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Scenic Rim Flood Modelling

Teviot Brook Flood Modelling – Consolidated Final Report

Scenic Rim Regional Council

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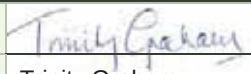
Author signature		Approver signature	
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1 Introduction

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 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 Teviot Brook catchment.

1.2 Study area

Teviot Brook is a tributary of the Logan River with the downstream confluence at Yarrahappini. The upper reaches of the Teviot Brook catchment extends to Mount Roberts. The catchment is predominantly rural particularly in its upper reaches. The Logan River Basin is a large river system which discharges into Moreton Bay. The Scenic Rim Local Government boundary extends to Mount Wilbraham and defines the boundary for the lower extent of this study.

1.3 Study objectives

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 Teviot Brook 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 Teviot Brook 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 studies

The Teviot Brook RAFTS model was adapted from a model original developed by Logan City Council (LCC) as part of the 2014 hydrology study analysing the Teviot Brook, Albert and Logan catchments.

2.2 Survey Data

2.2.1 Aerial LiDAR Survey

SRRC's 2011 Aerial LiDAR Survey (ALS) data was utilised as the basis for topographic representation within the Teviot Brook catchment as per the 2016 study. ALS data typically produces levels within an accuracy of ±150 mm and a horizontal accuracy of ±300 mm.

As part of the Logan River Flood Study (Aurecon, 2014), the ALS data was verified against ground survey (2013) of Permanent Survey Marks (PSM). 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.

In 2017, Council also provided data generated by SEQ Catchments 2013 which provided refinement of the topographic data. However, it was found that this data did not provide coverage of Teviot Brook catchment only in the upper reaches of the Warrill Creek catchment and as such it was not used for the additional flood modelling.

No bathymetric data was provided for this study and it was noted for the 1% AEP modelling that the river bed definition was limited by the presence standing water. Whilst this limitation was not considered significant for the 1% AEP event due to the high proportion of overbank flow in the major storm event, it was considered more significant for the analysis of minor to moderate storm events due to the higher proportion of flow conveyed within the banks.

2.2.2 Structure data

2.2.2.1 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. The following simplified assumptions have been 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% has been assumed to allow for pier losses

2.2.2.2 2%, 5% and 10% AEP events

To assist with providing information for emergency management response critical road crossings were identified within the Teviot Brook Catchment. This was carried out in consultation with Council. Detailed field survey was commissioned to obtain structure details for incorporation into the hydraulic model. In the Teviot Brook catchment, the following crossings were surveyed:

- Carney's Creek Road
- Boonah-Rathdowney Road
- Yeats Avenue
- Beaudesert-Boonah Road
- Undullah Road
- Kilmoylar Road

Using this field survey improvements were made to the bathymetric representation within the current model. This is discussed further in Section 5.2.3.2.

2.3 GIS data

The following GIS datasets were provided by SRRC which were utilised as per the 2016 study:

- 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 5.2.3.2.
- Updated DCDB (2017)

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

2.4 Calibration data

A number of rainfall gauges and stream gauges data, and historical recordings were available for this project. This data was used for the calibration of the models for the 1974, 1990, 1991 and 2013 events. The details of the available calibration data are detailed in Section 4.3.

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 Models Development

3.1 Hydrologic Model

The Logan City Council RAFTS model for the Teviot brook catchment was considered suitable for use and adopted for this study. RAFTS is a runoff routing model and an industry standard tool commonly used for hydrologic studies.

3.1.1 Modelling extents

The Teviot brook sub-model adopted for this assessment extends from the upper limits of the catchment down to Yarrahappini and was previously calibrated for the 1974, 1990 and 2013 events. Calibration was undertaken using gauge records. Figure 1 presents the Teviot Brook hydrologic model layout and extents.

3.1.2 LCC RAFTS model parameters

As noted above the adopted LCC Teviot Brook catchment hydrologic model was calibrated to the 1974, 1990 and 2013 flood events. The LCC RAFTS model flood routing utilised the Muskinghum-Cunge channel routing method. This method specifies the storage constant and weighting factors (k and x) to be applied between nodes. It is noted that the source calculations for the storage factors applied to the LCC RAFTS model were not available for verification.

The LCC RAFTS also includes a storage coefficient factor 'Bx'. This uniformly modifies all subcatchment Storage Time Delay Coefficient values. The parameters applied to the LCC RAFTS model for storage factors, 'k', 'x' and 'Bx' were assumed appropriate and adopted for use in this study. Review of the hydrographs from the LCC RAFTS model against historic gauge records shows a reasonable match in term of flood time lag supporting the use of the previously developed storage factors.

The parameters adopted for the LCC RAFTS model for each calibration event are outlined in Table 2. The RAFTS model catchment is presented in Figure 1.

Table 2 LCC RAFTS model calibration event parameters

Event	Calibration parameters		
	IL (mm)	CL (mm/hr)	Bx
1974	75	1.75	1.4
1990	42	2.0	1.4
2013	100	3.5	1.4

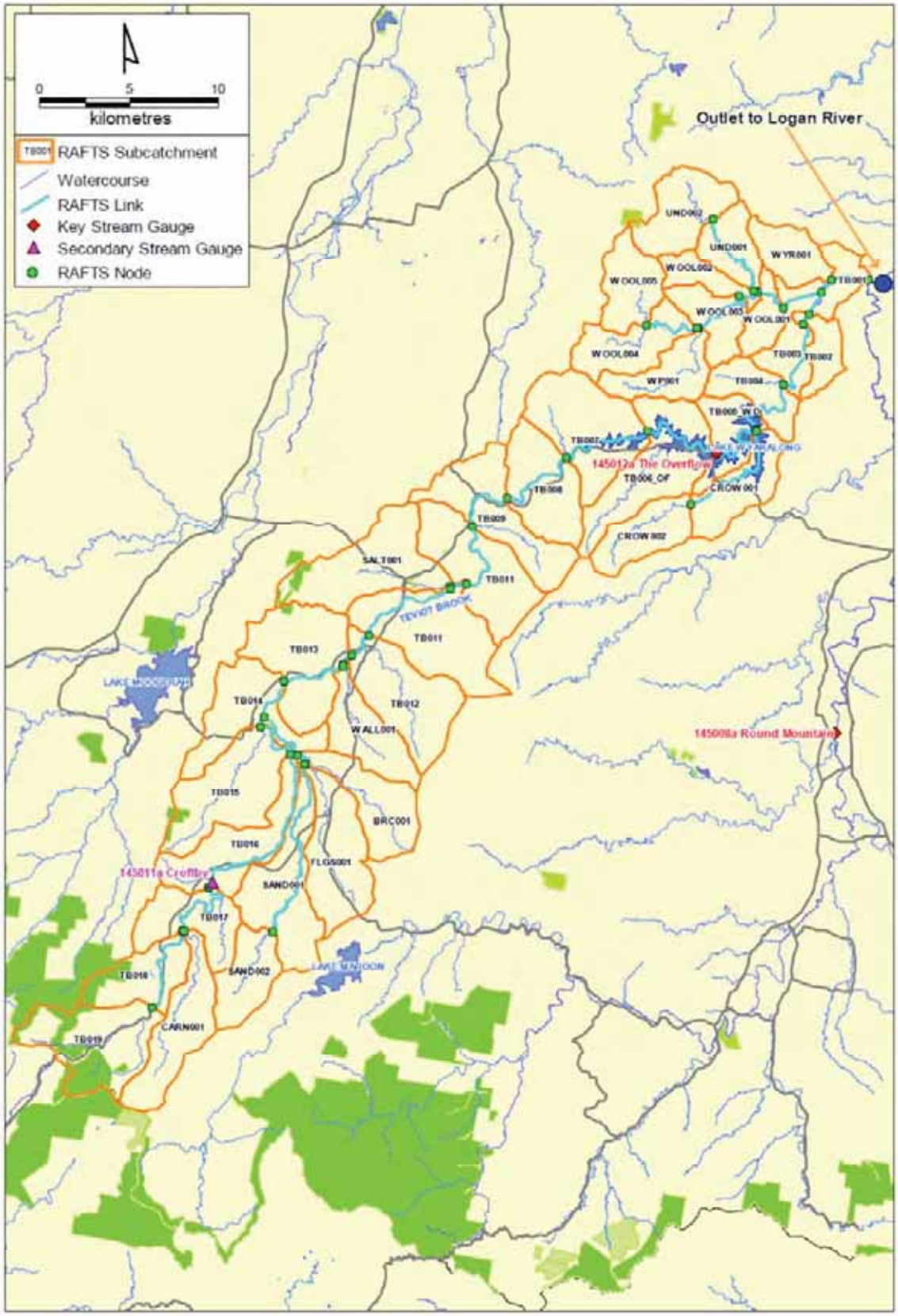

Figure 1 RAFTS model catchment

3.2 Hydraulic Model

3.2.1 Software platform and modelling approach

A 2-dimensional (2D) hydraulic modelling approach was adopted for this study. The Teviot Brook 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 2016-03-AA).

3.2.2 Model setup

The model was run as an unsteady simulation. Therefore, the storage characteristics of the flood plain are accurately accounted for in the model (as represented in the topographic data). The TUFLOW hydraulic model parameters are listed in Table 3.

Table 3 Hydraulic model setup

Model Parameter	Value
Model Type	2D TUFLOW (version 2016-03-AA) Single Precision
Model Width	55000m
Model Height	50000m
Grid Resolution	20

A four second time step was adopted in the model. This is typical for a model of this nature taking into account the grid cell size and flow depths encountered in the 2D domain. This resulted in the model being run in a robust and stable manner.

3.2.3 Modelling extents

The hydraulic model domain is presented in Figure 2 and in Figure A-4, Appendix A. It is noted that the extent of the Teviot Brook system modelled and mapped correlates well to the extents presented by the Queensland Reconstruction Authority (QRA) interim flood lines for the SRRC area. The model extends from downstream of Yaharappini to Carneys Creek in the upper reaches of the catchment and includes an area of approximately 630 km^2.

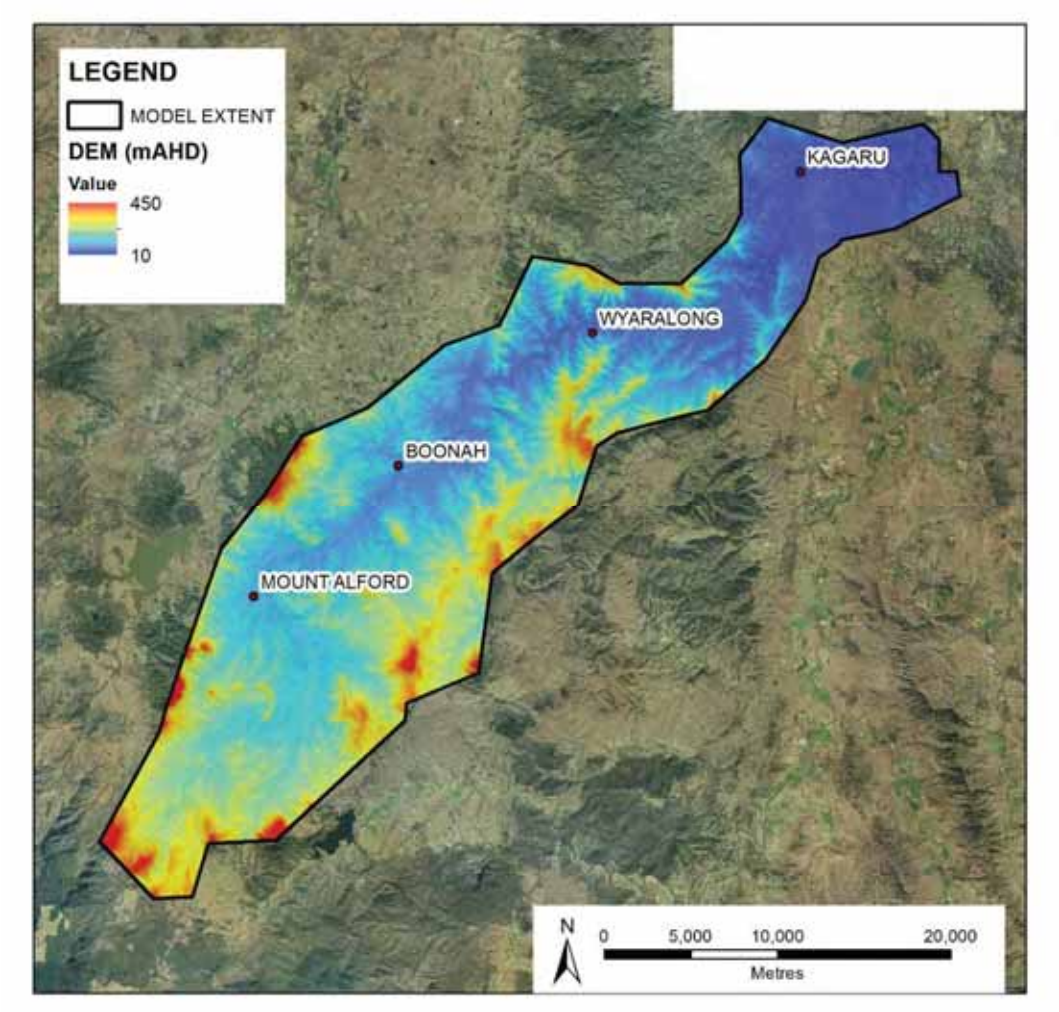

Figure 2 2D model extent

3.2.4 Topography

The hydraulic model was based on topographic information sourced from the 2011 LiDAR survey provided by SRRC. The topography is represented using a 20m grid size. This grid size allows sufficient detail for the channel and flood plain representation in the hydraulic model suitable for the 1% AEP flood event, whilst allowing for reasonable run times.

3.2.5 Initial roughness assumptions

Initial surface roughness values used in the hydraulic model are presented in Table 4 and were based on accepted industry values. Land use types were identified for areas using the aerial photography provided. The spatial discretisation of land use (roughness) in the 2D model domain is shown in Figure 3.

Table 4 Adopted 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
Fields (crops)	0.050
Grazing	0.045

Land use type	Manning's n
River Bed	0.035
Quarries	0.030
Road Reserve	0.020
Dam	0.010

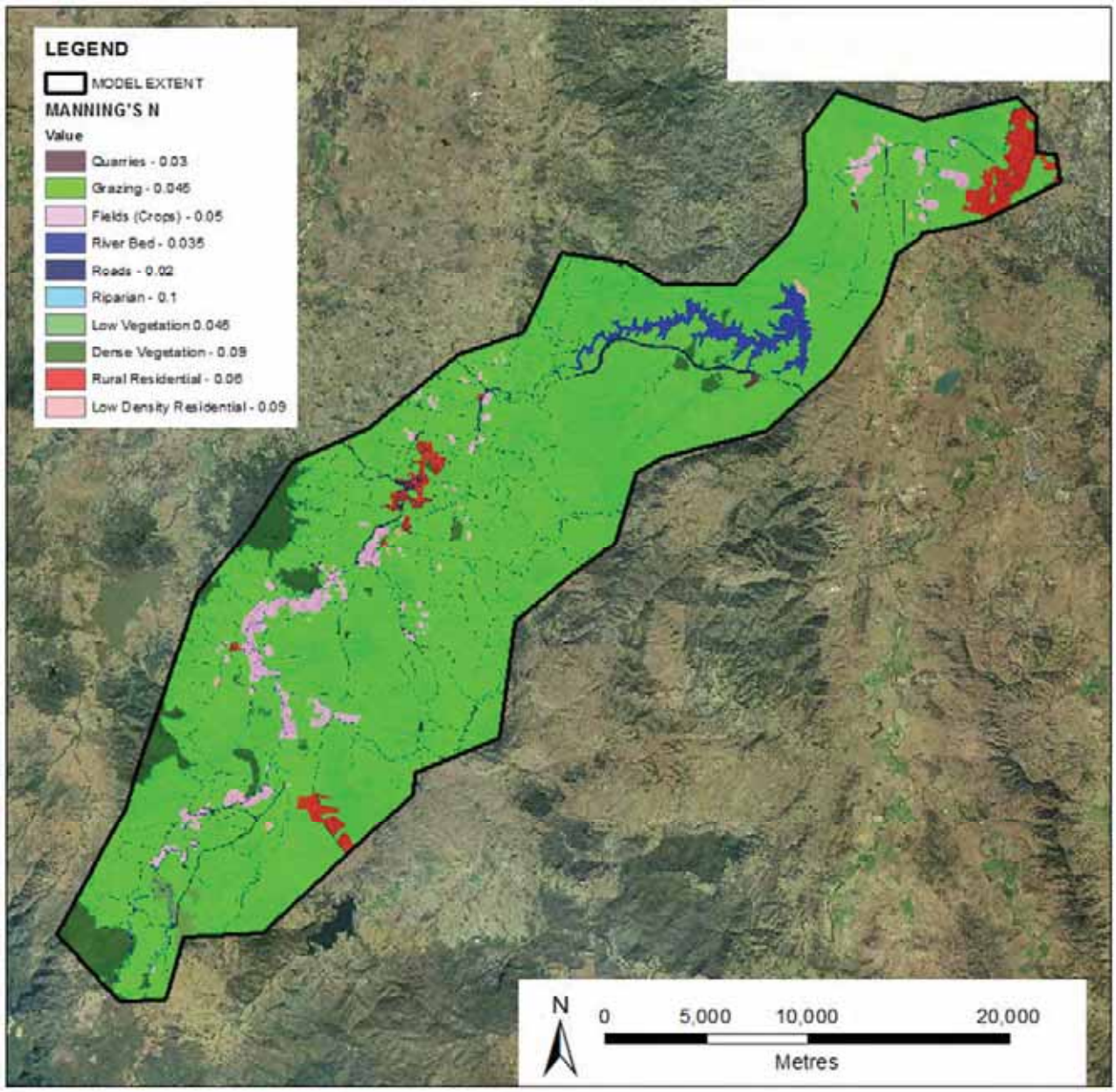

Figure 3 Model roughness

3.2.6 Hydraulic structures

Only limited information for bridges and cross-drainage structures was available with no As-Constructed details available. The following simplified assumptions have been made regarding bridge structures:

- The bridge deck has the same level as the adjacent road level
- The thickness of the deck has been assumed to be 900mm
- A blockage factor of 20% has been assumed for pier losses

Table 5 outlines the bridges that have been included in the hydraulic model.

Table 5 Existing bridges

Name	Locality	Description	Bridge Type	Bridge Length
Causeway	Croftby	Carneys Creek crossing at Head Rd	Concrete	n/a
Causeway	Croftby	Carneys Creek crossing at Carneys Creek Rd	Concrete	n/a
Ganthorpe	Boonah	Black Rock Creek crossing at Munbilla Rd	Concrete	15.8m
Causeway	Boonah	Black Rock Creek crossing at Bell Rd	Concrete	n/a
Sams	Boonah	Teviot Brook crossing at Brent Rd	Timber	25.4m
Chinamans	Boonah	Teviot Brook crossing at Allandale Rd	Concrete	31m
Bartholomew	Boonah	Teviot Brook crossing at Old Rifle Range Rd	Concrete	20.5m
Allandale	Boonah	Teviot Brook Crossing at Allandale Rd	Concrete	n/a
n/a	Boonah	Salt Gully at Macquarie St	Concrete	n/a
n/a	Boonah	Salt Gully at Elliot Rd	Concrete	n/a
n/a	Coulson	Teviot Brook crossing at McConnel Rd	Concrete	n/a
n/a	Beaudesert	Teviot Brook crossing at Old Beaudesert Rd	Timber	n/a
Brookland	Beaudesert	Teviot Brook crossing at Undullah Rd	Timber	51.8m
Edward O'Neill	Beaudesert	Teviot Brook crossing at Kilmoylar	Timber	43.6m
Wilbraham	Beaudesert	Wild Pig Creek crossing at Wild Pig Creek Rd	Timber	8.7m

3.2.7 Wyaralong Dam

Wyaralong Dam is located along Teviot Brook. The dam was completed in 2011 and is captured in the current LiDAR data set adopted for this assessment. Wyaralong dam was included in the TUFLOW model and the spillway modelled as a 1D Channel embedded in the 2D domain. The spillway was represented using the rating curve provided with the LCC RAFTS hydraulic model. This was confirmed against the rating curve presented in the Wyaralong Dam Emergency Action Plan (Seqwater, 2014).

