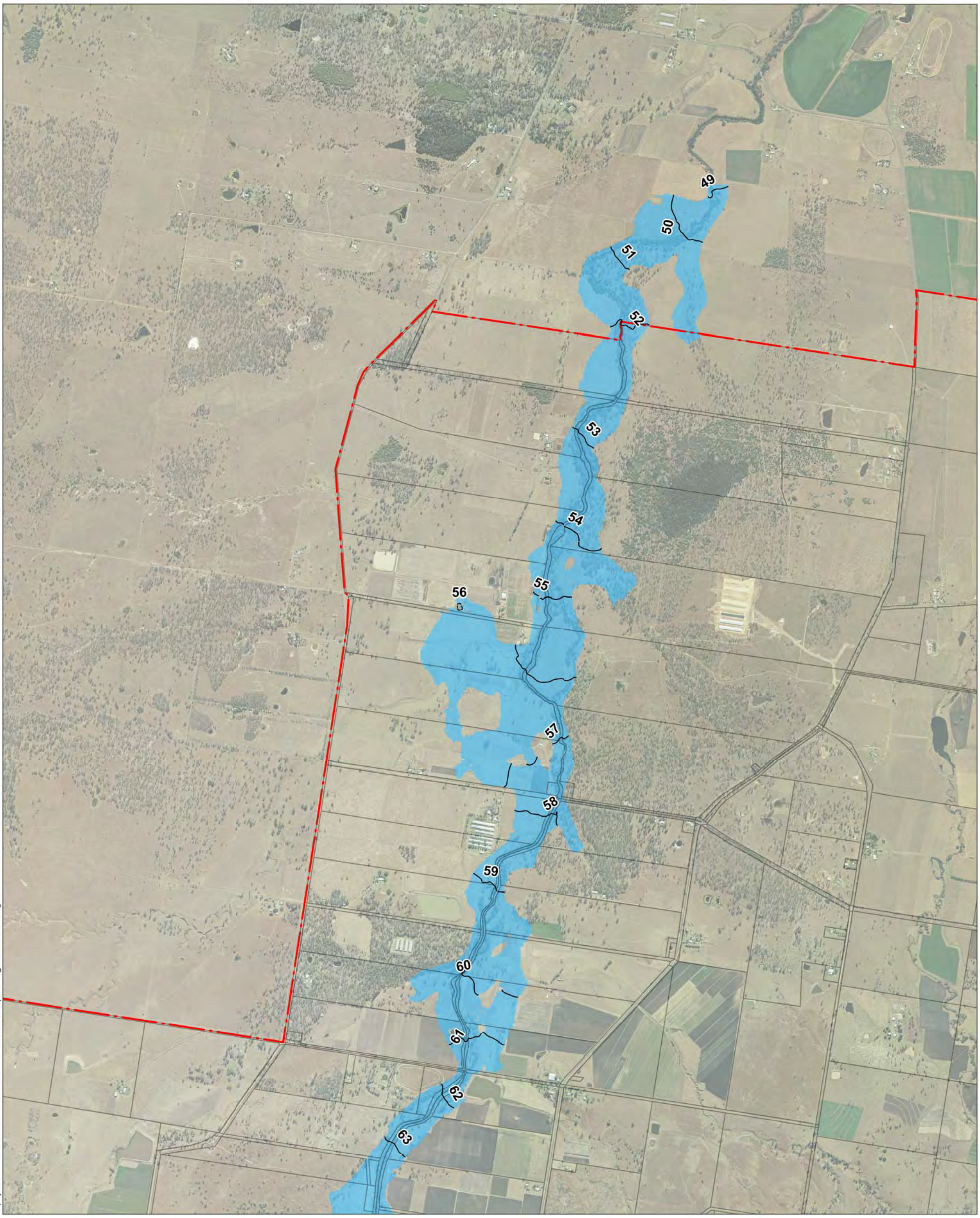
Date: 22/06/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure C1-c**

2% AEP Event - Inundation Extent

aurecon



Legend

SRRC Boundary

Cadastral Boundary

Inundation Extent

Peak Water level Contour (mAHD)

Notes:

1:25,000

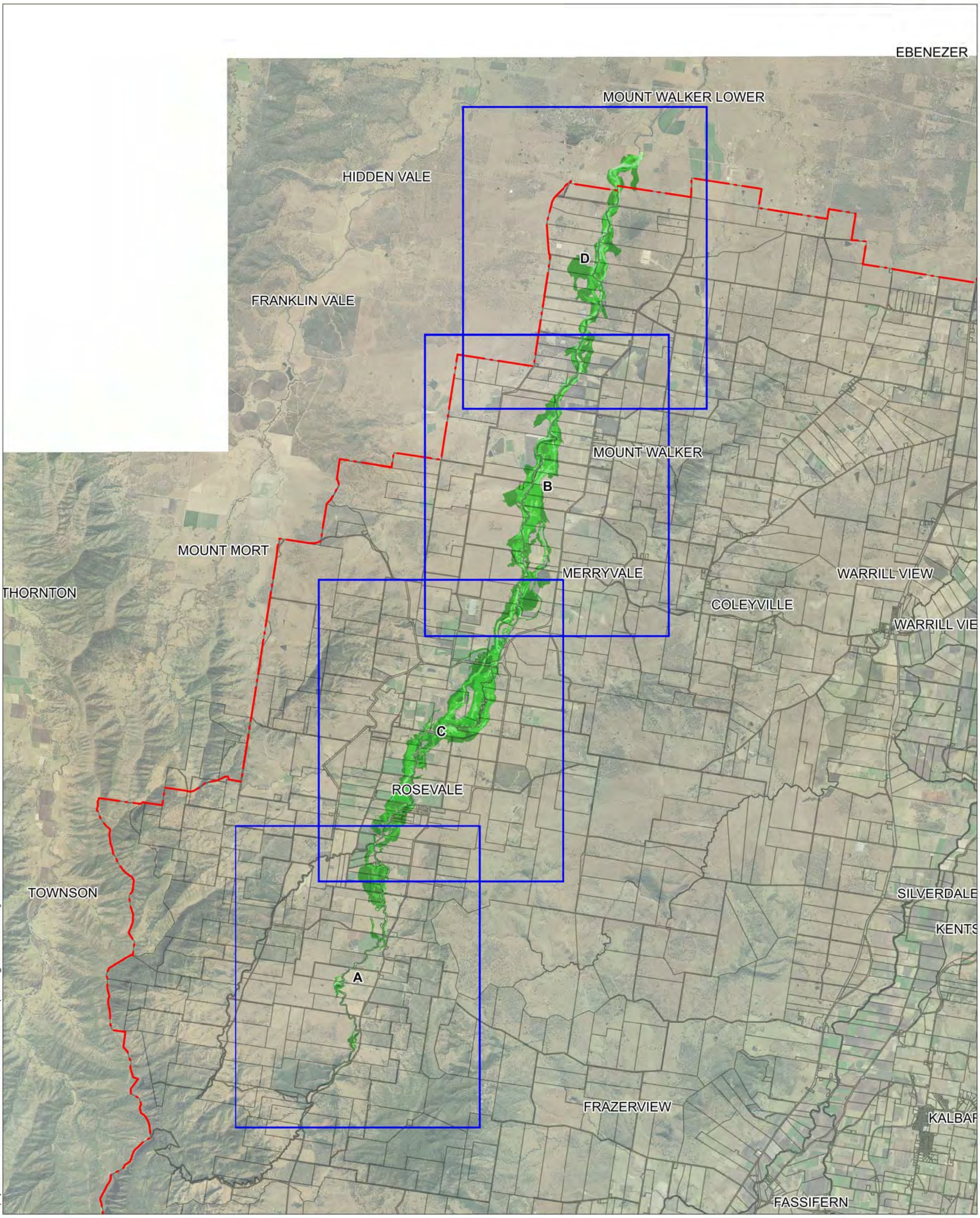
0 625 m 1,250 m

Date: 22/06/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure C1-d**

2% AEP Event - Inundation Extent



Legend

SRRC Boundary

Cadastral Boundary

Velocity (m/s)

0.0 to 0.5
0.5 to 1.0
1.0 to 1.5
1.5 to 2.0
2.0 to 2.5
2.5 to 3.0
3.0 to 3.5
3.5 to 4.0
4.0 to 4.5
4.5 to 5.0
> 5.0

Notes:

1:100,000

0 2,500 m 5,000 m

Date: 22/06/2017 Version: 0 Job No: 255060

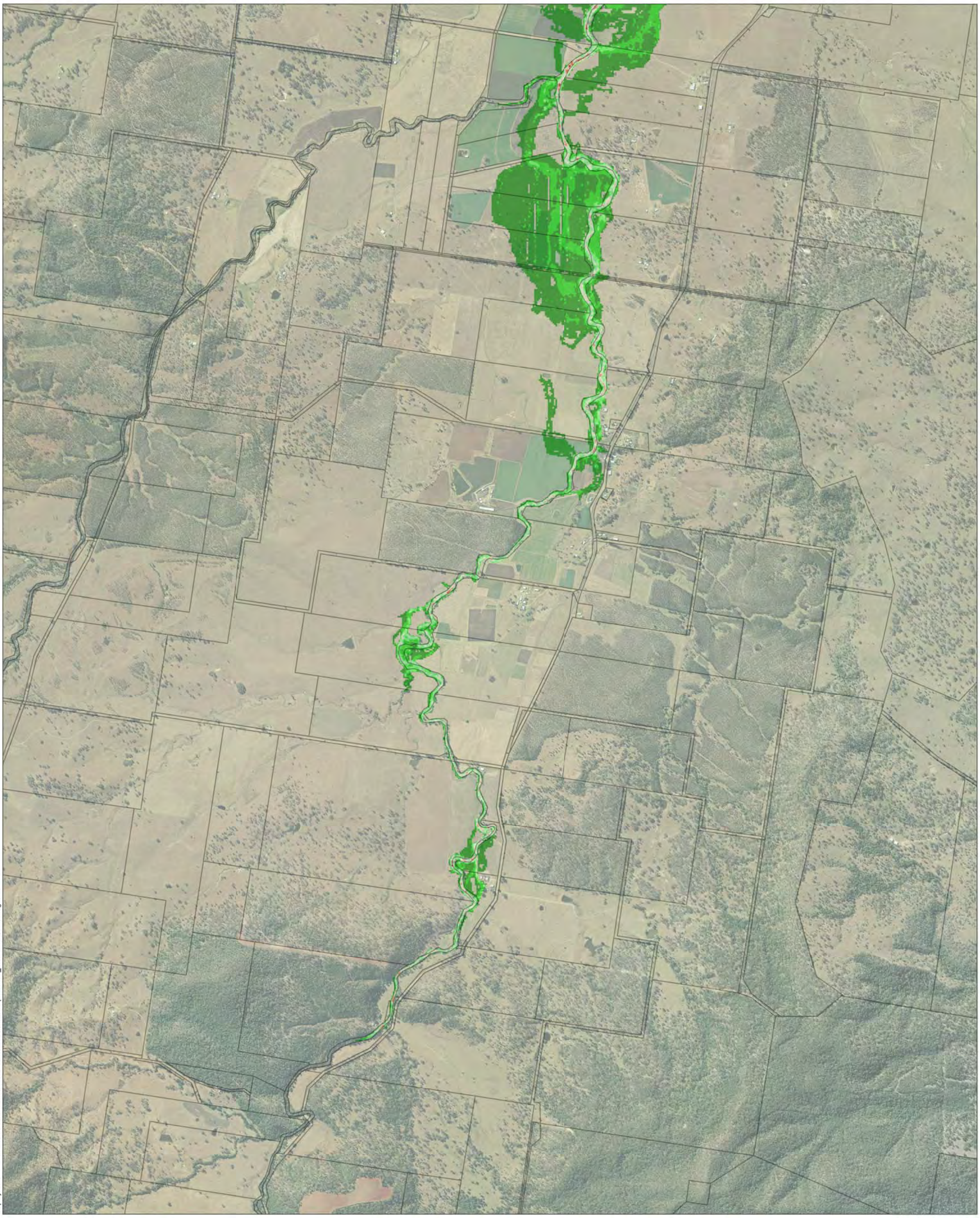
Projection: MGA Zone 56

aurecon

Bremer River Flood Study **Figure C2**

2% AEP Event - Peak Velocities

aurecon



Map by: JDT P:\SWM\Work\255060 Scenic Rim Flood Models Expansion\2_Bremer River\GIS\Figures\

Legend

Velocity (m/s)

SRRC Boundary	0.0 to 0.5	3.0 to 3.5
Cadastral Boundary	0.5 to 1.0	3.5 to 4.0
	1.0 to 1.5	4.0 to 4.5
	1.5 to 2.0	4.5 to 5.0
	2.0 to 2.5	> 5.0
	2.5 to 3.0	

Notes:

1:25,000

0 625 m 1,250 m

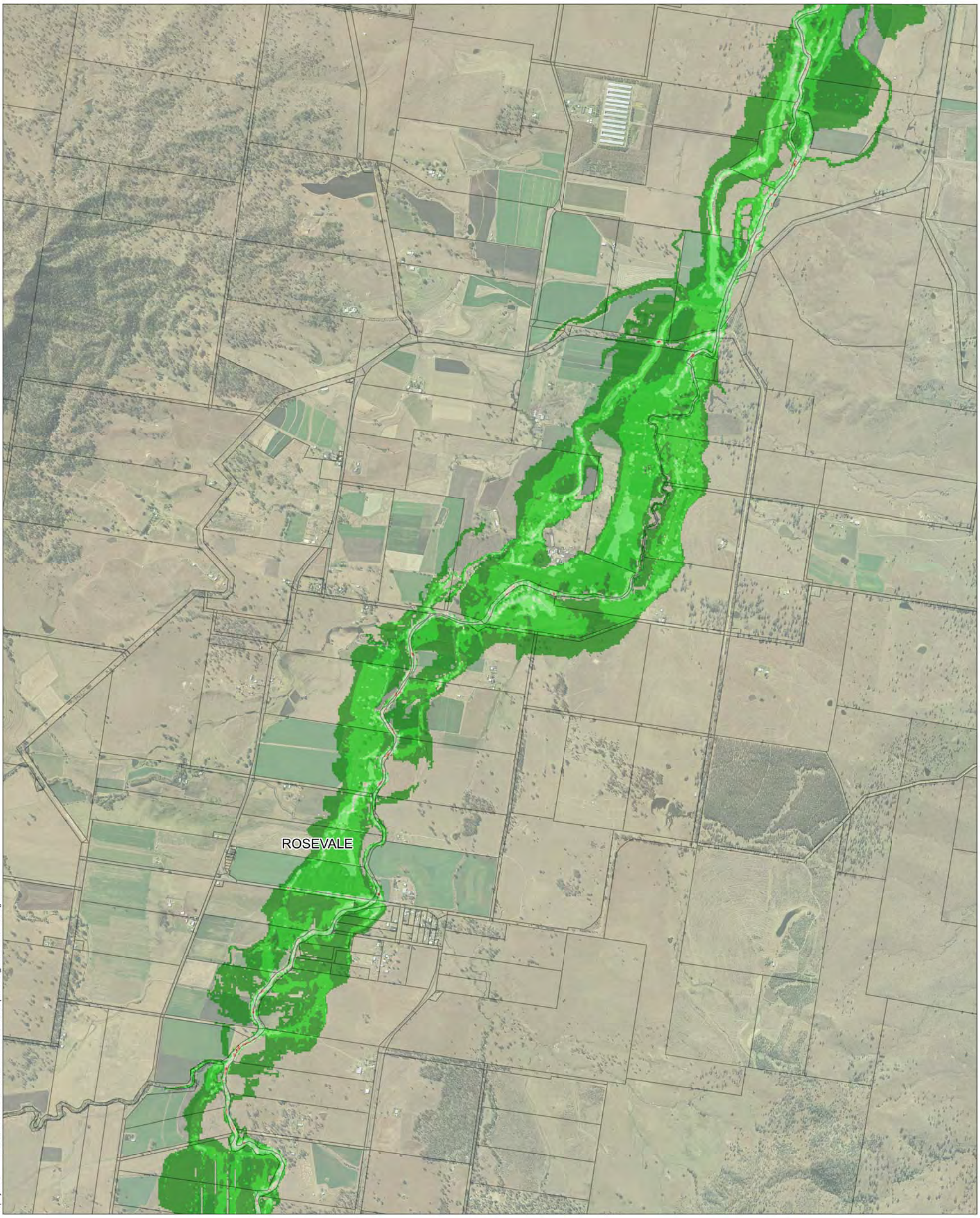
Date: 22/06/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure C2-a**

2% AEP Event - Peak Velocities

aurecon



Legend

Velocity (m/s)

- SRRC Boundary
- Cadastral Boundary
- 0.0 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 2.5
- 2.5 to 3.0
- 3.0 to 3.5
- 3.5 to 4.0
- 4.0 to 4.5
- 4.5 to 5.0
- > 5.0

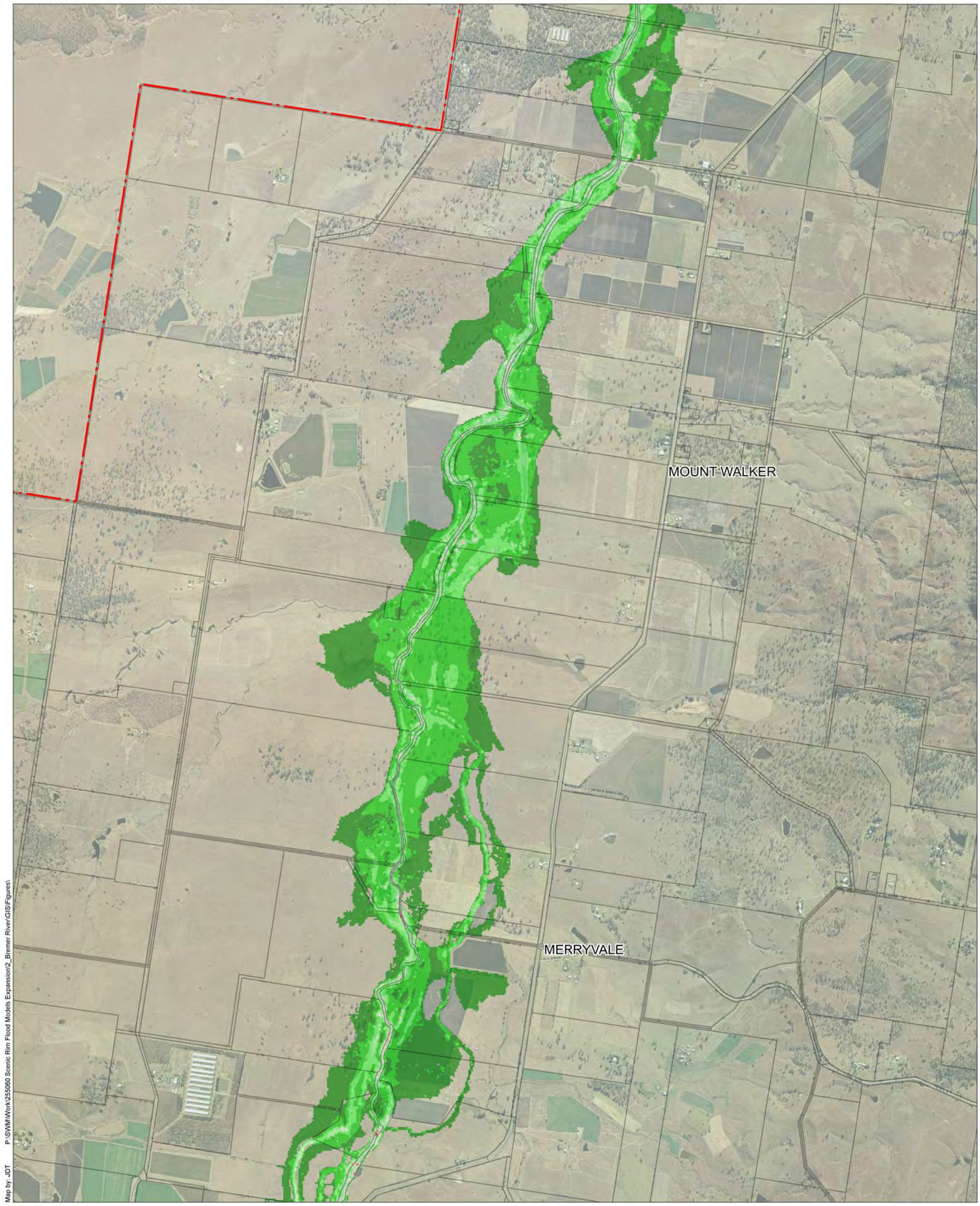
Notes:

1:25,000
0 625 m 1,250 m

Date: 22/06/2017 Version: 0 Job No: 255060
Projection: MGA Zone 56

Bremer River Flood Study **Figure C2-b**

2% AEP Event - Peak Velocities



Legend

SRRC Boundary

Cadastral Boundary

Velocity (m/s)

- 0.0 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 2.5
- 2.5 to 3.0
- 3.0 to 3.5
- 3.5 to 4.0
- 4.0 to 4.5
- 4.5 to 5.0
- > 5.0

Notes:

1:25,000

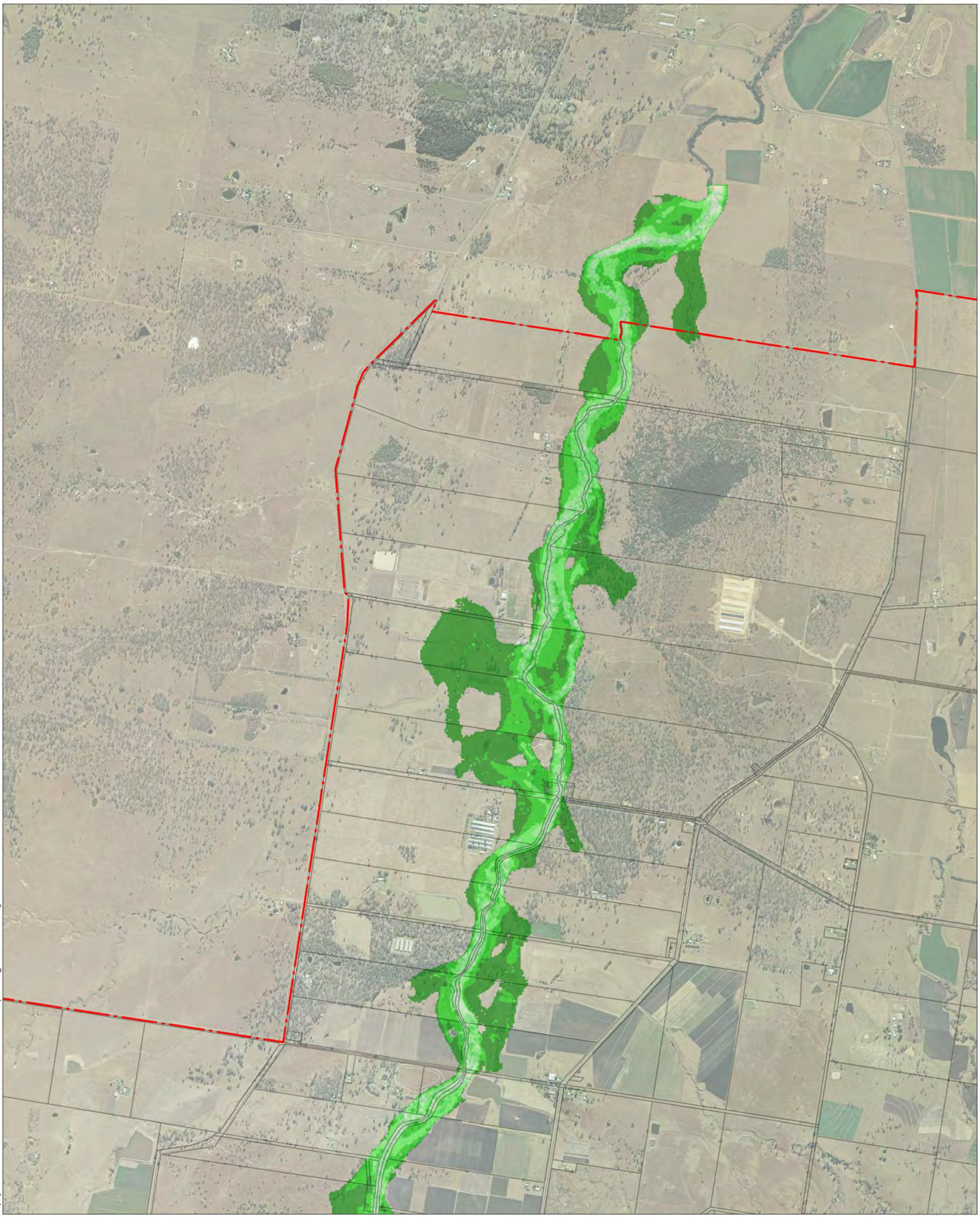
0 625 m 1,250 m

Date: 22/06/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure C2-c**

2% AEP Event - Peak Velocities



Legend

Velocity (m/s)

SRRC Boundary	0.0 to 0.5	3.0 to 3.5
Cadastral Boundary	0.5 to 1.0	3.5 to 4.0
	1.0 to 1.5	4.0 to 4.5
	1.5 to 2.0	4.5 to 5.0
	2.0 to 2.5	> 5.0
	2.5 to 3.0	

Notes:

1:25,000

0 625 m 1,250 m

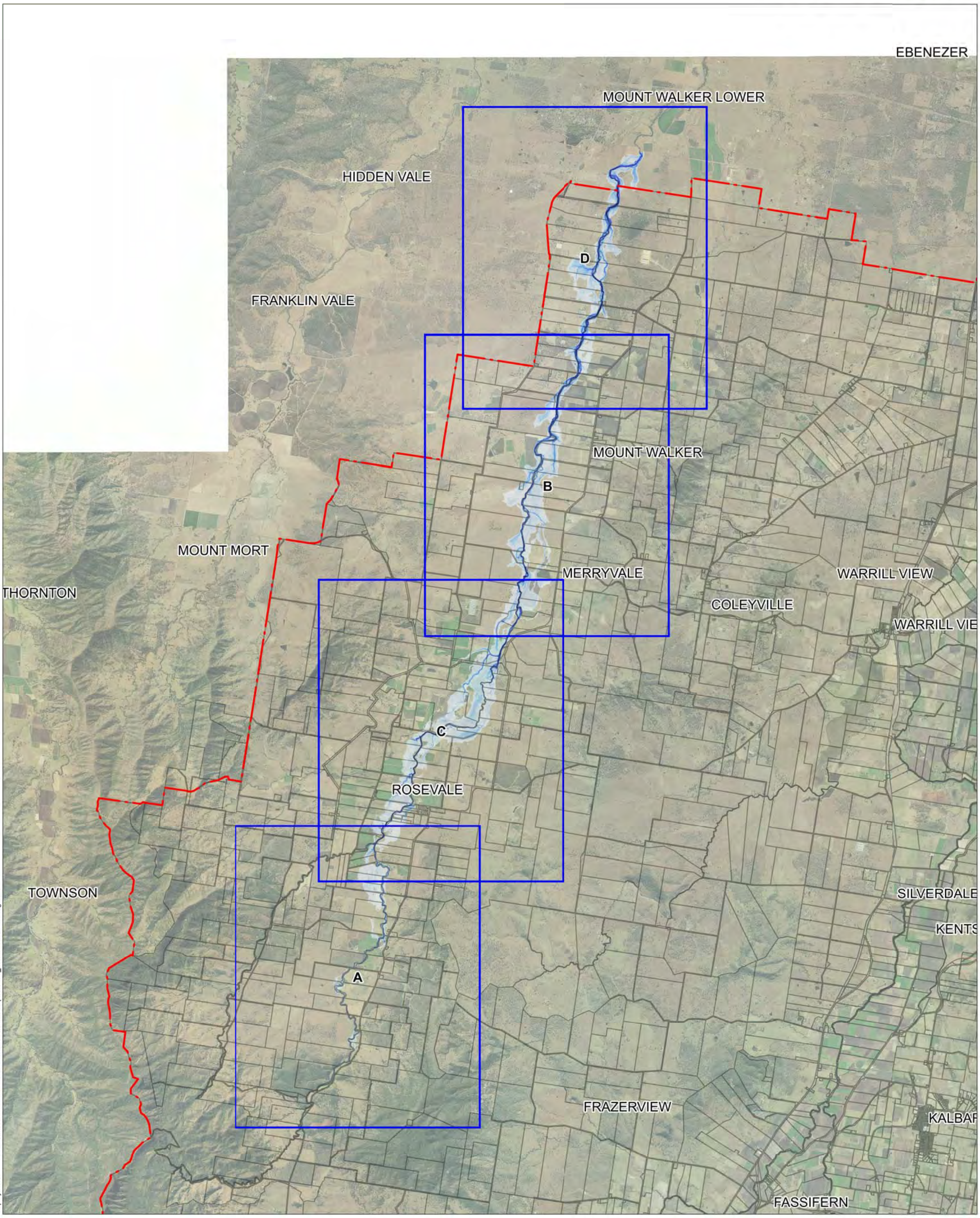
Date: 22/06/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure C2-d**

2% AEP Event - Peak Velocities

aurecon



Legend

SRRC Boundary

Cadastral Boundary

Depth (m)

- 0.0 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 2.5
- 2.5 to 3.0
- 3.0 to 3.5
- 3.5 to 4.0
- 4.0 to 4.5
- 4.5 to 5.0
- > 5.0

Notes:

1:100,000

0 2,500 m 5,000 m

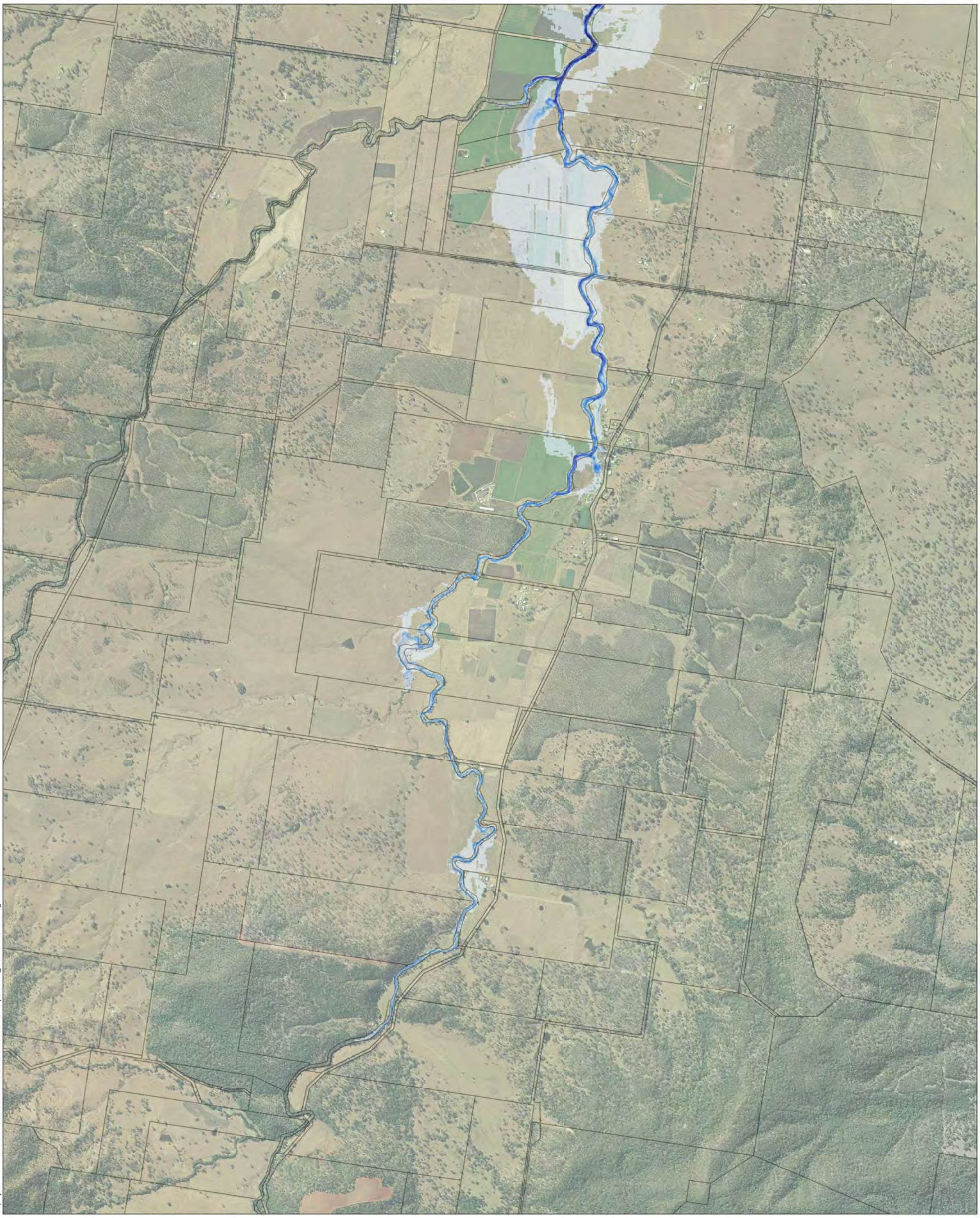
Date: 22/06/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure C3**