As Wyaralong Dam was only constructed in 2011, the dam was not included in the 1974, 1990 and 1991 calibration events.

Initial water levels for Wyaralong Dam were obtained from gauge records for the 2013 calibration event. The dam was assumed to be at the full supply level of 63.6 mAHD (Seqwater, 2014) for the 1% AEP design events. The dam initial water levels adopted for the calibration and design event scenarios are presented in Table 6.

Table 6 Wyaralong Dam initial water levels

Flood Scenario	Wyaralong Dam Initial Water Level (m AHD)
2013 Calibration	63.02
1% AEP Design Event	63.60

3.2.8 Boundary conditions

The RAFTS 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. A total inflow from the Logan River RAFTS model (Aurecon, 2014) representing the Logan River flows was included as a boundary inflow near Yaharappini. Local inflows from areas within the TUFLOW model were applied throughout the domain.

A normal depth boundary condition was applied at the downstream boundary assuming a water surface slope of 0.003 m/m. Since the downstream boundary is not a well-defined water level, a stage-discharge relationship was used in TUFLOW to define the boundary condition. This boundary was located approximately 5km downstream from the study area. Boundary effects on the study area are not expected.

4 Calibration

4.1 Process of calibration

Four events were used in the model calibration process being 1974, 1990, 1991 and 2013. The RAFTS hydrologic model was calibrated to flow records at rated stream gauges. The calibration is based on achieving a reasonable match against the rising limb of the flood hydrograph, the peak levels, and flood volumes

Inflow hydrographs from the calibrated RAFTS model were then incorporated into the TUFLOW hydraulic model at a number of locations within the study area. The hydraulic model was run for the 2013 event and resulting water levels and discharges were compared to the data available at the stream gauge and survey marks. An iterative joint calibration approach was undertaken with both hydrologic and hydraulic model parameters adjusted to achieve the best match against the available historical data.

It is noted that Wyaralong Dam was constructed in 2011 and is captured in the available LiDAR survey including a standing water level of 61mAHD. Consequently, the hydraulic model cannot be calibrated against storm events prior to this date as the topography for the no-dam condition cannot be adequately represented. Furthermore, there would be little value in calibrating the hydraulic model to pre-dam conditions. Therefore, only the 2013 event was considered in the hydraulic model calibration.

4.2 Calibration targets

Ideally, the following tolerances for stream gauge locations indicate a good calibration has been achieved:

Table 7 Calibration targets

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

For flood levels derived from flood marks or debris a lesser tolerance of +/- 0.50m for peak levels applies.

4.3 Calibration data

4.3.1 Stream gauge data

A review of the stream gauge data within the project extents was undertaken. There are several gauges within the area reported by either the Bureau of Meteorology (BoM) or the Department of Natural Resources and Mines (DNRM). All available stream gauge information is detailed in Table 8 and the locations of each of the gauges presented in Figure A-2, Appendix A. Croftby gauge is located in the upper reaches of the catchment whilst the Overflow, Coulson and Boonah gauges are located around mid-catchment. In addition to the three historical events previously modelled (1974, 1990 and 2013), the 1991 event has been included given its importance within the Logan River catchment for the Scenic Rim Local Government area.

The Overflow is a DNRM rated gauge providing flow rates corresponding to recorded river heights. SunWater undertook a detailed review of the rating curve for The Overflow as part of the Wyaralong Dam hydrology investigations (SunWater, 2007). The SunWater revised rating curve was adopted by LCC in their RAFTS model calibrations. This rating curve has been adopted for the current assessment.

Table 8 Available stream gauge information

Gauge	Owner	Comments	Historic Data			
			1974	1990	1991	2013
145012A The Overflow[1]	DNRM	▪ Primary gauge in the catchment ▪ Flow and level data available for calibration with DNRM rating curve and SunWater revised rating curve (2007) ▪ High confidence in recorded levels and corresponding flows	✓	✓	✓	n/a
145031A Coulson	DNRM	▪ Flow and level data available for calibration with DNRM rating curve ▪ Maximum gauged flow of 184 m^3/s. Calibration to a peak of 670 m3/s ie significantly larger than the gauged rating. ▪ Medium confidence in recorded levels and corresponding flows	n/a	n/a	n/a	✓
145908 Boonah	BoM	▪ BoM flood alert gauge. Primary use for flood level warning. Low confidence in rating curve. ▪ Flow and level data available for calibration ▪ Medium confidence in recorded levels. Low confidence in recorded flows.	n/a	✓	✓	✓
145011A Croftby	DNRM	▪ Flow and level data available for calibration with DNRM rating curve ▪ Maximum gauged flow of 72 m^3/s. Calibration to peaks of 86 to 250 m3/s ie significantly larger than the gauged rating. ▪ Medium confidence in recorded levels and corresponding flows	✓	✓	✓	✓

[1] The Overflow gauge was removed after construction of Wyaralong Dam. During the 2013 flood event Wyaralong dam gauge failed.

4.3.2 1991 Rainfall data

Previously three calibration events, 1974, 1990 and 2013 had already been modelled by LCC, therefore only rainfall data for the 1991 event was sourced for this investigation. The rainfall stations used for the calibration of the 1991 event are displayed on Figure A-3, Appendix A. There were no pluviographs available within the Teviot Brook catchment and only three suitable pluviographs available for use from neighbouring catchments, located at Moogerah Dam, Maroon Dam and Beaudesert.

4.3.3 Surveyed historical flood markings

SRRC have provided historic flood level records at bridges within the catchment. There are only observations at a single bridge location for the 1974, 1991 and 2008 flood events. The 2013 flood event has the most comprehensive coverage of flood level observations with approximately 82 recordings across the catchment.

4.4 Calibration results summary

Overall, a reasonable calibration has been achieved based on the available information and the objectives of this study. As discussed above an iterative calibration process was followed with the following parameters adjusted to achieve the best match to the available historical data:

- Initial and continuing loss rates for each historical event
- Roughness values on Teviot Brook and its tributaries

The results of the calibration process were discussed with SRRC as the calibration progressed to confirm acceptance of the outcomes. This report presents the final calibration results.

4.4.1 1974 Event

Due to survey limitations, only hydrologic model calibration was considered for this event.

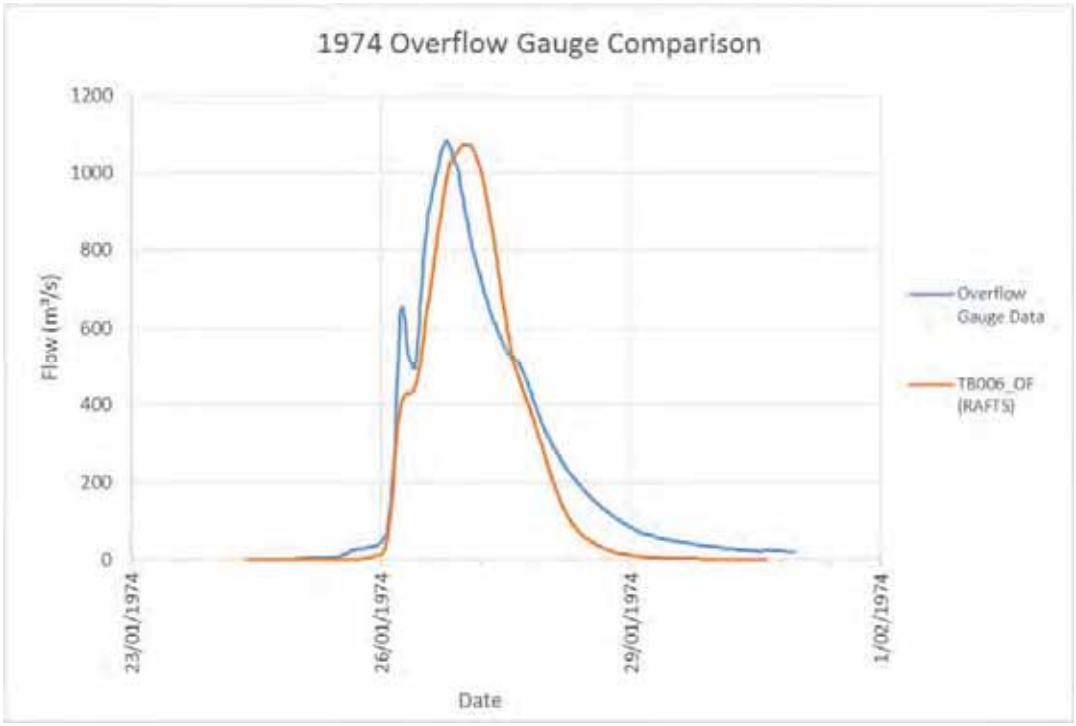

Figure 4 RAFTS hydrologic model calibration at The Overflow gauge

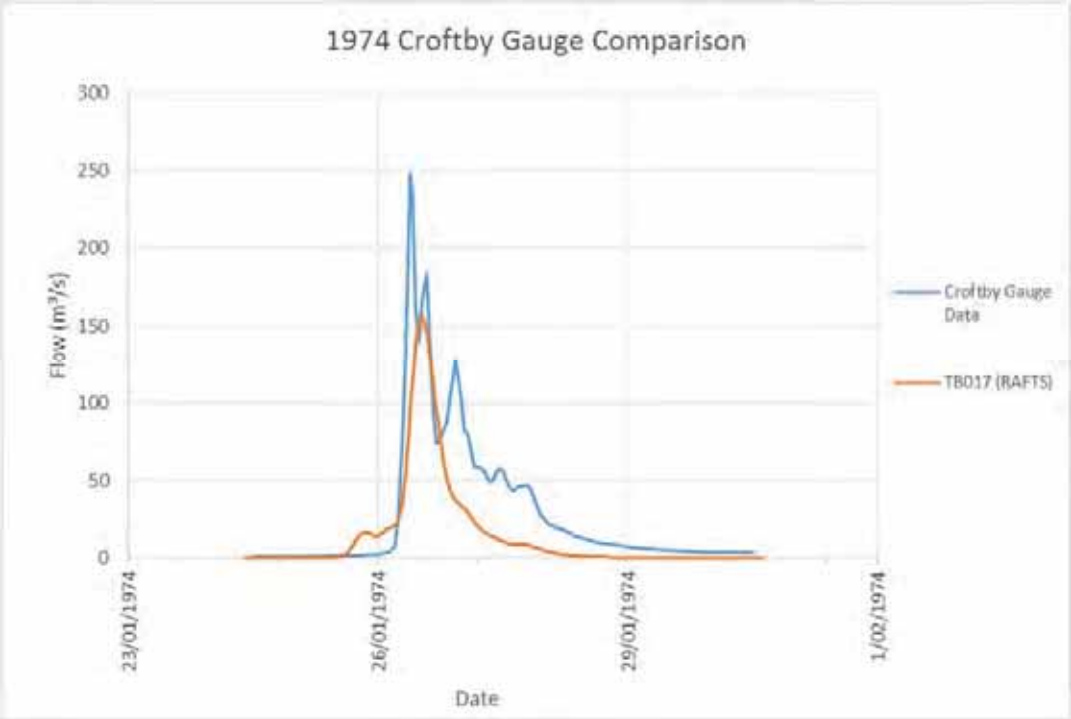

Figure 5 RAFTS hydrologic model calibration at Croftby gauge

4.4.2 1990 Event

Due to survey limitations, only hydrologic model calibration was considered for this event.

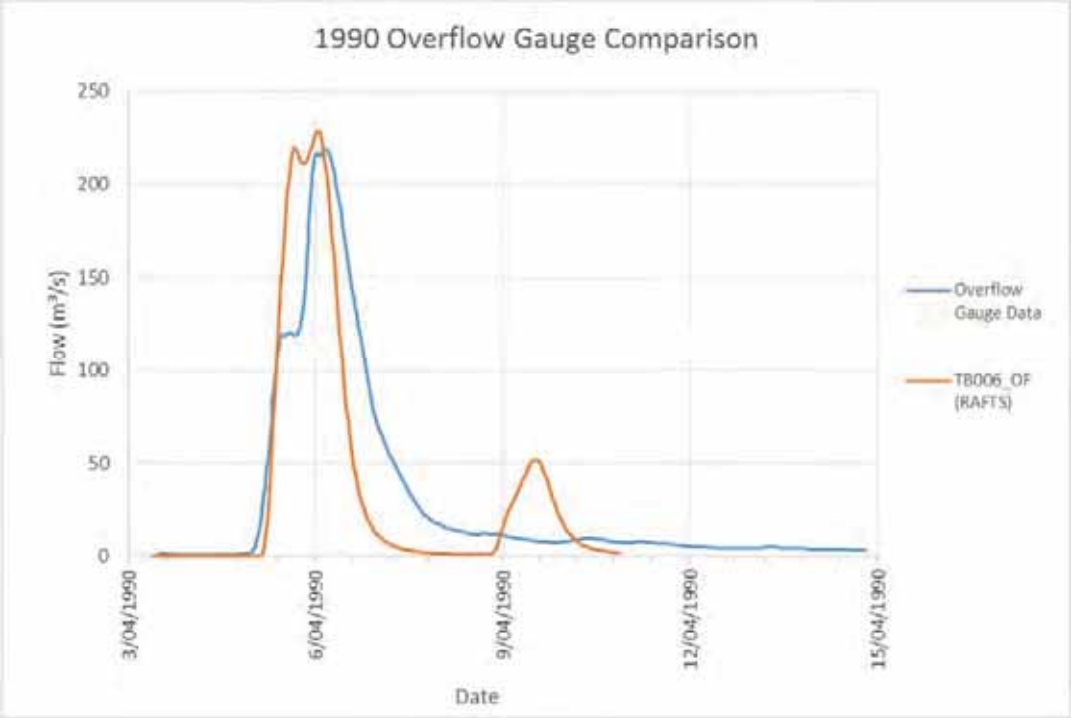

Figure 6 RAFTS hydrologic model calibration at The Overflow gauge

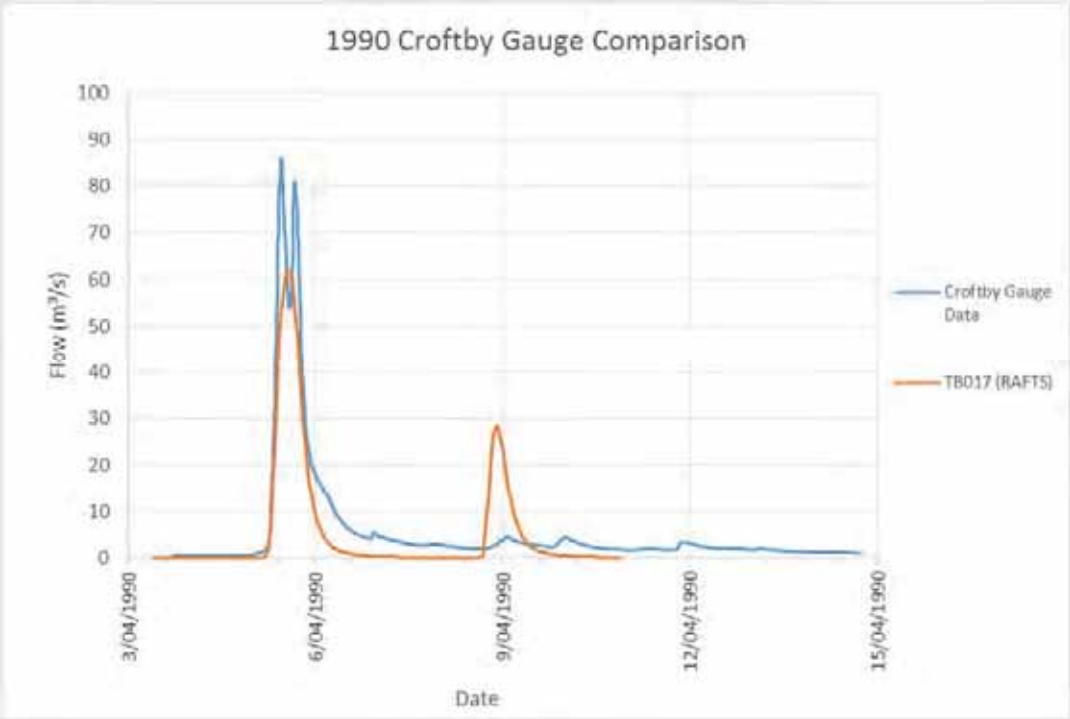

Figure 7 RAFTS hydrologic model calibration at Croftby gauge

4.4.3 1991 Event

Due to survey limitations, only hydrologic model calibration was considered for this event.

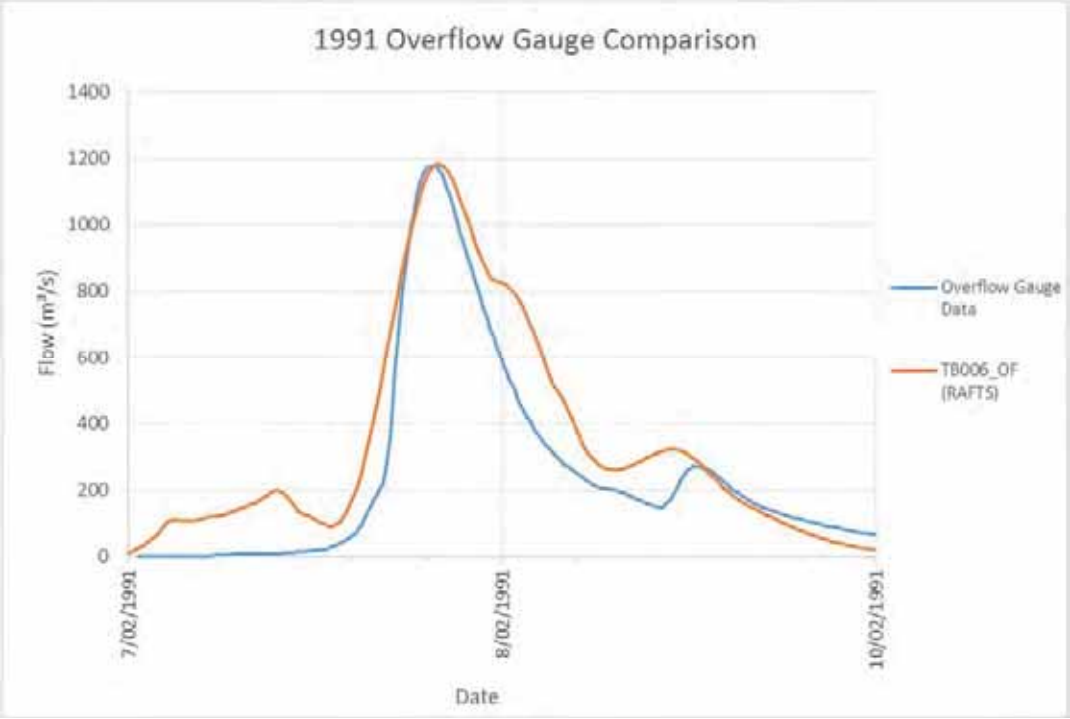

Figure 8 RAFTS hydrologic model calibration at The Overflow gauge

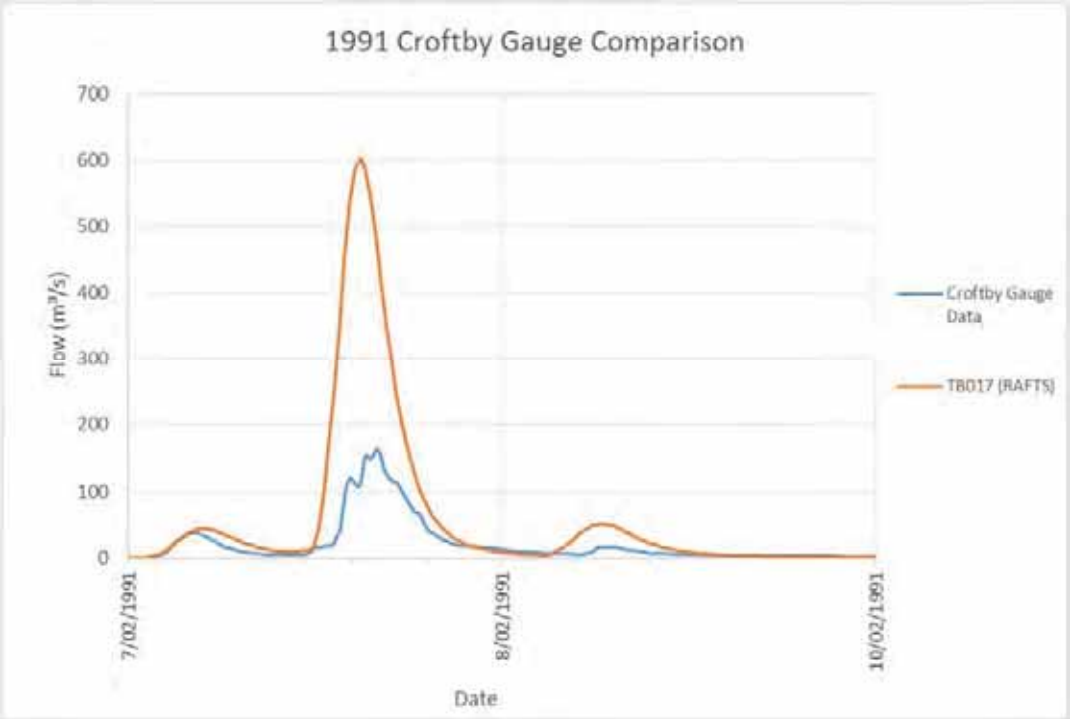

Figure 9 RAFTS hydrologic model calibration at Croftby gauge

4.4.4 2013 Event

Table 9 2013 Calibration Summary

Gauge	Peak Gauge Recording (m AHD)	TUFLOW Peak WSL (m AHD)	Difference (m)
Croftby	167.23	165.77	-1.46
Boonah	86.36	86.50	+0.14
Coulson	68.16	68.26	+0.10

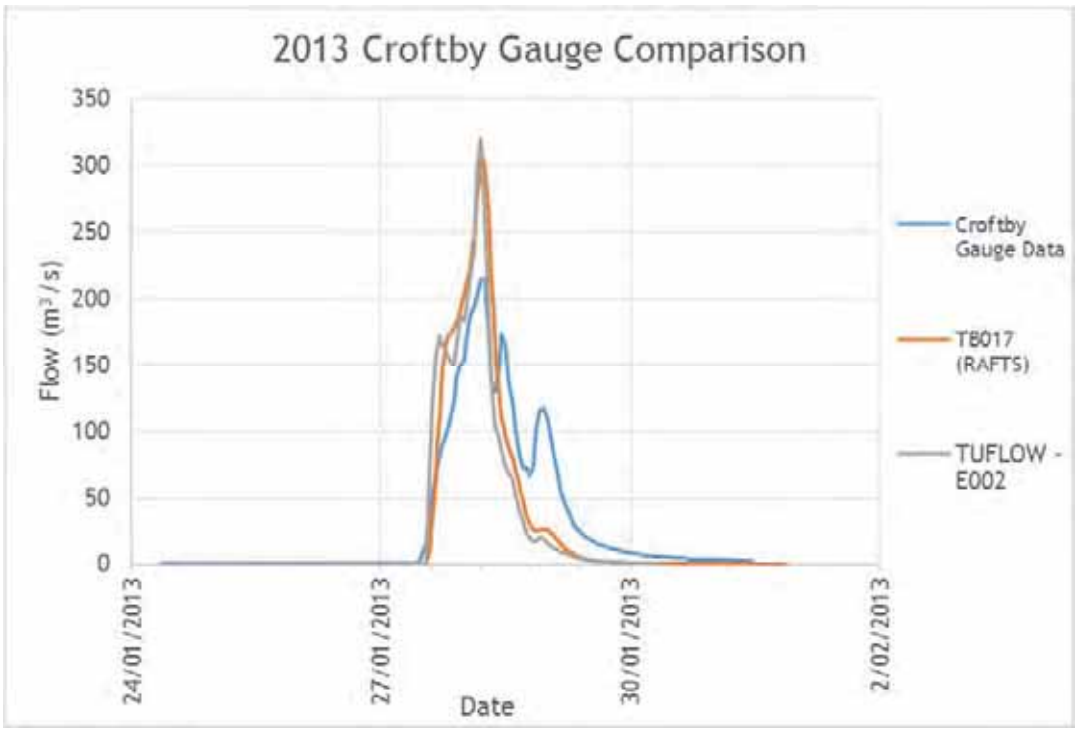

Figure 10 Model calibration at Croftby gauge – Discharge

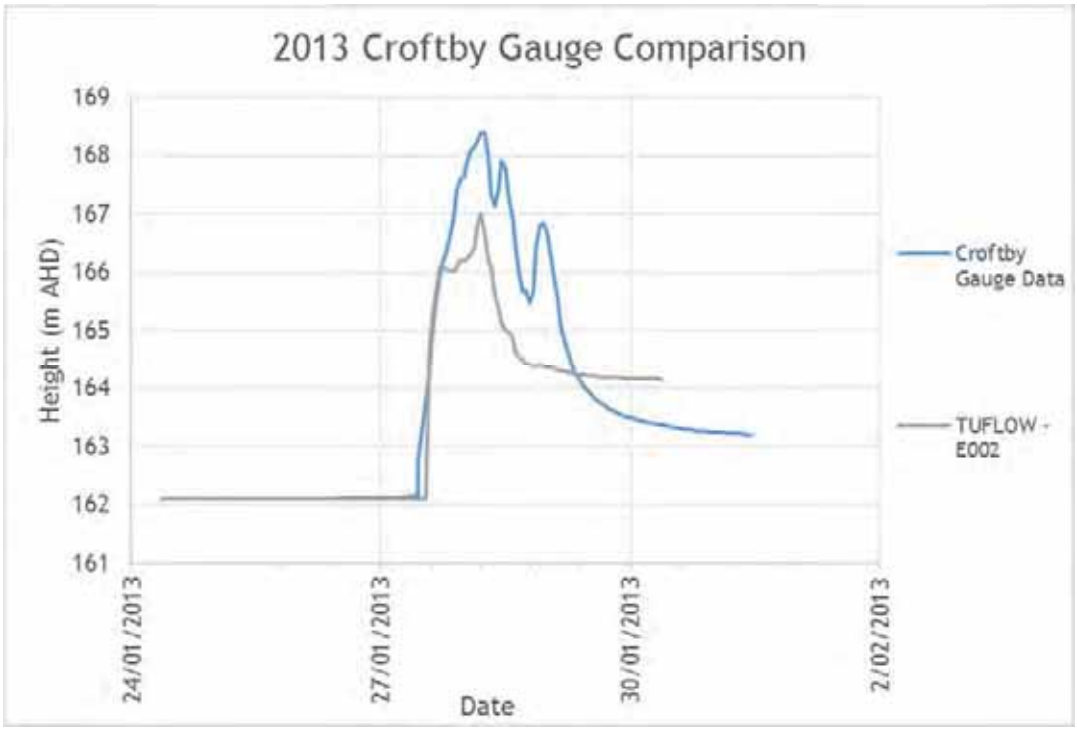

Figure 11 Model calibration at Croftby gauge – Water levels

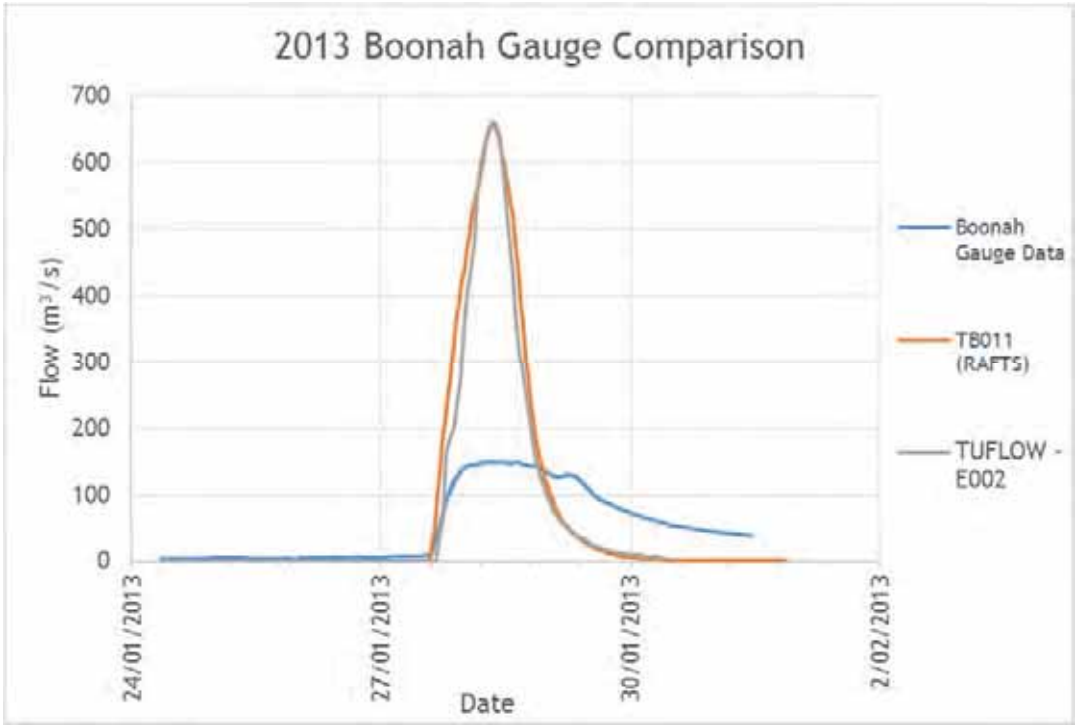

Figure 12 Model calibration at Boonah gauge – Discharge

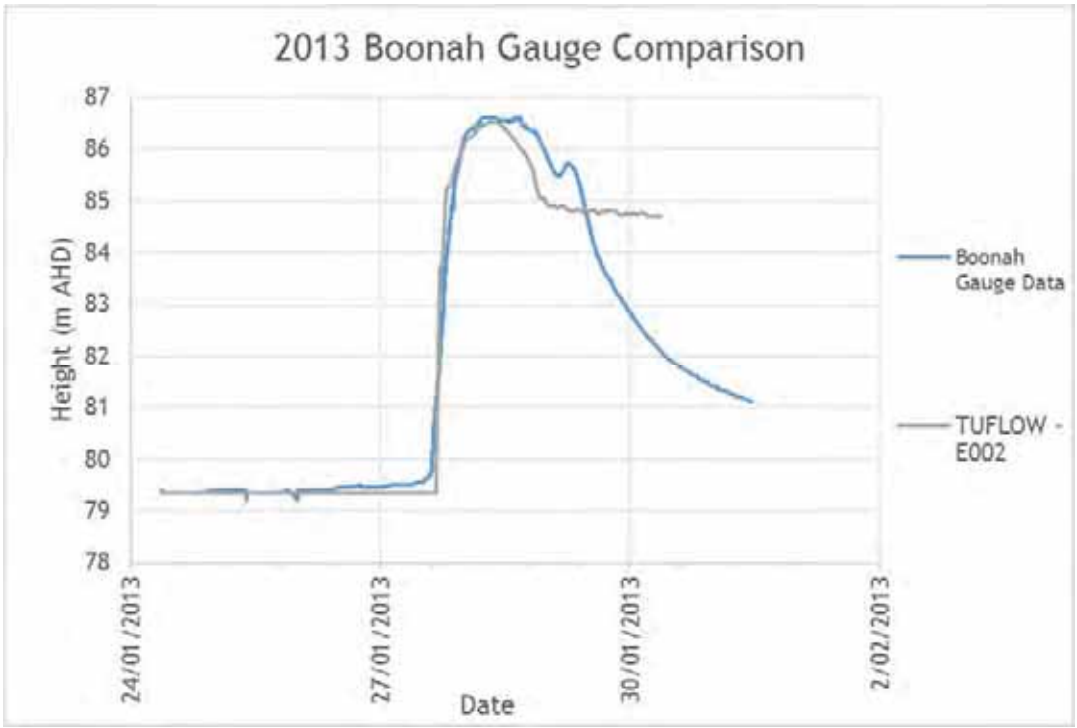

Figure 13 Model calibration at Boonah gauge – Water levels

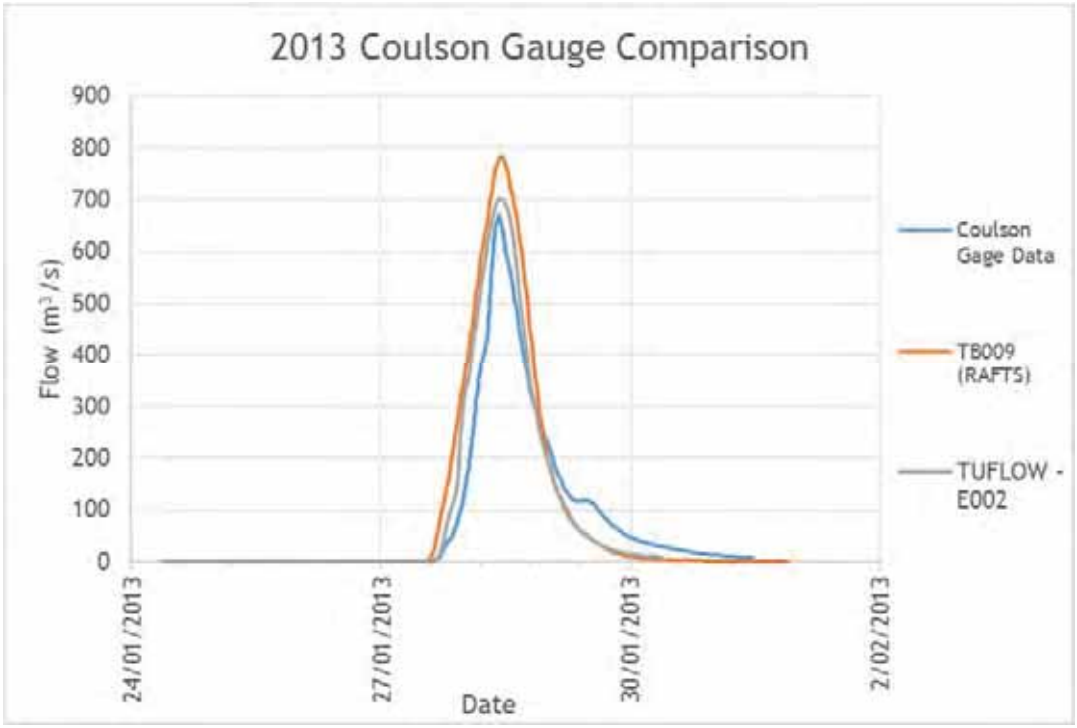

Figure 14 Model calibration at Coulson gauge – Discharge

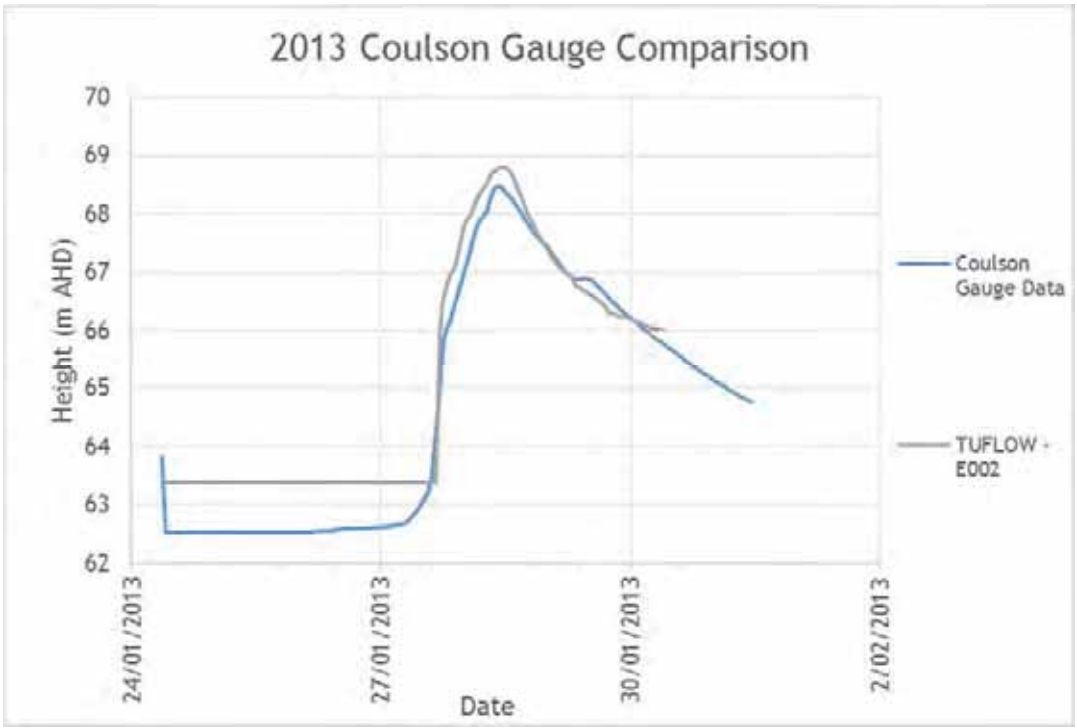

Figure 15 Model calibration at Coulson gauge – Water levels

4.5 Discussion

4.5.1 1974 Event

The hydrologic results are compared below.

4.5.1.1 Gauge Data

- The Overflow Gauge
  - Good match in terms of both shape, volume and peak flow. The peak flows fall within the +/- 10% tolerance.
- Croftby Gauge
  - The RAFTS hydrology model shows significantly lower peaks and volumes compared with the gauge records. There is a reasonable match in terms of the hydrograph shape. The modelled peak flows are significantly outside the +/- 10% tolerance. The differences may be due to the following:
    - Limited rainfall data is available for calibration as this gauge is located in the upper reaches of the catchment.
    - Limitations of the rating curve adopted by DNRM

4.5.2 1990 Event

The hydrologic results are compared below.