2% AEP Event - Peak Depth Map

aurecon



Map by: JDT P:\SWM\Work\255060 Scenic Rim Flood Models Expansion\2_Bremer River\GIS\Figures\

Legend

SRRC Boundary

Cadastral Boundary

Depth (m)

0.0 to 0.5	3.0 to 3.5
0.5 to 1.0	3.5 to 4.0
1.0 to 1.5	4.0 to 4.5
1.5 to 2.0	4.5 to 5.0
2.0 to 2.5	> 5.0
2.5 to 3.0	

Notes:

1:25,000

0 625 m 1,250 m

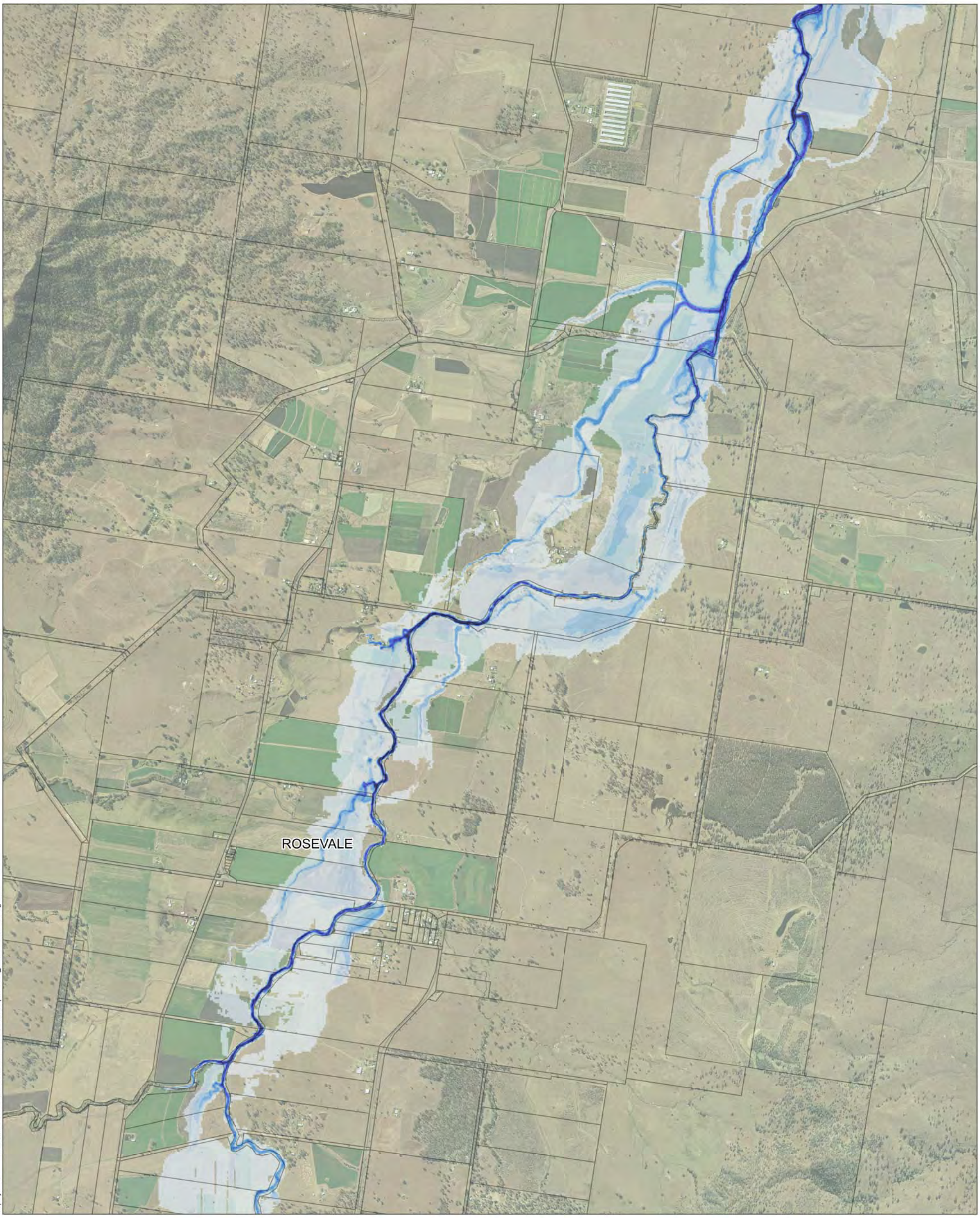
Date: 22/06/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure C3-a**

2% AEP Event - Peak Depth Map

aurecon



Legend

SRRC Boundary

Cadastral Boundary

Depth (m)

0.0 to 0.5	3.0 to 3.5
0.5 to 1.0	3.5 to 4.0
1.0 to 1.5	4.0 to 4.5
1.5 to 2.0	4.5 to 5.0
2.0 to 2.5	> 5.0
2.5 to 3.0	

Notes:

1:25,000

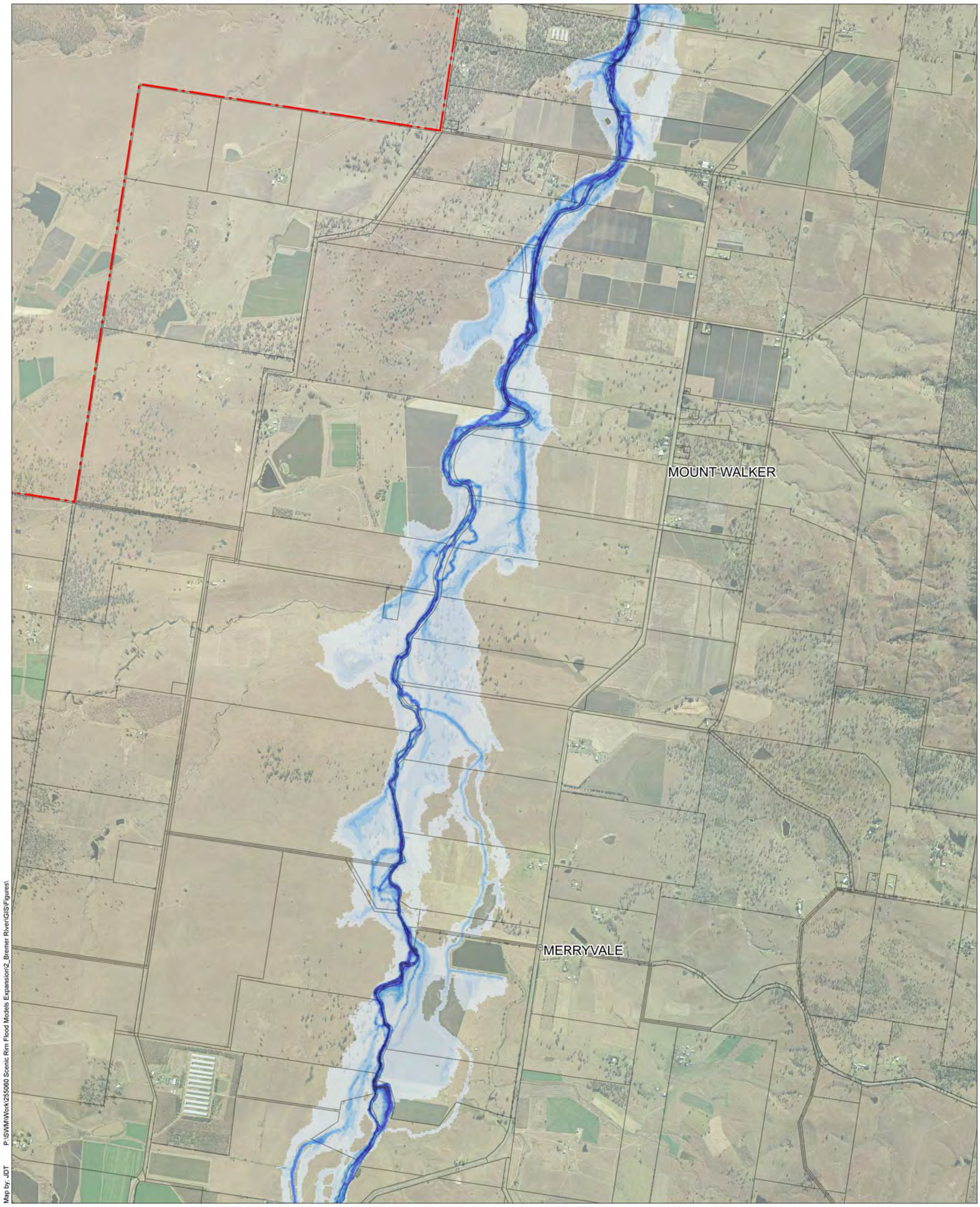
0 625 m 1,250 m

Date: 22/06/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure C3-b**

2% AEP Event - Peak Depth Map



Legend

SRRC Boundary
Cadastral Boundary

Depth (m)

- 0.0 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 2.5
- 2.5 to 3.0
- 3.0 to 3.5
- 3.5 to 4.0
- 4.0 to 4.5
- 4.5 to 5.0
- > 5.0

Notes:

1:25,000

0 625 m 1,250 m

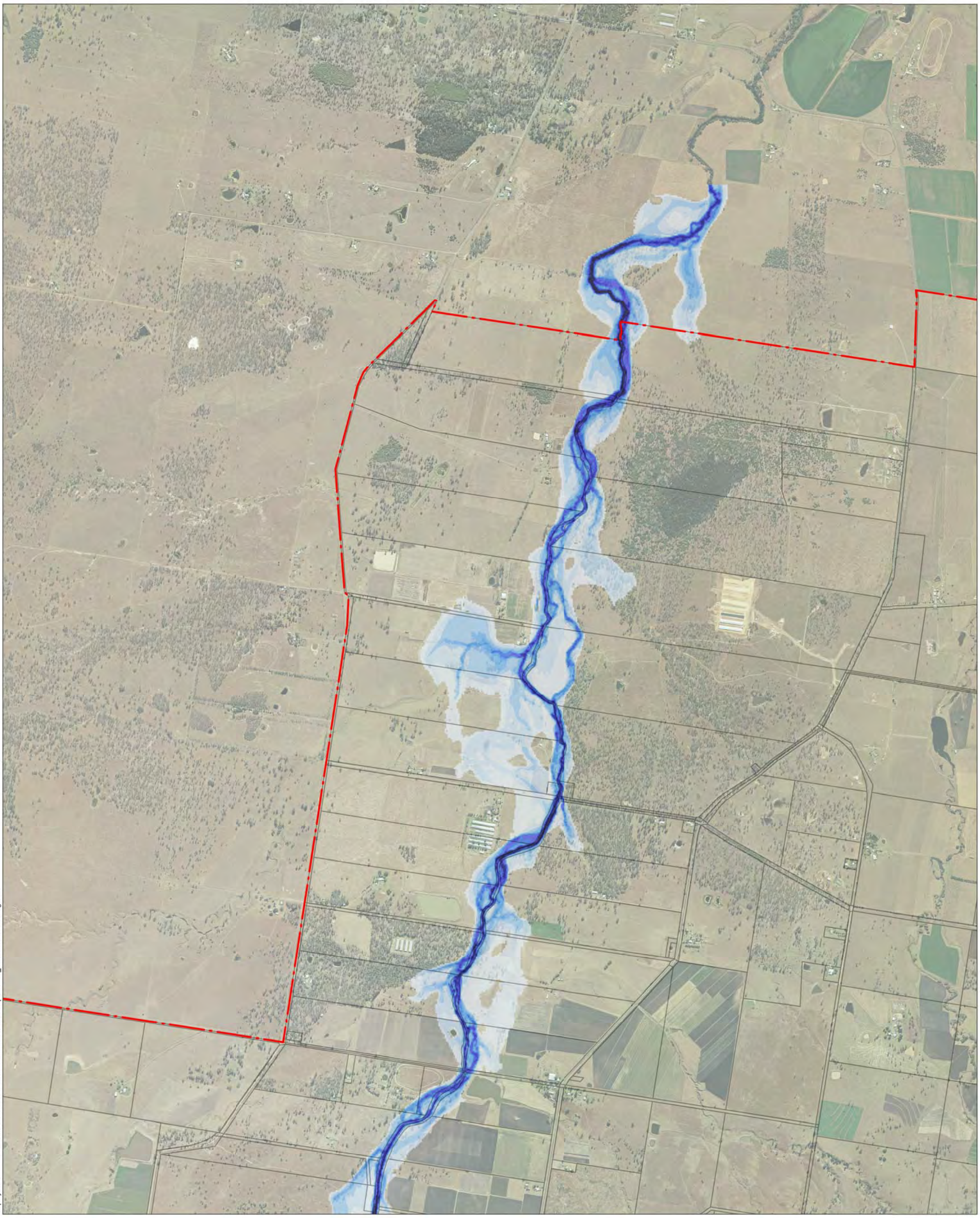
Date: 22/06/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure C3-c**

2% AEP Event - Peak Depth Map

aurecon



Legend

Depth (m)

SRRC Boundary	0.0 to 0.5
Cadastral Boundary	0.5 to 1.0
	1.0 to 1.5
	1.5 to 2.0
	2.0 to 2.5
	2.5 to 3.0
	3.0 to 3.5
	3.5 to 4.0
	4.0 to 4.5
	4.5 to 5.0
	> 5.0

Notes:

1:25,000

0 625 m 1,250 m

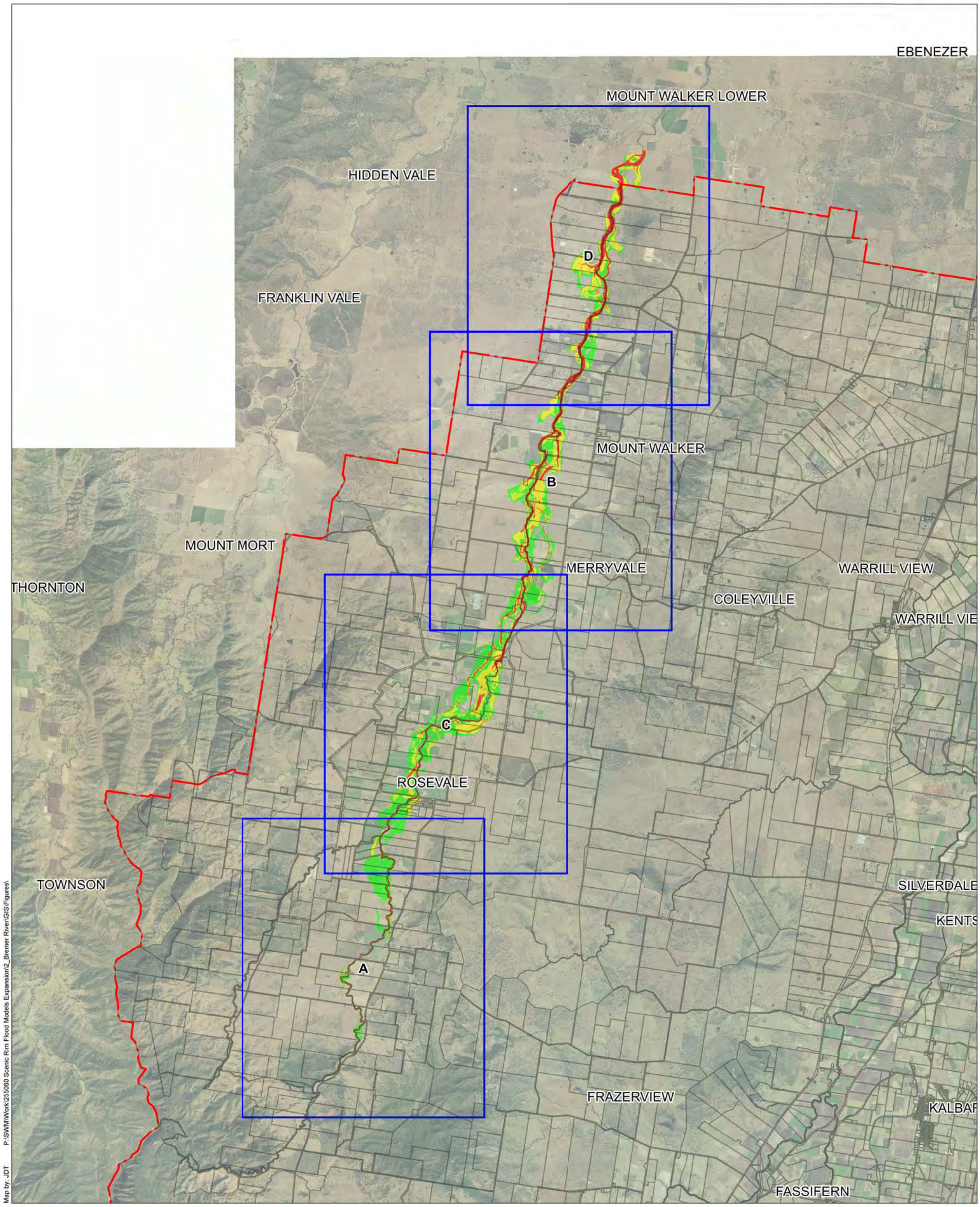
Date: 22/06/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure C3-d**

2% AEP Event - Peak Depth Map

aurecon



Legend

SRRC Boundary
Cadastral Boundary

Low Hazard
Medium Hazard
High Hazard

Notes:

1:100,000

0 2,500 m 5,000 m

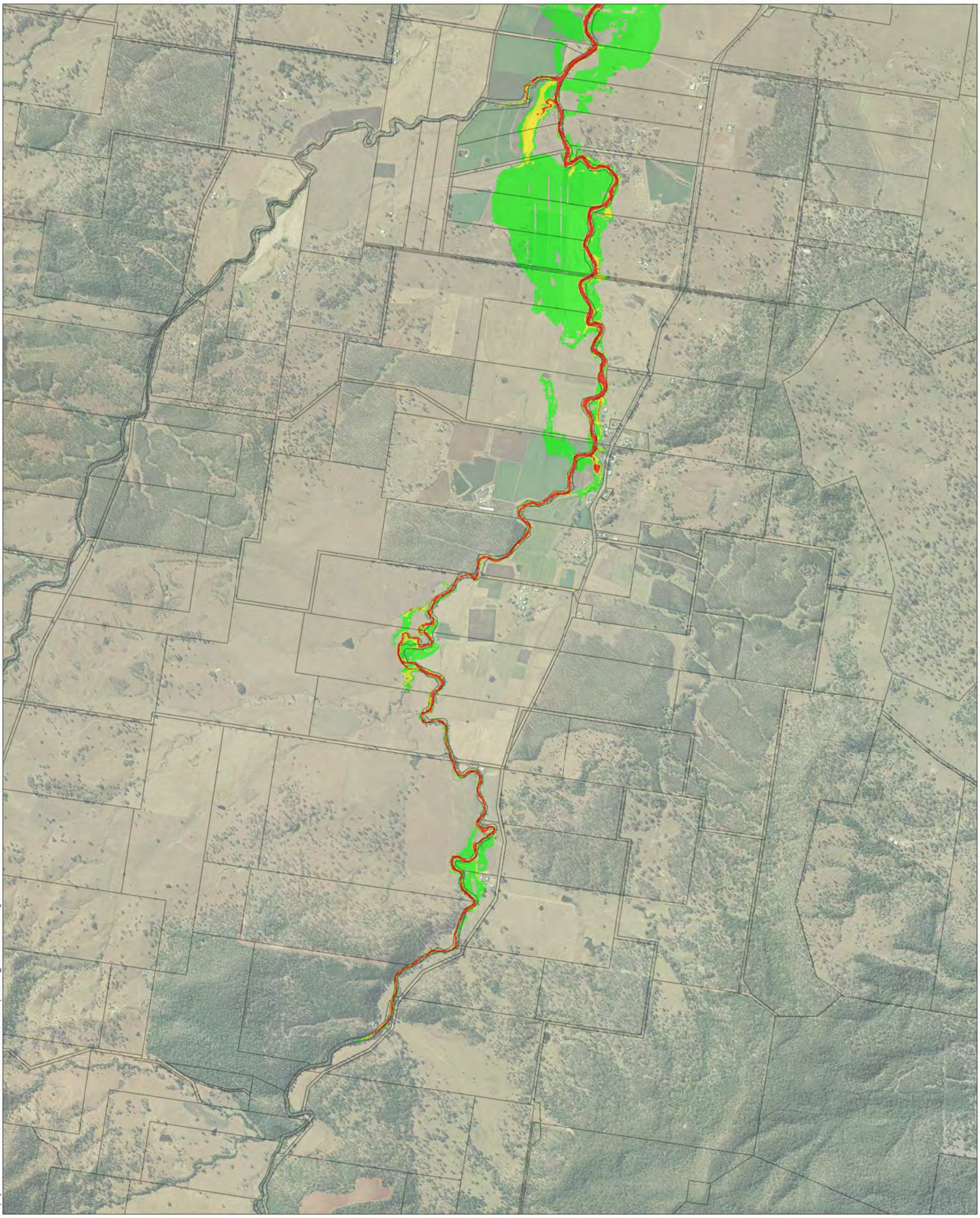
Date: 22/06/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure C4**

2% AEP Event - Peak Hazard Map

aurecon



Legend

SRRC Boundary
Cadastral Boundary

Low Hazard
Medium Hazard
High Hazard

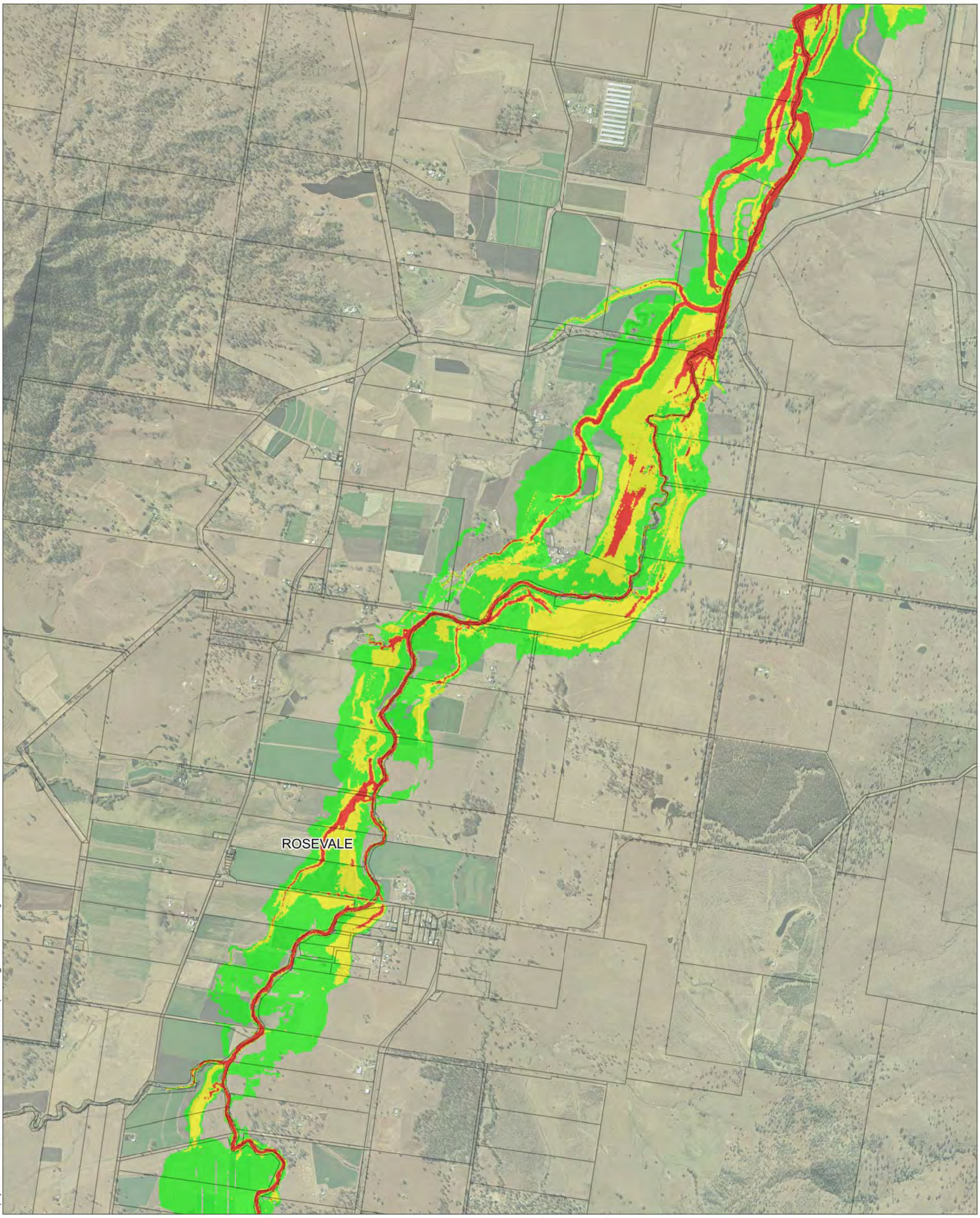
Notes:

1:25,000
0 625 m 1,250 m

Date: 22/06/2017 Version: 0 Job No: 255060
Projection: MGA Zone 56

Bremer River Flood Study **Figure C4-a**

2% AEP Event - Peak Hazard Map



Legend

SRRC Boundary
Cadastral Boundary
Low Hazard
Medium Hazard
High Hazard

Notes:

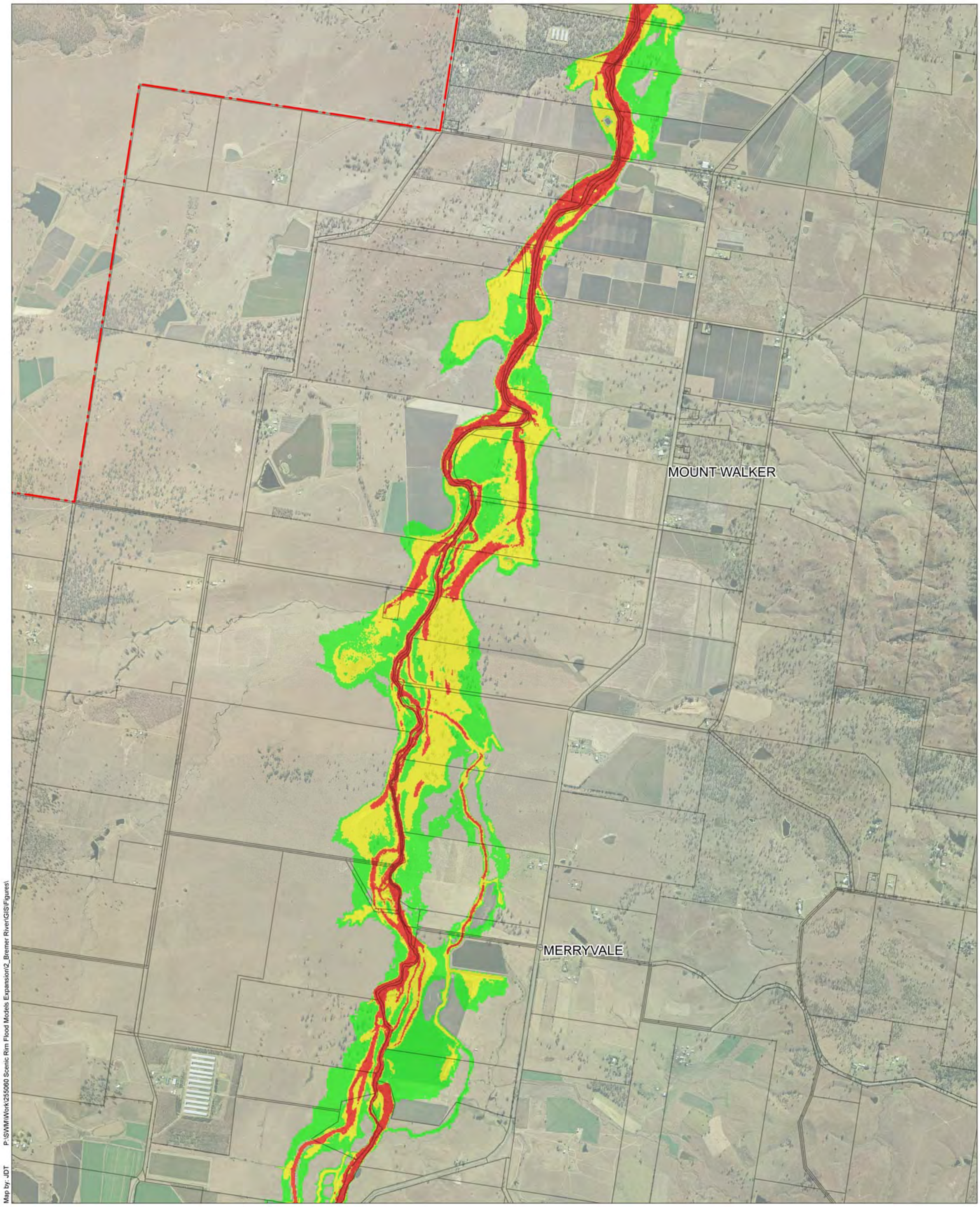
1:25,000
0 625 m 1,250 m

Date: 22/06/2017 Version: 0 Job No: 255060
Projection: MGA Zone 56

Bremer River Flood Study **Figure C4-b**

2% AEP Event - Peak Hazard Map

aurecon



Legend

SRRC Boundary

Cadastral Boundary

Low Hazard

Medium Hazard

High Hazard

Notes:

1:25,000

0 625 m 1,250 m

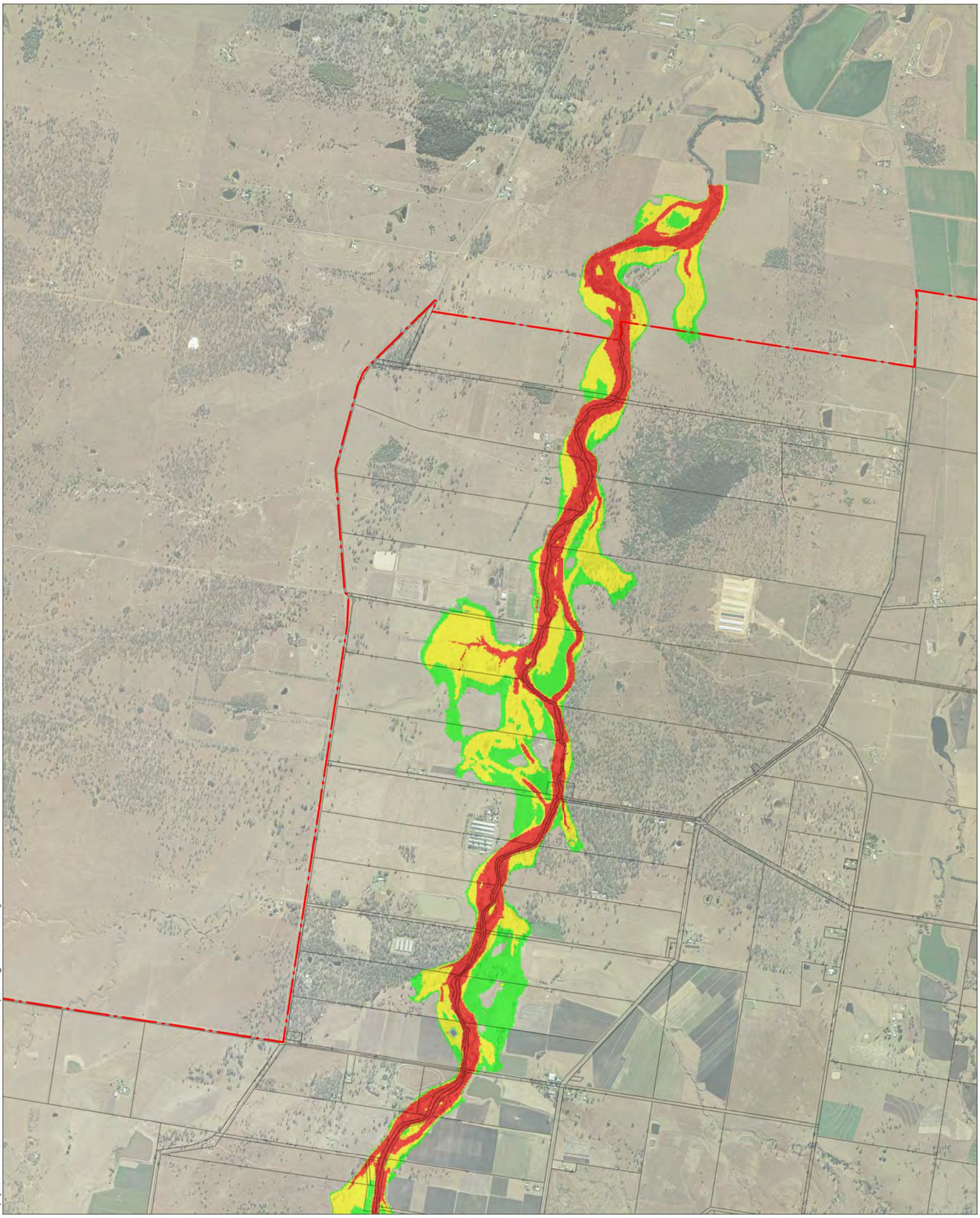
Date: 22/06/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure C4-c**

2% AEP Event - Peak Hazard Map

aurecon



Map by: JDT P:\SWM\Work\255060 Scenic Rim Flood Models Expansion\2_Bremer River\GIS\Figures\