4.5.2.1 Gauge Data

- The Overflow Gauge
  - Good match in terms of both shape, volume and peak flow. The peak flows fall within the +/- 10% tolerance.
- Croftby Gauge
  - The RAFTS hydrology model shows significantly lower peaks compared with the gauge records. There is a reasonable match in terms of the hydrograph shape and volume. The modelled peak flows are not within the +/- 10% tolerance. The differences may be due to the following:
    - Limited rainfall data is available for calibration as this gauge is located in the upper reaches of the catchment.
    - Limitations of the rating curve adopted by DNRM

4.5.3 1991 Event

The hydrologic results are compared below.

4.5.3.1 Gauge Data

- The Overflow Gauge
  - Good match in terms of both shape, volume and peak flow. The peak flows fall within the +/- 10% tolerance.
- Croftby Gauge
  - The RAFTS hydrology model shows significantly higher peak and volume compared with the gauge records. There is a reasonable match in terms of the hydrograph shape and timing. The modelled peak flows are significantly outside the +/- 10% tolerance. The differences may be due to the following:
    - Limited rainfall data is available for calibration as this gauge is located in the upper reaches of the catchment. Isohyets were not prepared for this calibration event. However, it is unlikely that this will reduce the differences exhibited at Croftby gauge.

- Gauge failure during this event may explain the significant difference between modelled and recorded flows. The DNRM data quality codes suggest discharges were derived for the peak of this event.

4.5.4 2013 Event

A joint hydrologic and hydraulic model calibration was prepared for this event. A discussion of the results at each of the gauges is outlined below.

4.5.4.1 Gauge Data

- Croftby Gauge
  - The RAFTS hydrology model shows significantly higher peaks and volumes compared with the gauge records. There is a reasonable match in terms of the hydrograph shape. The modelled peak flows are not within the +/- 10% tolerance. The differences may be attributed to the following:
    - Limited rainfall data is available for calibration as this gauge is located in the upper reaches of the catchment
    - Limitations of the rating curve adopted by DNRM
  - The hydraulic model shows a good match with the gauge records in terms of timing and shape. However, the peak levels are significantly lower than the gauge readings. The modelled peak levels are not within the +/- 0.15m tolerance. Similar differences were observed against flood survey marks in this area (refer attached Figure A2). These difference may be due to the following:
    - Croftby gauge is located in the upper reaches of the catchment with flows confined to the channel with no floodplain flow (for this event). The adopted 20 m grid hydraulic model may not represent these smaller in-channel flows as accurately.
    - Assumptions of modelled blockages at bridges
- Boonah Gauge
  - The RAFTS hydrology model shows good timing of the hydrograph, but the peaks and volumes are significantly higher than the recorded gauge flows. The modelled peak flows are not within the +/- 10% tolerance.
  - The hydraulic model shows a reasonable match in terms of both shape and peak heights. The modelled peak levels fall within the +/- 0.15m tolerance.
  - The flow data is significantly different and does not provide a reasonable match. This is likely due to the BoM rating curve adopted. This is a flood level alert gauge with low confidence in the reported flows.
- Coulson Gauge
  - The RAFTS hydrology model matches the recorded gauge hydrograph shape closely. The peak flows fall within the +/- 10% tolerance.
  - The hydraulic model shows a reasonable match in terms of both shape and peak heights. The modelled peak levels fall within the +/- 0.15m tolerance.

4.5.4.2 Historic flood levels

The modelled results compare closely with the recorded flood markings. The majority of the compared results fall within the +/- 0.5m tolerance. Outliers are likely to be a result of wind and wave effects increasing the height of debris marks, or from structure or waterway blockages. Figure 16 shows a scatter plot of the difference between recorded and modelled results at all locations (Modelled peak flood levels minus the recorded peak levels). These results are presented spatially on Figure A-5, Appendix A.

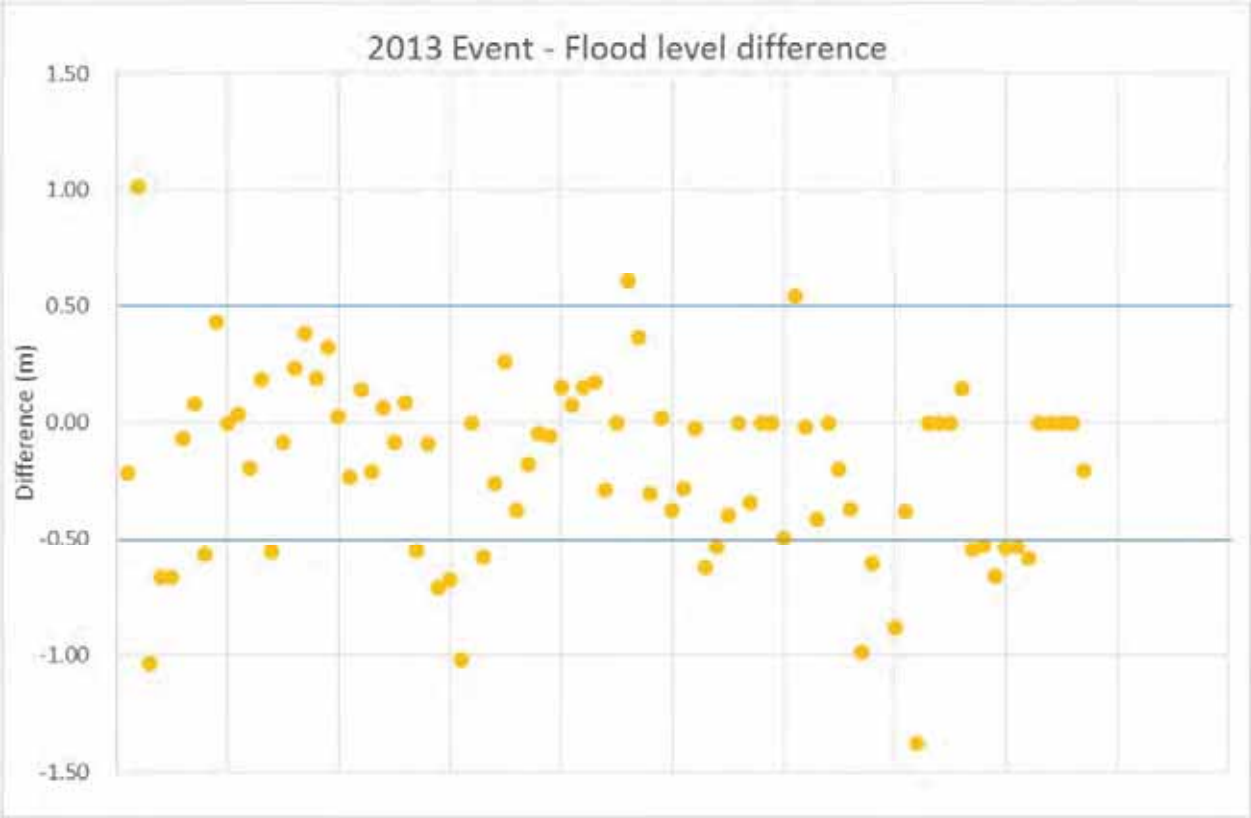

Figure 16 Flood level comparison at bridge survey marks

4.6 Adopted calibration parameters

As detailed above, a joint calibration exercise was undertaken and the parameters presented in Table 10 were adopted for the RAFTS model for each historical event. The parameters that were used in the LCC hydrology were confirmed and adopted through the calibration process. These parameters provided the most accurate results and a uniform approach between Councils.

Table 10 Adopted RAFTS model parameters

Event	Calibration parameters	
	Initial Losses (mm)	Continuous Losses (mm/hr)
1974	75	1.75
1990	42	2
1991	70	3.5
2013	100	3.5

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 11.

Table 11 Adopted Manning's 'n' roughness values

Land use type	Manning's n
Low Density Residential	0.09
Dense Vegetation	0.09
Medium Vegetation	0.07

Land use type	Manning's n
Low Vegetation	0.045
Road Reserve	0.02
River Bed	0.035
Fields (crops)	0.05
Grazing	0.045
Dam	0.01
Quarries	0.03

5 Design Events

As the design event modelling was undertaken in two stages, the following section of the report covers the 1% AEP event first then the additional design events and refinements undertaken for those events.

5.1 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 12.

Table 12 1% AEP design event parameters

Design Event	Calibration parameters		
	Initial Loss Rate (mm)	Continuing Loss Rate (mm/hr)	Bx
1% AEP	0	0.5	1.4

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).

5.1.1 Flood Frequency Analysis

A Flood frequency analysis (FFA) was undertaken to provide further validation to the Teviot Brook design event flood modelling. The FFA utilised the available stream gauge data at The Overflow and Croftby to estimate the peak flow for the 1% AEP design event. This was then used to confirm the design event modelling parameters.

The FFA is limited by the historical data available at each site. However, despite the limitations of the historical data, the FFA provides an appropriate reference point against which to compare the design event results and confirm adopted parameters.

The FFA for the Croftby gauge is shown in Figure 17. The predicted 1% AEP flow at Croftby is 487 m^3/s, which is lower than the FFA 1% AEP estimate of 568 m^3/s. Only 49 years of data was available at Croftby for preparation of the FFA. The predicted 1% AEP flow is within the 90% confidence limits.

The FFA for the Overflow gauge is presented in Figure 18. The predicted 1% AEP flow at The Overflow is 1,129 m^3/s, which is considerably lower than the FFA 1% AEP estimate of 2,103 m^3/s. Only 44 years of data was available at the Overflow gauge for preparation of the FFA. The predicted 1% AEP flow is within the 90% confidence limits.

The differences between the modelled 1% AEP design event flows and the FFA estimates are attributed to:

- Limited historical gauge records available for statically estimating the 1% AEP (1 in 100 year) flows

- Several extreme events occurring in the catchment over the 44 year recording period at the Overflow gauge. The 1991 and 1974 events were the largest recorded at Overflow. Inspection of the recorded rainfall intensities for these two events against the AR&R design rainfall intensity curves suggest these events were greater than the 1% AEP. The 1976 event was of a similar magnitude and is expected to also be around the 1% AEP event. Rainfall data for the 1976 event was not available to confirm this. The relatively short recording period and occurrence of three extreme events during this time results in a statistical skew of the FFA and a larger 1% AEP estimate compared with the modelled results.
- The current AR&R intensity-frequency-duration (IFD) curves may be under-predicting rainfall for this region. A similar anomaly has been identified by others in neighbouring catchments and investigated. No published material is as yet available on these investigations. It is possible that this may be corrected in future IFD releases.

The results show a considerable disparity between the FFA and the design event modelling. While it is likely this difference is a result of the length of available data and the magnitude of the events within the available recording period for the FFA, there is a possibility that the modelling may be significantly under-predicting the 1% AEP flows. Similar findings were identified as part of the BRCFS (Aurecon, 2015) for the neighbouring catchments of Purga Creek, Bremer River and Warrill Creek with the lower flows predicted by the design event approach adopted in the final report. Aurecon recommends Council take this into consideration and review impending IFD revisions against the findings of this study.

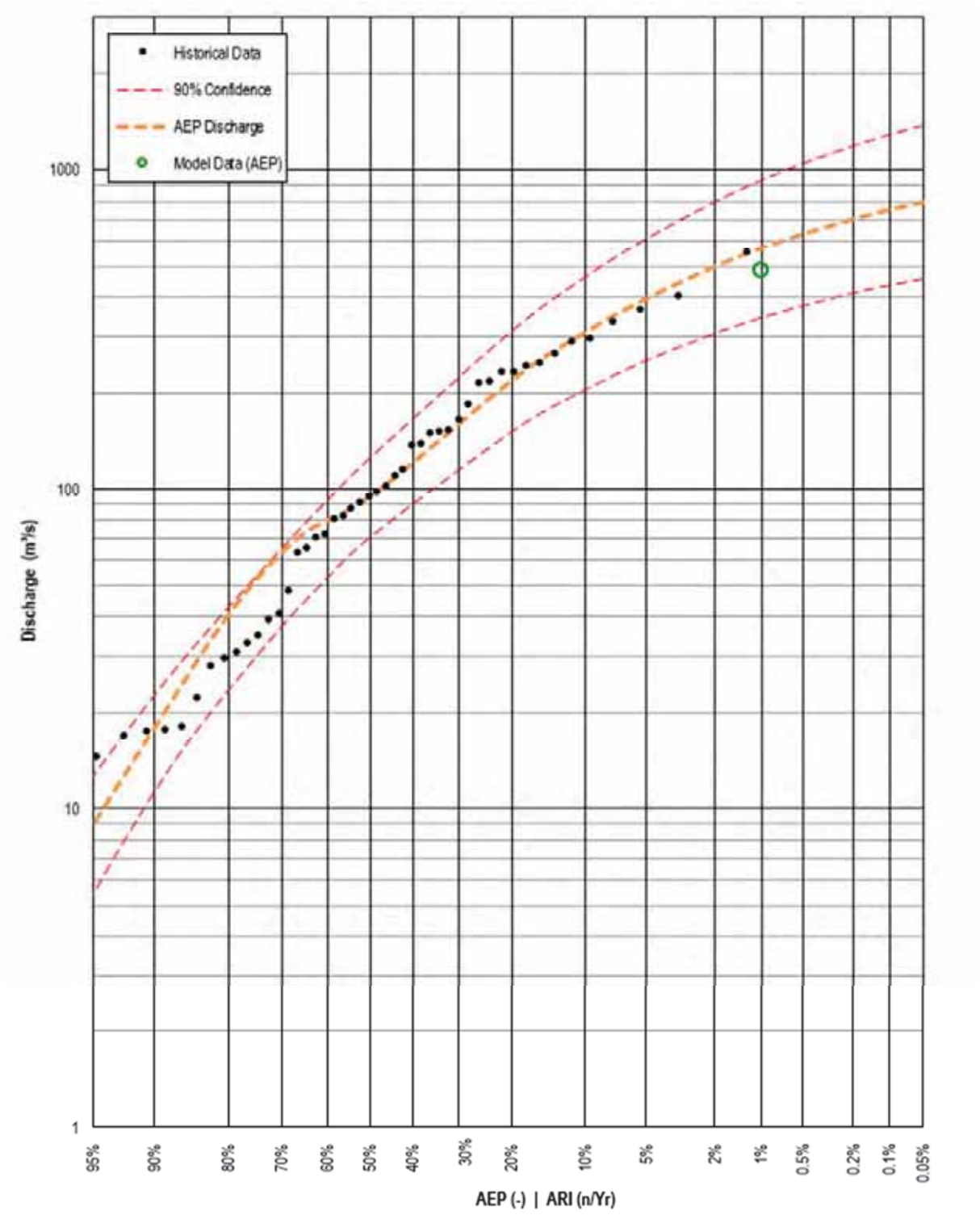

Figure 17 Flood frequency analysis – Croftby gauge

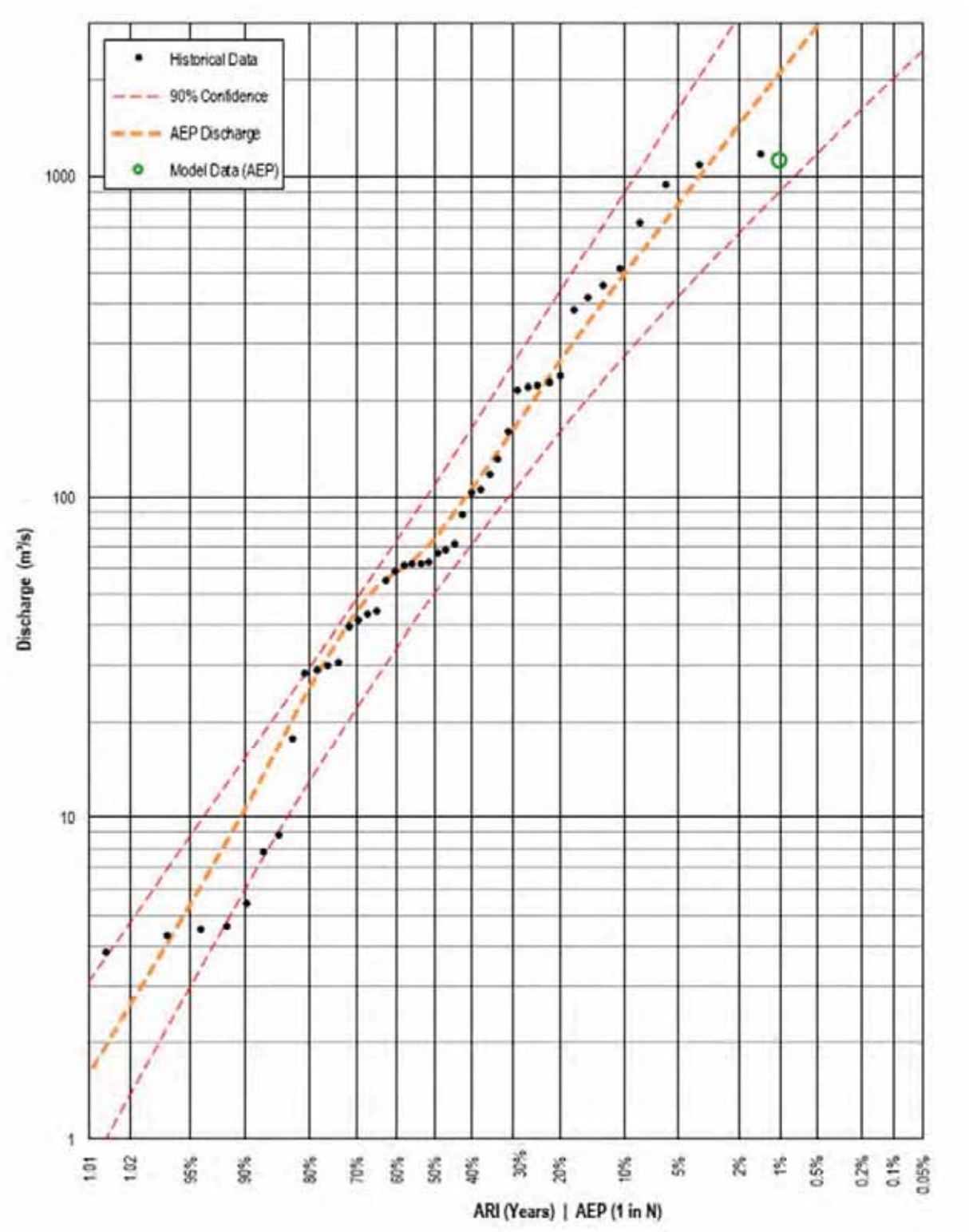

Figure 18 Flood frequency analysis – Overflow gauge

5.2 2%, 5% and 10% AEP events

5.2.1 Hydrology

Parameterisation of the RAFTS model for the 10%, 5% and 2% AEP events was based on the calibrated 1% AEP event hydrologic model. The event independent Alpha, Beta and m parameters were retained as per the calibrated 1% AEP event Teviot Brook RAFTS 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. Loss parameters were defined for the lower events which were already defined in the existing study. Adopted RAFTS loss model parameters are shown in Table 13.

Table 13 Teviot Brook RAFTS model design event parameters

Design Event	Loss model parameters	
	Initial Loss (mm)	Continuing Loss Rate (mm/hr)
2% AEP	0	0.5
5% AEP	0	1.0
10% AEP	20	2.0

5.2.2 Hydraulics

The calibrated TUFLOW model developed to investigate the 1% AEP flooding behaviour within the Teviot Brook catchment was adopted to assess the additional smaller design events. The 1% AEP event model was developed using a 20 m 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. A number of model refinements have been undertaken to more accurately assess the smaller design events as detailed in the following sections.

5.2.3 Model refinements

5.2.3.1 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 and 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.

5.2.3.2 Hydraulic structures

Improvements to the representation of hydraulic structures details and watercourse bathymetry has been achieved using new ground survey undertaken by Aurecon in June 2017. Locations for ground survey were based on the review of the initial modelling and discussions between Council and Aurecon. Waterway crossings that were identified were of significance in terms of understanding flooding impacts on access through the Teviot Brook 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 14 details the Teviot Brook crossing locations selected for survey. These structures have been included in the refined hydraulic model.

Table 14 Surveyed Teviot Brook crossings

Locality	Description	Structure Type	Key structure dimensions (m)	Deck/Road Level (m AHD)
Croftby	Teviot Brook Crossing at Carney's Creek Road	Concrete bridge	31.3 m (l) x 7.6 m (w)	152.1 m AHD
Boonah	Dugandan Bridge – Teviot Brook Crossing at Boonah-Rathdowney Road	Concrete bridge	58.1 m (l) x 10.8 m (w)	82.7 m AHD
Kagaru	Teviot Brook Crossing at Undullah Road	Timber bridge	51.4 m (l) x 4.5 m (w)	22.9 m AHD
Kagaru	Teviot Brook Crossing at Kilmoylar Road	Concrete bridge	65.2 m (l) x 4.6 m(w)	21.2 m AHD
Coulson	Teviot Brook Crossing at Beaudesert-Boonah Road	Culvert with 5 RCBCs	80 m (l) x 8 m (w) with 5 x 3 m (l) x 3 m (w) Culverts	66.3 m AHD
Boonah	Yeates Avenue	Culvert with 10 RCBCs	86.6 m (l) x 20.3 m (w) with 10 x 3 m (l) x 3 m (w) Culverts	90.9 AHD

5.2.3.3 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 improved delineation between in and out of bank flow conditions.

6 Modelling Results

6.1 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 Teviot Brook 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 15 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.

6.2 Mapping

The TUFLOW model results were analysed and a series of maps (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 – Guidelines for presentation of flood mapping are provided in the Australian Emergency Management Handbook Series (2013) produced by Emergency Management Australia (EMA). The guidelines include categorisation for flood hazard as shown below in Figure 19. The prepared 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.

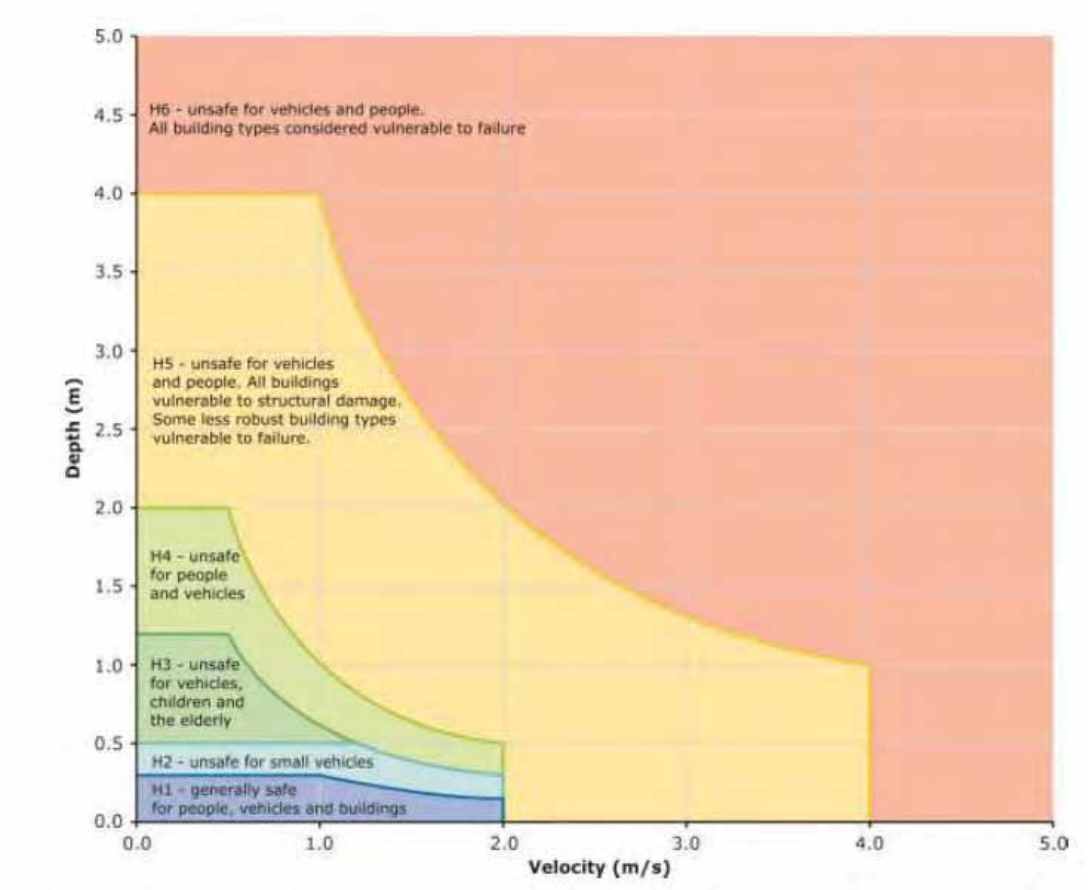

Figure 19 EMA revised flood hazard classification. ***Source: Australian Emergency Management Handbook Series (2013) - Technical flood risk management guideline: Flood hazard***

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.

6.3 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.

6.4 Design event discharges

Peak design event discharges are shown below in Table 16. The table shows the increasing in peak discharge both with severity of the event and increasing distance travelled downstream through the catchment.

Table 16 Design event (AEP) peak discharges at key locations

Location	Peak Discharge (m^3/s)		
	10% AEP	5% AEP	2% AEP
Teviot Brook Crossing, Carney's Creek Road	204	205	382
Dugandan Bridge, Boonah-Rathdowney Road	316	675	923
Yeates Avenue	62	122	151
Teviot Brook Crossing, Beaudesert-Boonah Road	442	753	1009
Teviot Brook Crossing, Undullah Road	330	603	730

6.5 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.

6.5.1 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 Teviot Brook 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.

6.6 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 for the gauge level flood classifications has therefore been undertaken as detailed in the following sections.

6.6.1 Harpers Crossing Alert

The Harpers Crossing alert gauge is located on Teviot Brook in a rural area immediately downstream of Mount Alford Road. There are currently no published flood classification levels for this gauge. The primary land use in the area is grazing with associated farm dwellings. The area is sparsely populated as is typical for rural grazing areas. Whilst gauge flood classifications were not available from the BoM for the Harpers Crossing gauge, a set of flood gauge level classifications are suggested below based on the BoM hazard rating.

Table 17 Harpers Crossing Alert gauge level analysis

Proposed Water level (m AHD)	Peak flood conditions description	Suggested flood classification
92.0	▪ Flood waters break the banks of the Albert River main channel upstream and downstream of the gauge ▪ Significant inundation of farmland on the Oaky Creek tributary ▪ Isolation of properties on the Oaky Creek tributary ▪ Numerous local access roads/tracks inundated ▪ Mount Alford Road is inundated between the Teviot Brook crossing and Boonah Rathdowney Road but is still trafficable ▪ Boonah-Rathdowney Road is first inundated south of the connection with Mount Alford Road but is still trafficable	Minor
92.8	▪ Significant inundation of farmland upstream and downstream of the gauge ▪ Boonah-Rathdowney Road is further inundated and access is lost ▪ Mount Alford Road is further inundated and access is lost ▪ First habitable dwelling is inundated. Dwelling in rural area.	Moderate
95.0	▪ All surrounding major roads are inundated ▪ Extensive inundation over the entire floodplain ▪ Numerous properties isolated ▪ A number of habitable dwellings are inundated	Major

6.6.2 Boonah Alert

The Boonah Alert gauge is located 1.2 km upstream of the Allandale Road crossing of Teviot Brook. This gauge is directly south of the Boonah Township in a primarily residential area. The current flood classification gauge levels for the Boonah Alert are shown in Table 18.

Table 18 Existing BoM flood classifications – Boonah Alert gauge

Flood height (m)		
Minor	**Moderate**	**Major**
Boonah Alert (Station #540510)		
4.0	5.0	6.0

A review of flood classification levels in light of modelled flooding conditions is provided below in Table 19 with amendments to the existing levels proposed. The review indicates that the current flood

classifications at the Kalbar Weir gauge are compatible with the adopted definitions and the flood behaviour observed in the hydraulic model simulations.

Table 19 Boonah Alert gauge analysis

Gauge Level (m)	Water level (m AHD)	Flood condition description	Flood Classification
4.0	**83.4**	▪ Salt Gully has broken its banks and there is significant flooding on the floodplain of this tributary ▪ Flow is still completely contained in the Teviot Brook main channel ▪ Numerous local roads/tracks are inundated in the Boonah Township ▪ Macquarie Street is overtopped ▪ Boonah Fassifern Road is overtopped ▪ Several non-habitable buildings are inundated ▪ Flood water are encroaching on habitable dwellings	Minor
5.0	**84.4**	▪ Flow is still completely contained in the Teviot Brook main channel ▪ Extensive floodplain inundation on the Salt Gully tributary ▪ More urban non-habitable buildings are inundated by Salt Gully ▪ A number of urban habitable dwellings are inundated by Salt Gully ▪ More local roads/tracks in the Boonah township are inundated	Moderate
6.0	**85.4**	▪ Flow is still completely contained in the Teviot Brook main channel ▪ Extensive floodplain inundation on the Salt Gully tributary ▪ Numerous urban non-habitable buildings are inundated by Salt Gully ▪ More urban habitable dwellings are inundated by Salt Gully ▪ Extensive flooding of local roads/tracks in the Boonah Township ▪ The Teviot Brook main channel is breaking its banks upstream and downstream of the gauge ▪ Boonah-Rathdowney Road is inundated and access is lost ▪ Numerous properties are isolated ▪ Boonah Rathdowney Road is overtopped at Gauge Level **7.2m** ▪ Bruckner Hill Road is overtopped at Gauge Level **6.2m**	Major

6.6.3 Coulson Crossing Alert

The Coulson Crossing alert gauge is located on Teviot Brook in a rural area immediately upstream of Beaudesert-Boonah road. There are currently no published flood classification levels for this gauge. The primary land use in the area is grazing with associated farm dwellings. The area is sparsely populated as is typical for rural grazing areas. Whilst gauge flood classifications were not available

from the BoM for the Coulson Crossing gauge, a set of flood gauge level classifications are suggested below based on the BoM hazard rating.

Table 20 Coulson Crossing Alert gauge level analysis

Proposed Water level (m AHD)	Peak flood conditions description	Suggested flood classification
69.0	■ Flood waters break the banks of the Teviot Brook main channel upstream and downstream of the gauge ■ Some local access roads/tracks are inundated ■ Ipswich-Boonah Road is inundated but still trafficable	Minor
69.5	■ Significant inundation of farmland immediately upstream of the gauge ■ Beaudesert-Boonah Road is inundated and access is lost ■ Ipswich-Boonah Road is further inundated and access is lost ■ Old Beaudesert Road is overtopped and access is lost	Moderate
70.4	■ Widespread inundation farmland surrounding the gauge ■ Beaudesert-Boonah Road is inundated in another location further downstream from the gauge ■ Numerous local access roads/tracks are inundated ■ A number of rural habitable properties are isolated	Major

6.6.4 Wyaralong Dam Gauge

The Wyaralong Dam gauge is located at the dam wall. This gauge is located in a rural area and is primarily surrounded by dense vegetation. Whilst gauge flood classifications were not available from the BoM for the gauge, a set of flood gauge level classifications are suggested below based on the BoM hazard rating.

Due to the location of this gauge, the analysis did not look purely at the flood extents but also took into consideration information provided in the *Wyaralong Dam – Emergency Action Plan (SEQ Water).*

This review outlined the following important levels at the gauge.

- Spillway Crest Level – 63.6 m AHD (Full Supply Level)
- Flood of Record – 66.2 m AHD (January 2013), noting that the dam was only constructed in 2011
- Main Dam Crest Level – 70.1 m AHD

The information in this document outlines emergency actions to be taken at the dam by the Dam Supervisor and the frequency of surveillance required. The EAP also defines the Downstream Release Hazard categories which are summarised as follows:

- Stand-down: Lake level below FSL (EL63.6AHD), no spillway overflow and no flood warning expected to be issued by BoM
- Alert: Lake Level above FSL (EL 63.6 m AHD) and first spillway overflow occurring, BoM expected to issue a flood warning for SE-QLD
- Lean Forward: Lake Level reaches Flood of Record Level (EL 66.2 m AHD) and flood overflow continuing
- Stand Up: Lake Level: Extreme Lake Level (EL 69.0 m AHD), dam crest overtopping is possible

Review of this gauge indicates that levels in accordance with the action plan should be adopted as outlined in Table 21. The review indicates that the current flood classifications at the Wyaralong Dam Gauge are inadequate.

Table 21 Wyaralong Dam Gauge analysis

Proposed Water level (m AHD)	Flood condition description	Suggested flood classification
64.1	▪ This level is 0.5 m above the full supply level of the dam ▪ Reduced amenity to the camping and picnic area on the eastern side of the dam	Minor
65.1	▪ This level is 1.5 m above full supply level ▪ Some minor access roads/tracks in the upstream area are inundated	Moderate
66.2	▪ This is the level of the January 2013 flood. This was a major flood and is recorded as the 'Flood of Record' at the gauge. ▪ Some rural properties upstream of the gauge are inundated (Seqwater owns the majority of this land).	Major

6.6.5 Croftby Alert

The Croftby Alert gauge is located 2.5 km upstream of the Carney's Creek Road crossing of Teviot Brook. The primary land use in the area is grazing with associated farm dwellings. The area is sparsely populated as is typical for rural grazing areas. The current flood classification gauge levels for the Croftby Alert are shown in Table 22.

Table 22 Existing BoM flood classifications – Croftby Alert gauge

Flood height (m)		
Minor	**Moderate**	**Major**
Croftby Alert (Station #04097)		
3.0	4.5	6.0

A review of flood classification levels in light of modelled flooding conditions is provided below in Table 23 with amendments to the existing levels proposed. The review indicates that the current flood classifications at the Kalbar Weir gauge are compatible with the adopted definitions and the flood behaviour observed in the hydraulic model simulations.

Table 23 Croftby Alert gauge analysis

Gauge Level (m)	Water level (m AHD)	Flood condition description	Flood Classification
3.0	**164.4**	▪ Flood waters begin to break the banks of the Teviot Brook main channel upstream of the gauge ▪ Some local access roads/tracks are inundated ▪ Minor flooding occurring on pasture land upstream of the gauge	Minor
4.5	**165.9**	▪ Significant inundation of farmland upstream of the gauge ▪ Numerous local access roads/tracks are inundated ▪ First habitable rural property is inundated	Moderate

Gauge Level (m)	Water level (m AHD)	Flood condition description	Flood Classification
6.0	**167.4**	■ Numerous local access roads/tracks are further inundated ■ Significant inundation of farmland upstream of the gauge ■ Several rural properties are isolated ■ Carneys Creek Road is overtopped upstream of the connection with Dwyer Ridges Road	Major

6.6.6 Opportunities for additional alert gauges

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

7 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 Teviot Brook catchment within Council's boundaries to provide Council with detailed flood information across the catchment.

Hydrologic modelling has been carried out using the established LCC RAFTS 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 four 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.

8 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 20 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.

9 References

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

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Appendices

Appendix A
Figures

Figure	Description
Figure A-1	RAFTS Layout
Figure A-2	Stream Gauge Locations
Figure A-3	Rainfall Gauge Locations
Figure A-4	Hydraulic Model Extents
Figure A-5	January 2013 Calibration
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
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Figure C4	2% AEP Event – Hazard Map
Figure C5-a	2% AEP Event – Inundation Extent Map with 4.5 Climate Change Scenario
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Figure D1	5% AEP Event – Inundation Extent Map
Figure D2	5% AEP Event – Peak Velocities Map
Figure D3	5% AEP Event – Peak Depth Map
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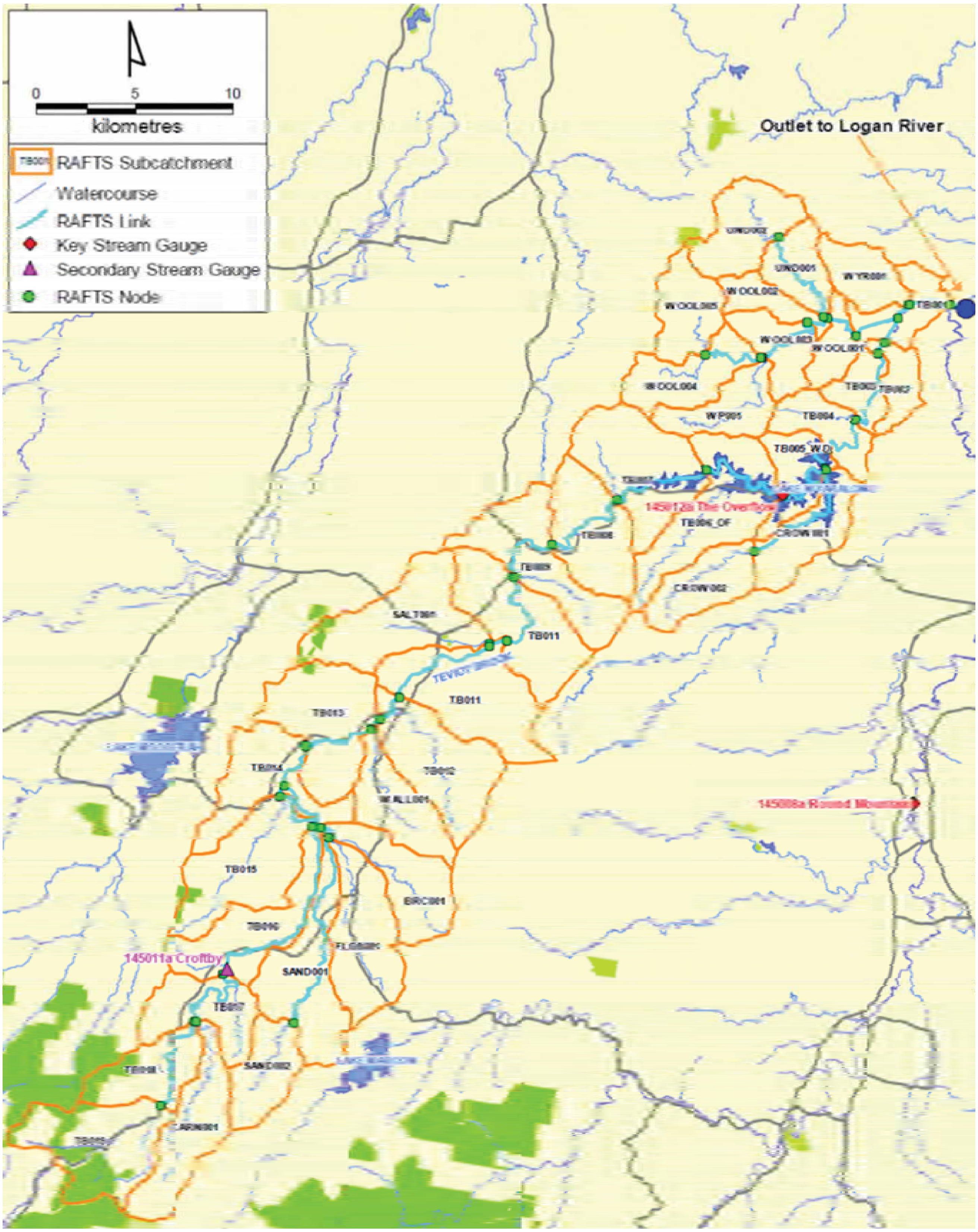
Figure D5-a	5% AEP Event – Inundation Extent Map with 4.5 Climate Change Scenario
Figure D5-b	5% AEP Event – 4.5 Climate Change Scenario – Afflux Map
Figure E1	10% AEP Event – Inundation Extent Map