Legend

- SRRC Boundary
- Cadastral Boundary
- Low Hazard
- Medium Hazard
- High Hazard

Notes:

1:25,000

0 625 m 1,250 m

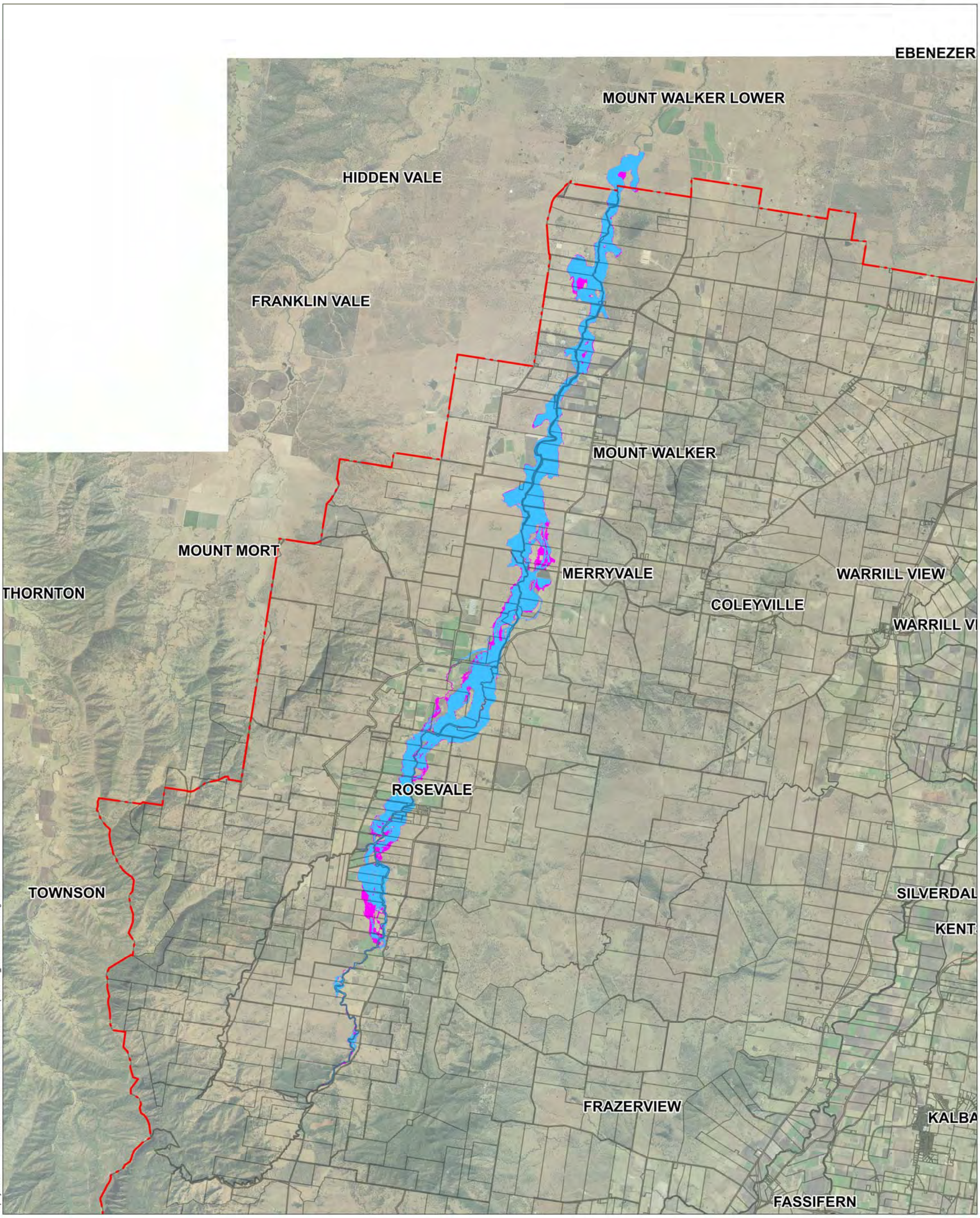
Date: 22/06/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure C4-d**

2% AEP Event - Peak Hazard Map

aurecon



Map by: JDT   P:\SWM\Work\255060 Scenic Rim Flood Models Expansion\2_Bremer River\GIS\Figures\

Legend

SRRC Boundary

Cadastral Boundary

Existing Scenario Inundation Extents

Climate Change Scenario 4.5 Inundation Extent

Notes:

1:50,000

0   1,250 m   2,500 m

Date: 22/06/2017   Version: 0   Job No: 255060

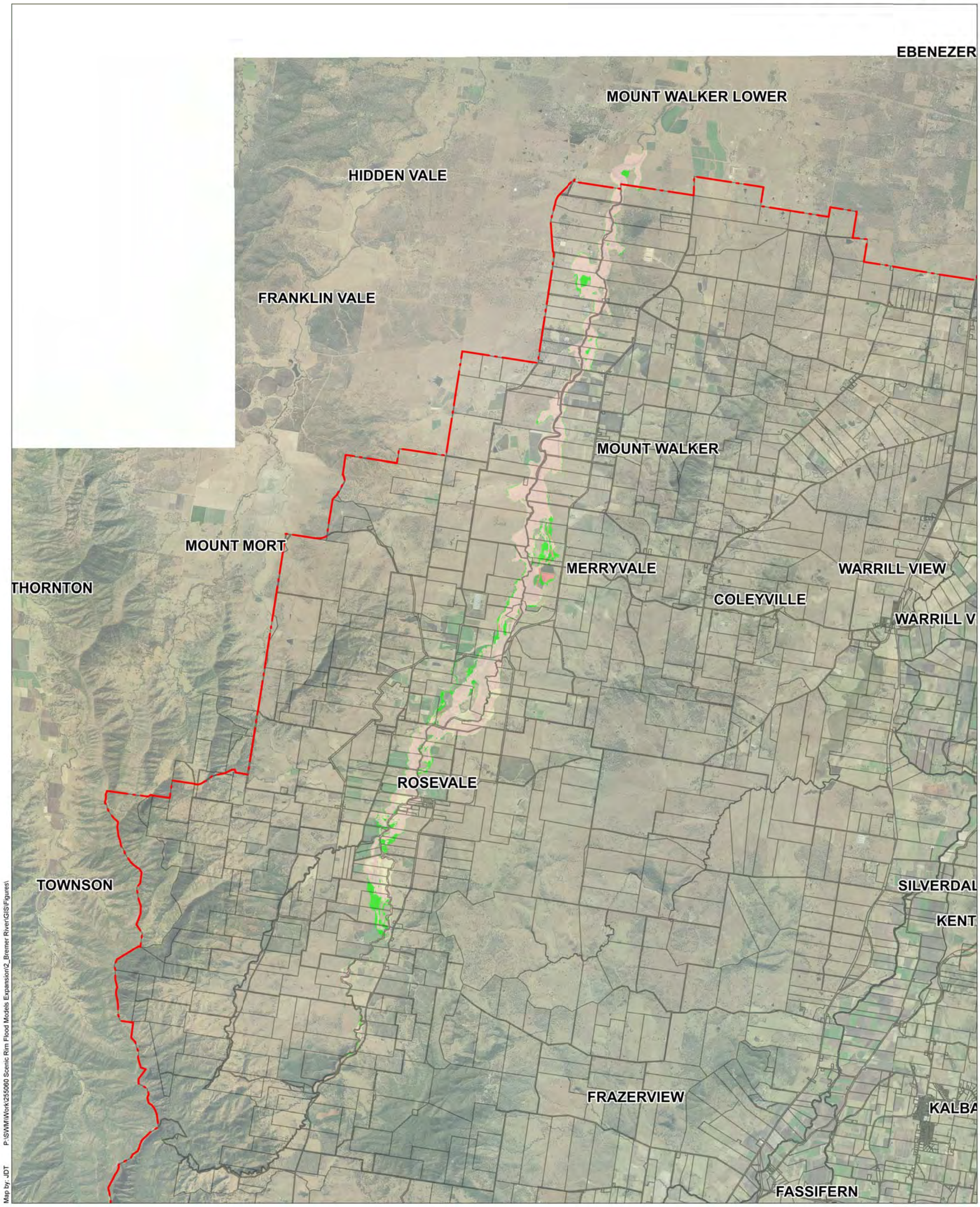
Projection: MGA Zone 56

Bremer River Flood Study

Figure C5-a

Climate Change Scenario 4.5 - 2% AEP Event Inundation Extent

aurecon



Legend

SRRC Boundary

Cadastral Boundary

Afflux (m)

< -0.80
-0.80 to -0.60
-0.60 to -0.40
-0.40 to -0.20
-0.20 to -0.03
-0.03 to 0.03
0.03 to 0.20
0.20 to 0.40
0.40 to 0.60
0.60 to 0.80
0.80 to 1.20
> 1.20
Was Dry Now Wet
Was Wet Now Dry

Notes:

1:50,000

0 1,250 m 2,500 m

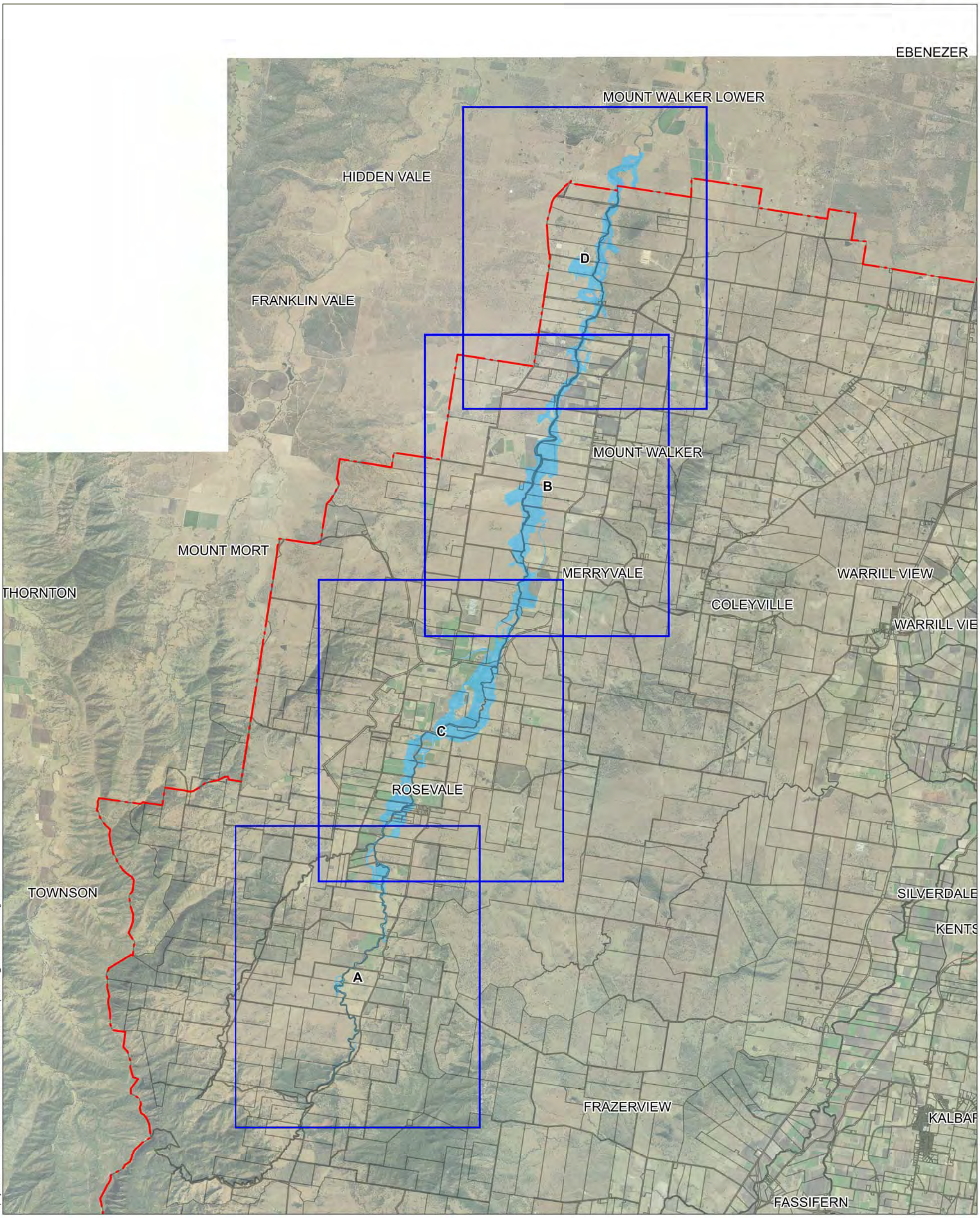
Date: 22/06/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study

Figure C5-b

Climate Change Scenario 4.5 - 2% AEP Event Afflux Map



Map by: JDT P:\SWM\Work\255060 Scenic Rim Flood Models Expansion\2_Bremer River\GIS\Figures\

Legend

SRRC Boundary

Cadastral Boundary

Inundation Extent

Peak Water level Contour (mAHD)

Notes:

1:100,000

0 2,500 m 5,000 m

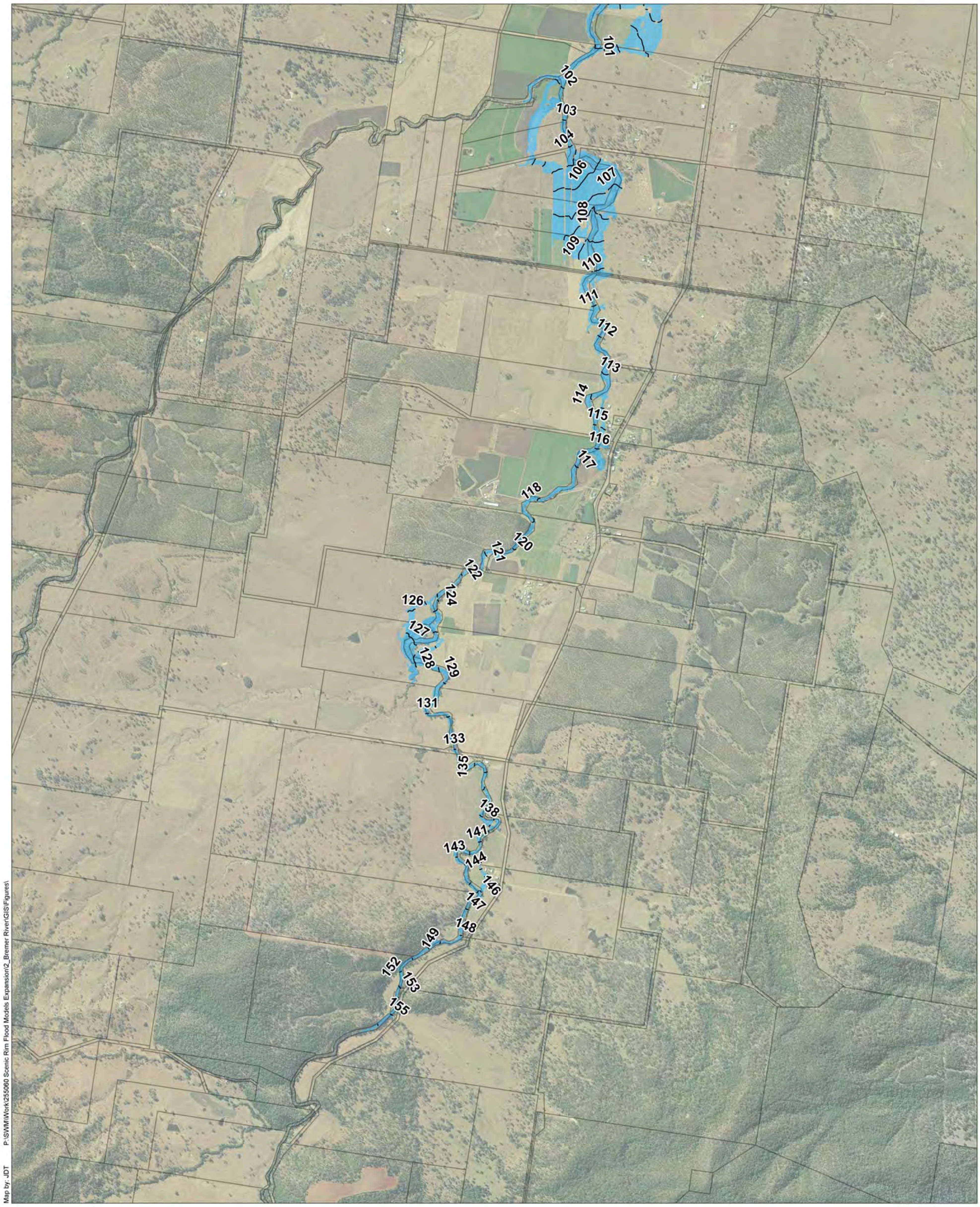
Date: 22/06/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure D1**

5% AEP Event - Inundation Extent

aurecon



Legend

SRRC Boundary

Cadastral Boundary

Inundation Extent

Peak Water level Contour (mAHD)

Notes:

1:25,000

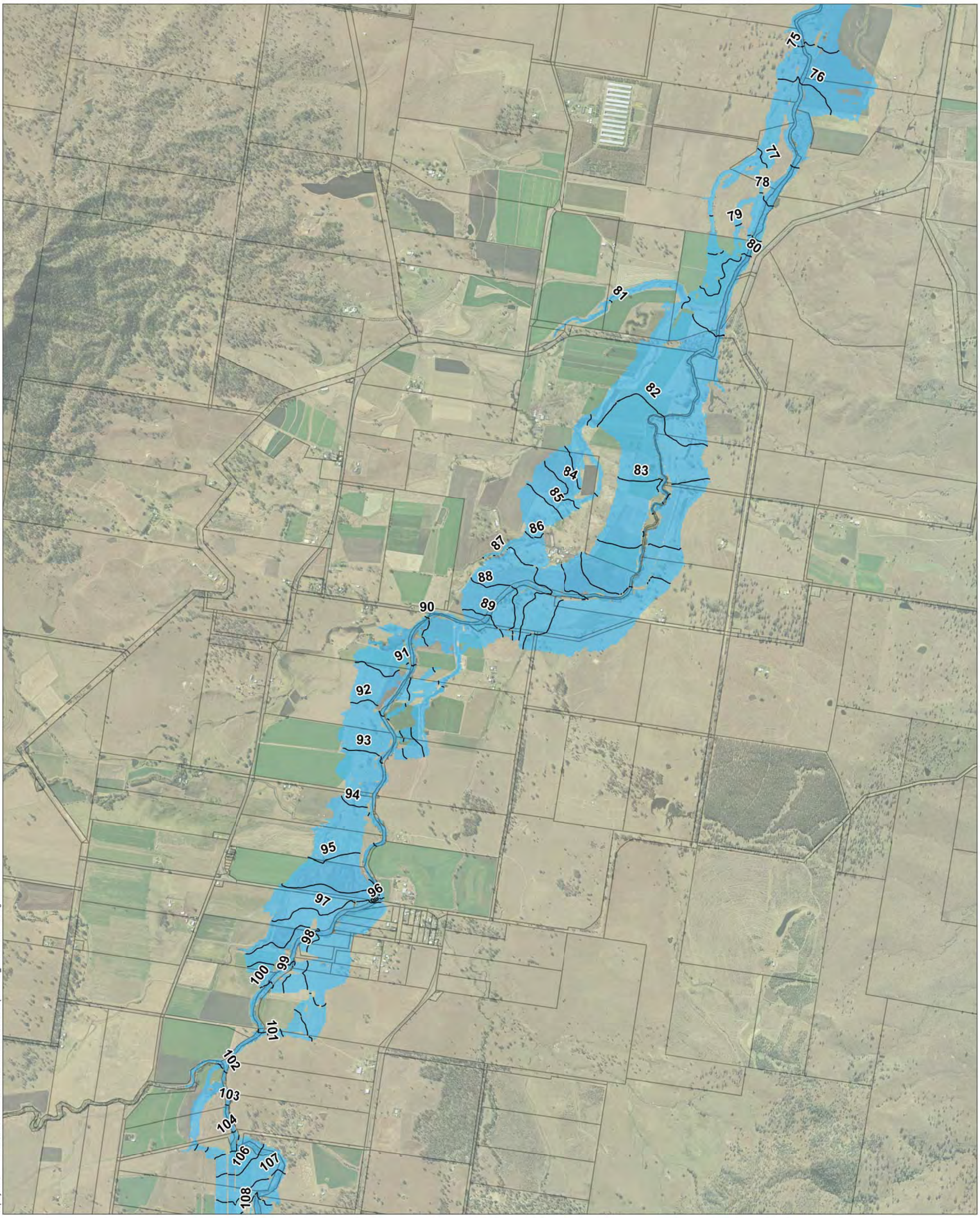
0 625 m 1,250 m

Date: 22/06/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure D1-a**

5% AEP Event - Inundation Extent



Map by: JDT P:\SWM\Work\255060 Scenic Rim Flood Models Expansion\2_Bremer River\GIS\Figures\

aurecon

Legend

SRRC Boundary

Cadastral Boundary

Inundation Extent

Peak Water level Contour (mAHD)

Notes:

1:25,000

0 625 m 1,250 m

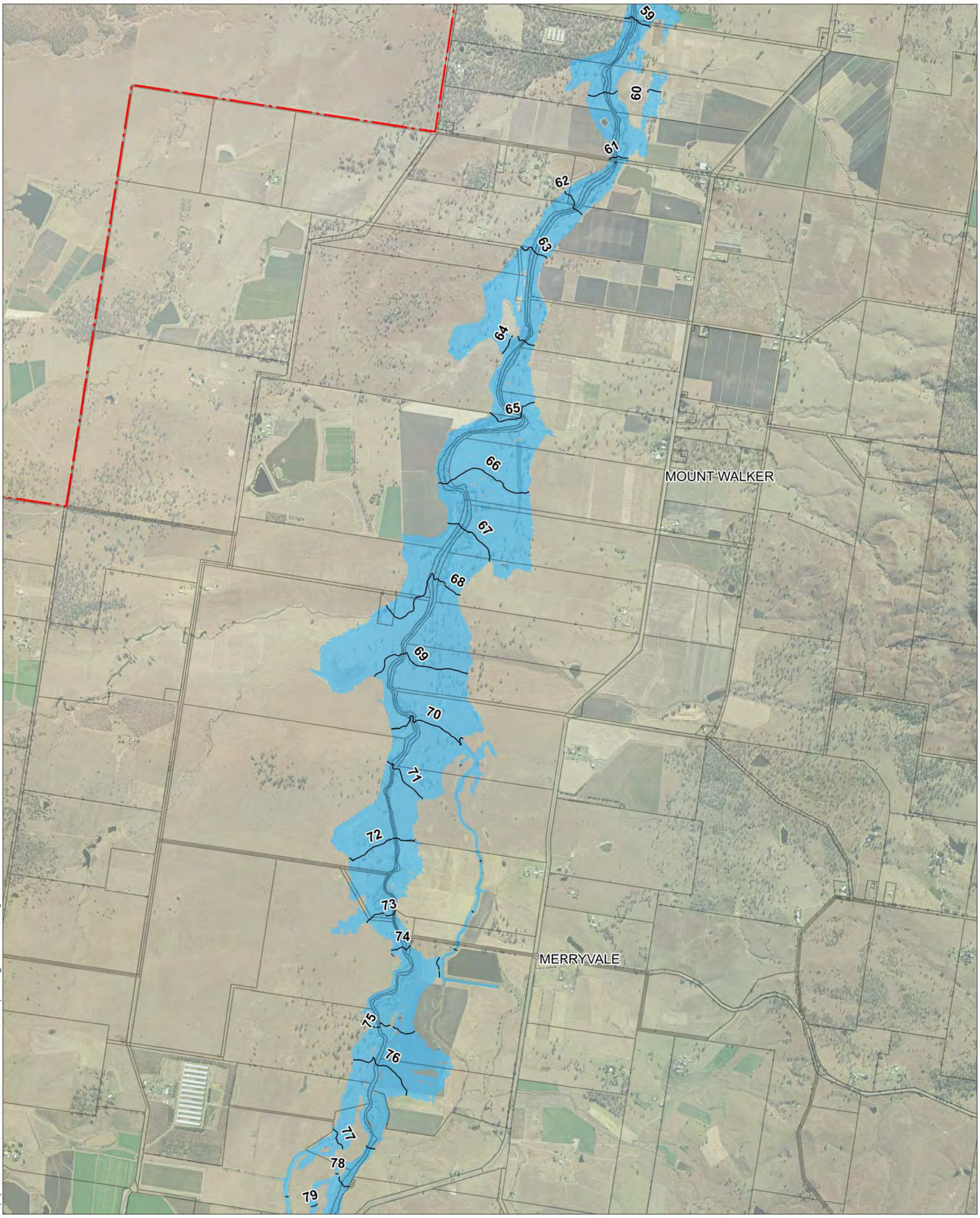
Date: 22/06/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure D1-b**

5% AEP Event - Inundation Extent

aurecon



Map by: JDT P:\SWM\Work\255060 Scenic Rim Flood Models Expansion\2_Bremer River\GIS\Figures\

Legend

SRRC Boundary

Cadastral Boundary

Inundation Extent

Peak Water level Contour (mAHD)

Notes:

1:25,000

0 625 m 1,250 m

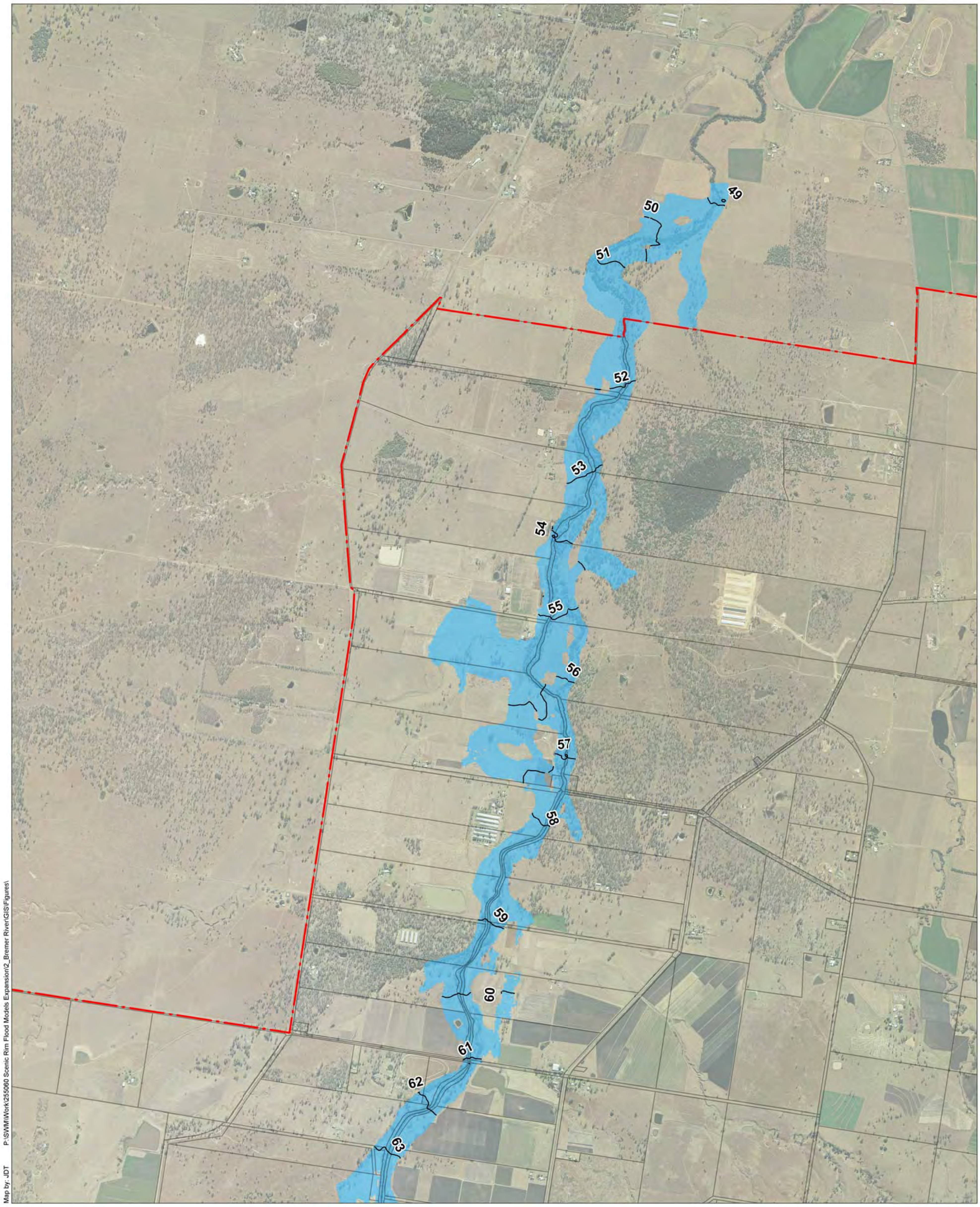
Date: 22/06/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure D1-c**

5% AEP Event - Inundation Extent

aurecon



Legend

SRRC Boundary

Cadastral Boundary

Inundation Extent

Peak Water level Contour (mAHD)

Notes:

1:25,000

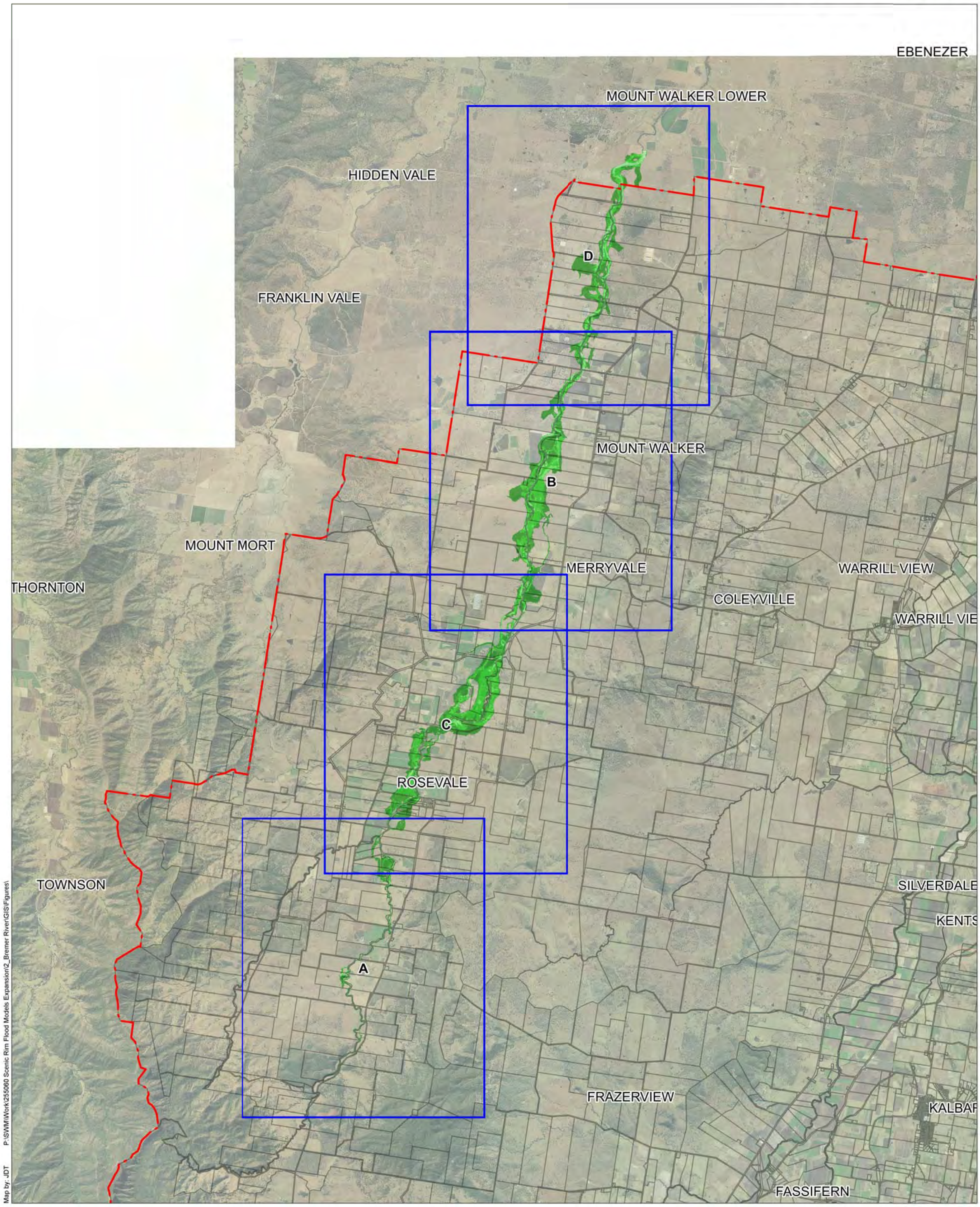
0 625 m 1,250 m

Date: 22/06/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study Figure D1-d

5% AEP Event - Inundation Extent



Legend

Velocity (m/s)

SRRC Boundary
Cadastral Boundary

0.0 to 0.5
0.5 to 1.0
1.0 to 1.5
1.5 to 2.0
2.0 to 2.5
2.5 to 3.0
3.0 to 3.5
3.5 to 4.0
4.0 to 4.5
4.5 to 5.0
> 5.0

Notes:

1:100,000

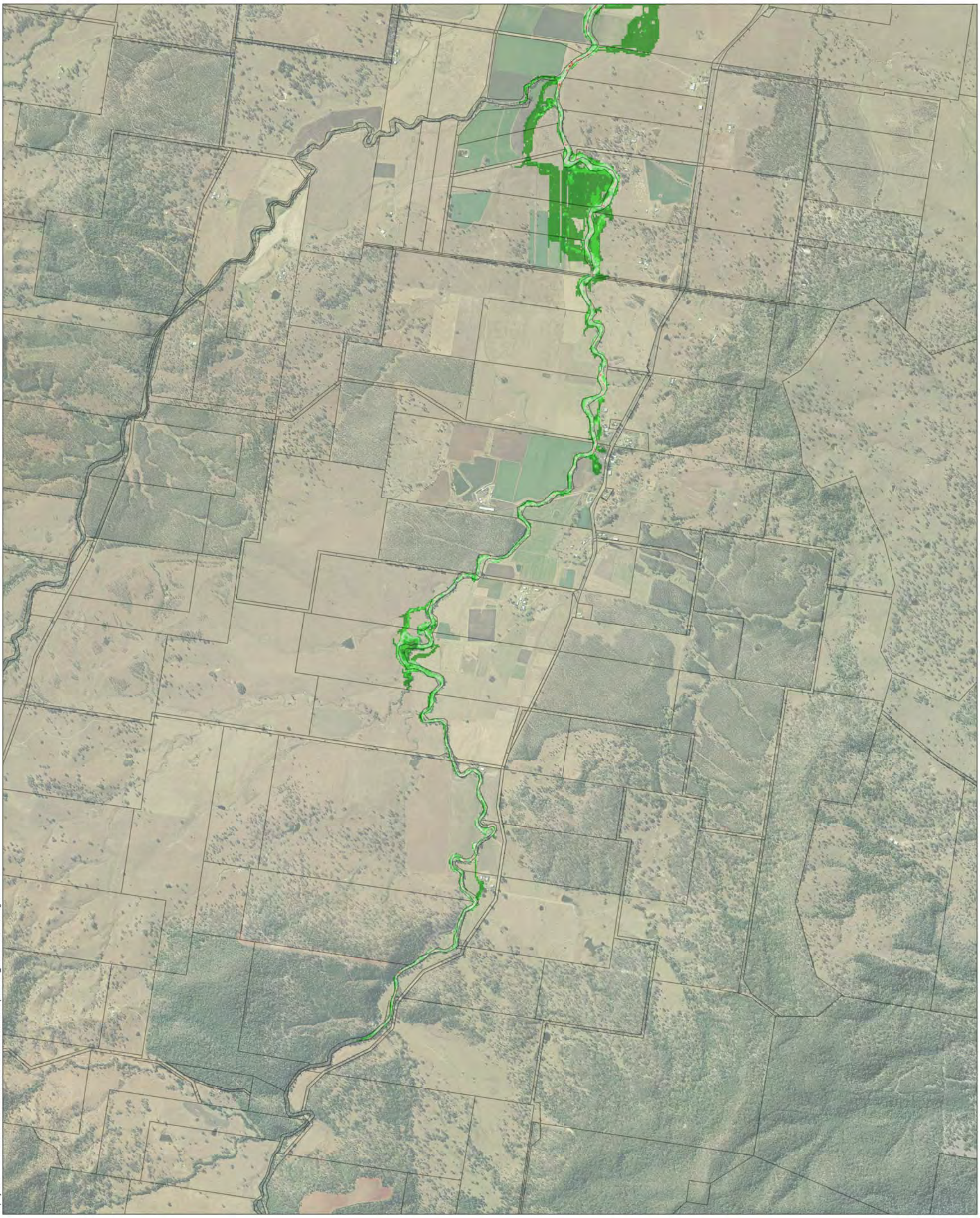
0 — 2,500 m — 5,000 m

Date: 22/06/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure D2**

5% AEP Event - Peak Velocities



Map by: JDT P:\SWM\Work\255060 Scenic Rim Flood Models Expansion\2_Bremer River\GIS\Figures\

Legend

SRRC Boundary	
Cadastral Boundary	

Velocity (m/s)

0.0 to 0.5	3.0 to 3.5
0.5 to 1.0	3.5 to 4.0
1.0 to 1.5	4.0 to 4.5
1.5 to 2.0	4.5 to 5.0
2.0 to 2.5	> 5.0
2.5 to 3.0	

Notes:

1:25,000

0 625 m 1,250 m

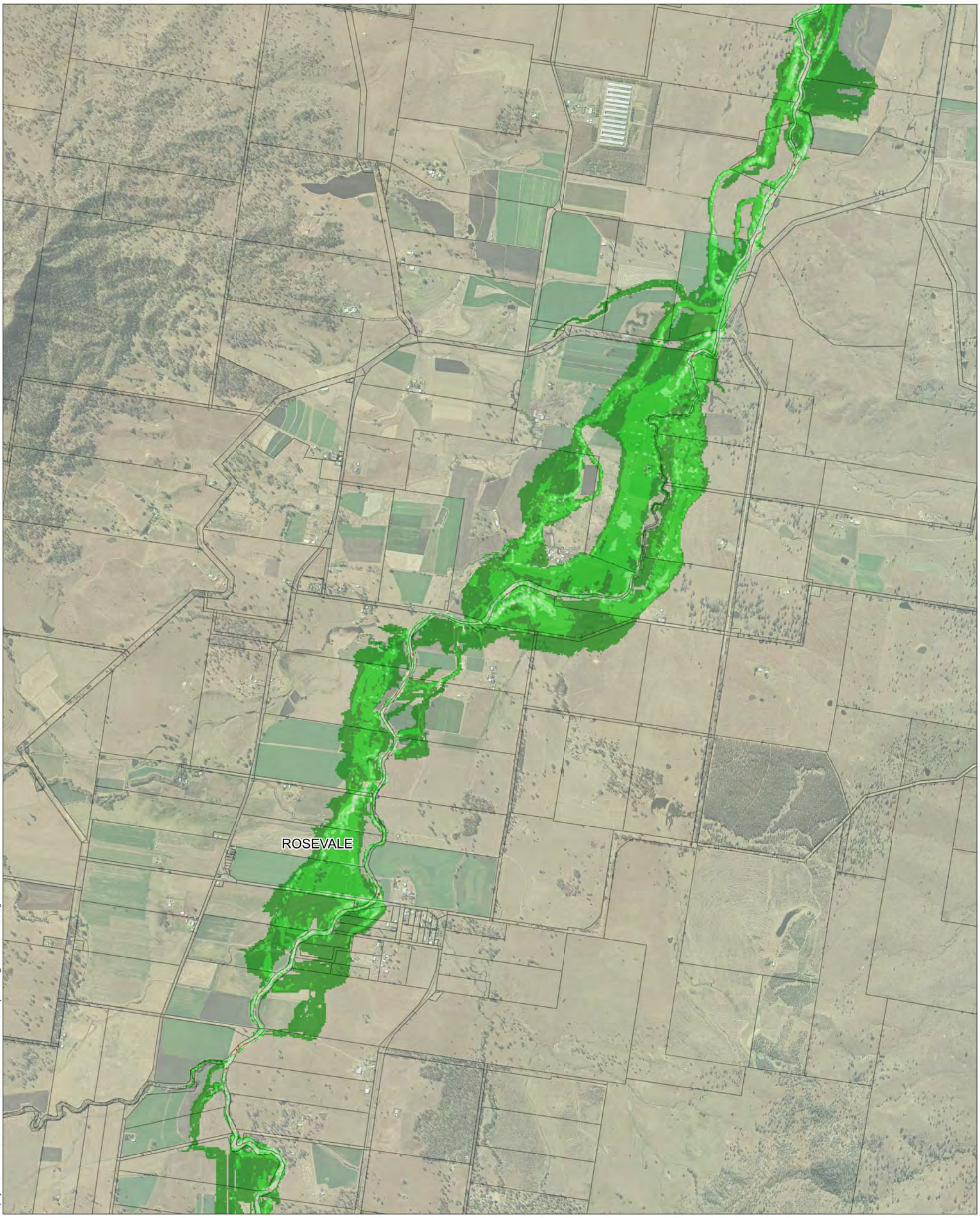
Date: 22/06/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure D2-a**

5% AEP Event - Peak Velocities

aurecon



Map by: JDT P:\SWM\Work\255060 Scenic Rim Flood Models Expansion\2_Bremer River\GIS\Figures\

Legend

SRRC Boundary

Cadastral Boundary

Velocity (m/s)

- 0.0 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 2.5
- 2.5 to 3.0
- 3.0 to 3.5
- 3.5 to 4.0
- 4.0 to 4.5
- 4.5 to 5.0
- > 5.0

Notes:

1:25,000

0 625 m 1,250 m

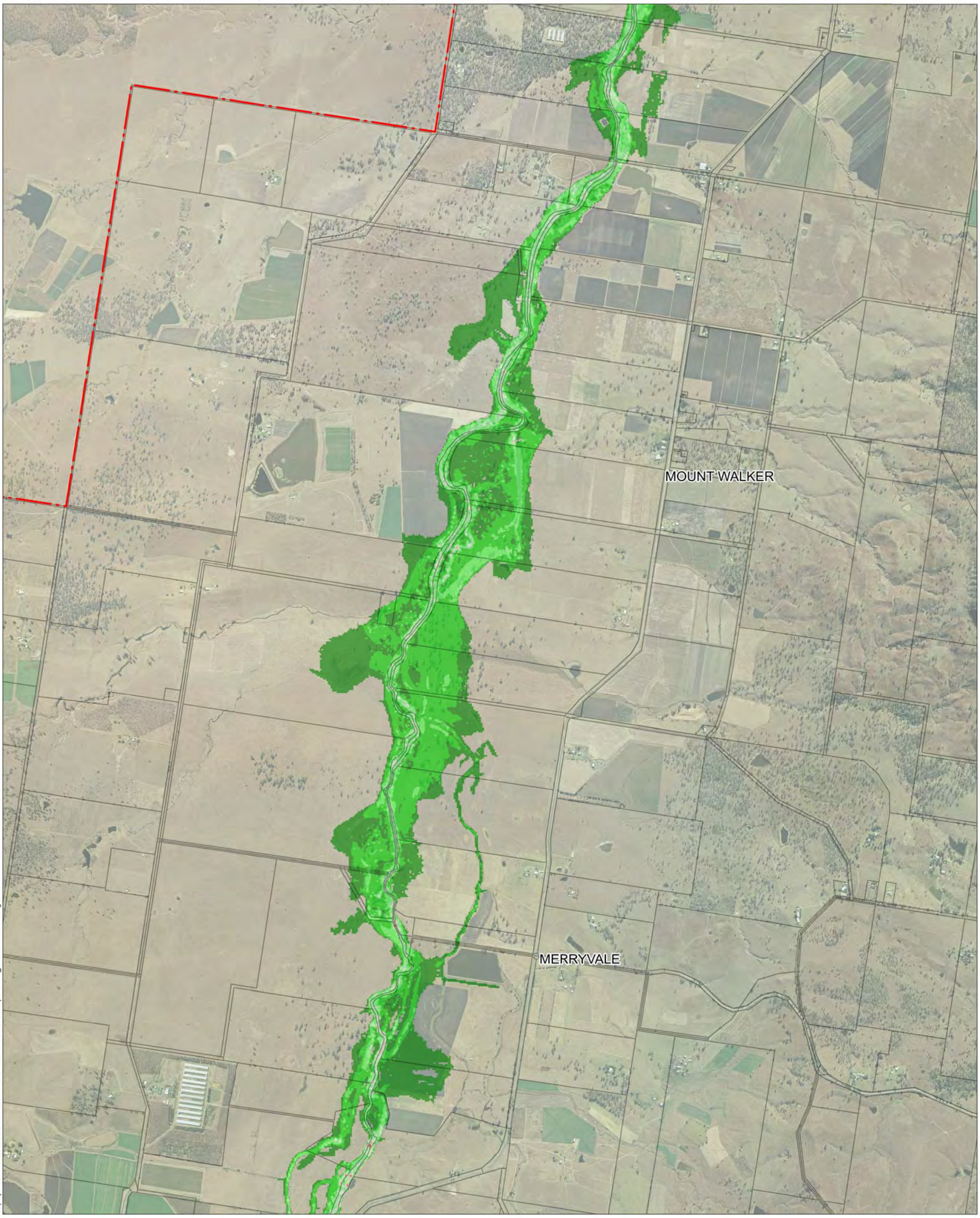
Date: 22/06/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure D2-b**

5% AEP Event - Peak Velocities

aurecon



Map by: JDT P:\SWM\Work\255060 Scenic Rim Flood Models Expansion\2_Bremer River\GIS\Figures\

Legend

SRRC

Cadastral

Velocity (m/s)

- 0.0 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 2.5
- 2.5 to 3.0
- 3.0 to 3.5
- 3.5 to 4.0
- 4.0 to 4.5
- 4.5 to 5.0
- > 5.0

Notes:

1:25,000

0 625 m 1,250 m

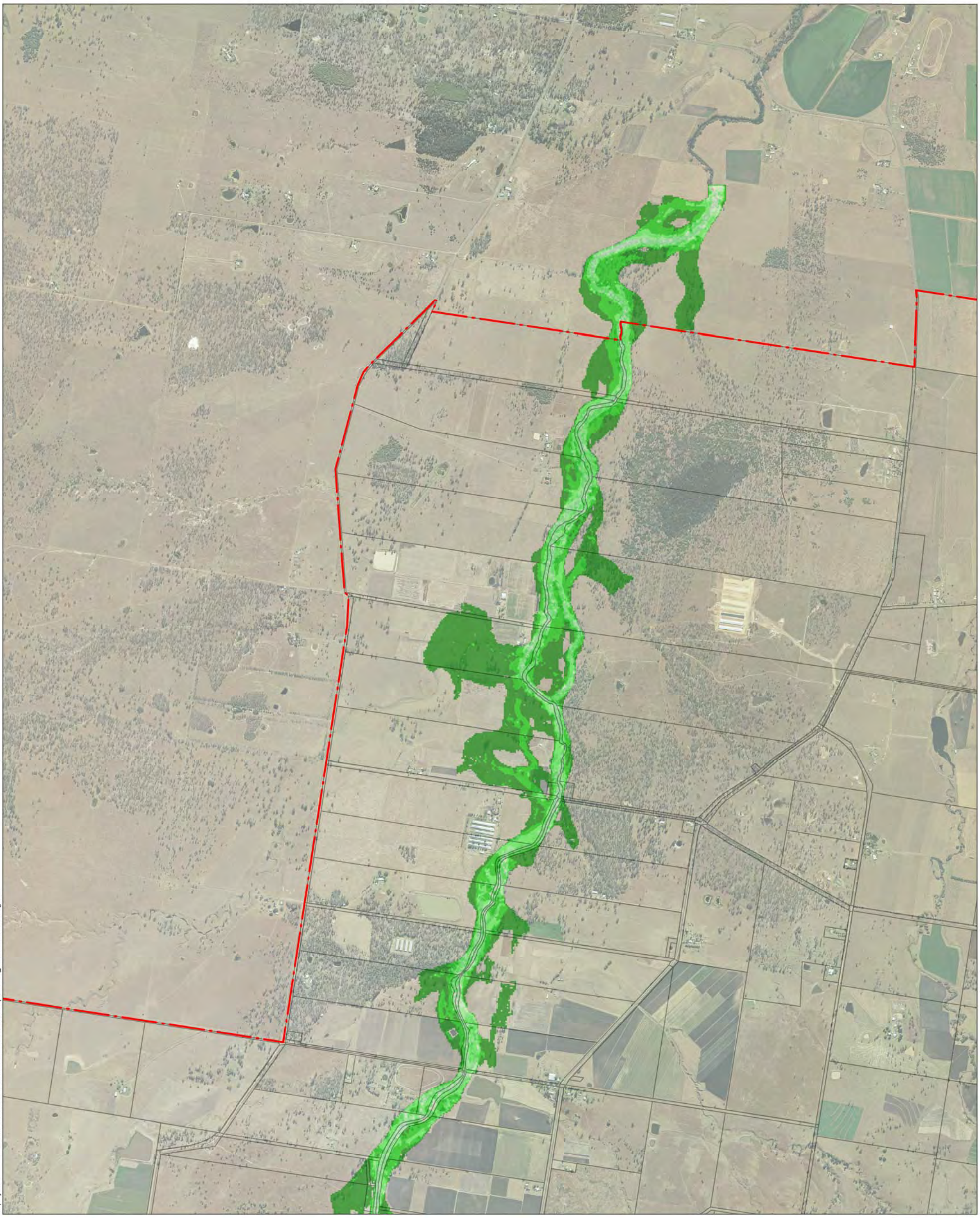
Date: 22/06/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure D2-c**

5% AEP Event - Peak Velocities

aurecon



Map by: JDT P:\SWM\Work\255060 Scenic Rim Flood Models Expansion\2_Bremer River\GIS\Figures\

Legend

SRRC Boundary

Cadastral Boundary

Velocity (m/s)

- 0.0 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 2.5
- 2.5 to 3.0
- 3.0 to 3.5
- 3.5 to 4.0
- 4.0 to 4.5
- 4.5 to 5.0
- > 5.0

Notes:

1:25,000

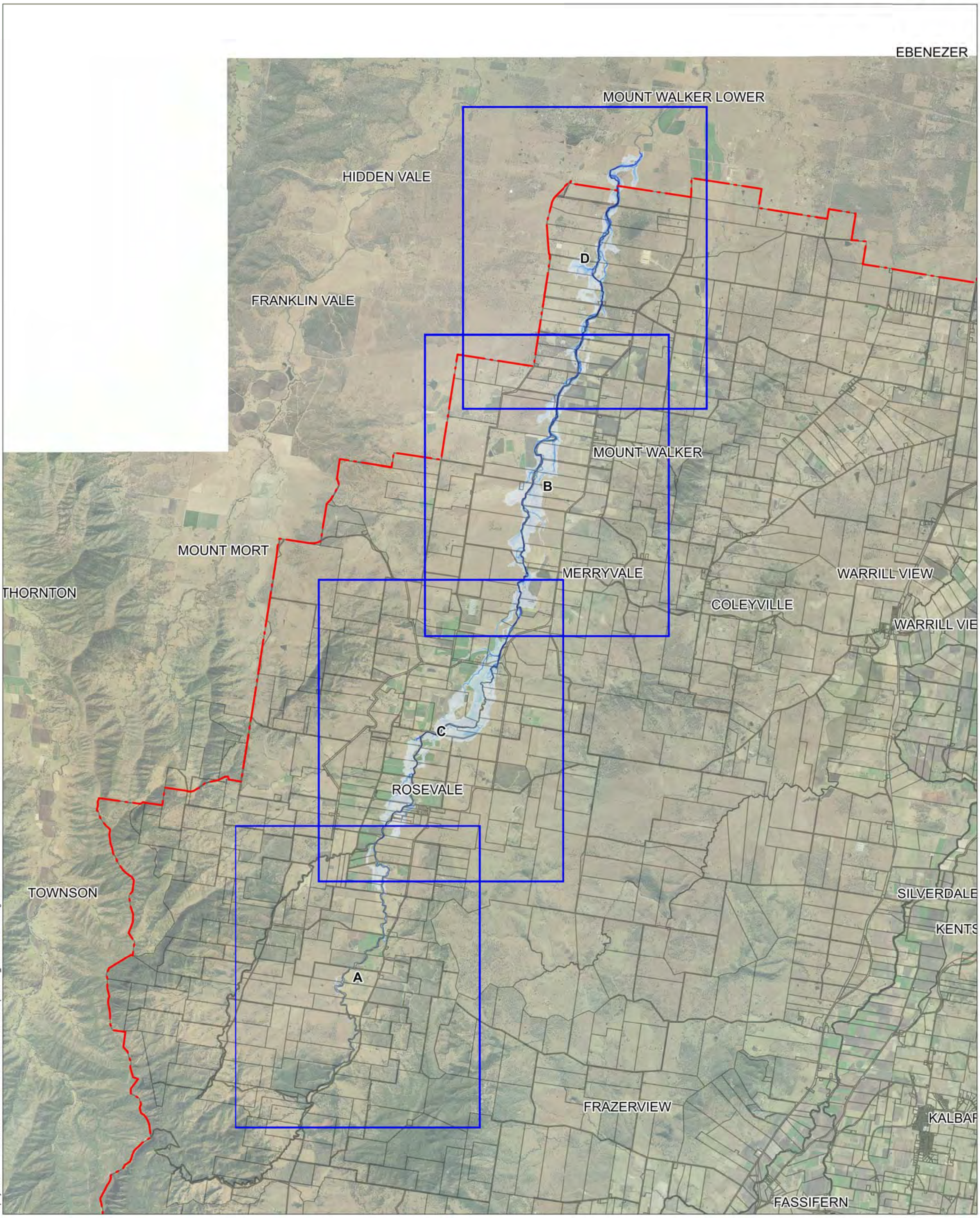
0 625 m 1,250 m

Date: 22/06/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure D2-d**

5% AEP Event - Peak Velocities



Map by: JDT P:\SWM\Work\255060 Scenic Rim Flood Models Expansion\2_Bremer River\GIS\Figures\

Legend

SRRC Boundary

Cadastral Boundary

Depth (m)

- 0.0 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 2.5
- 2.5 to 3.0
- 3.0 to 3.5
- 3.5 to 4.0
- 4.0 to 4.5
- 4.5 to 5.0
- > 5.0

Notes:

1:100,000

0 2,500 m 5,000 m

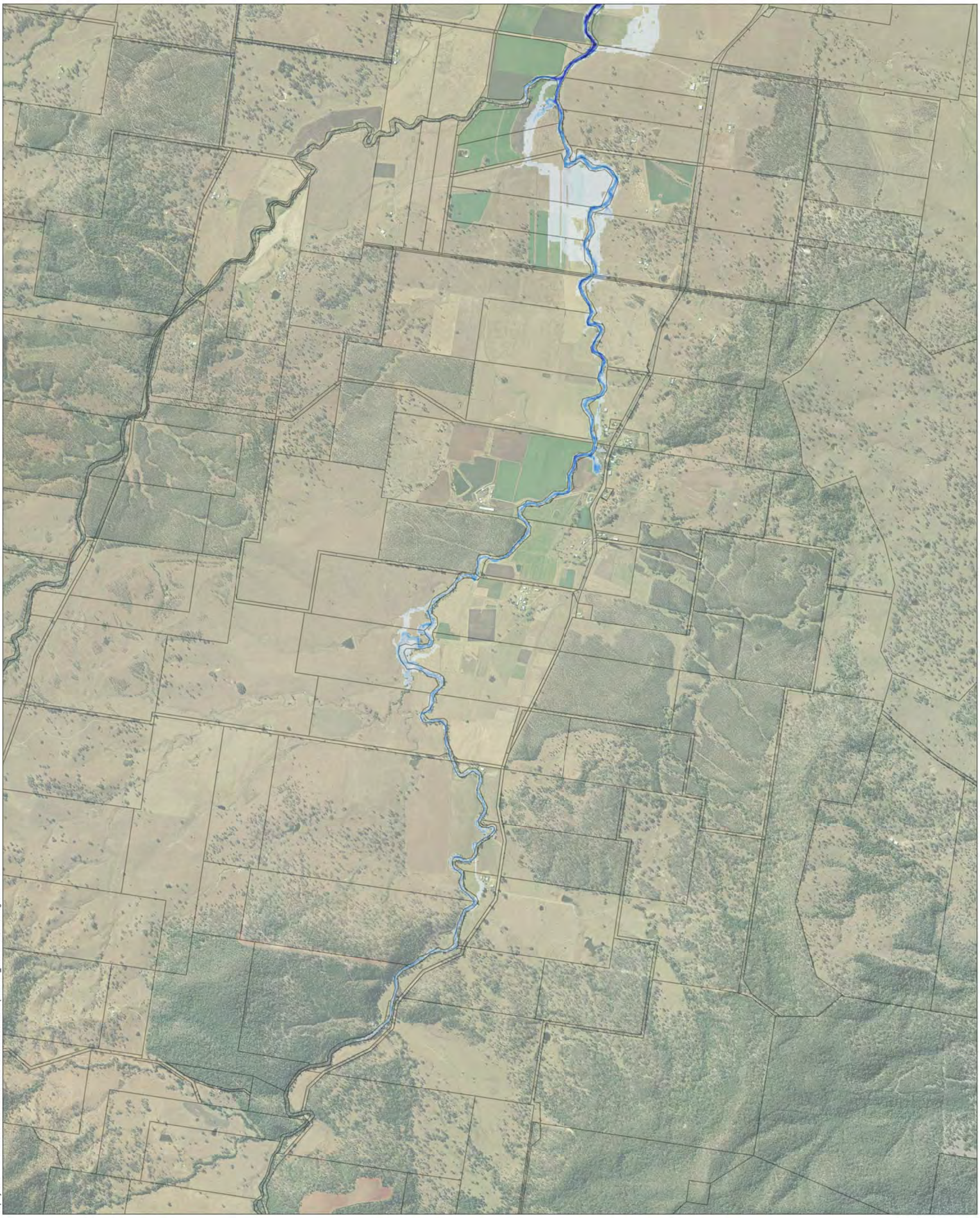
Date: 22/06/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure D3**

5% AEP Event - Peak Depth Map

aurecon



Map by: JDT   P:\SWM\Work\255060 Scenic Rim Flood Models Expansion\2_Bremer River\GIS\Figures\

Legend

SRRC Boundary

Cadastral Boundary

Depth (m)

- 0.0 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 2.5
- 2.5 to 3.0
- 3.0 to 3.5
- 3.5 to 4.0
- 4.0 to 4.5
- 4.5 to 5.0
- > 5.0

Notes:

1:25,000

0   625 m   1,250 m

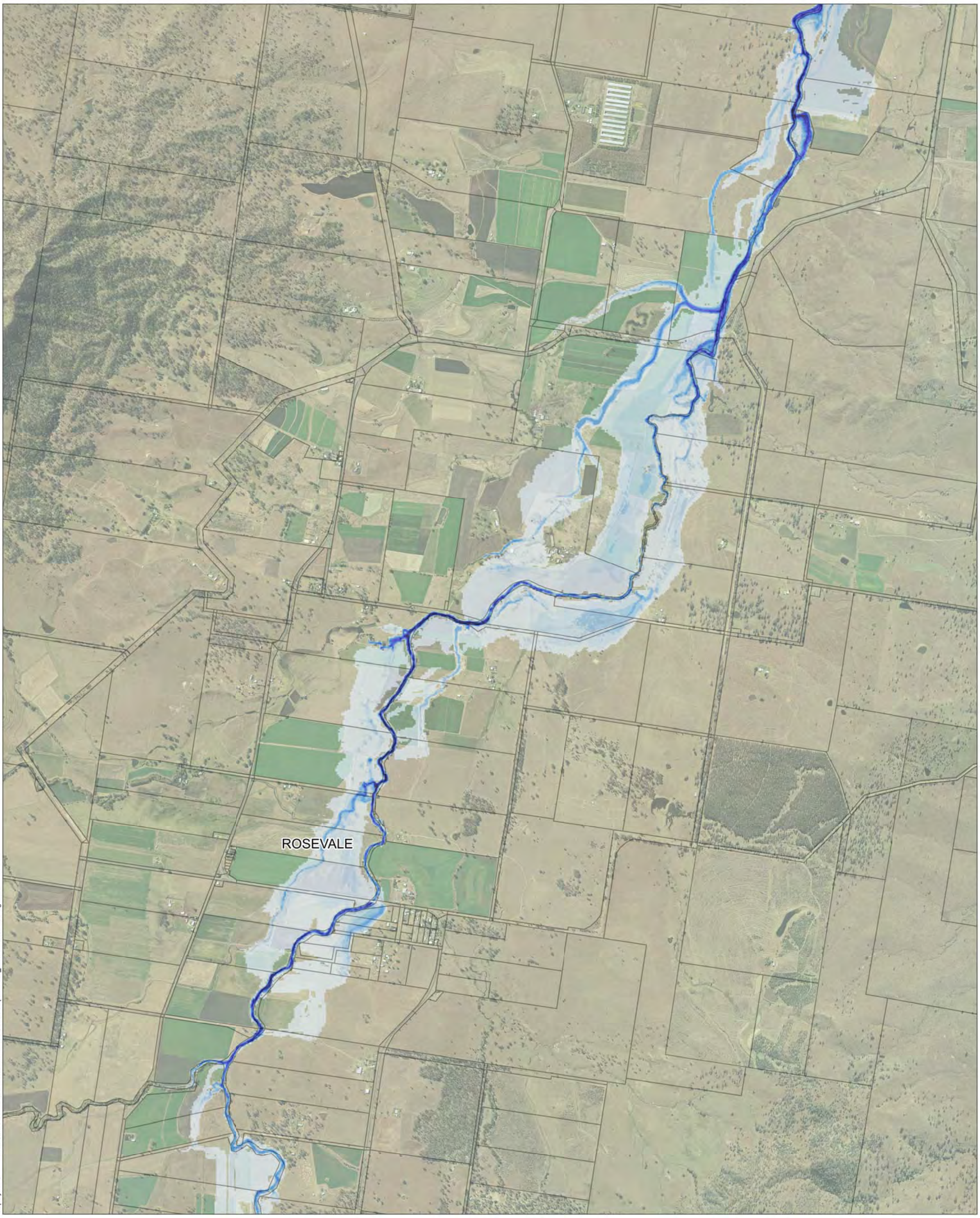
Date: 22/06/2017   Version: 0   Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study   **Figure D3-a**

5% AEP Event - Peak Depth Map

aurecon



Map by: JDT

P:\SWM\Work\255060 Scenic Rim Flood Models Expansion\2_Bremer River\GIS\Figures\

Legend

SRRC Boundary

Cadastral Boundary

Depth (m)

0.0 to 0.5	3.0 to 3.5
0.5 to 1.0	3.5 to 4.0
1.0 to 1.5	4.0 to 4.5
1.5 to 2.0	4.5 to 5.0
2.0 to 2.5	> 5.0
2.5 to 3.0	

Notes:

1:25,000

0 625 m 1,250 m

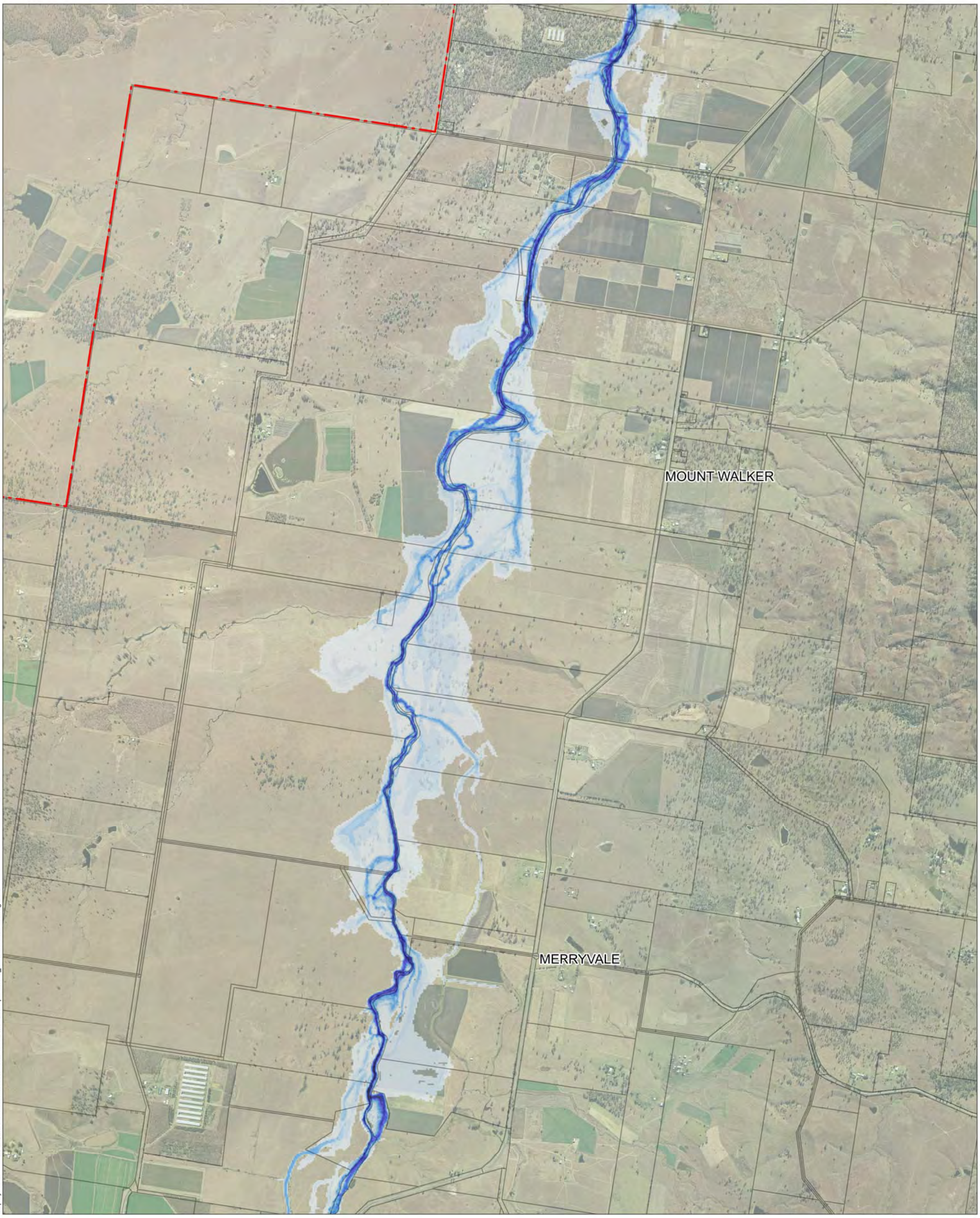
Date: 22/06/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure D3-b**