Figure	Description
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
Figure F	Emergency Response Mapping



P:\SWM\Work\251533 Teviot Brook Flood Study\GIS\Mapping

Map by: JD

Legend

Notes:

No Window

A3 scale 1:200,000

0 5,000 m 10,000 m

Date: 29/06/2016 Version: 0 Job No: 251533

Projection: MGA Zone 56

Teviot Brook Flood Study **Figure A-1**

RAFTS Layout - Sourced from Logan City Council

aurecon

Map by: JD
P:\SWMWork\251533 Teviot Brook Flood Study\GIS\Mapping

Legend

- 2D Model Boundary
- Stream Gauges

Notes:

A3 scale 1:200,000

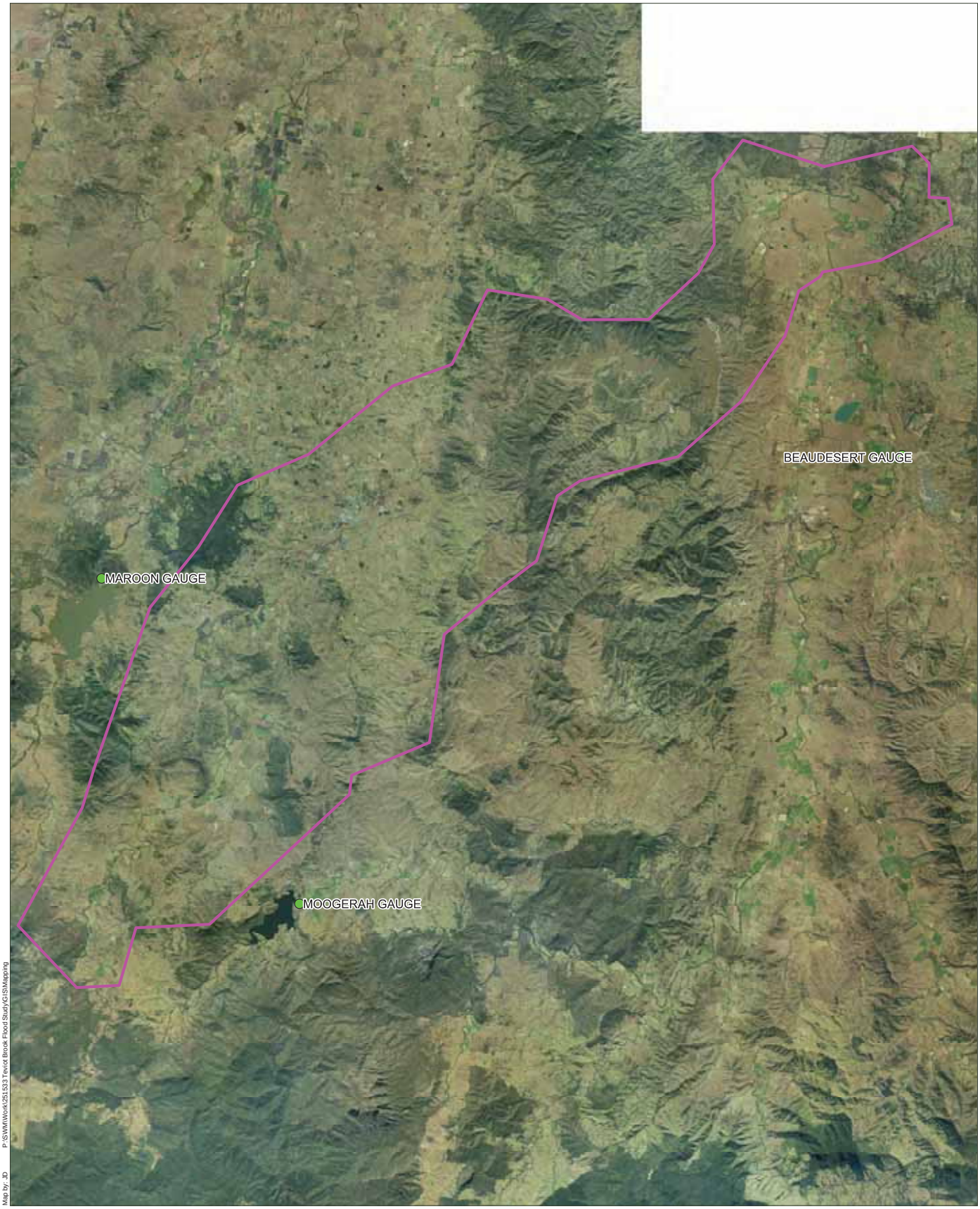
0 5,000 m 10,000 m

Date: 29/06/2016 Version: 0 Job No: 251533

Projection: MGA Zone 56

Teviot Brook Flood Study **Figure A-2**

Stream Gauge Locations



Map by: JD
P:\SWMWork\251533 Teviot Brook Flood Study\GIS\Mapping

Legend

- 2D Model Boundary
- Rainfall Gauges

Notes:

A3 scale 1:200,000

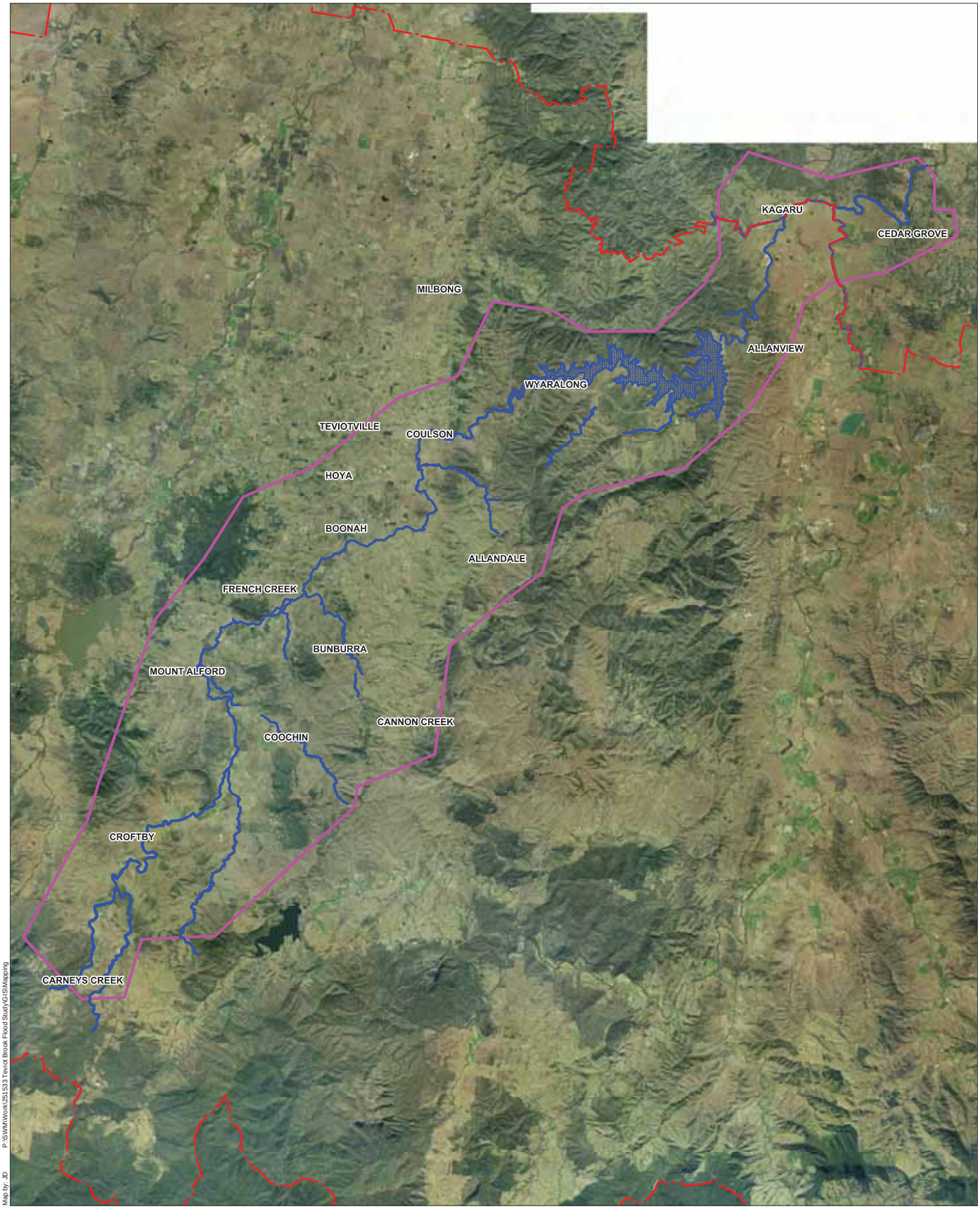
0 5,000 m 10,000 m

Date: 29/06/2016 Version: 0 Job No: 251533

Projection: MGA Zone 56

Teviot Brook Flood Study **Figure A-3**

Rainfall Gauge Locations



P:\SWMWork\251533 Teviot Brook Flood Study\GIS\Mapping

Map by: JD

Legend

- SRRC Boundary
- Channel Land Use
- 2D Model Boundary

Notes:

A3 scale 1:200,000

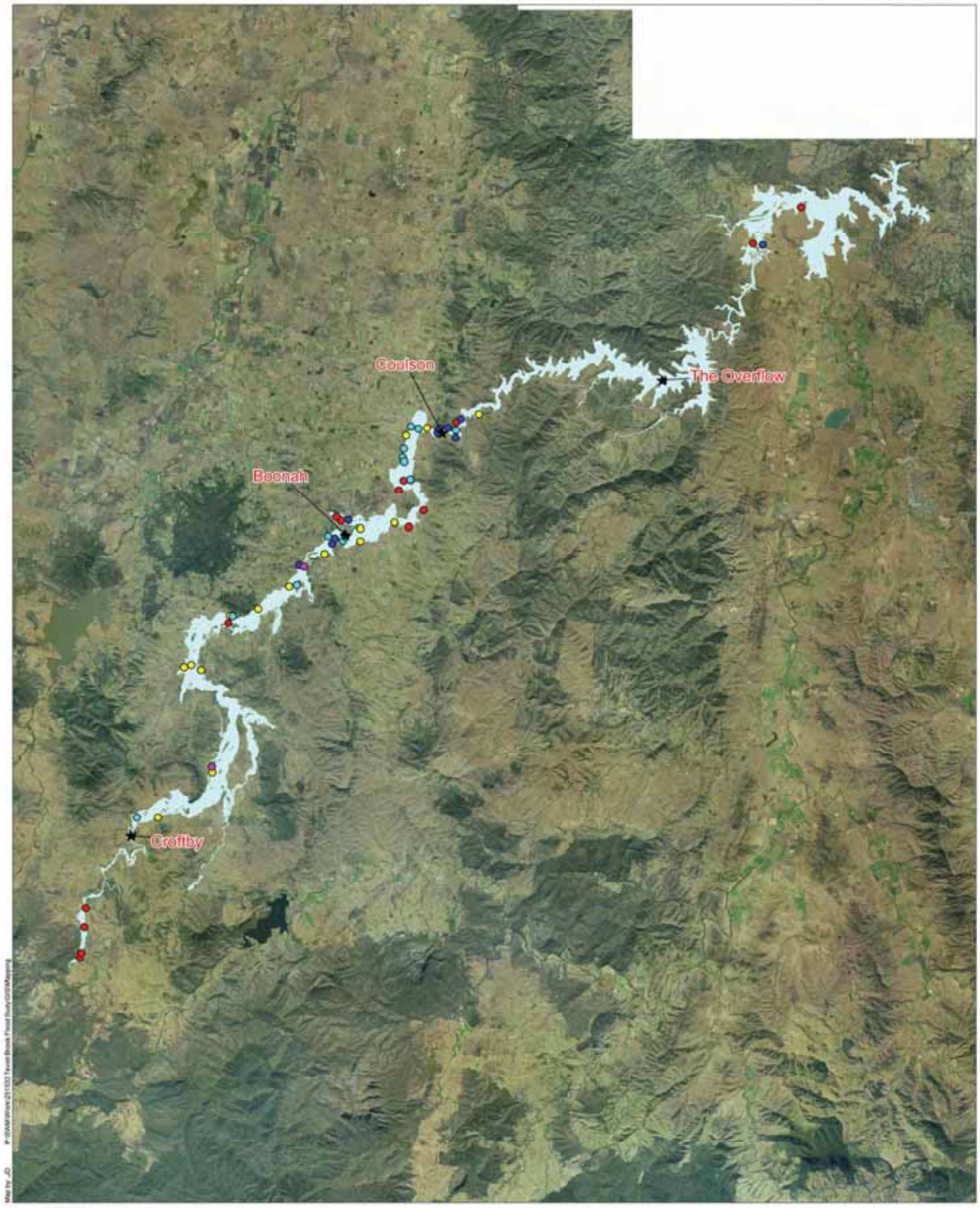
0 5,000 m 10,000 m

Date: 29/06/2016 Version: 0 Job No: 251533

Projection: MGA Zone 56

Teviot Brook Flood Study **Figure A-4**

Hydraulic Model Extents



Legend

★ Stream Gauges

Flood Marks (Modelled height - observed height)

- > 0.50m
- 0.15m to 0.50m
- -0.15m to 0.15m
- -0.50m to -0.15m
- < -0.50m

Notes:

A3 scale 1:200,000

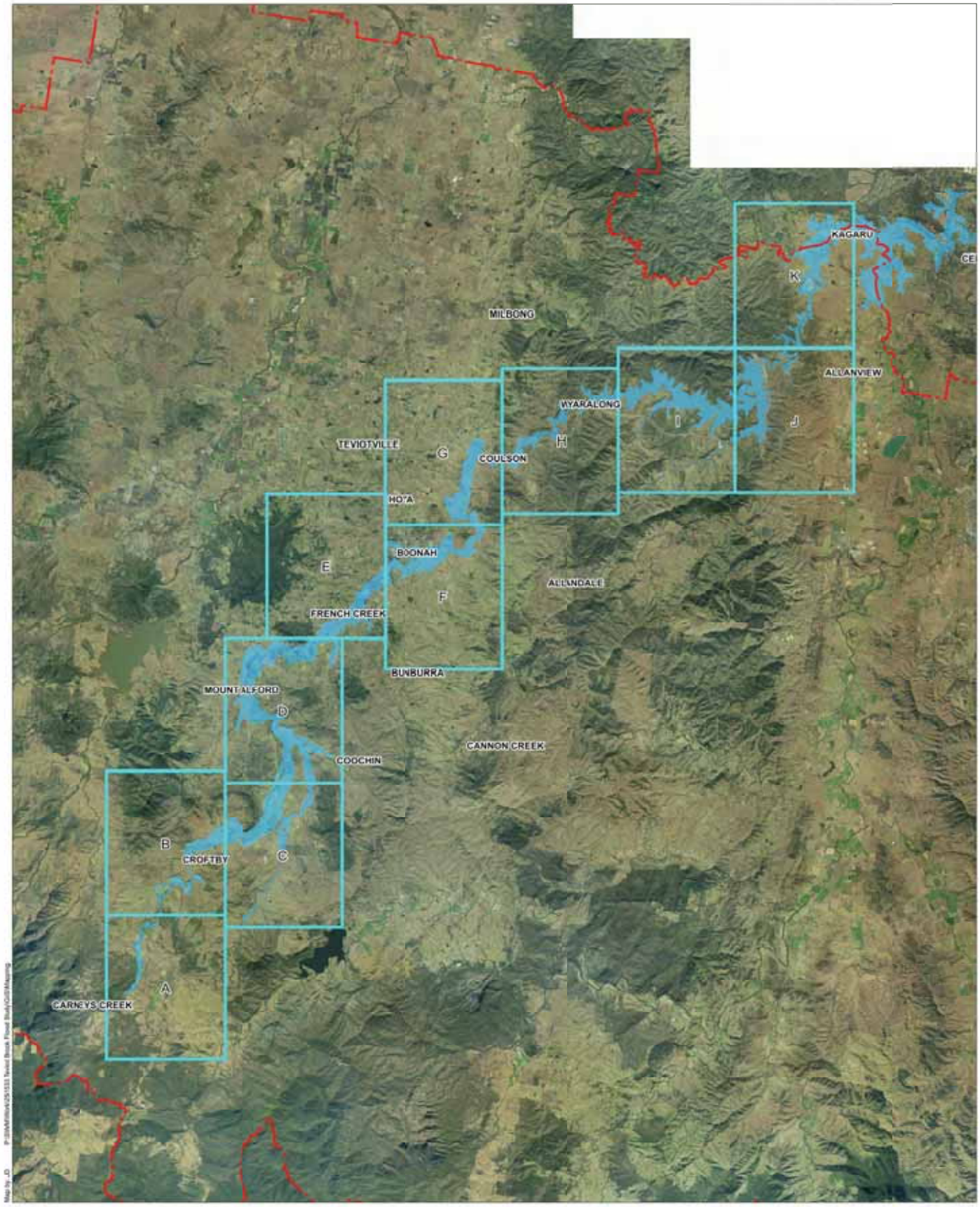
0 5,000 m 10,000 m

Date: 29/06/2016 Version: 0 Job No: 251533

Projection: MGA Zone 56

Teviot Brook Flood Study **Figure A-5**

January 2013 Calibration
(Modelled height - observed height)



Legend

SRRC Boundary

Inundation Extents

Notes:

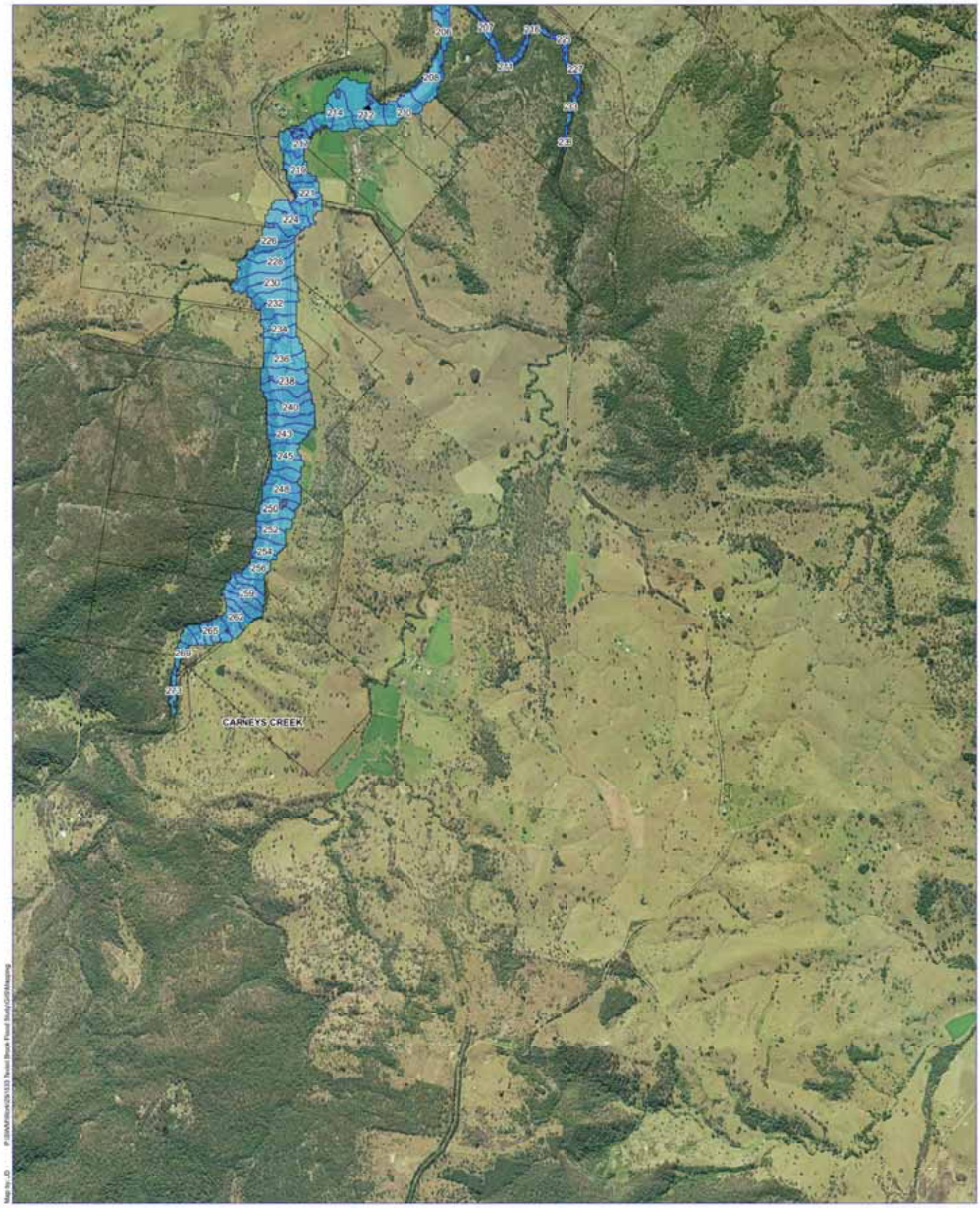
A3 scale 1:200,000

0 5,000 m 10,000 m

Date: 29/06/2016 Version: 0 Job No: 251533

Teviot Brook Flood Study **Figure B1**

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

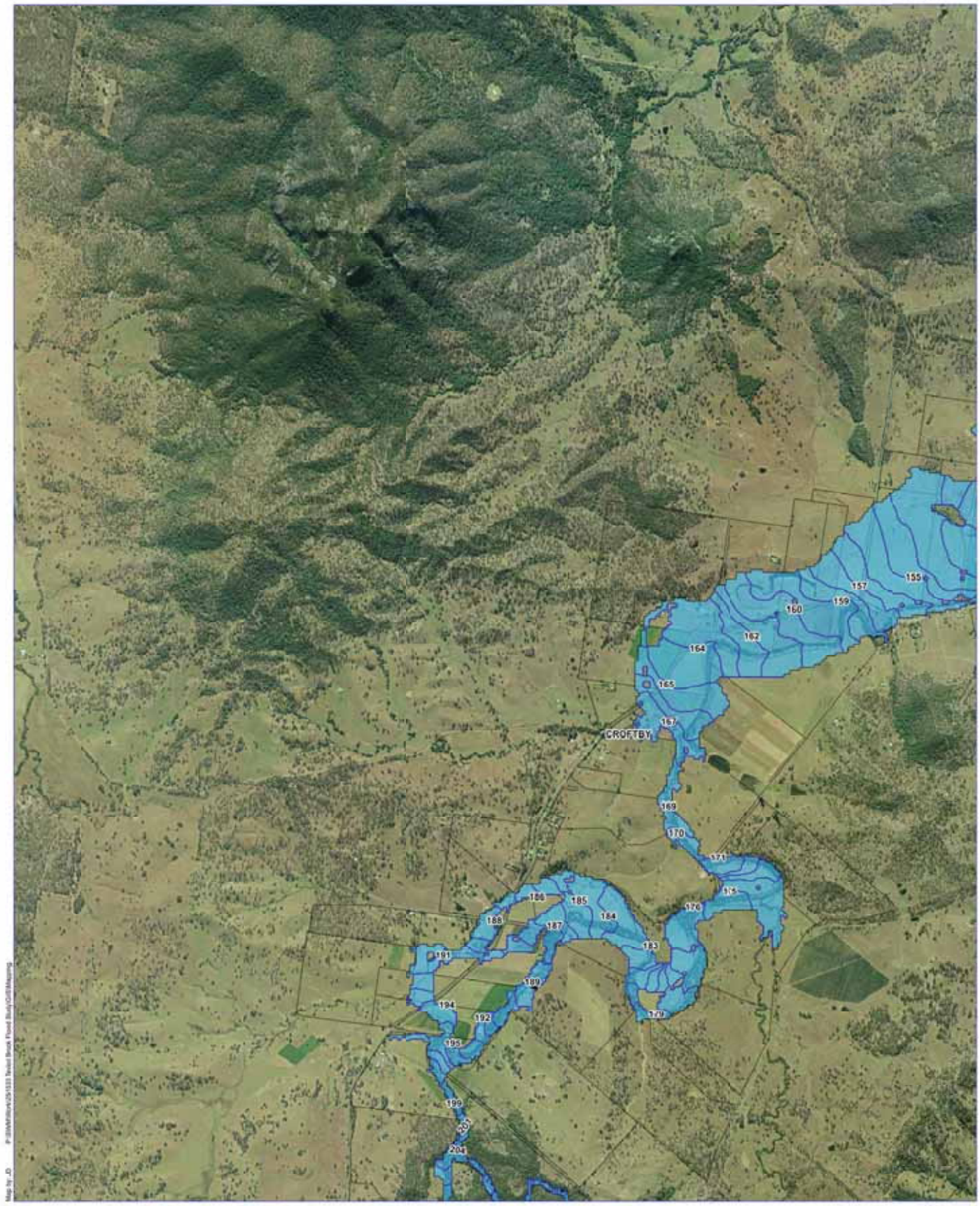
0 625 m 1,250 m

Date: 29/06/2016 Version: 0 Job No: 251533

Projection: MGA Zone 55

Teviot Brook Flood Study **Figure B1 - A**

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

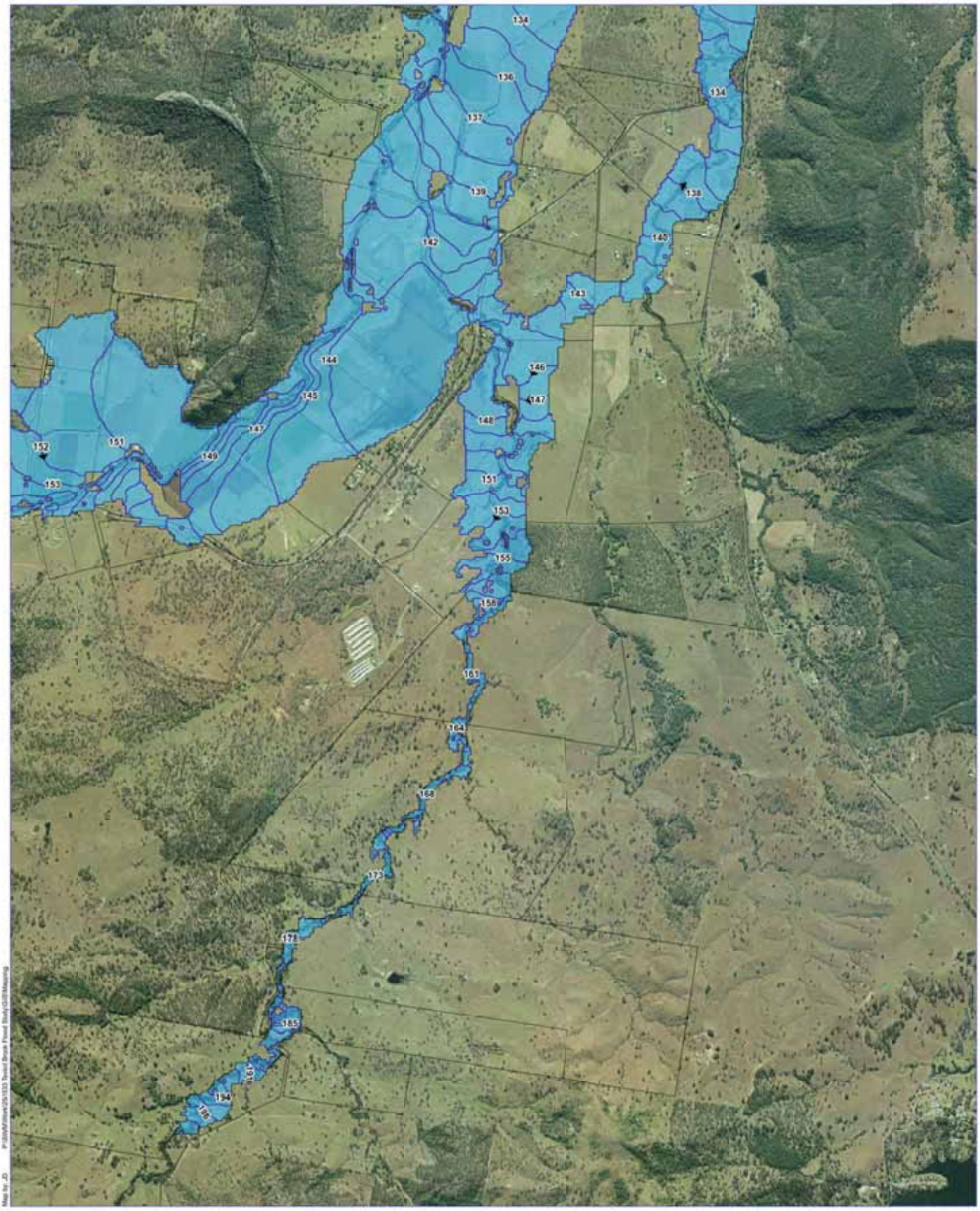
0 625 m 1,250 m

Date: 29/06/2016 Version: 0 Job No: 251533

Projection: MGA Zone 55

Teviot Brook 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

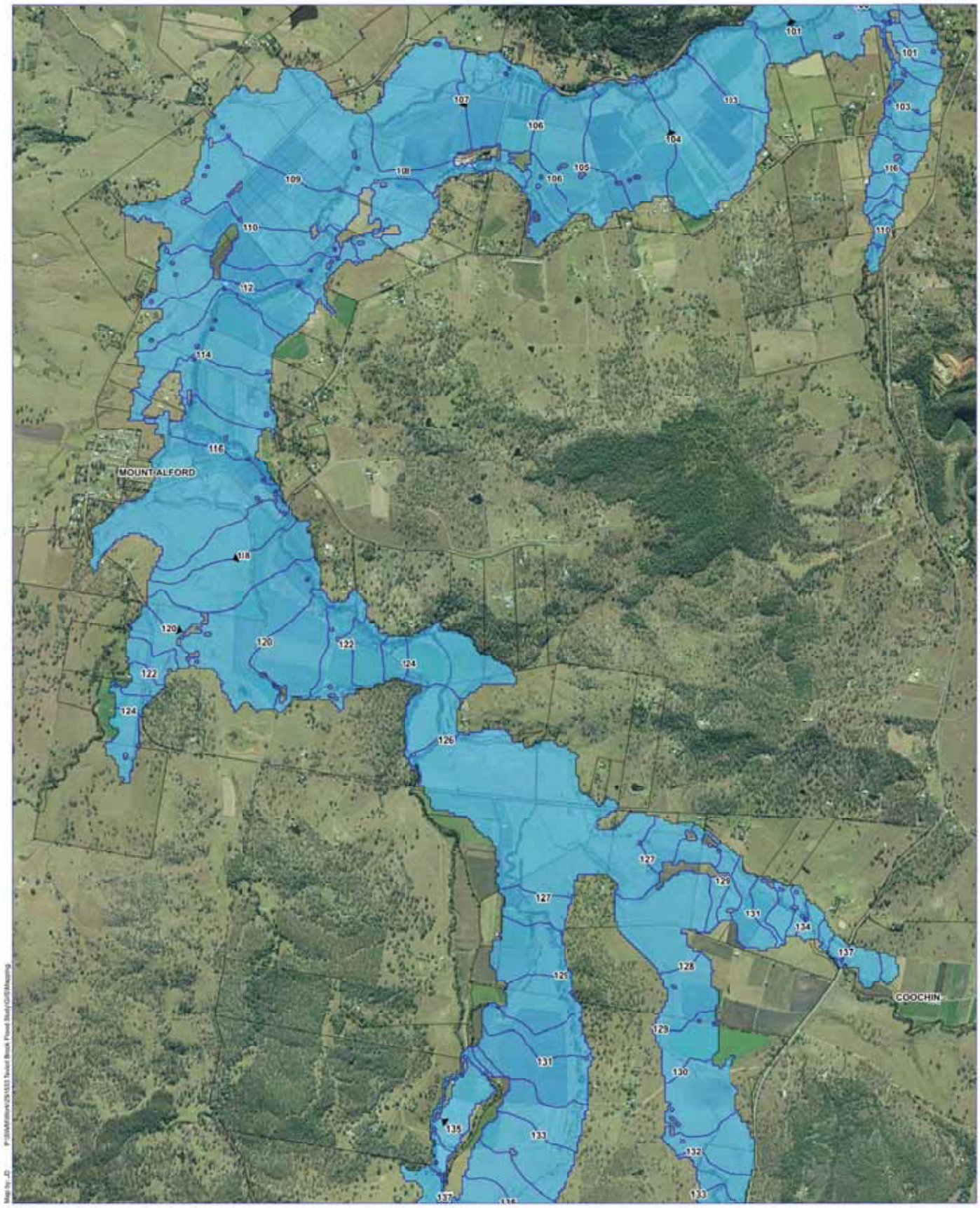
0 625 m 1,250 m

Date: 29/06/2016 Version: 0 Job No: 251533

Projection: MGA Zone 55

Teviot Brook Flood Study **Figure B1 - C**

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

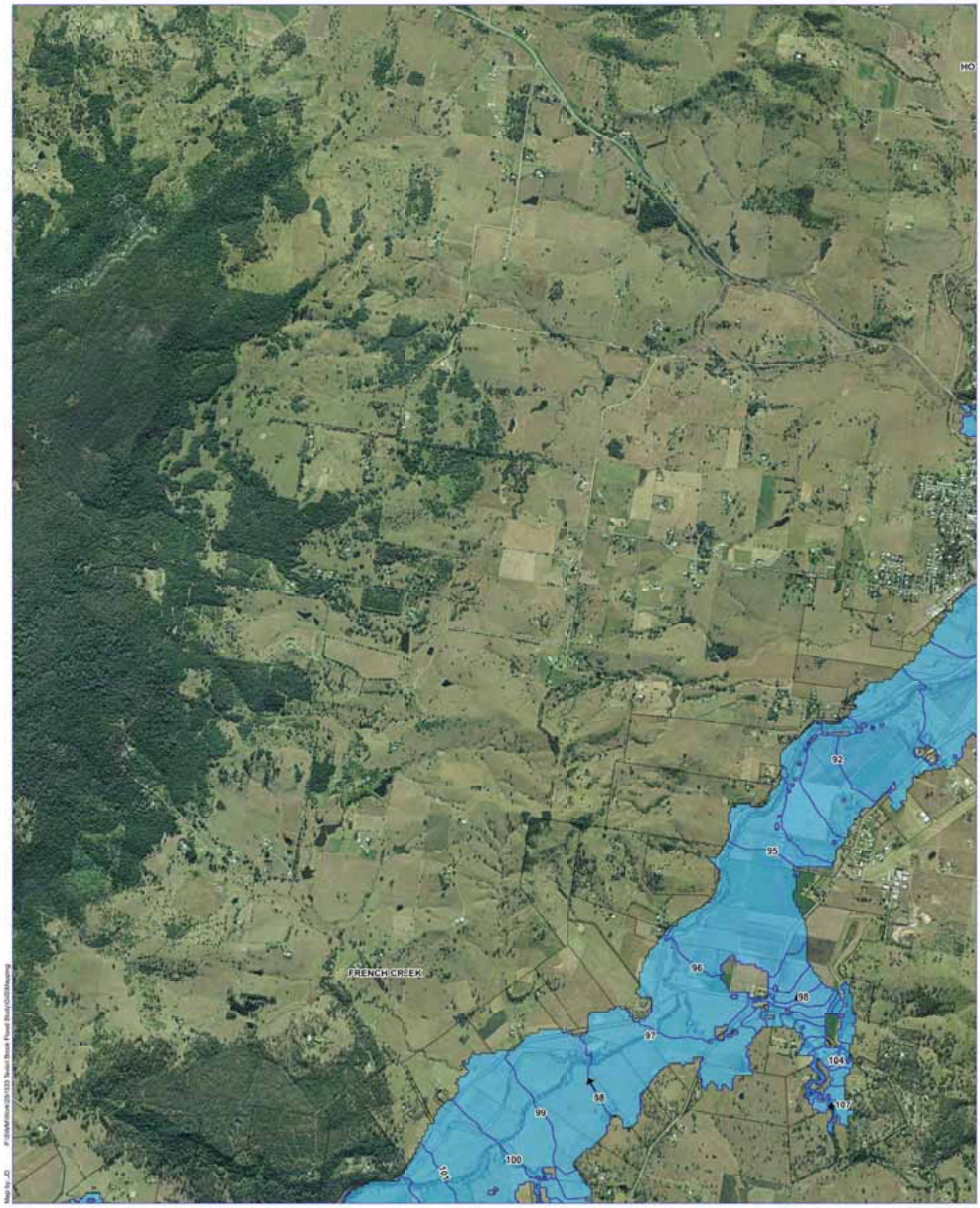
Date: 29/06/2016 Version: 0 Job No: 251533