5% AEP Event - Peak Depth Map

aurecon



Map by: JDT P:\SWM\Work\255060 Scenic Rim Flood Models Expansion\2_Bremer River\GIS\Figures\

Legend

SRRC Boundary

Cadastral Boundary

Depth (m)

- 0.0 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 2.5
- 2.5 to 3.0
- 3.0 to 3.5
- 3.5 to 4.0
- 4.0 to 4.5
- 4.5 to 5.0
- > 5.0

Notes:

1:25,000

0 625 m 1,250 m

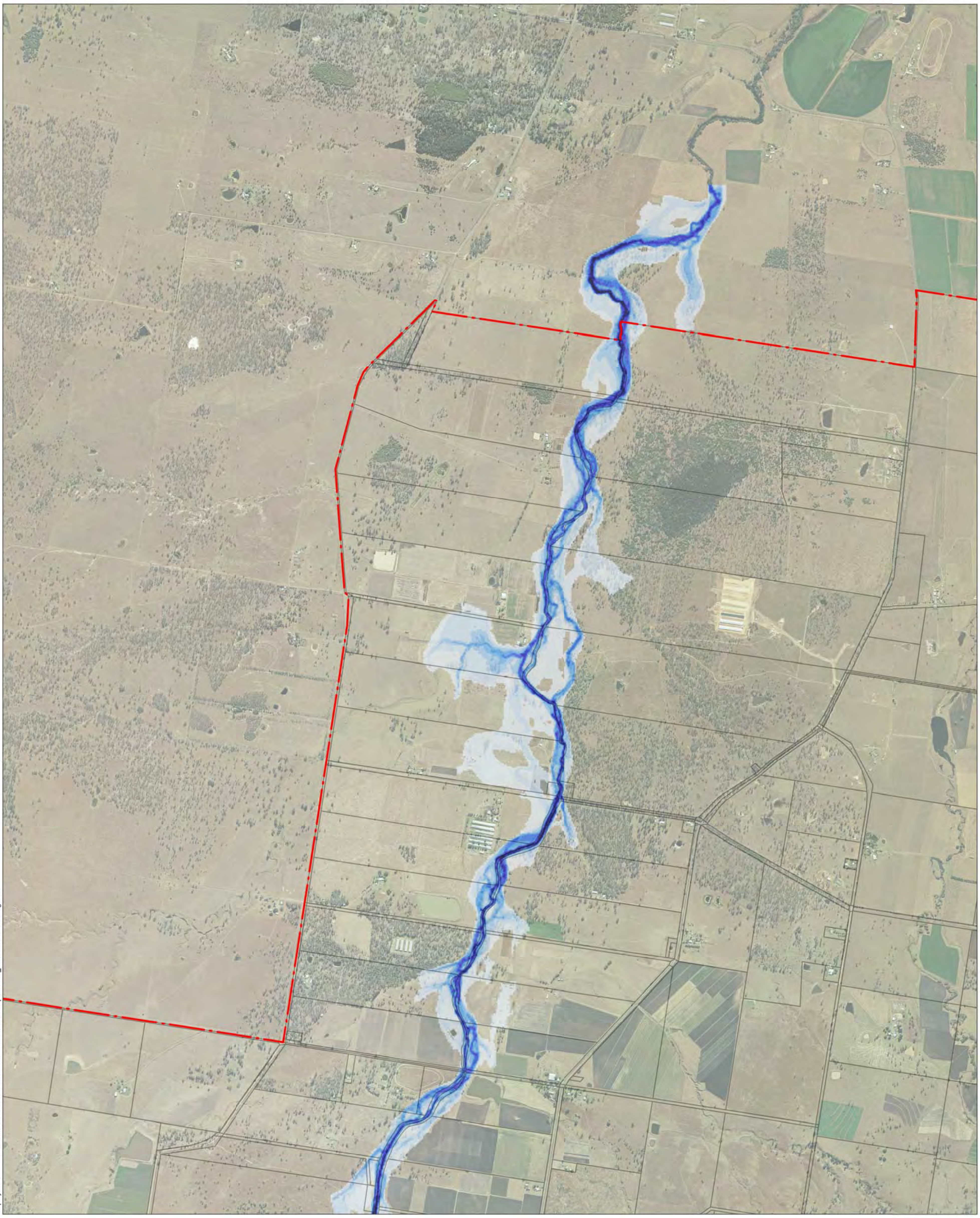
Date: 22/06/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure D3-c**

5% AEP Event - Peak Depth Map

aurecon



Map by: JDT P:\SWM\Work\255060 Scenic Rim Flood Models Expansion\2_Bremer River\GIS\Figures\

Legend

- SRRC Boundary
- Cadastral Boundary

Depth (m)

0.0 to 0.5	3.0 to 3.5
0.5 to 1.0	3.5 to 4.0
1.0 to 1.5	4.0 to 4.5
1.5 to 2.0	4.5 to 5.0
2.0 to 2.5	> 5.0
2.5 to 3.0	

Notes:

1:25,000

0 625 m 1,250 m

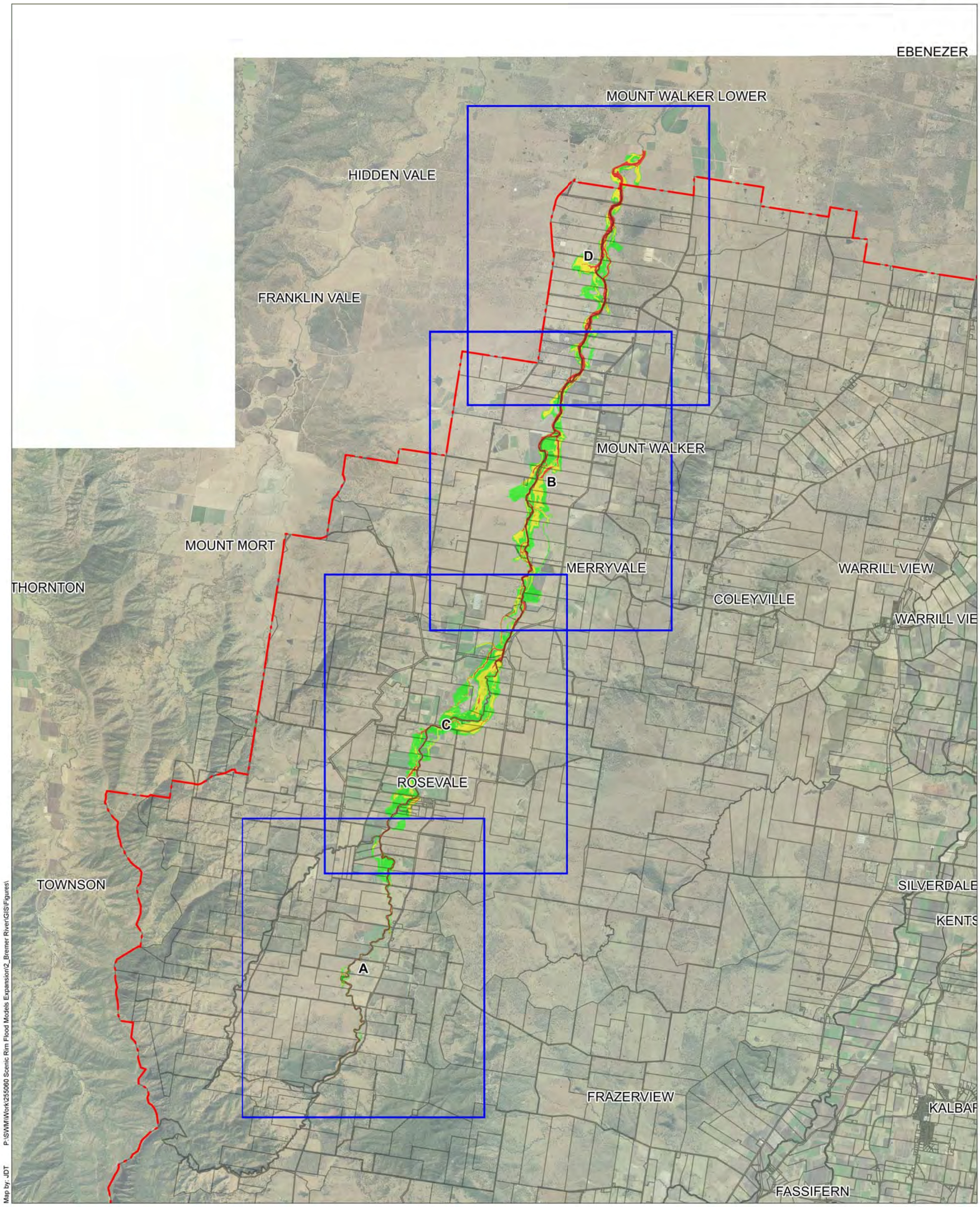
Date: 22/06/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure D3-d**

5% AEP Event - Peak Depth Map

aurecon



Legend

SRRC Boundary
Cadastral Boundary
Low Hazard
Medium Hazard
High Hazard

Notes:

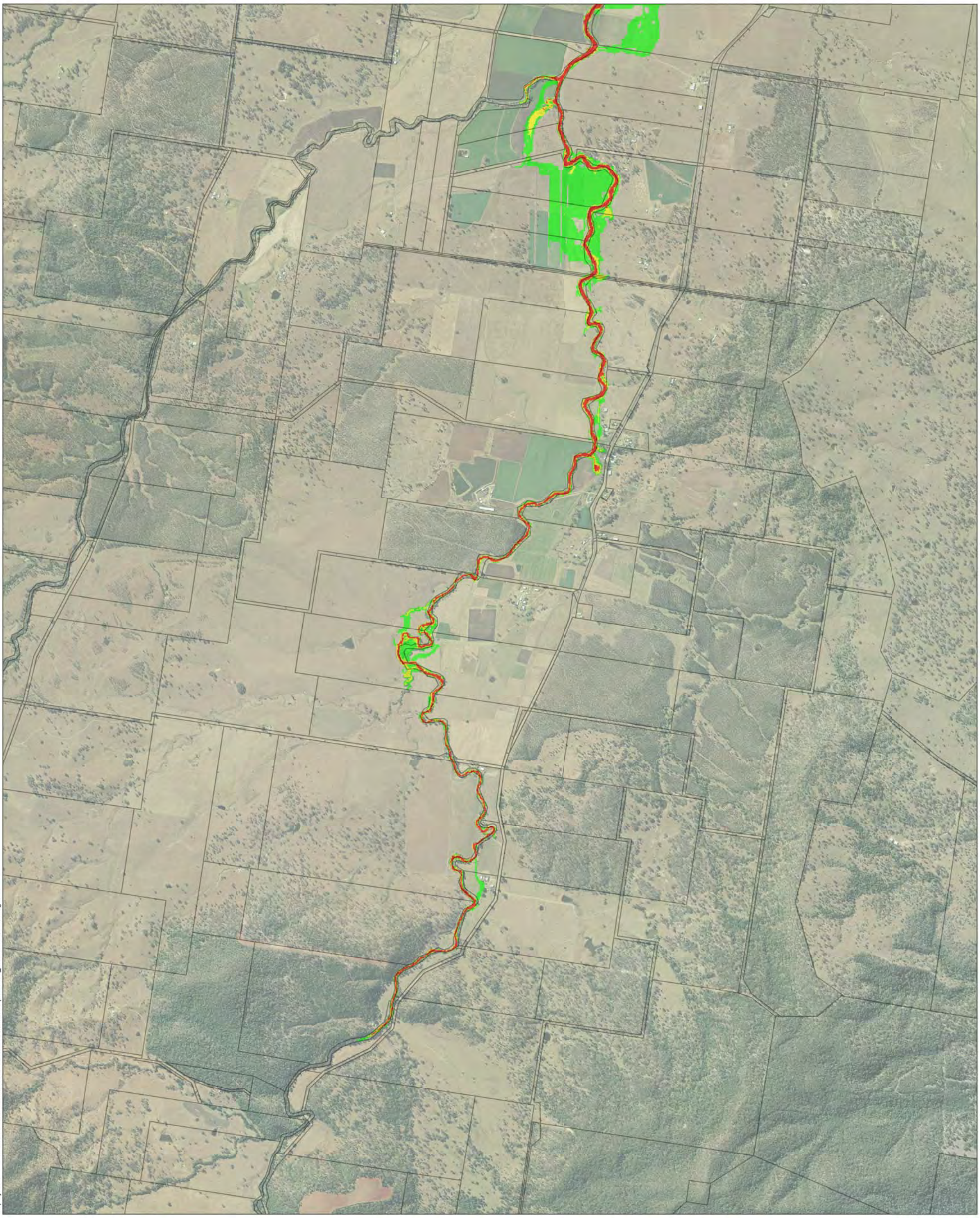
1:100,000
0 2,500 m 5,000 m

Date: 22/06/2017 Version: 0 Job No: 255060
Projection: MGA Zone 56

Bremer River Flood Study Figure D4

5% AEP Event - Peak Hazard Map

aurecon



Map by: JDT P:\SWM\Work\255060 Scenic Rim Flood Models Expansion\2_Bremer River\GIS\Figures\

Legend

SRRC Boundary

Cadastral Boundary

Low Hazard

Medium Hazard

High Hazard

Notes:

1:25,000

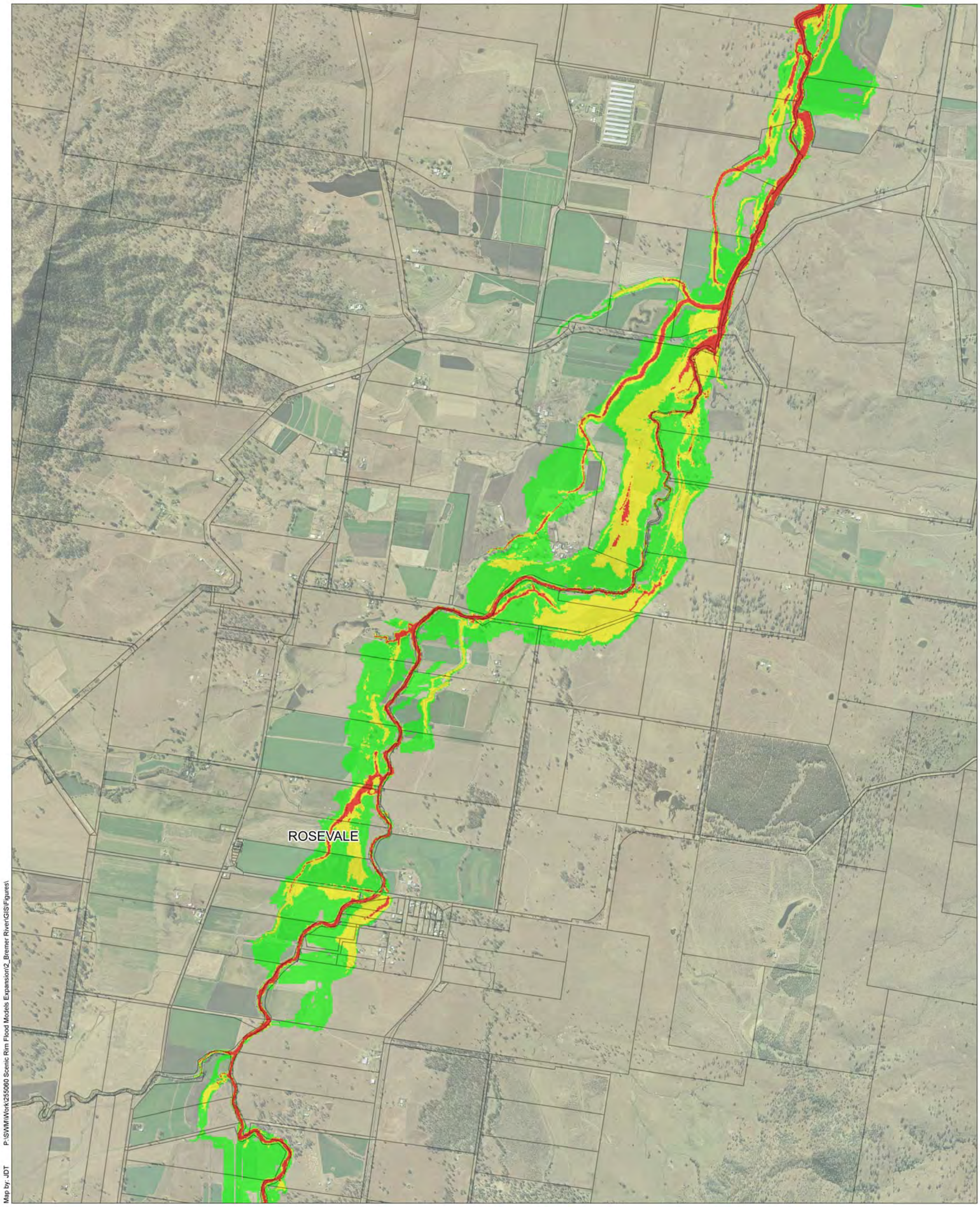
0 625 m 1,250 m

Date: 22/06/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure D4-a**

5% AEP Event - Peak Hazard Map



Legend

SRRC Boundary

Cadastral Boundary

Low Hazard

Medium Hazard

High Hazard

Notes:

1:25,000

0 625 m 1,250 m

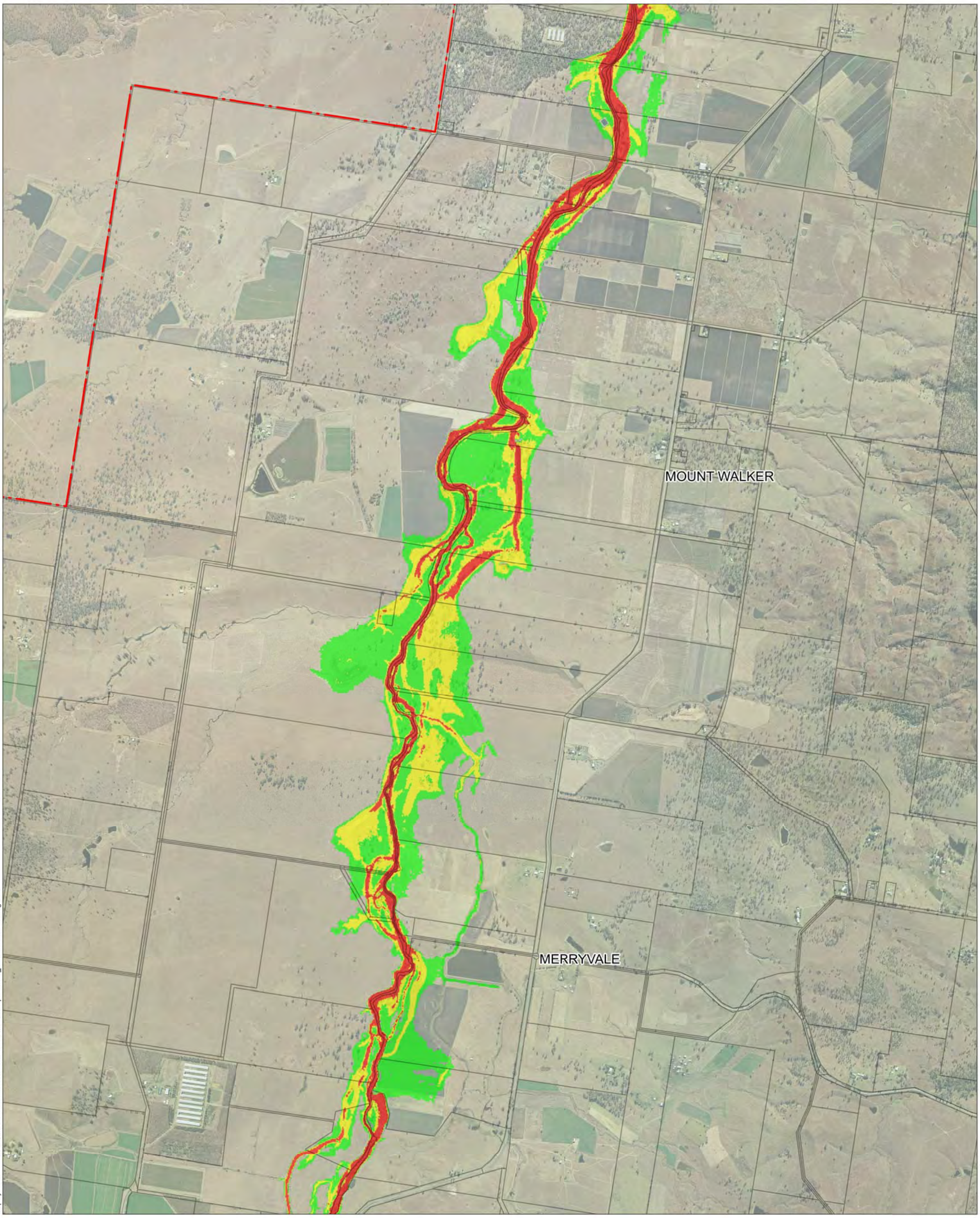
Date: 22/06/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure D4-b**

5% AEP Event - Peak Hazard Map

aurecon



Map by: JDT   P:\SWM\Work\255060 Scenic Rim Flood Models Expansion\2_Bremer River\GIS\Figures\

Legend

SRRC Boundary
Cadastral Boundary
Low Hazard
Medium Hazard
High Hazard

Notes:

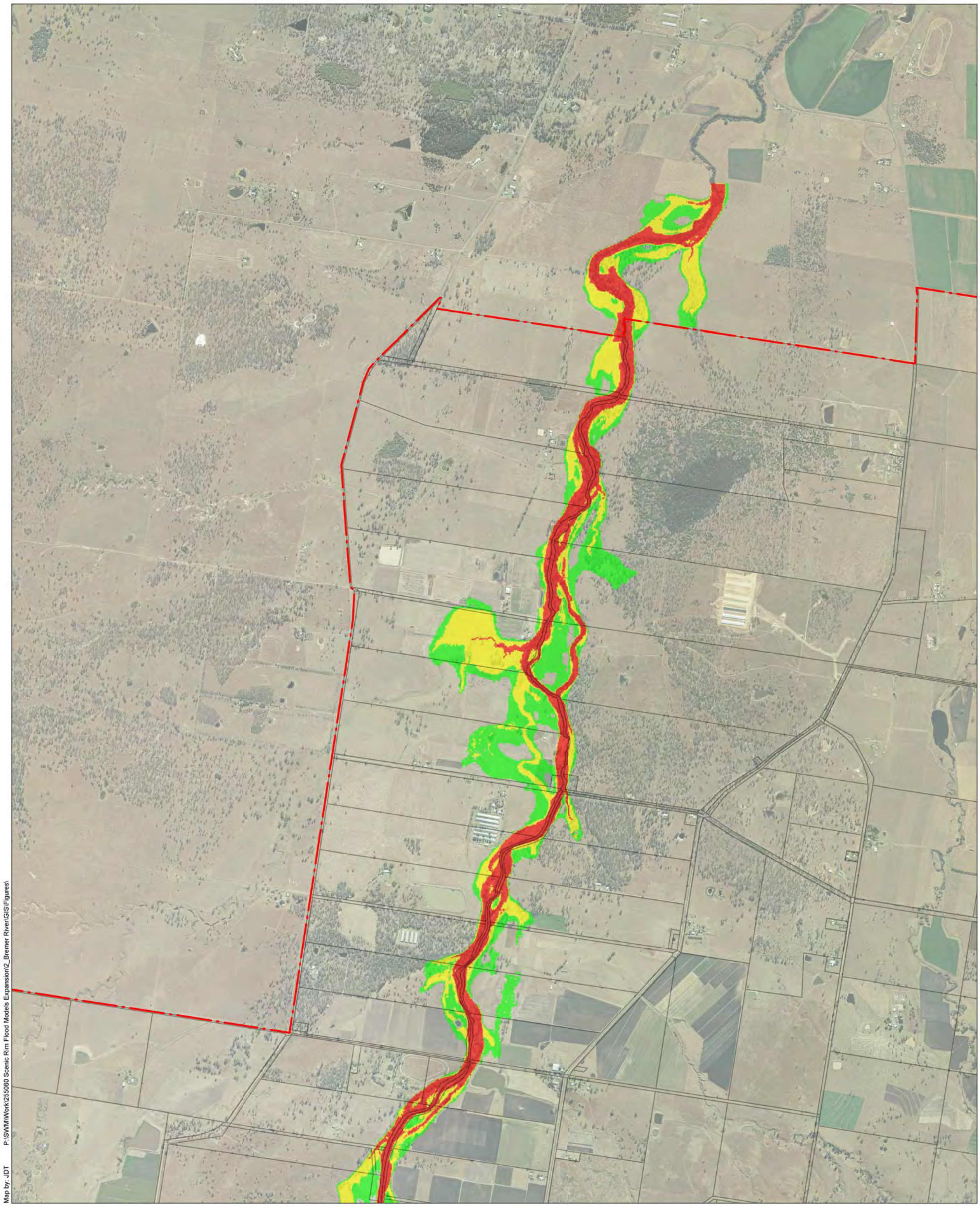
1:25,000
0   625 m   1,250 m

Date: 22/06/2017   Version: 0   Job No: 255060
Projection: MGA Zone 56

Bremer River Flood Study **Figure D4-c**

5% AEP Event - Peak Hazard Map

aurecon



Legend

SRRC Boundary
Cadastral Boundary
Low Hazard
Medium Hazard
High Hazard

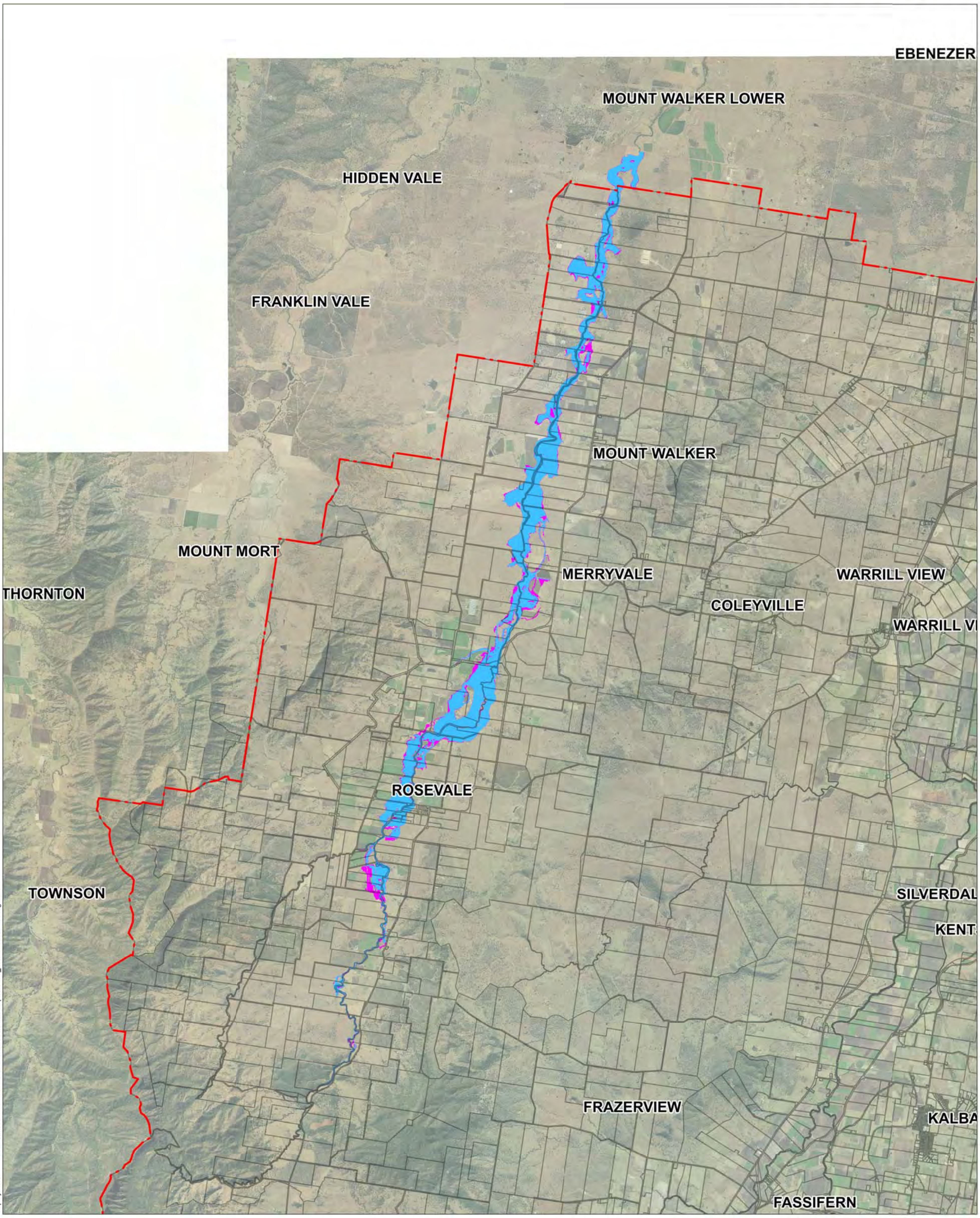
Notes:

1:25,000
0 625 m 1,250 m

Date: 22/06/2017 Version: 0 Job No: 255060
Projection: MGA Zone 56

Bremer River Flood Study **Figure D4-d**

5% AEP Event - Peak Hazard Map



Legend

SRRC Boundary

Cadastral Boundary

Existing Scenario Inundation Extents

Climate Change Scenario 4.5 Inundation Extent

Notes:

1:50,000

0 1,250 m 2,500 m

Date: 22/06/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

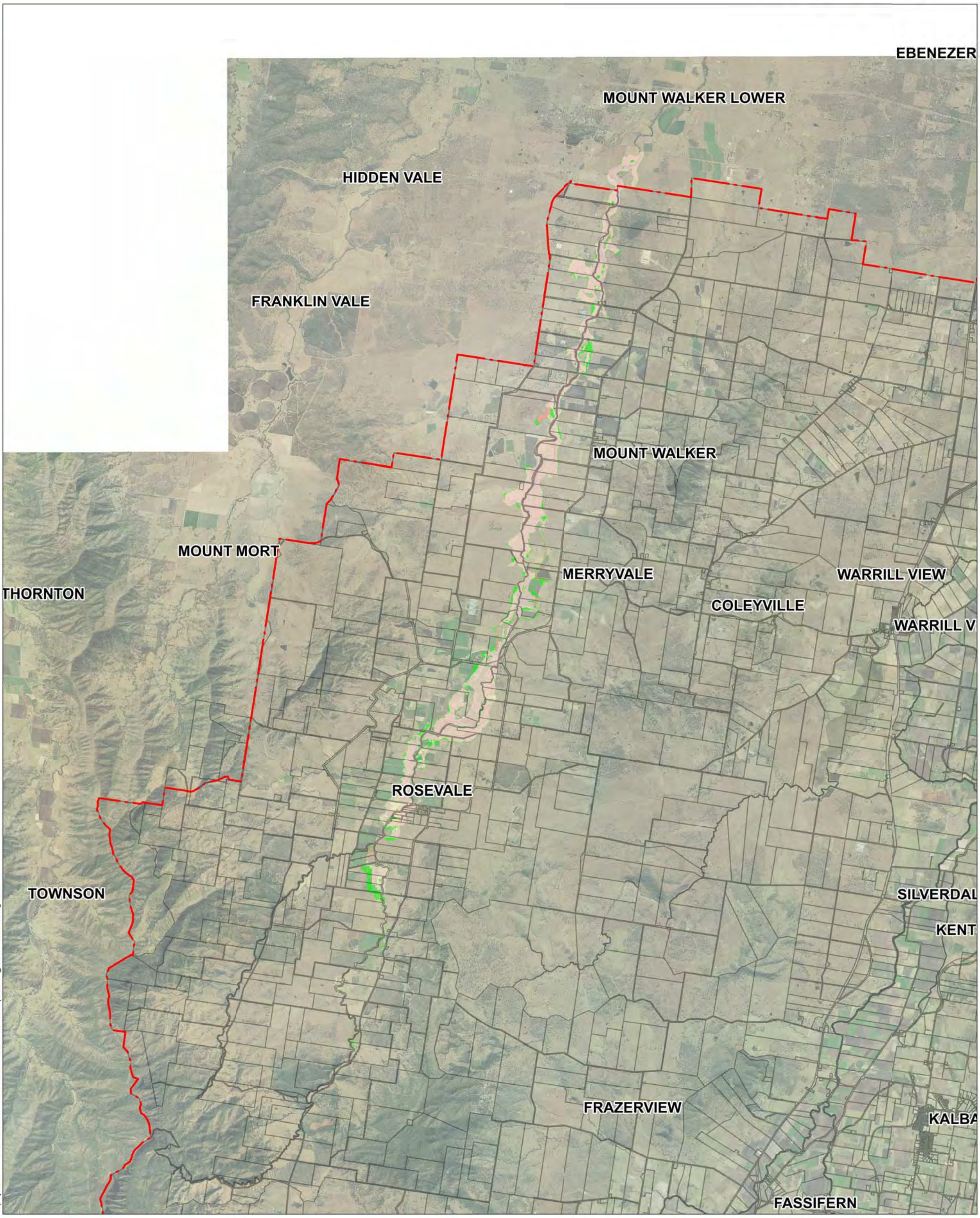
Bremer River Flood Study

Figure D5-a

Climate Change Scenario 4.5 - 5% AEP Event Inundation Extent

Document Set ID: 10154451
Version: 1, Version Date: 21/12/2017

aurecon



Map by: JDT P:\SWM\Work\255060 Scenic Rim Flood Models Expansion\2_Bremer River\GIS\Figures\

Legend

SRRC Boundary

Cadastral Boundary

Afflux (m)

- < -0.80
- -0.80 to -0.60
- -0.60 to -0.40
- -0.40 to -0.20
- -0.20 to -0.03
- -0.03 to 0.03
- 0.03 to 0.20
- 0.20 to 0.40
- 0.40 to 0.60
- 0.60 to 0.80
- 0.80 to 1.20
- > 1.20
- Was Dry Now Wet
- Was Wet Now Dry

Notes:

1:50,000

0 1,250 m 2,500 m

Date: 22/06/2017 Version: 0 Job No: 255060

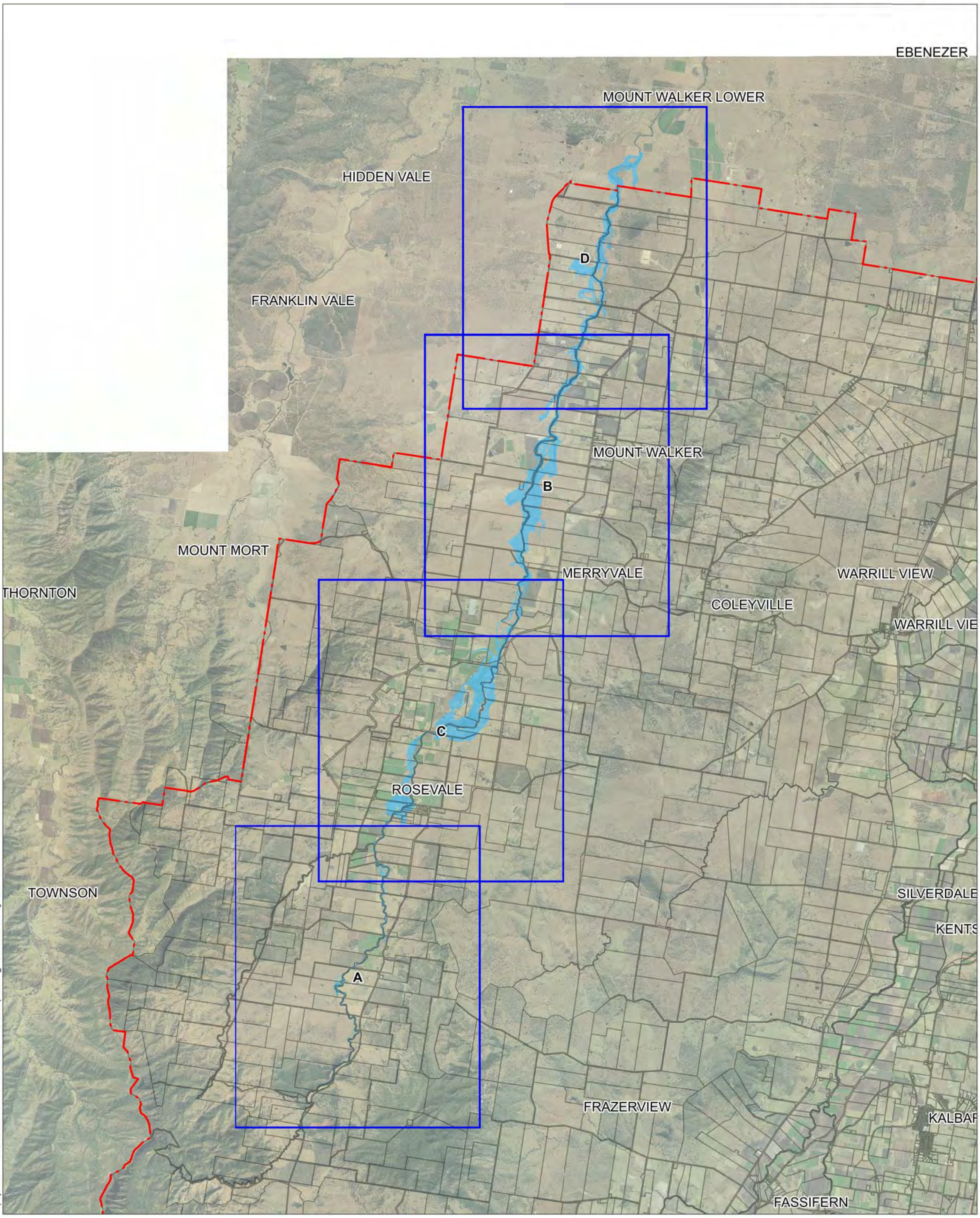
Projection: MGA Zone 56

Bremer River Flood Study

Figure D5-b

Climate Change Scenario 4.5 - 5% AEP Event Afflux Map

aurecon



Legend

SRRC Boundary

Cadastral Boundary

Inundation Extent

Peak Water level Contour (mAHD)

Notes:

1:100,000

0 2,500 m 5,000 m

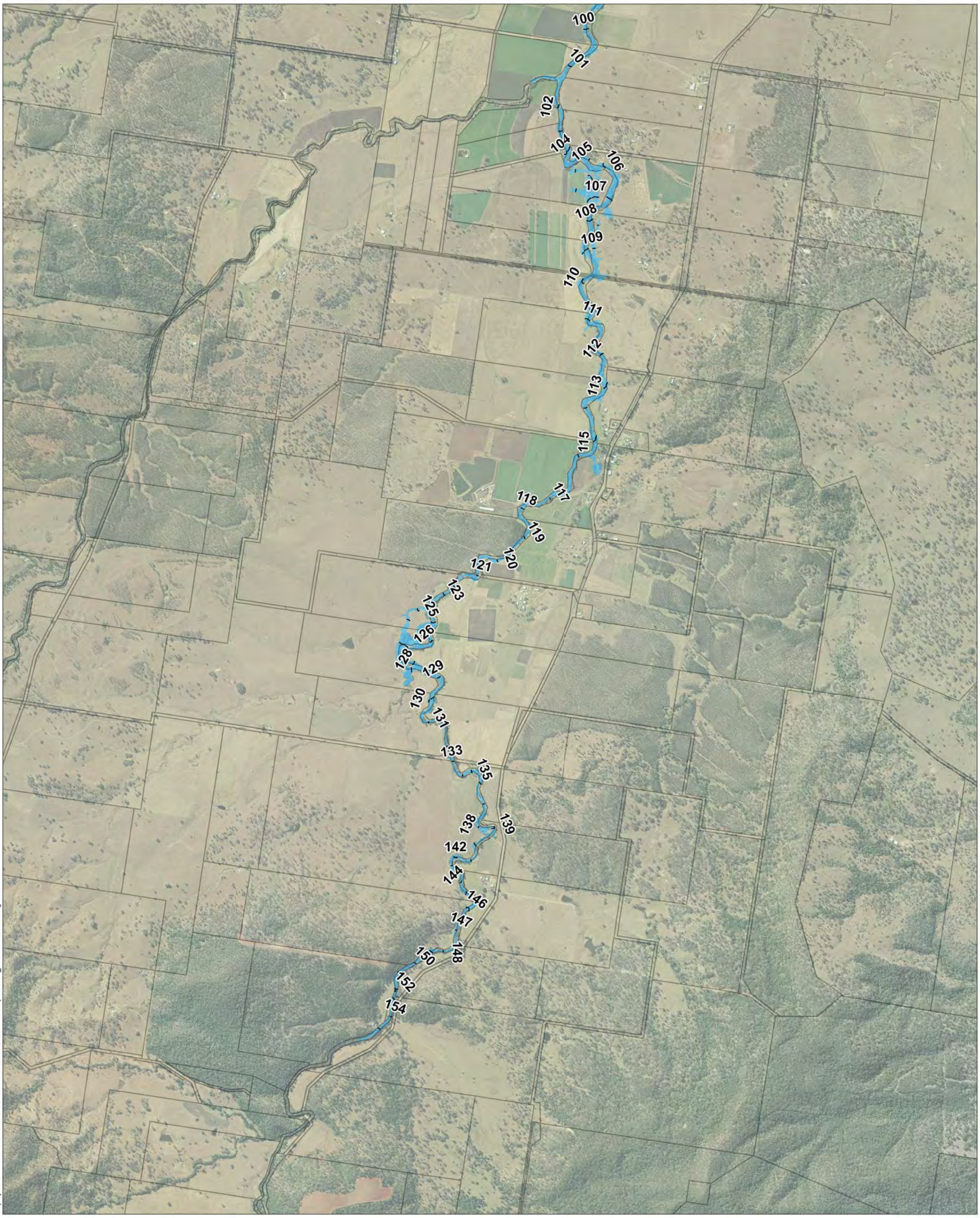
Date: 22/06/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure E1**

10% AEP Event - Inundation Extent

aurecon



Map by: JDT P:\SWM\Work\255060 Scenic Rim Flood Models Expansion\2_Bremer River\GIS\Figures\

Legend

SRRC Boundary

Cadastral Boundary

Inundation Extent

Peak Water level Contour (mAHD)

Notes:

1:25,000

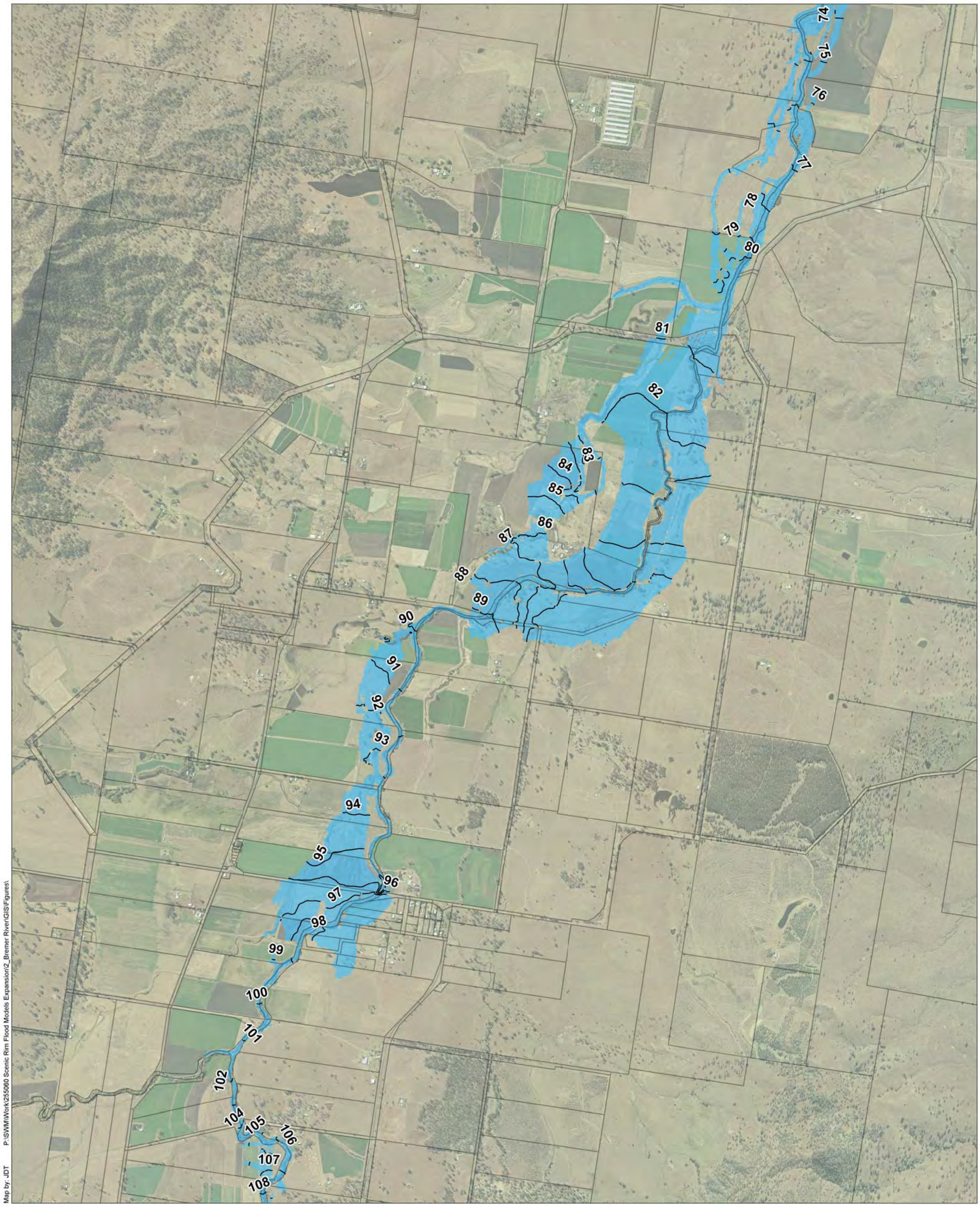
0 625 m 1,250 m

Date: 22/06/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure E1-a**

10% AEP Event - Inundation Extent



Legend

SRRC Boundary

Cadastral Boundary

Inundation Extent

Peak Water level Contour (mAHD)

Notes:

1:25,000

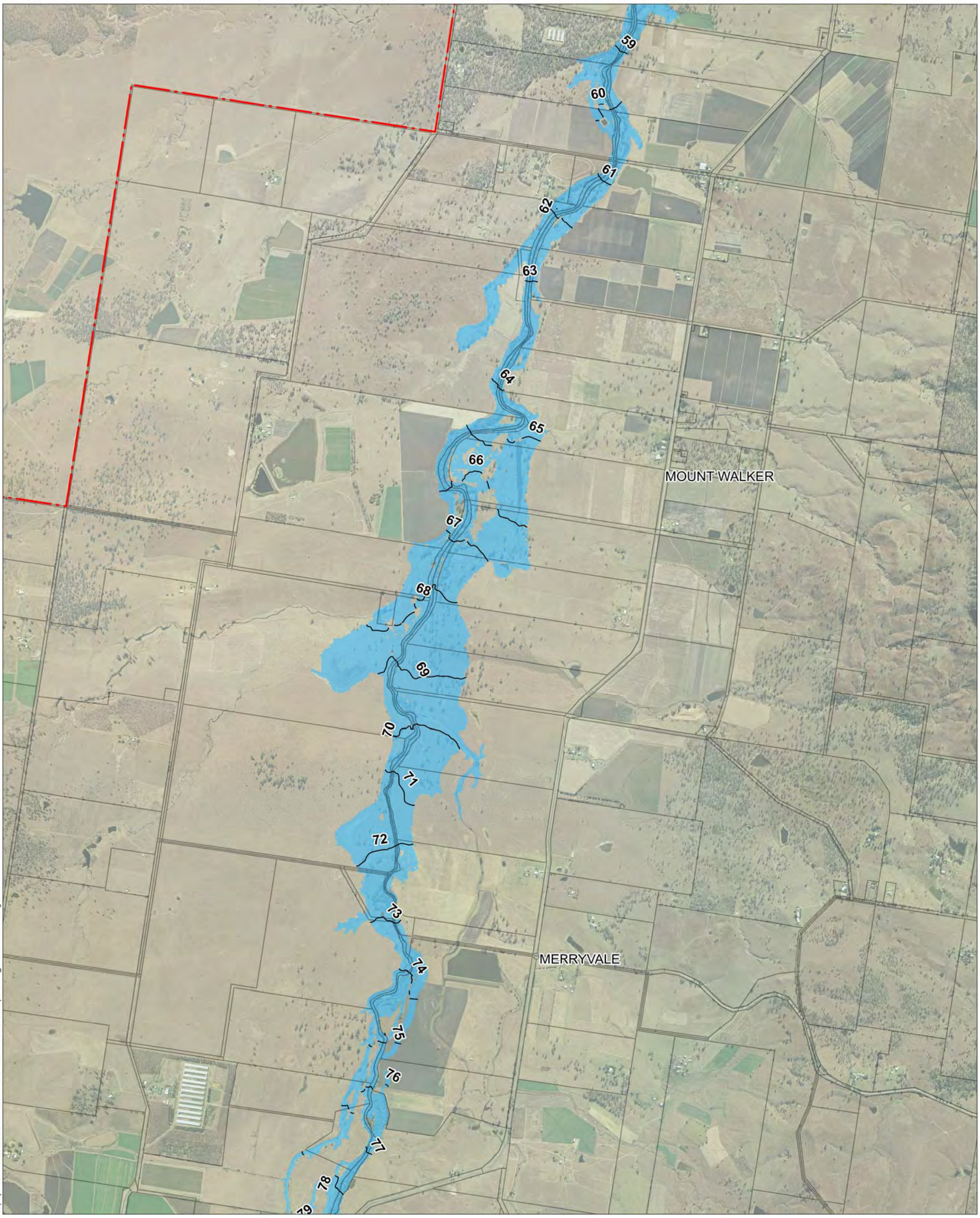
0 625 m 1,250 m

Date: 22/06/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure E1-b**

10% AEP Event - Inundation Extent



Legend

SRRC Boundary

Cadastral Boundary

Inundation Extent

Peak Water level Contour (mAHD)

Notes:

1:25,000

0 625 m 1,250 m

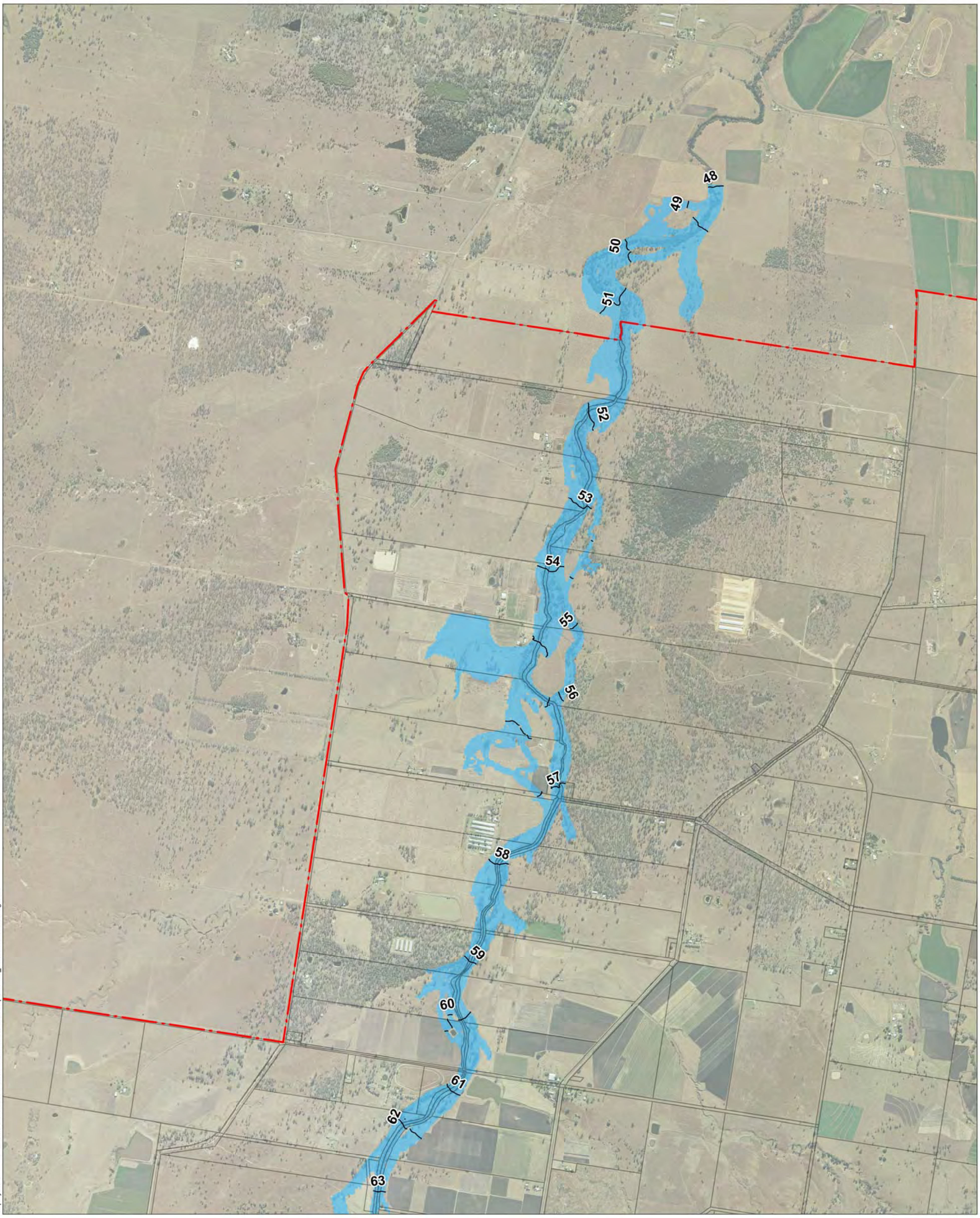
Date: 22/06/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure E1-c**

10% AEP Event - Inundation Extent

aurecon



Legend

SRRC Boundary

Cadastral Boundary

Inundation Extent

Peak Water level Contour (mAHD)

Notes:

1:25,000

0 625 m 1,250 m

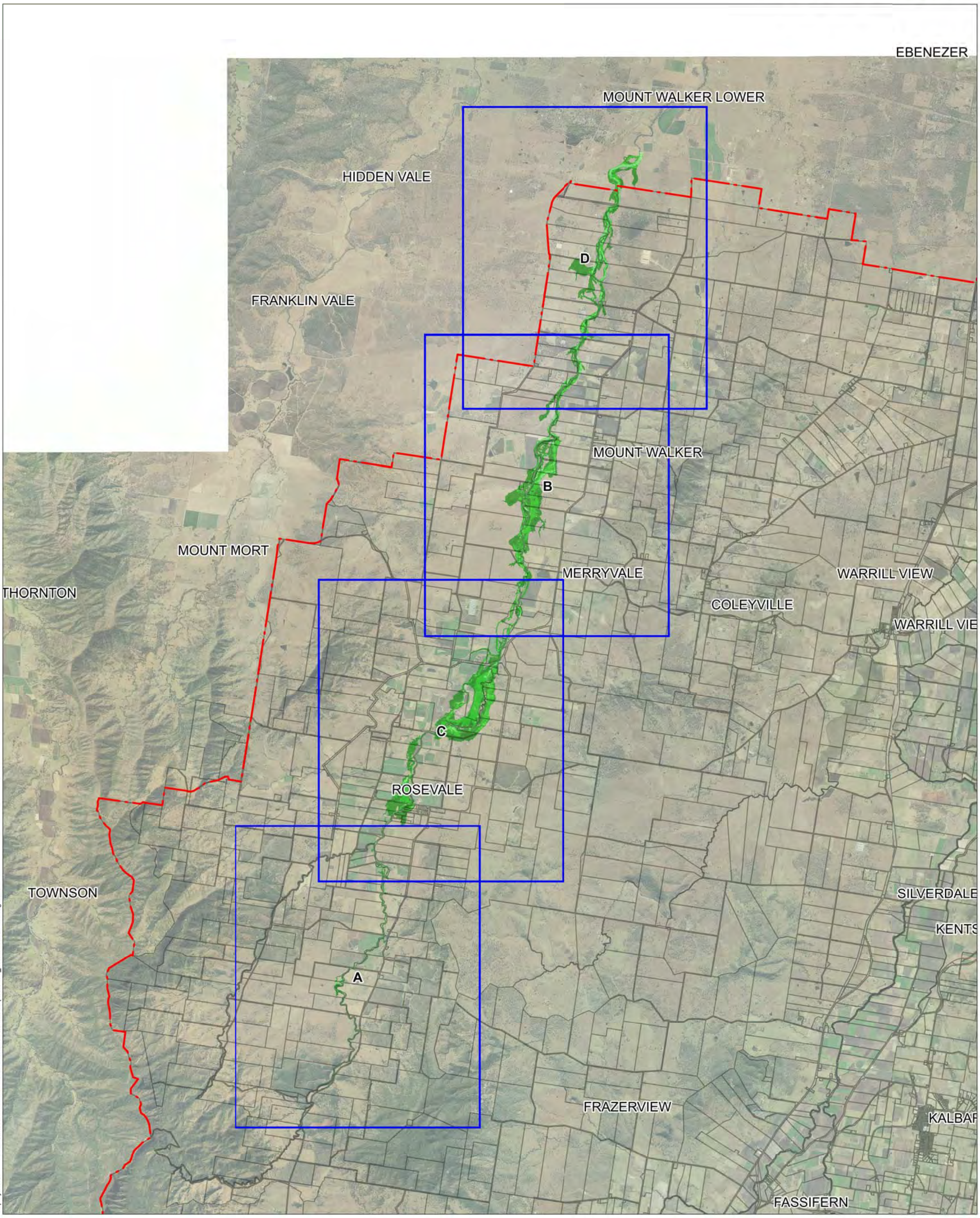
Date: 22/06/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study Figure E1-d

10% AEP Event - Inundation Extent

aurecon



Map by: JDT P:\SWM\Work\255060 Scenic Rim Flood Models Expansion\2_Bremer River\GIS\Figures\

Legend

SRRC Boundary

Cadastral Boundary

Velocity (m/s)

- 0.0 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 2.5
- 2.5 to 3.0
- 3.0 to 3.5
- 3.5 to 4.0
- 4.0 to 4.5
- 4.5 to 5.0
- > 5.0

Notes:

1:100,000

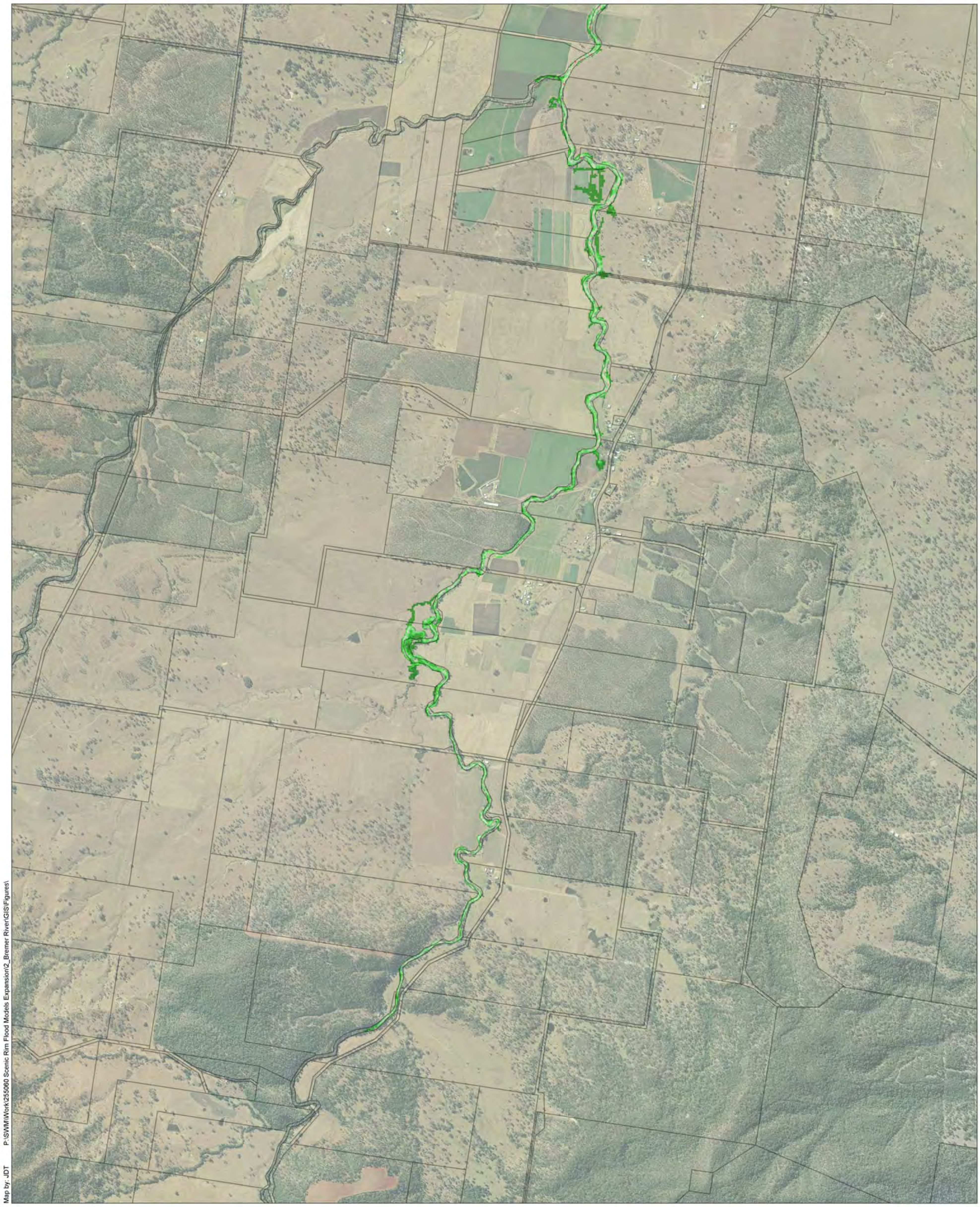
0 2,500 m 5,000 m

Date: 22/06/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure E2**

10% AEP Event - Peak Velocities



Legend

Velocity (m/s)

SRRC Boundary

Cadastral Boundary

0.0 to 0.5
0.5 to 1.0
1.0 to 1.5
1.5 to 2.0
2.0 to 2.5
2.5 to 3.0
3.0 to 3.5
3.5 to 4.0
4.0 to 4.5
4.5 to 5.0
> 5.0

Notes:

1:25,000
0 625 m 1,250 m

Date: 22/06/2017 Version: 0 Job No: 255060
Projection: MGA Zone 56

Bremer River Flood Study **Figure E2-a**

10% AEP Event - Peak Velocities

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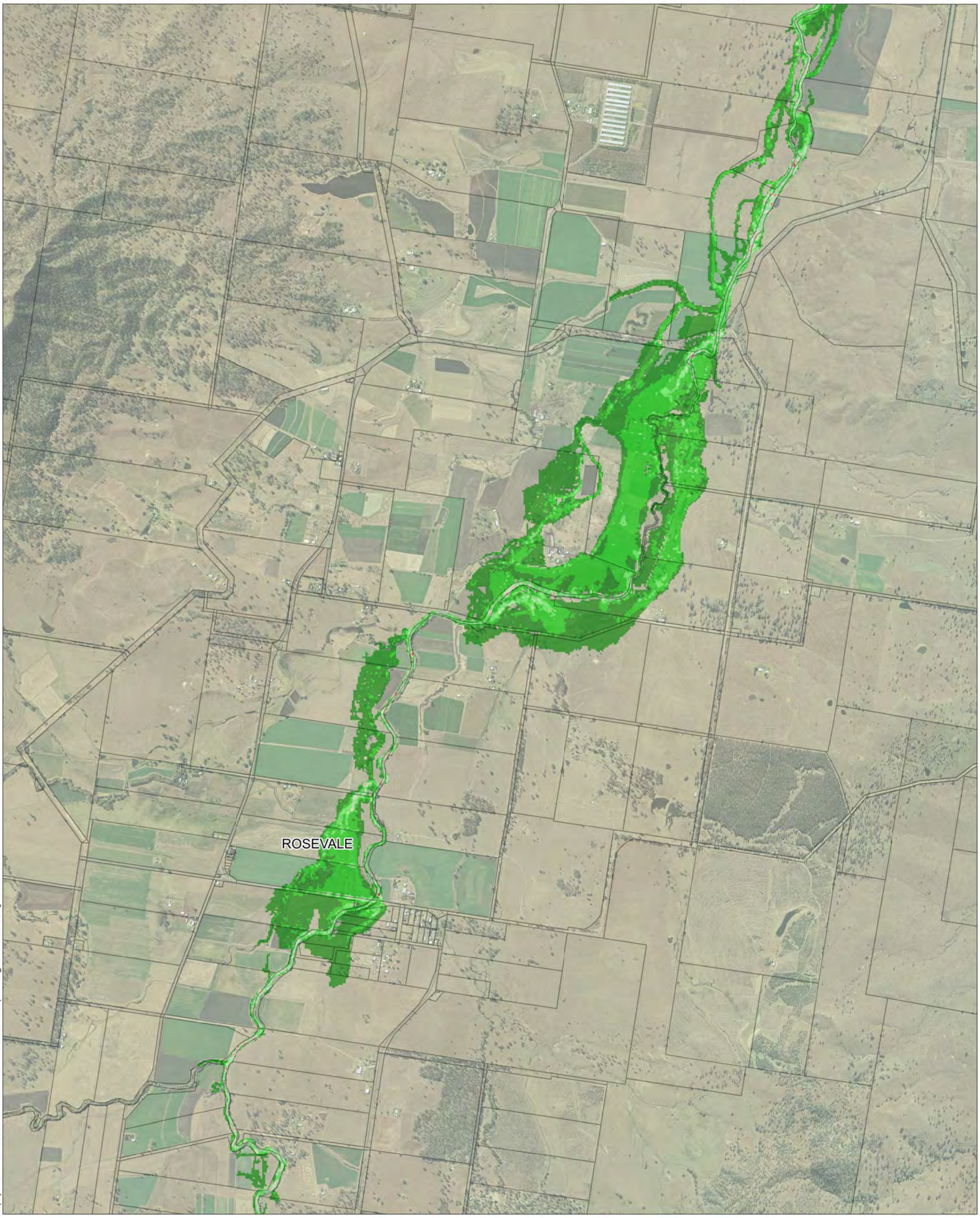
Version: 1, Version Date: 21/12/2017

aurecon



Map by: JDT

P:\SWM\Work\255060 Scenic Rim Flood Models Expansion\2_Bremer River\GIS\Figures\

Legend

Velocity (m/s)

- SRRC Boundary
- Cadastral Boundary
- 0.0 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 2.5
- 2.5 to 3.0
- 3.0 to 3.5
- 3.5 to 4.0
- 4.0 to 4.5
- 4.5 to 5.0
- > 5.0

Notes:

1:25,000

0 625 m 1,250 m

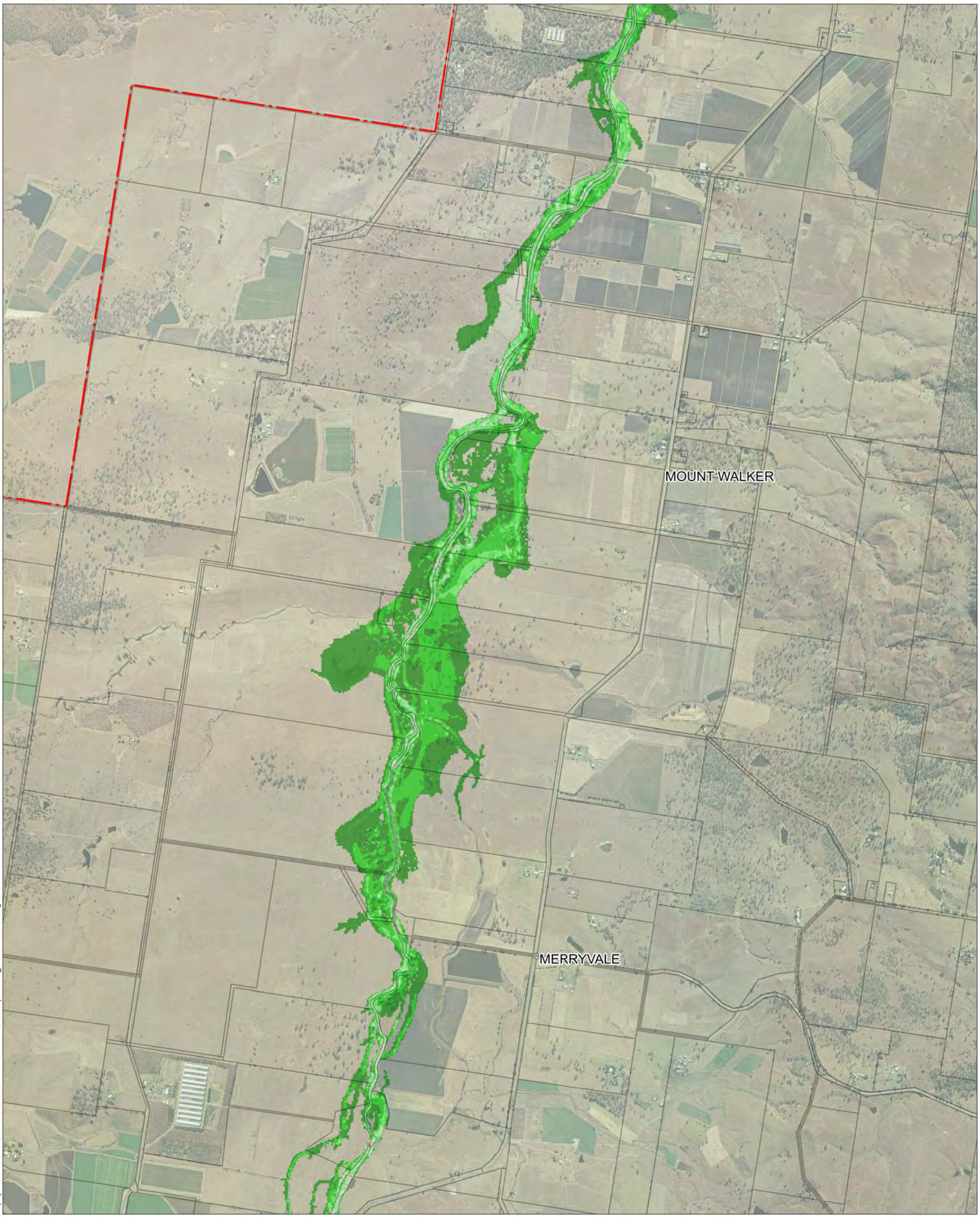
Date: 22/06/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure E2-b**

10% AEP Event - Peak Velocities

aurecon



Map by: JDT   P:\SWM\Work\255060 Scenic Rim Flood Models Expansion\2_Bremer River\GIS\Figures\

Legend

SRRC Boundary

Cadastral Boundary

Velocity (m/s)

- 0.0 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 2.5
- 2.5 to 3.0
- 3.0 to 3.5
- 3.5 to 4.0
- 4.0 to 4.5
- 4.5 to 5.0
- > 5.0

Notes:

1:25,000

0   625 m   1,250 m

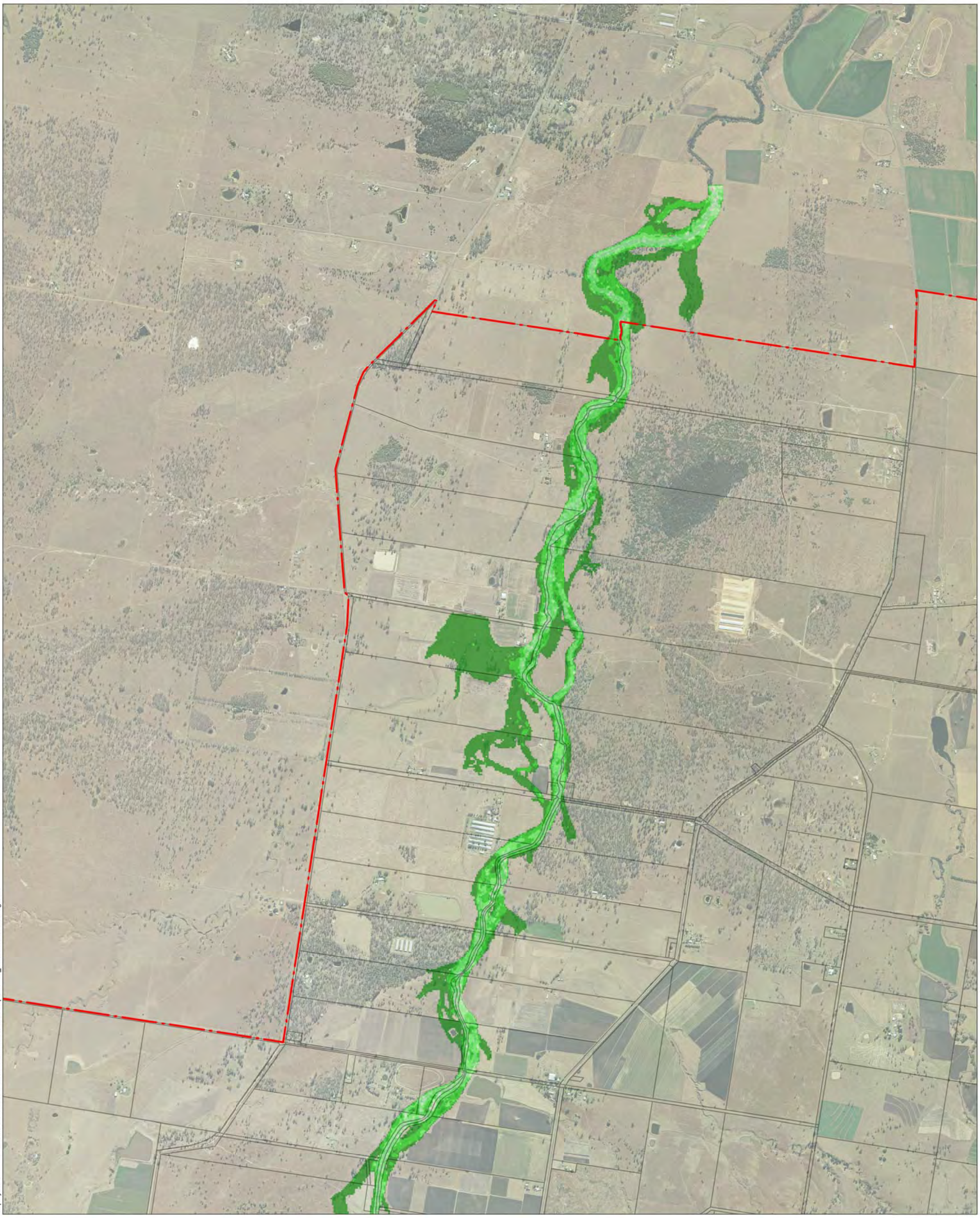
Date: 22/06/2017   Version: 0   Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study   **Figure E2-c**

10% AEP Event - Peak Velocities

aurecon



Map by: JDT P:\SWM\Work\255060 Scenic Rim Flood Models Expansion\2_Bremer River\GIS\Figures\

Legend

Velocity (m/s)

- SRRC Boundary
- Cadastral Boundary

Velocity (m/s)	Velocity (m/s)
0.0 to 0.5	3.0 to 3.5
0.5 to 1.0	3.5 to 4.0
1.0 to 1.5	4.0 to 4.5
1.5 to 2.0	4.5 to 5.0
2.0 to 2.5	> 5.0
2.5 to 3.0	

Notes:

1:25,000

0 625 m 1,250 m

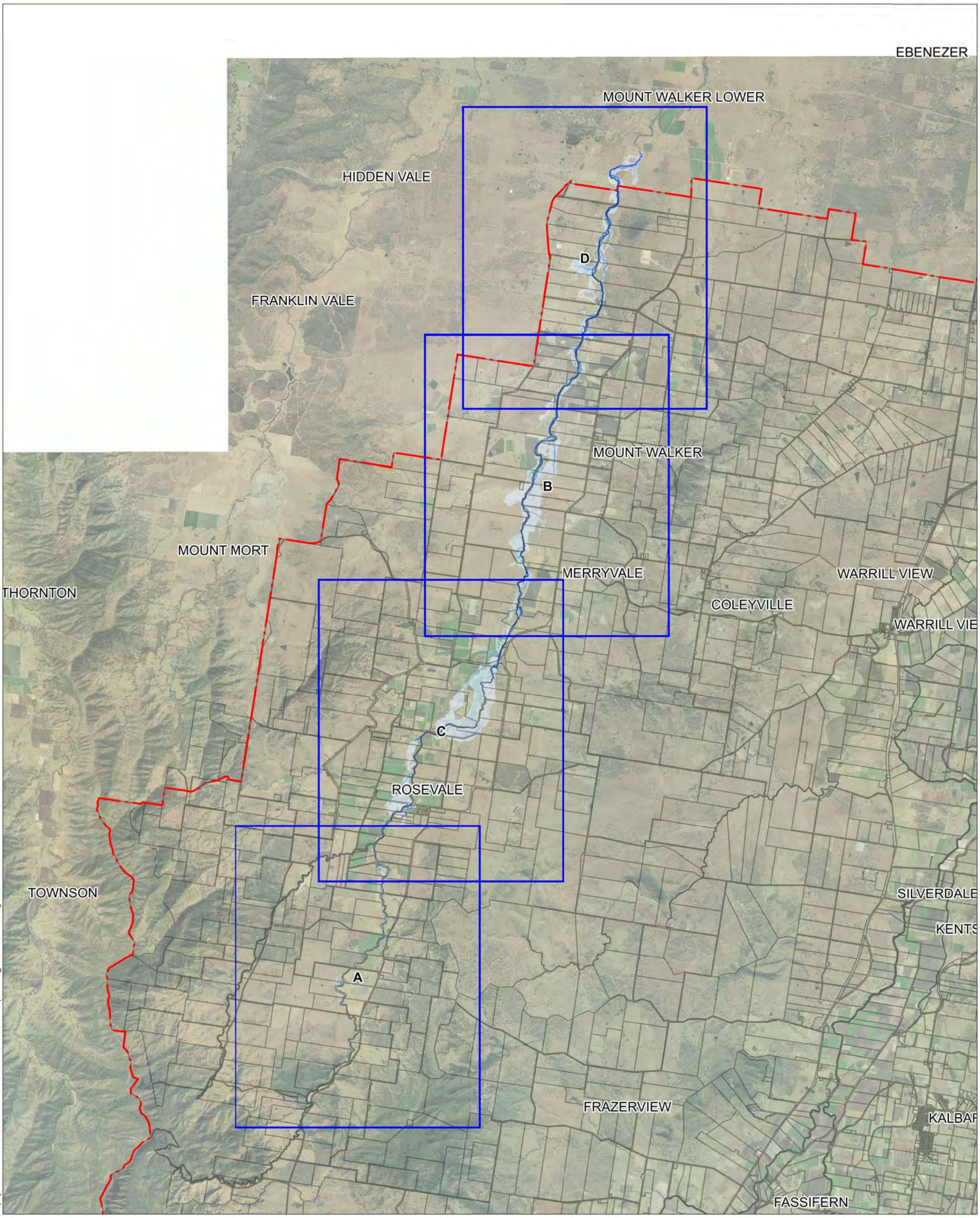
Date: 22/06/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure E2-d**

10% AEP Event - Peak Velocities

aurecon



P:\SWM\Work\255060 Scenic Rim Flood Models Expansion\2_Bremer River\GIS\Figures\

Map by: JDT

Legend

SRRC Boundary

Cadastral Boundary

Depth (m)

- 0.0 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 2.5
- 2.5 to 3.0
- 3.0 to 3.5
- 3.5 to 4.0
- 4.0 to 4.5
- 4.5 to 5.0
- > 5.0

Notes:

1:100,000

0 | 2,500 m | 5,000 m

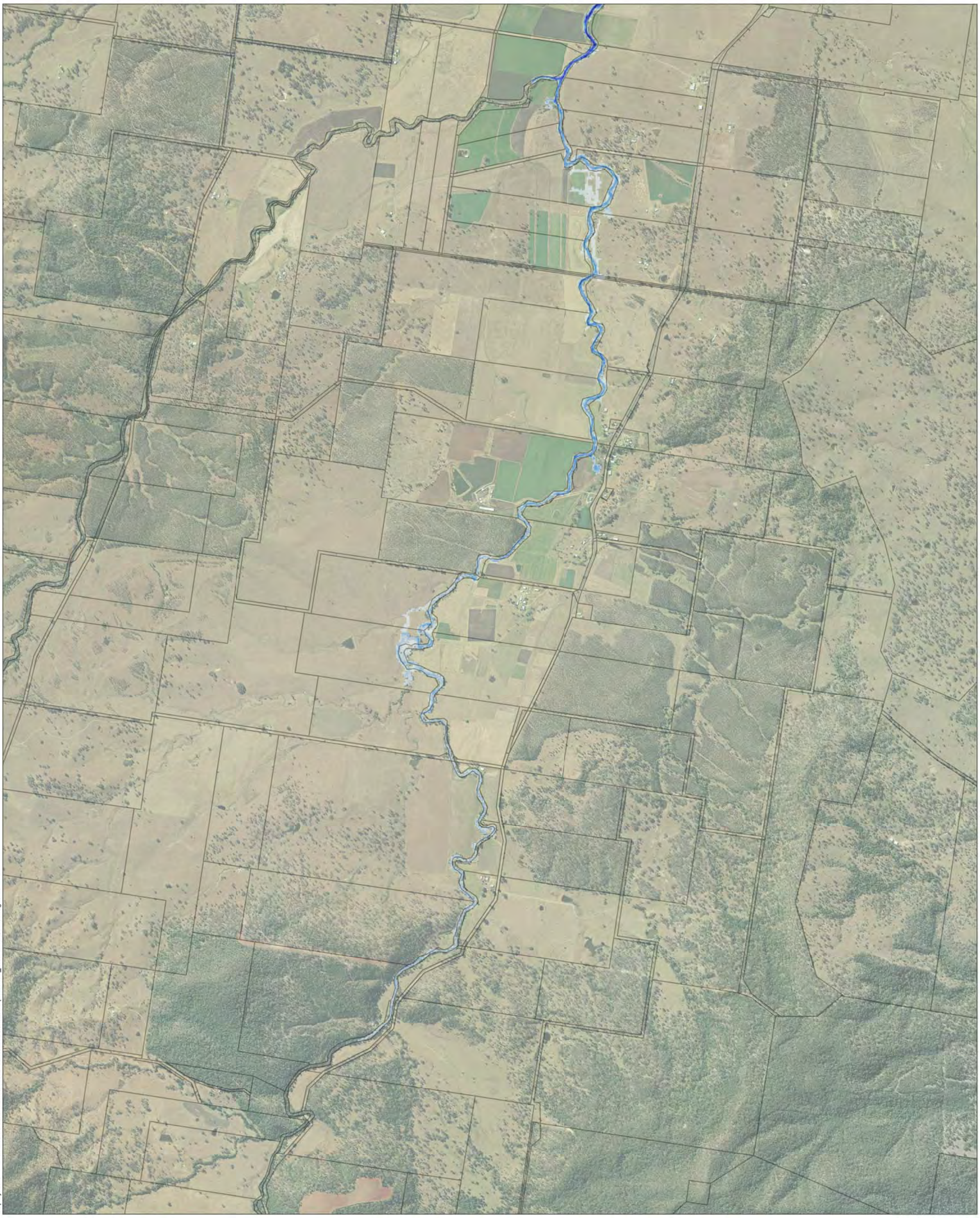
Date: 22/06/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure E3**

10% AEP Event - Peak Depth Map

aurecon



Map by: JDT P:\SWM\Work\255060 Scenic Rim Flood Models Expansion\2_Bremer River\GIS\Figures\

Legend

SRRC Boundary	
Cadastral Boundary	

Depth (m)

0.0 to 0.5	3.0 to 3.5
0.5 to 1.0	3.5 to 4.0
1.0 to 1.5	4.0 to 4.5
1.5 to 2.0	4.5 to 5.0
2.0 to 2.5	> 5.0
2.5 to 3.0	

Notes:

1:25,000

0 625 m 1,250 m

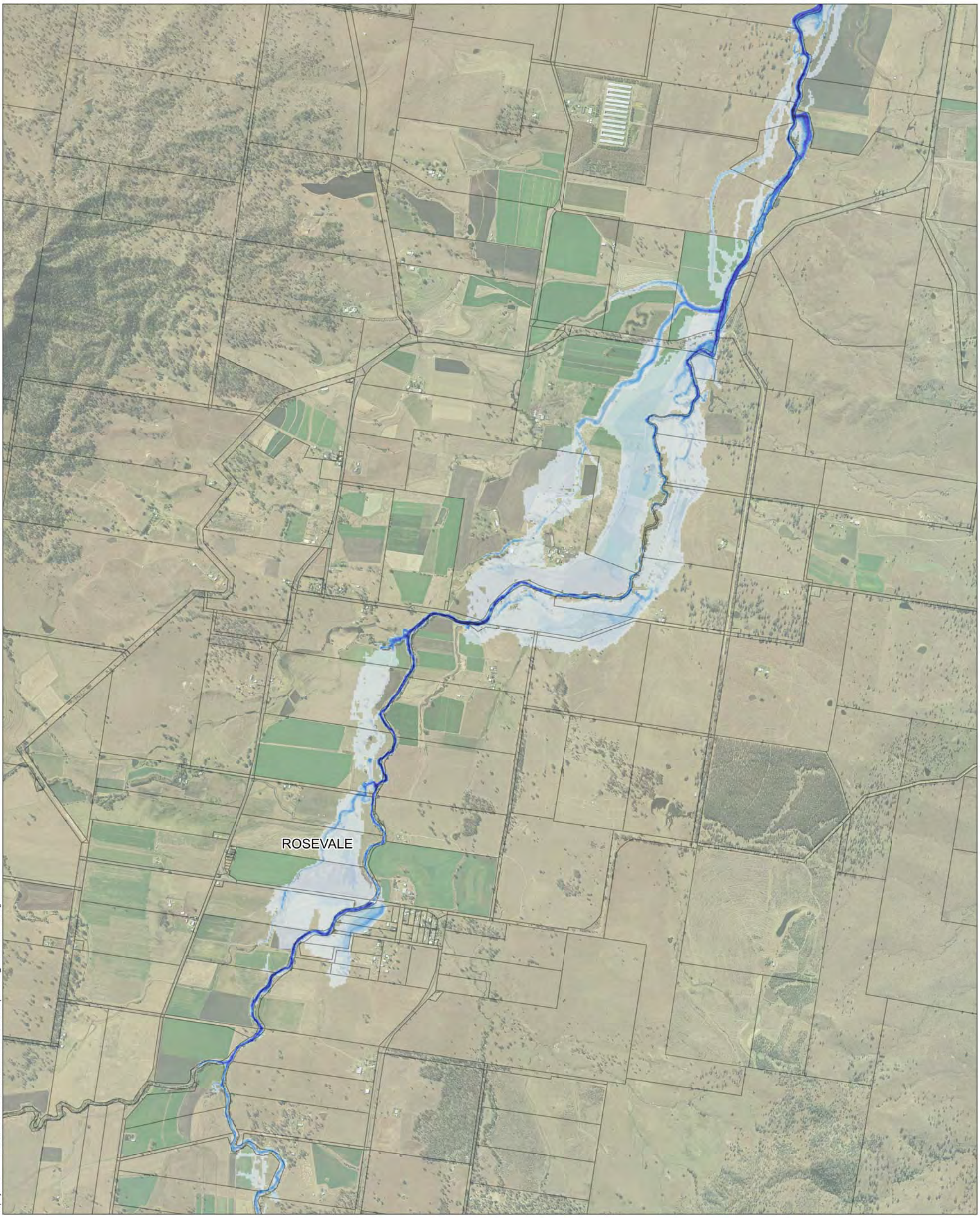
Date: 22/06/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure E3-a**

10% AEP Event - Peak Depth Map

aurecon



Map by: JDT   P:\SWM\Work\255060 Scenic Rim Flood Models Expansion\2_Bremer River\GIS\Figures\

Legend

SRRC Boundary

Cadastral Boundary

Depth (m)

- 0.0 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 2.5
- 2.5 to 3.0
- 3.0 to 3.5
- 3.5 to 4.0
- 4.0 to 4.5
- 4.5 to 5.0
- > 5.0

Notes:

1:25,000

0 625 m 1,250 m

Date: 22/06/2017 Version: 0 Job No: 255060

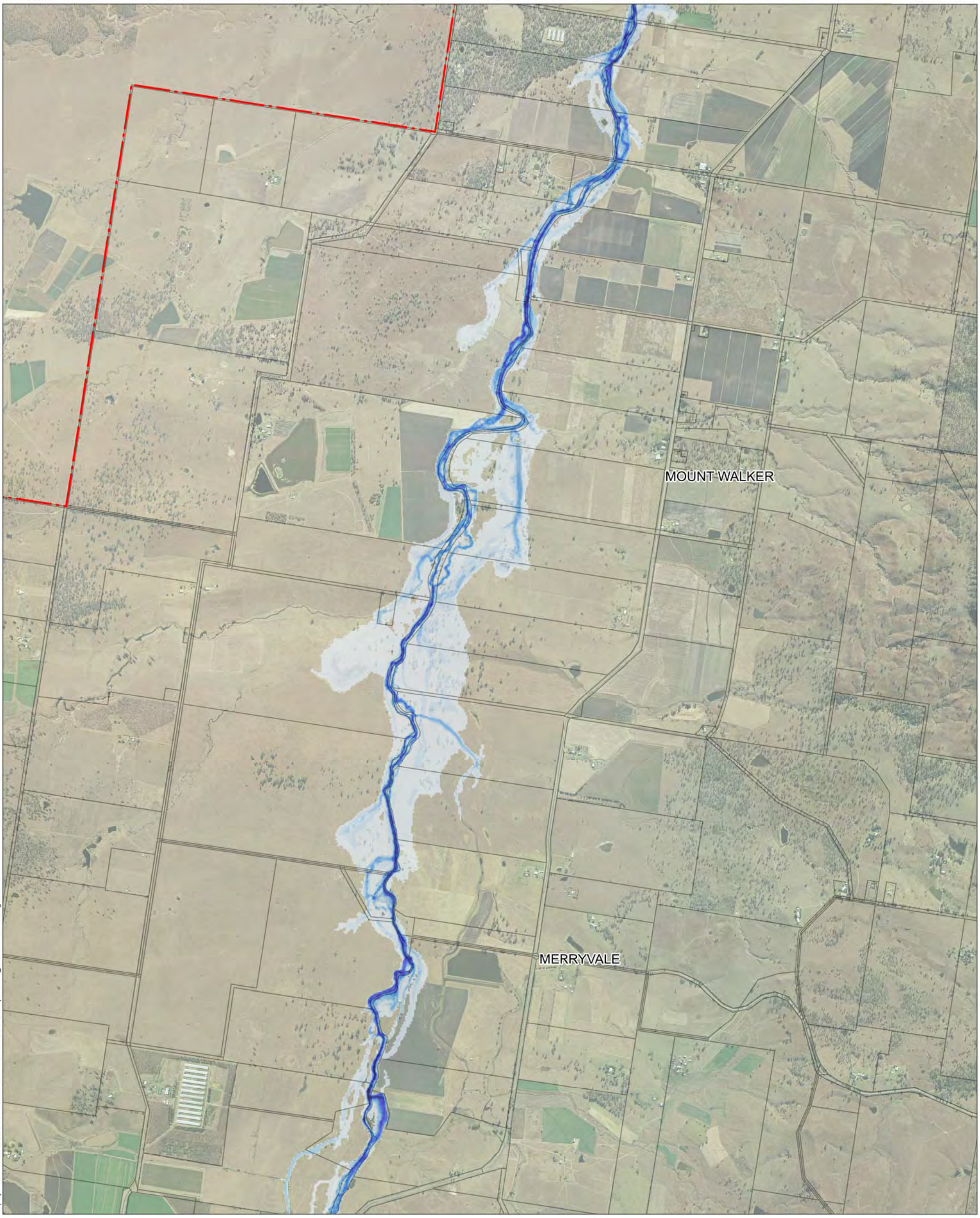
Projection: MGA Zone 56

Bremer River Flood Study **Figure E3-b**

10% AEP Event - Peak Depth Map

Document Set ID: 10154451
Version: 1, Version Date: 21/12/2017

aurecon



Map by: JDT   P:\SWM\Work\255060 Scenic Rim Flood Models Expansion\2_Bremer River\GIS\Figures\

Legend

Notes:

- SRRC Boundary
- Cadastral Boundary

Depth (m)

- 0.0 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 2.5
- 2.5 to 3.0
- 3.0 to 3.5
- 3.5 to 4.0
- 4.0 to 4.5
- 4.5 to 5.0
- > 5.0

1:25,000

0   625 m   1,250 m

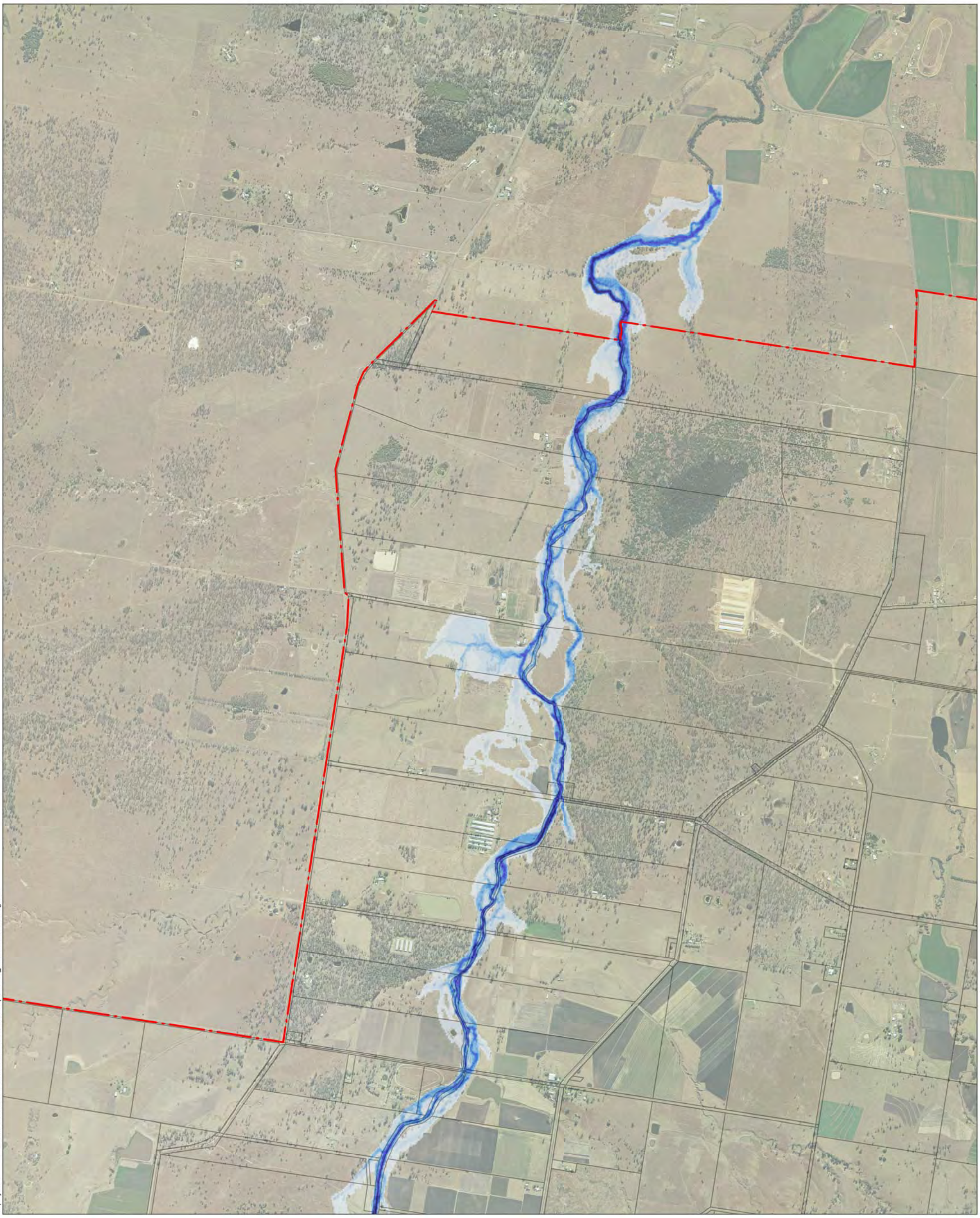
Date: 22/06/2017   Version: 0   Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study   **Figure E3-c**

10% AEP Event - Peak Depth Map

aurecon



Map by: JDT P:\SWM\Work\255060 Scenic Rim Flood Models Expansion\2_Bremer River\GIS\Figures\

Legend

SRRC Boundary

Cadastral Boundary

Depth (m)

0.0 to 0.5	3.0 to 3.5
0.5 to 1.0	3.5 to 4.0
1.0 to 1.5	4.0 to 4.5
1.5 to 2.0	4.5 to 5.0
2.0 to 2.5	> 5.0
2.5 to 3.0	

Notes:

1:25,000

0 625 m 1,250 m

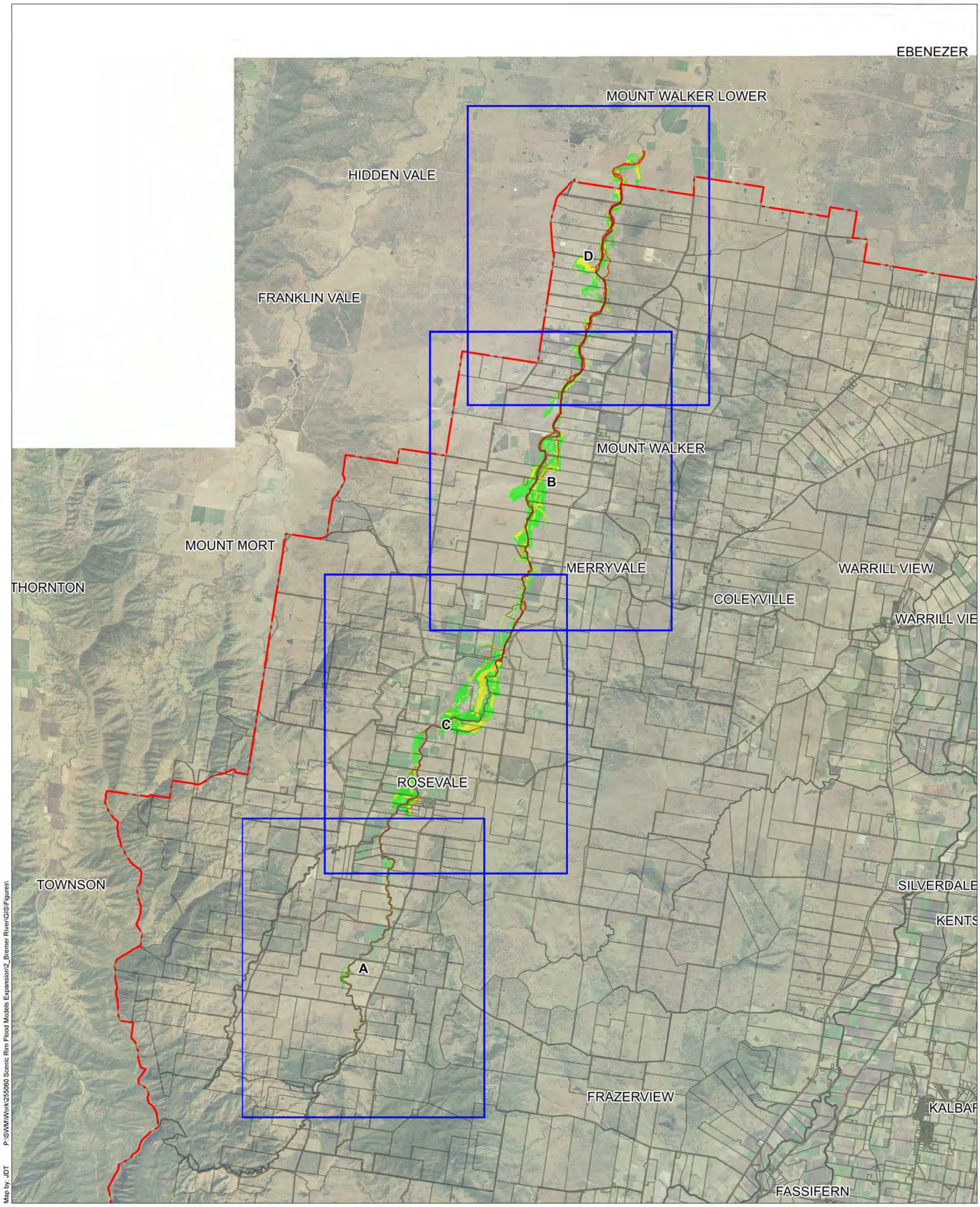
Date: 22/06/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure E3-d**

10% AEP Event - Peak Depth Map

aurecon



Legend

SRRC Boundary

Cadastral Boundary

Low Hazard

Medium Hazard

High Hazard

Notes:

1:100,000

0 2,500 m 5,000 m

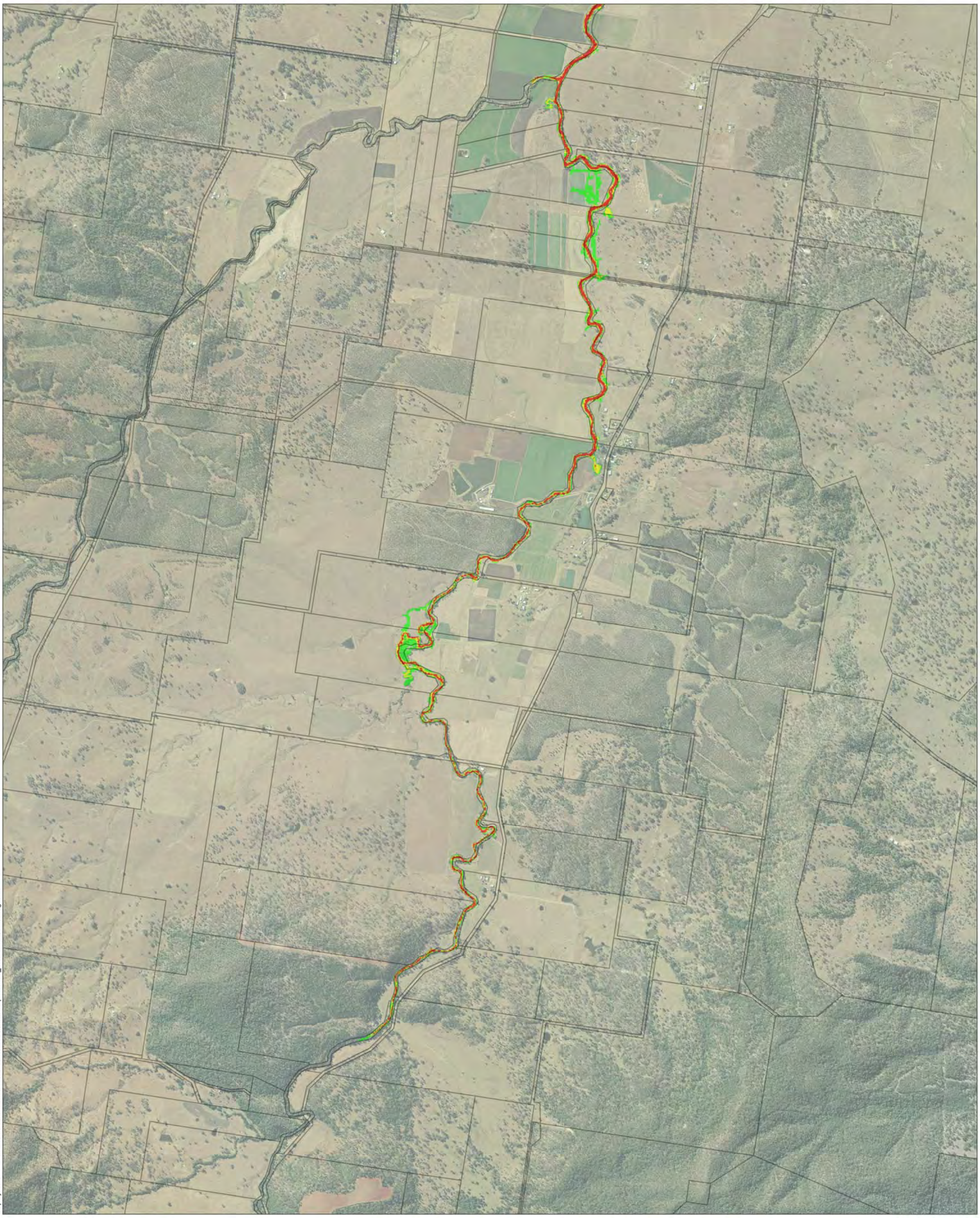
Date: 22/06/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure E4**

10% AEP Event - Peak Hazard Map

aurecon



Legend

SRRC Boundary

Cadastral Boundary

Low Hazard

Medium Hazard

High Hazard

Notes:

1:25,000

0 625 m 1,250 m

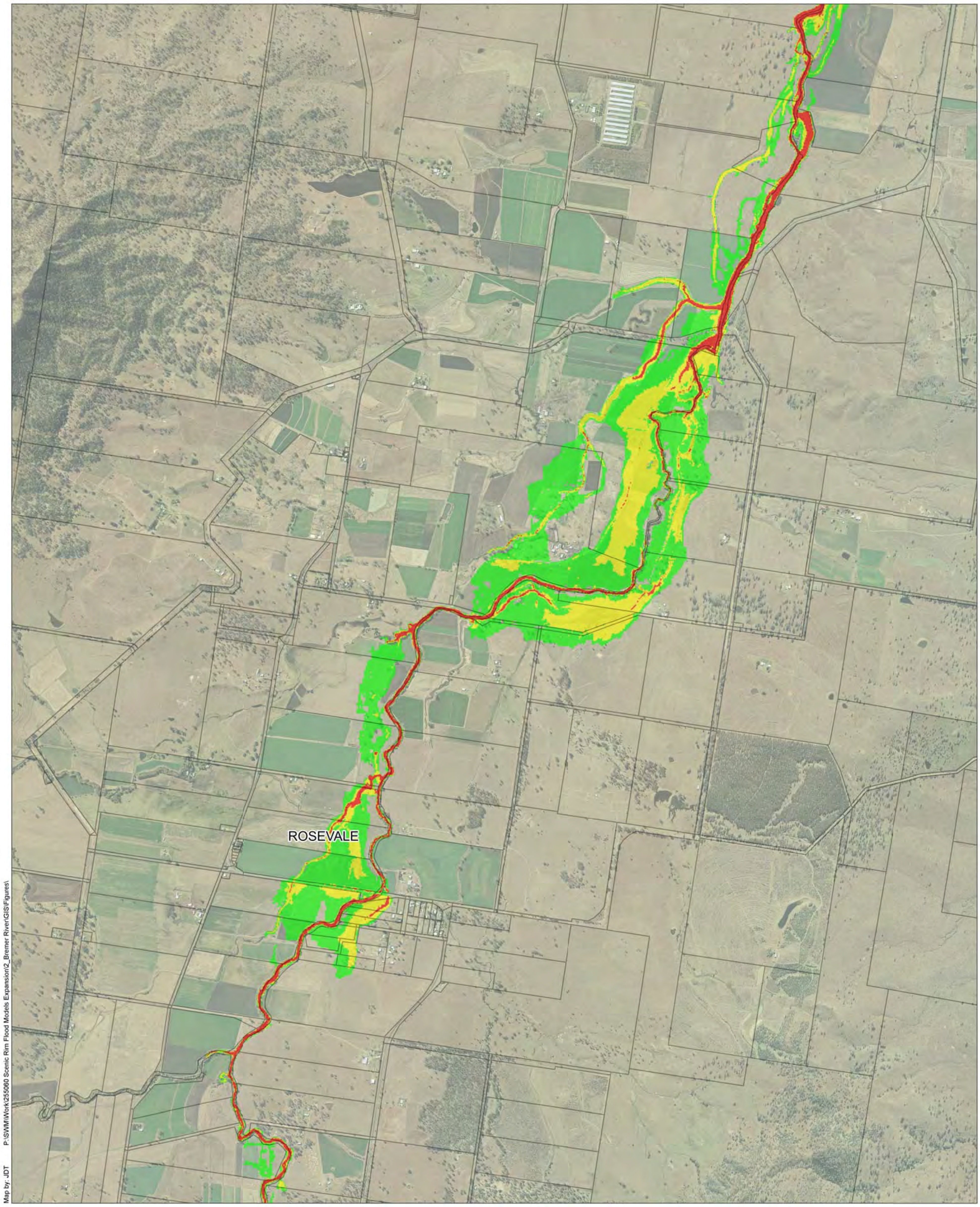
Date: 22/06/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure E4-a**

10% AEP Event - Peak Hazard Map

aurecon



Legend

SRRC Boundary
Cadastral Boundary
Low Hazard
Medium Hazard
High Hazard

Notes:

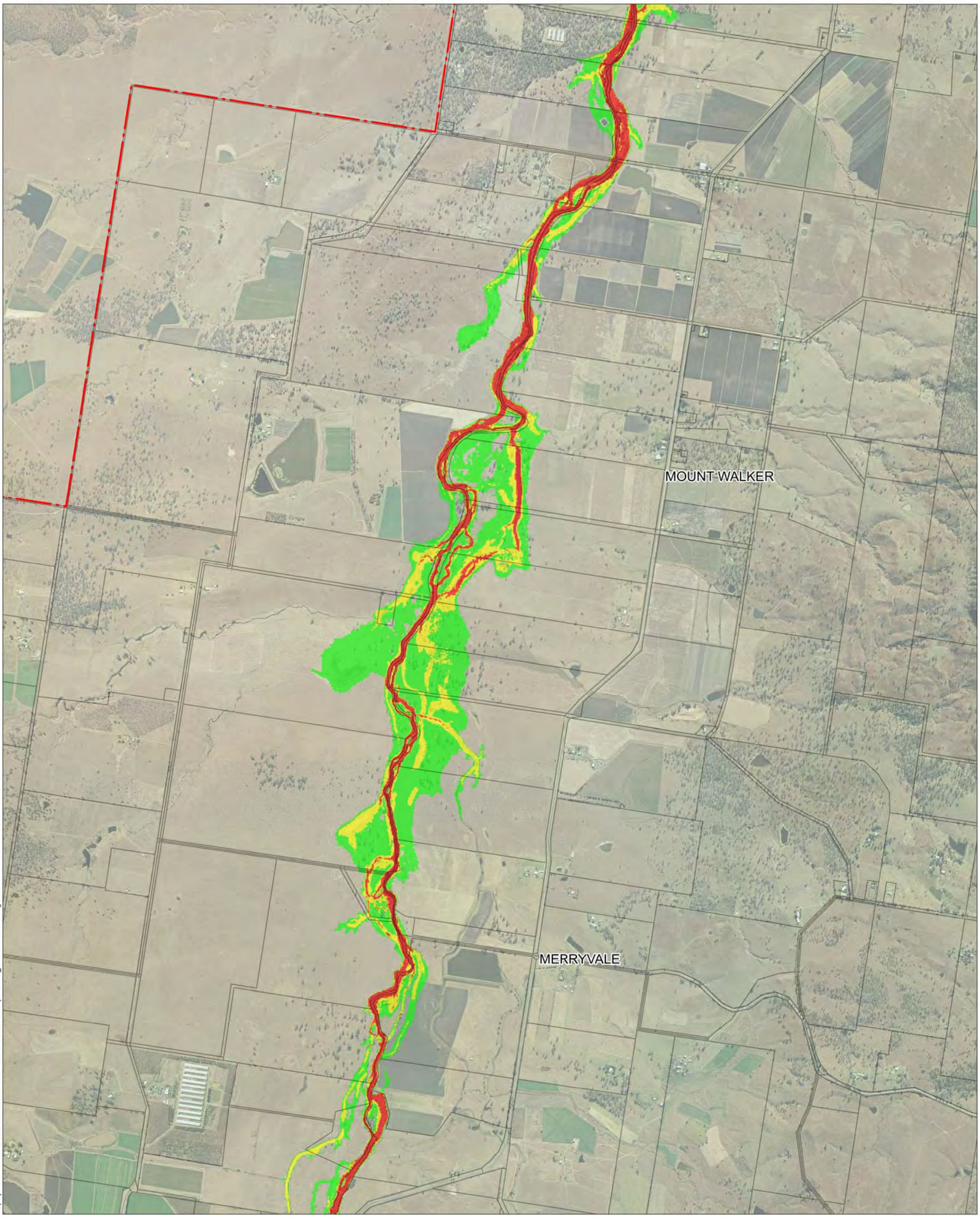
1:25,000
0 625 m 1,250 m

Date: 22/06/2017 Version: 0 Job No: 255060
Projection: MGA Zone 56

Bremer River Flood Study Figure E4-b

10% AEP Event - Peak Hazard Map

aurecon



Map by: JDT P:\SWM\Work\255060 Scenic Rim Flood Models Expansion\2_Bremer River\GIS\Figures\

Legend

SRRC Boundary
Cadastral Boundary
Low Hazard
Medium Hazard
High Hazard

Notes:

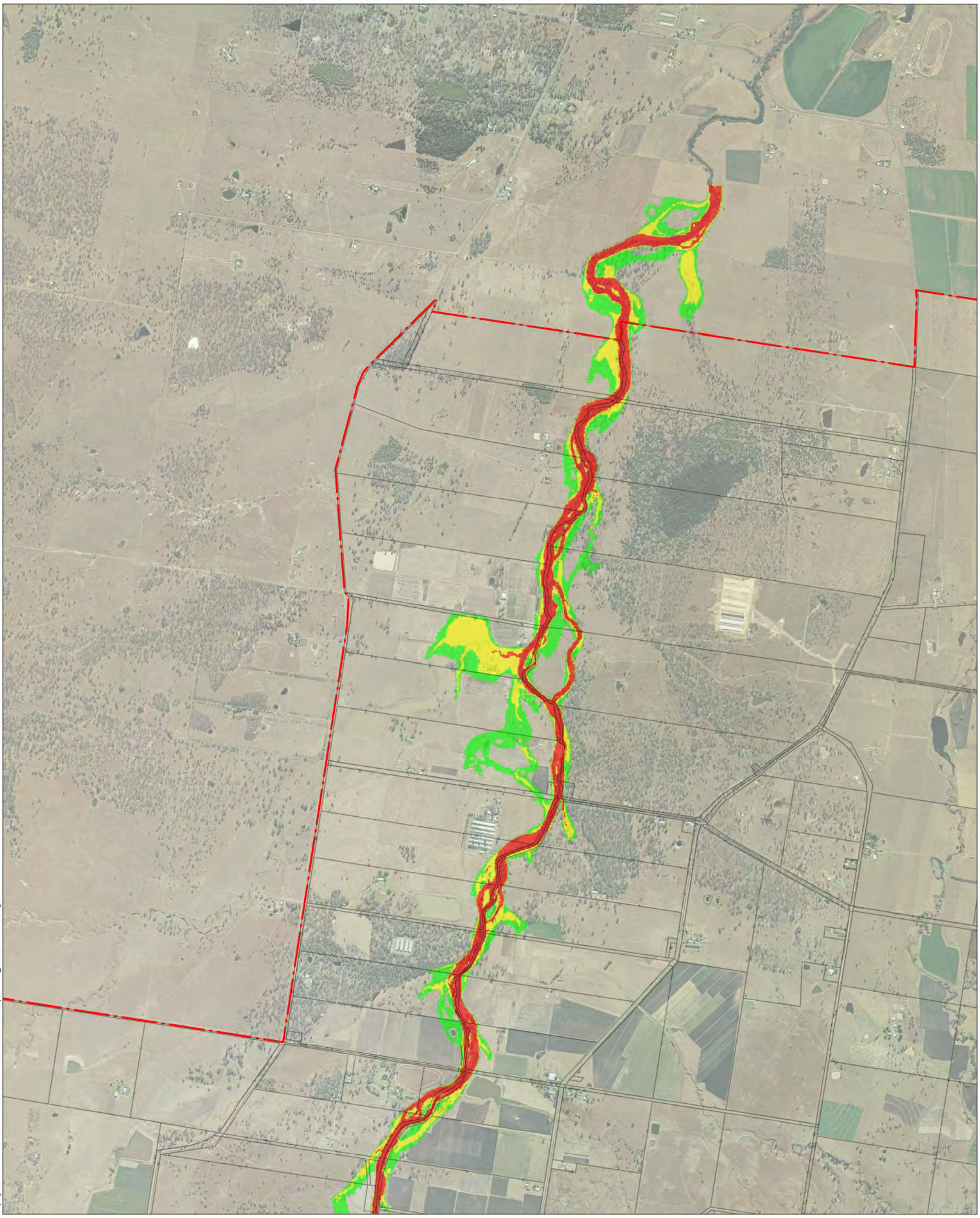
1:25,000
0 625 m 1,250 m

Date: 22/06/2017 Version: 0 Job No: 255060
Projection: MGA Zone 56

Bremer River Flood Study **Figure E4-c**

10% AEP Event - Peak Hazard Map

aurecon



Map by: JDT P:\SWM\Work\255060 Scenic Rim Flood Models Expansion\2_Bremer River\GIS\Figures\

Legend

- SRRC Boundary
- Cadastral Boundary
- Low Hazard
- Medium Hazard
- High Hazard

Notes:

1:25,000

0 625 m 1,250 m

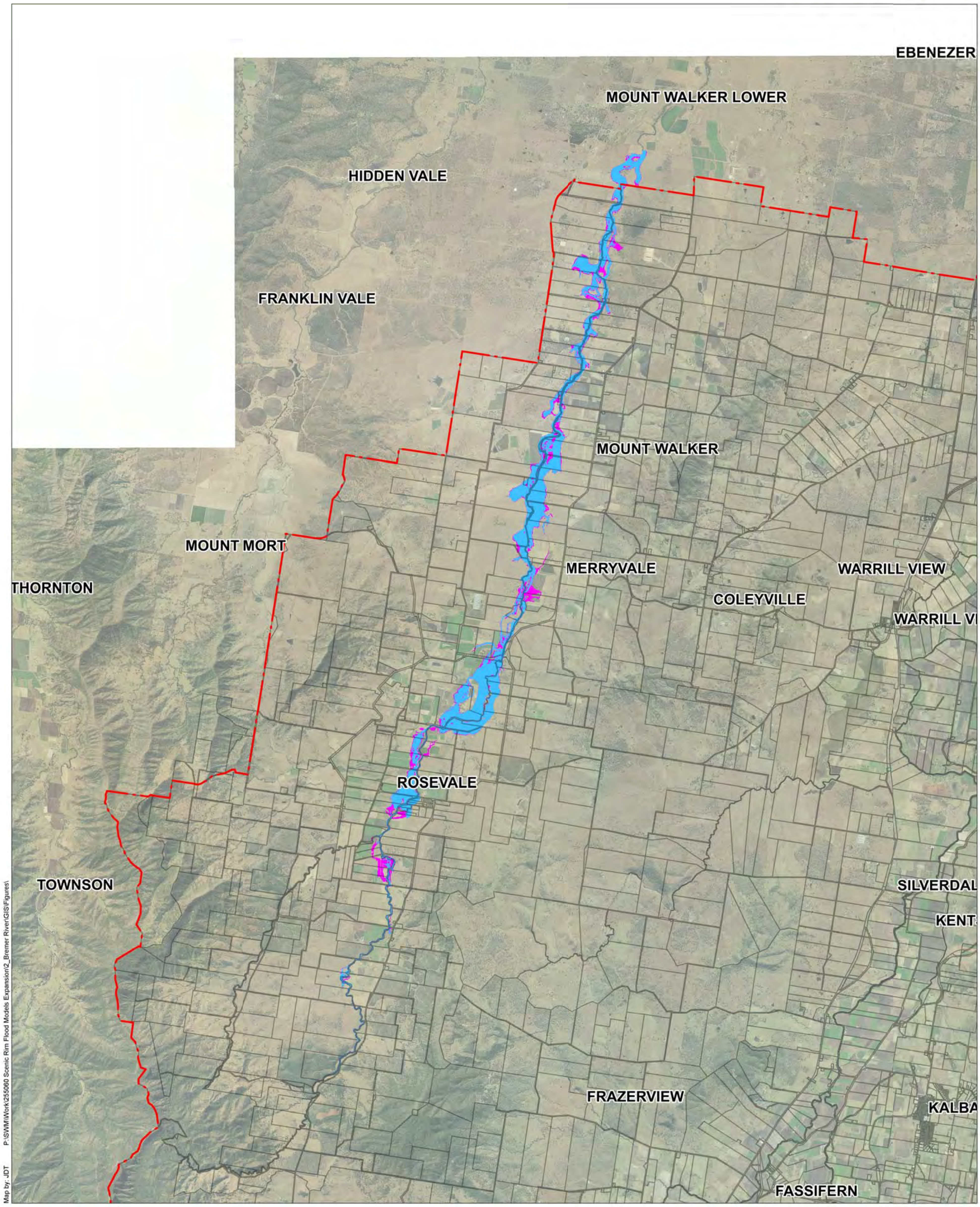
Date: 22/06/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure E4-d**

10% AEP Event - Peak Hazard Map

aurecon



Legend

SRRC Boundary
Cadastral Boundary

Existing Scenario Inundation Extents
Climate Change Scenario 4.5 Inundation Extent

Notes:

1:50,000
0 1,250 m 2,500 m

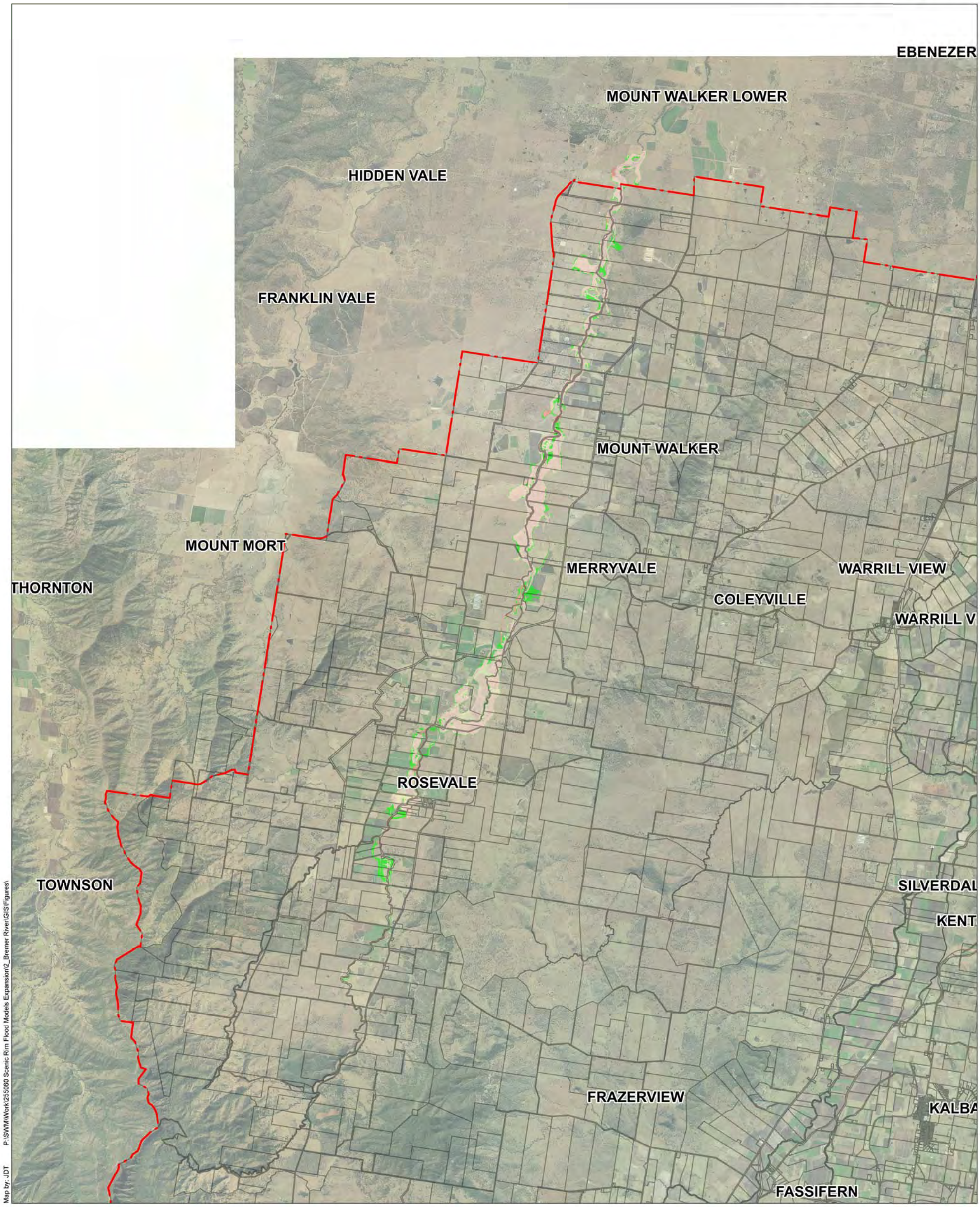
Date: 22/06/2017 Version: 0 Job No: 255060
Projection: MGA Zone 56

Bremer River Flood Study

Figure E5-a

Climate Change Scenario 4.5 - 10% AEP Event Inundation Extent

aurecon



Legend

SRRC Boundary

Cadastral Boundary

Afflux (m)

- < -0.80
- -0.80 to -0.60
- -0.60 to -0.40
- -0.40 to -0.20
- -0.20 to -0.03
- -0.03 to 0.03
- 0.03 to 0.20
- 0.20 to 0.40
- 0.40 to 0.60
- 0.60 to 0.80
- 0.80 to 1.20
- > 1.20
- Was Dry Now Wet
- Was Wet Now Dry

Notes:

1:50,000

0 | 1,250 m | 2,500 m

Date: 22/06/2017 Version: 0 Job No: 255060

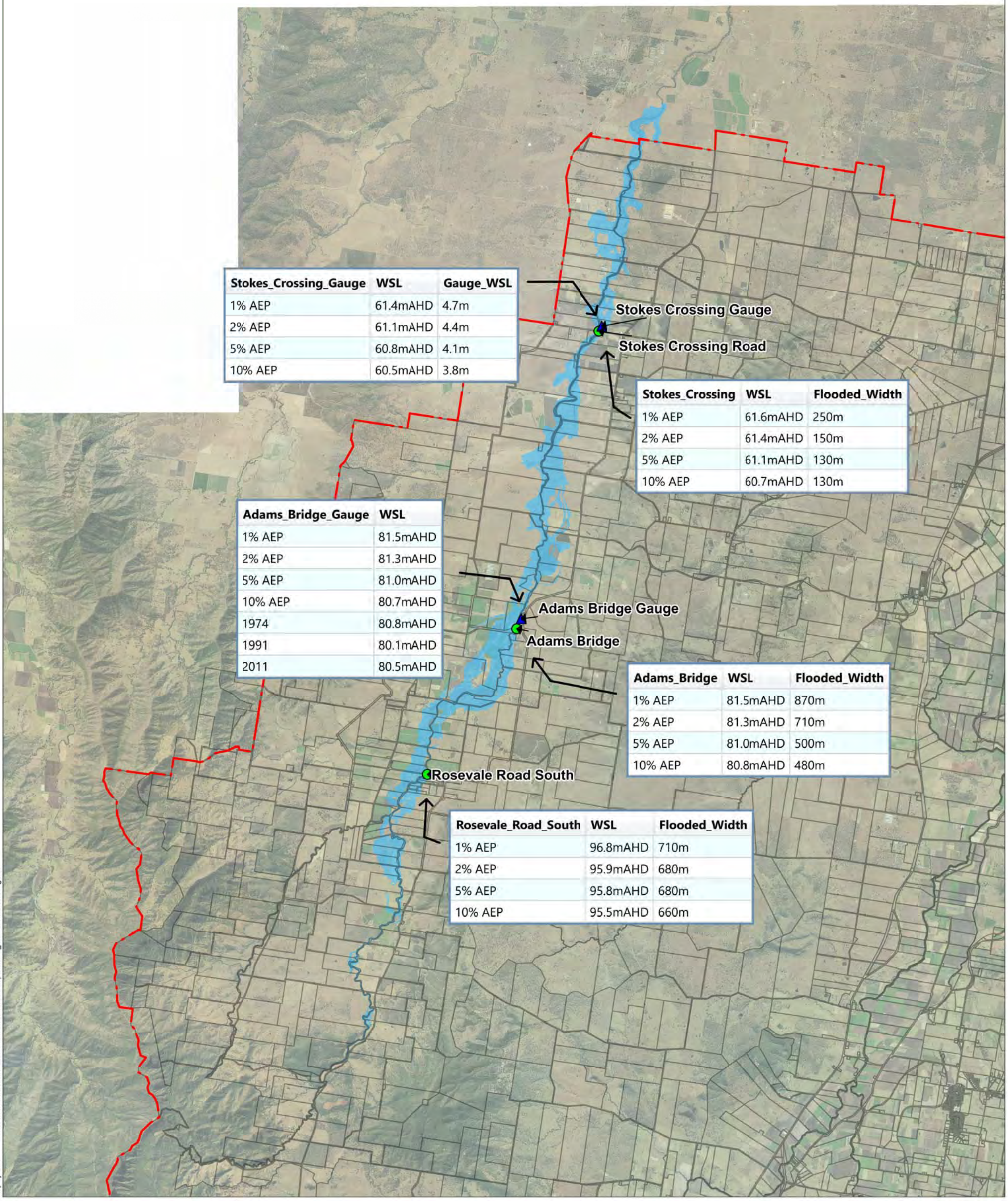
Projection: MGA Zone 56

Bremer River Flood Study

Figure E5-b

Climate Change Scenario 4.5 - 10% AEP Event Afflux Map

aurecon



Stokes_Crossing_Gauge	WSL	Gauge_WSL
1% AEP	61.4mAHD	4.7m
2% AEP	61.1mAHD	4.4m
5% AEP	60.8mAHD	4.1m
10% AEP	60.5mAHD	3.8m

Stokes_Crossing	WSL	Flooded_Width
1% AEP	61.6mAHD	250m
2% AEP	61.4mAHD	150m
5% AEP	61.1mAHD	130m
10% AEP	60.7mAHD	130m

Adams_Bridge_Gauge	WSL
1% AEP	81.5mAHD
2% AEP	81.3mAHD
5% AEP	81.0mAHD
10% AEP	80.7mAHD
1974	80.8mAHD
1991	80.1mAHD
2011	80.5mAHD

Adams_Bridge	WSL	Flooded_Width
1% AEP	81.5mAHD	870m
2% AEP	81.3mAHD	710m
5% AEP	81.0mAHD	500m
10% AEP	80.8mAHD	480m

Rosevale_Road_South	WSL	Flooded_Width
1% AEP	96.8mAHD	710m
2% AEP	95.9mAHD	680m
5% AEP	95.8mAHD	680m
10% AEP	95.5mAHD	660m

Map by: JDT P:\SWM\Work\255060 Scenic Rim Flood Models Expansion\2_Bremer River\GIS\Figures\

Legend

- SRRC Boundary
- Cadastral Boundary
- Inundation Extent
- Road Crossing
- Stream Gauge

Notes:

1:100,000

0 2,500 m 5,000 m

Date: 22/06/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Bremer River Flood Study **Figure F**

Emergency Response Mapping - Stream Gauge & Road Crossing Details

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Swaziland, Tanzania, Thailand, Uganda,
United Arab Emirates, Vietnam.