Projection: MGA Zone 55

Teviot Brook Flood Study **Figure B1 - D**

1% AEP Event - Inundation Extent & Peak Water Levels

aurecon



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

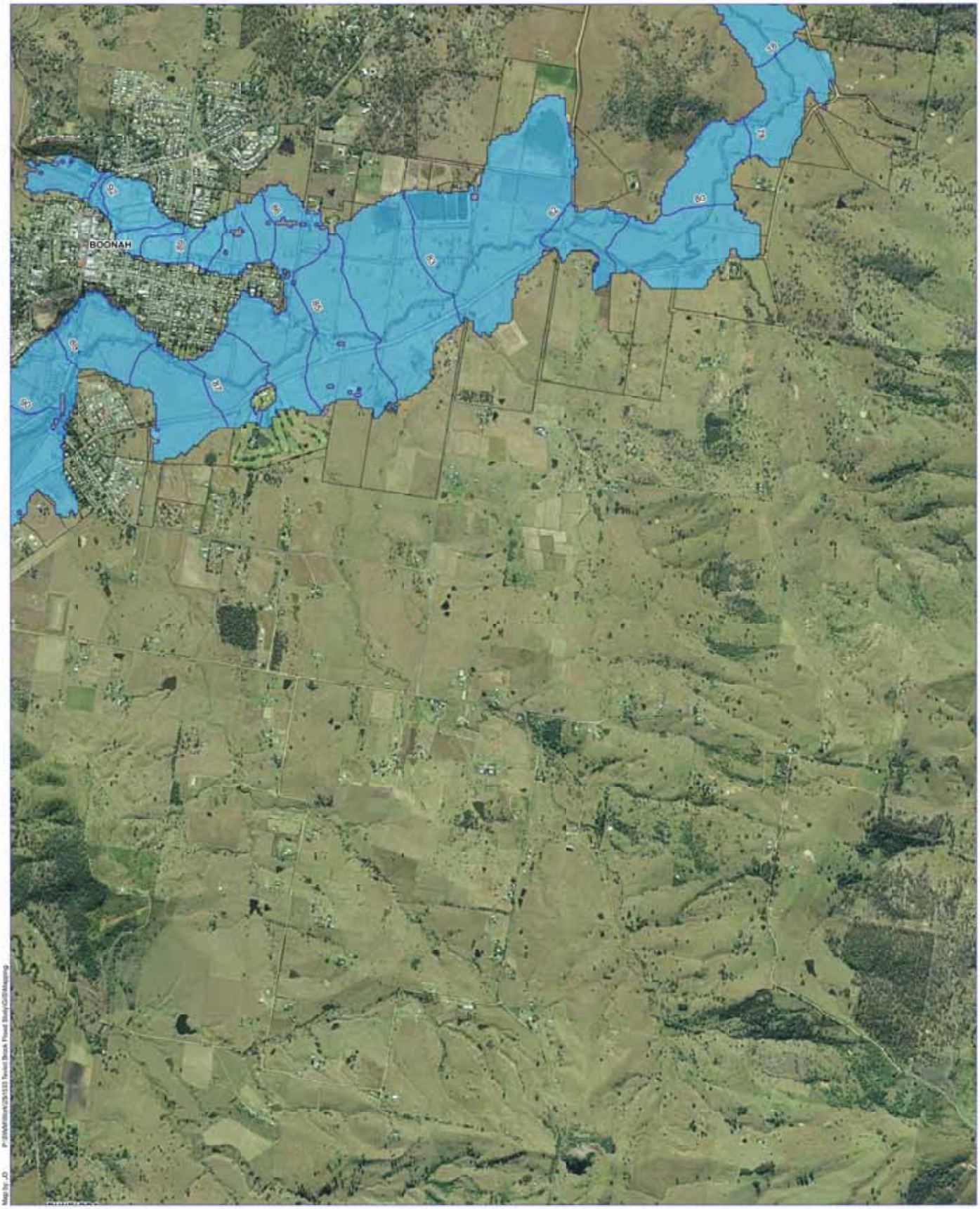
Date: 29/06/2016 Version: 0 Job No: 251533

Projection: MGA Zone 55

Teviot Brook Flood Study **Figure B1 - E**

1% AEP Event - Inundation Extent & Peak Water Levels

aurecon



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: 29/06/2016 Version: 0 Job No: 251533

Projection: MGA Zone 56

Teviot Brook Flood Study **Figure B1 - F**

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

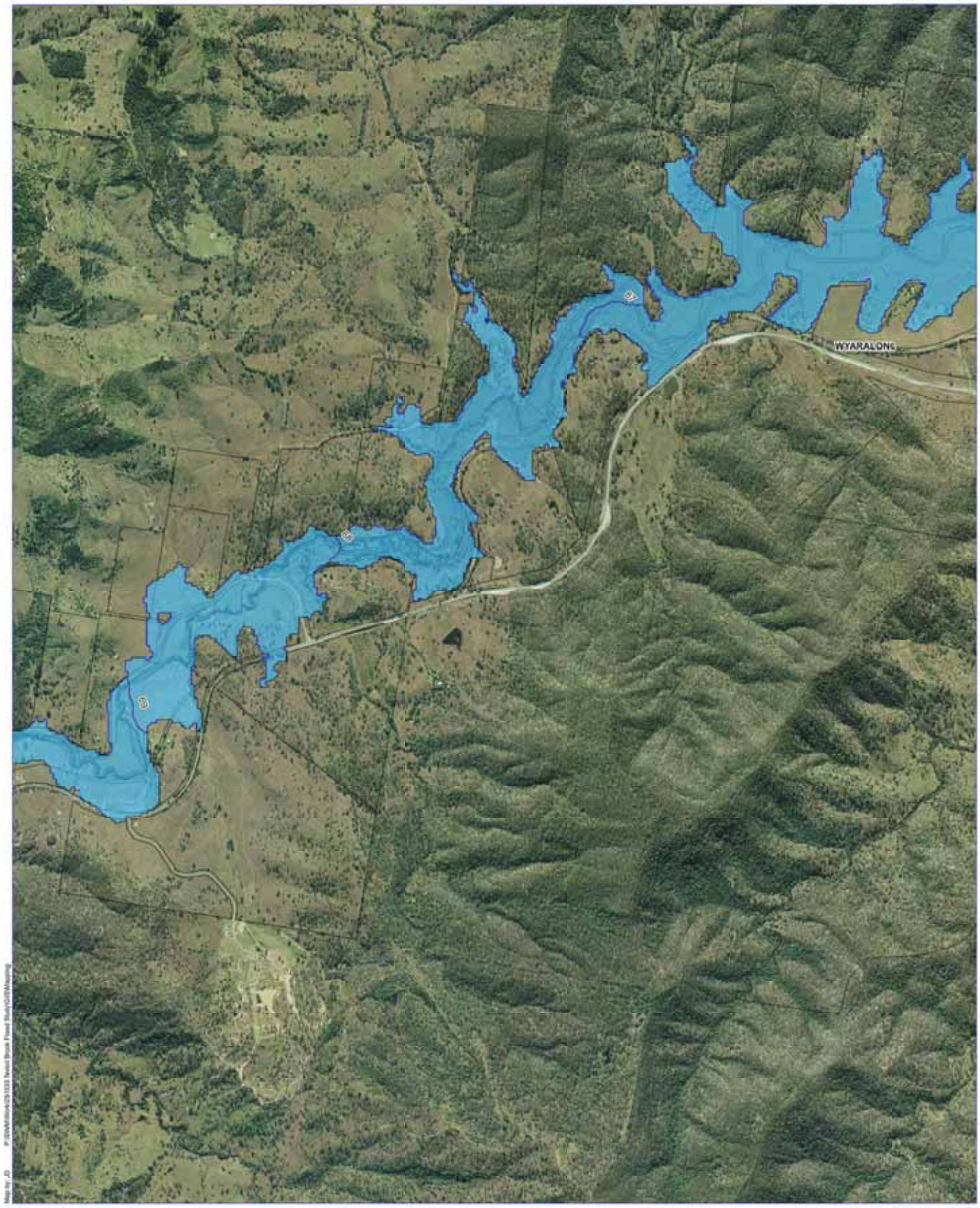
0 625 m 1,250 m

Date: 29/06/2016 Version: 0 Job No: 251533

Projection: MGA Zone 55

Teviot Brook Flood Study **Figure B1 - G**

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

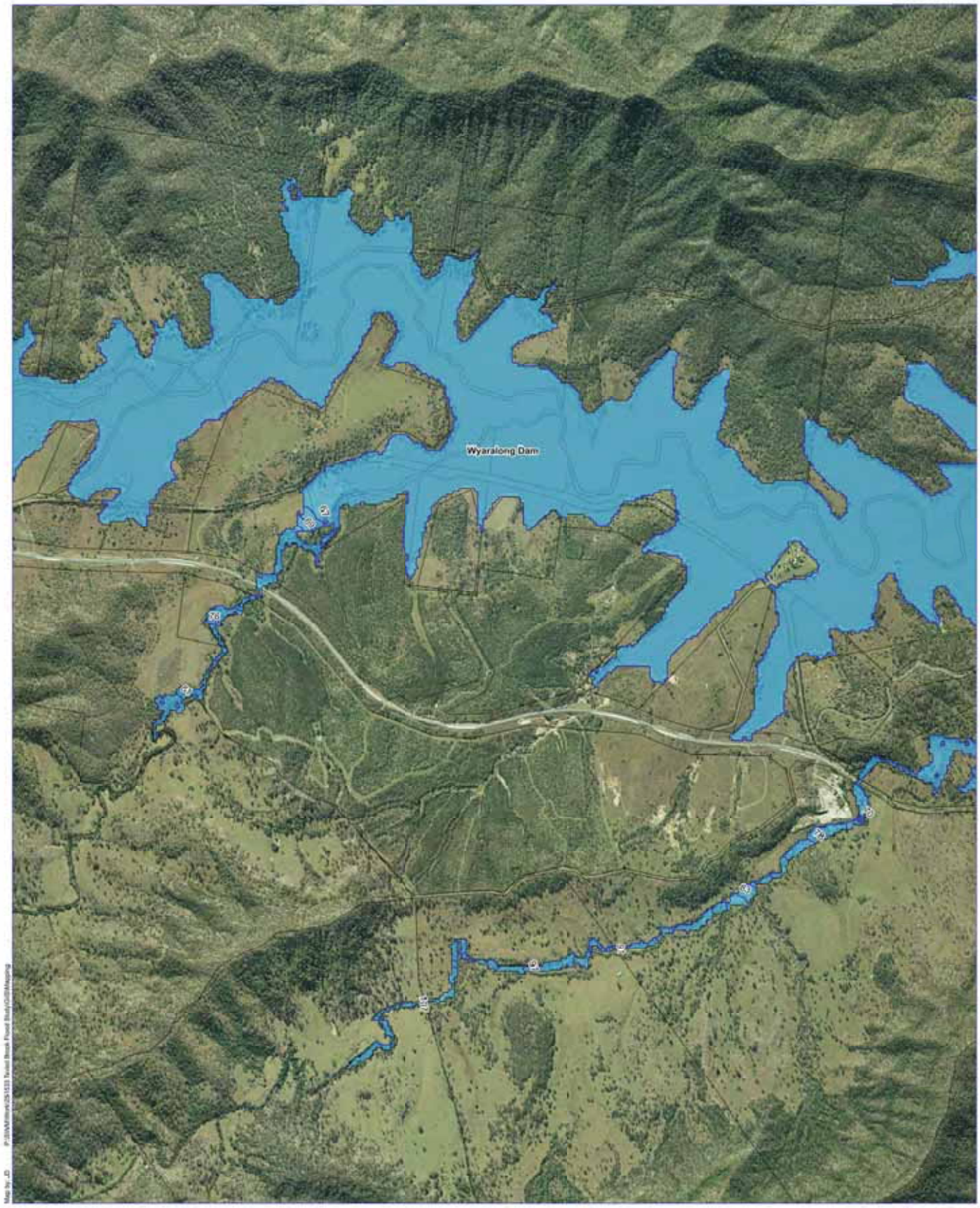
0 625 m 1,250 m

Date: 29/06/2016 Version: 0 Job No: 251533

Projection: MGA Zone 55

Teviot Brook Flood Study **Figure B1 - H**

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

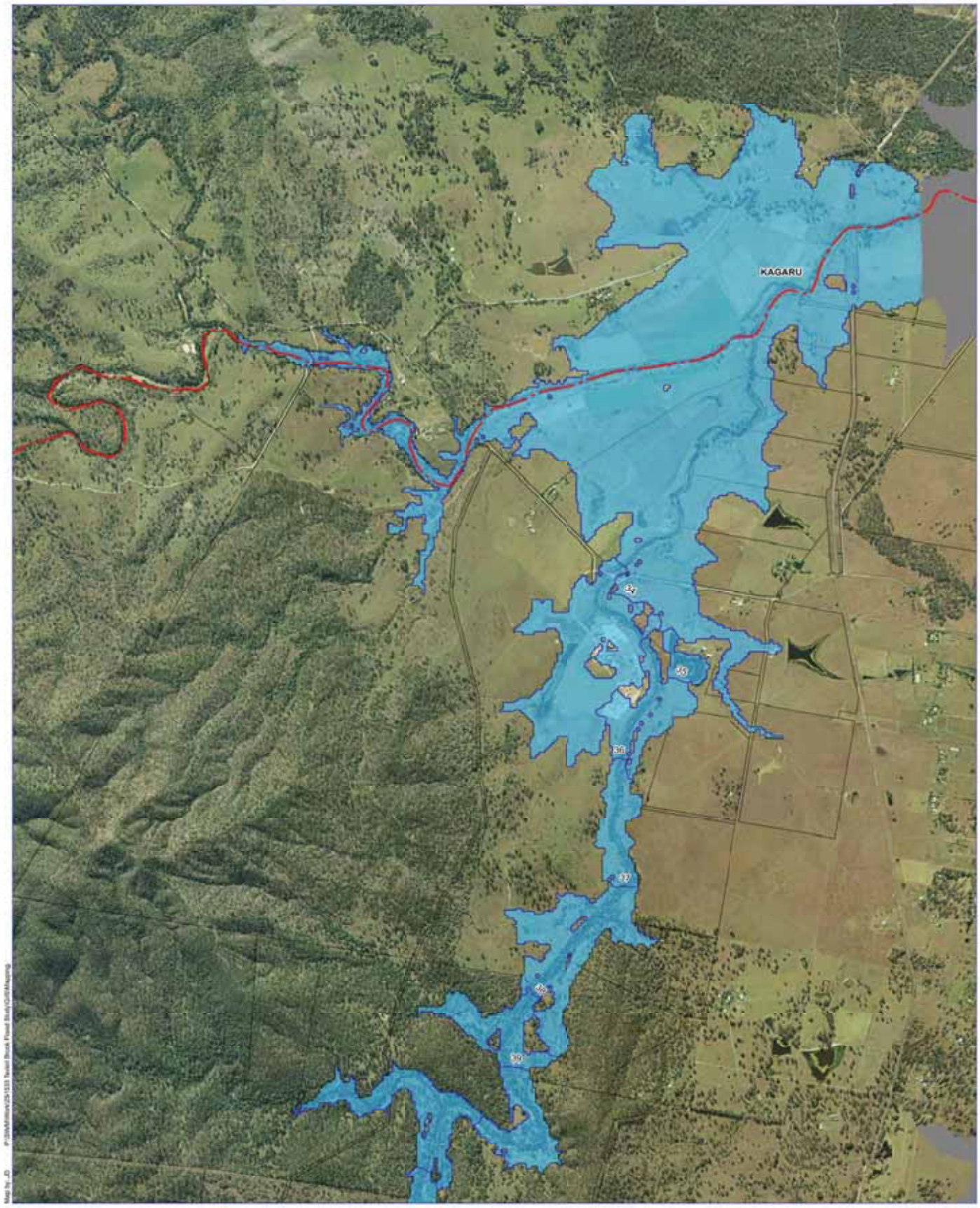
0 625 m 1,250 m

Date: 29/06/2016 Version: 0 Job No: 251533

Projection: MGA Zone 56

Teviot Brook Flood Study Figure B1 - I

1% AEP Event - Inundation Extent & Peak Water Levels



Legend

- SRRC Boundary
- Cadastral Boundary
- Inundation Extents
- Peak Water Level Contour (m AHD)
- Refer Logan River Flood Study Mapping

Notes:

A3 scale 1:25,000

0 625 m 1,250 m

Date: 29/06/2016 Version: 0 Job No: 251533

Projection: MGA Zone 56

Teviot Brook Flood Study

Figure B1 - K

1% AEP Event - Inundation Extent & Peak Water Levels

Legend

Aflux (m)

< -0.80	0.03 to 0.20
-0.80 to -0.60	0.20 to 0.40
-0.60 to -0.40	0.40 to 0.60
-0.40 to -0.20	0.60 to 0.80
-0.20 to -0.03	0.80 to 1.20
-0.03 to 0.03	> 1.20

Was Dry Now Wet

Was Wet Now Dry

SRRC Boundary

Notes:

A3 scale 1:200,000

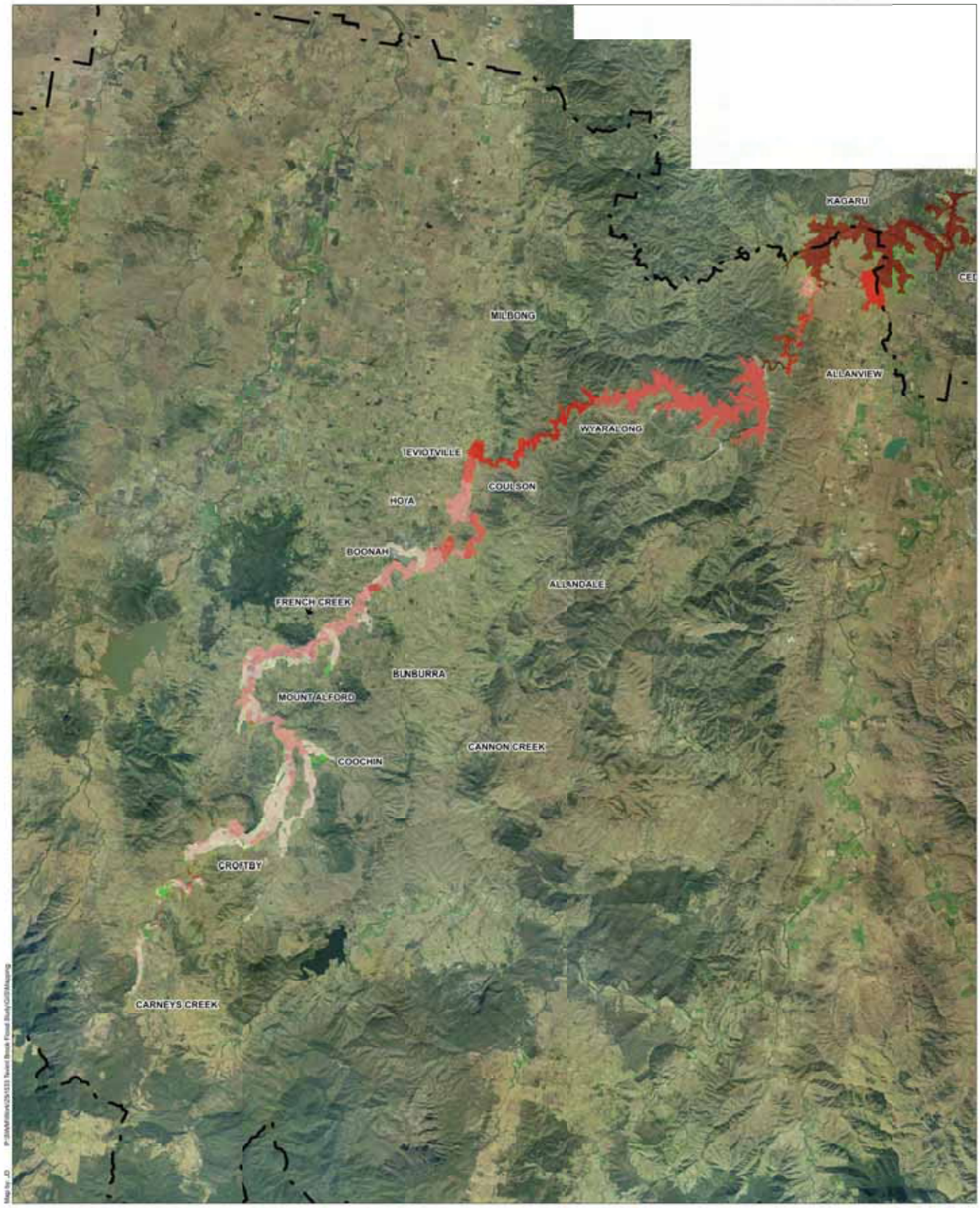
0 5,000 m 10,000 m

Date: 29/06/2016 Version: 0 Job No: 251533

Projection: MGA Zone 55

Teviot Brook Flood Study **Figure B2 - a**

Climate Change Scenario 4.5 - 1% Afflux Map



Legend

Aflux (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
- SRRC Boundary

Notes:

A3 scale 1:200,000

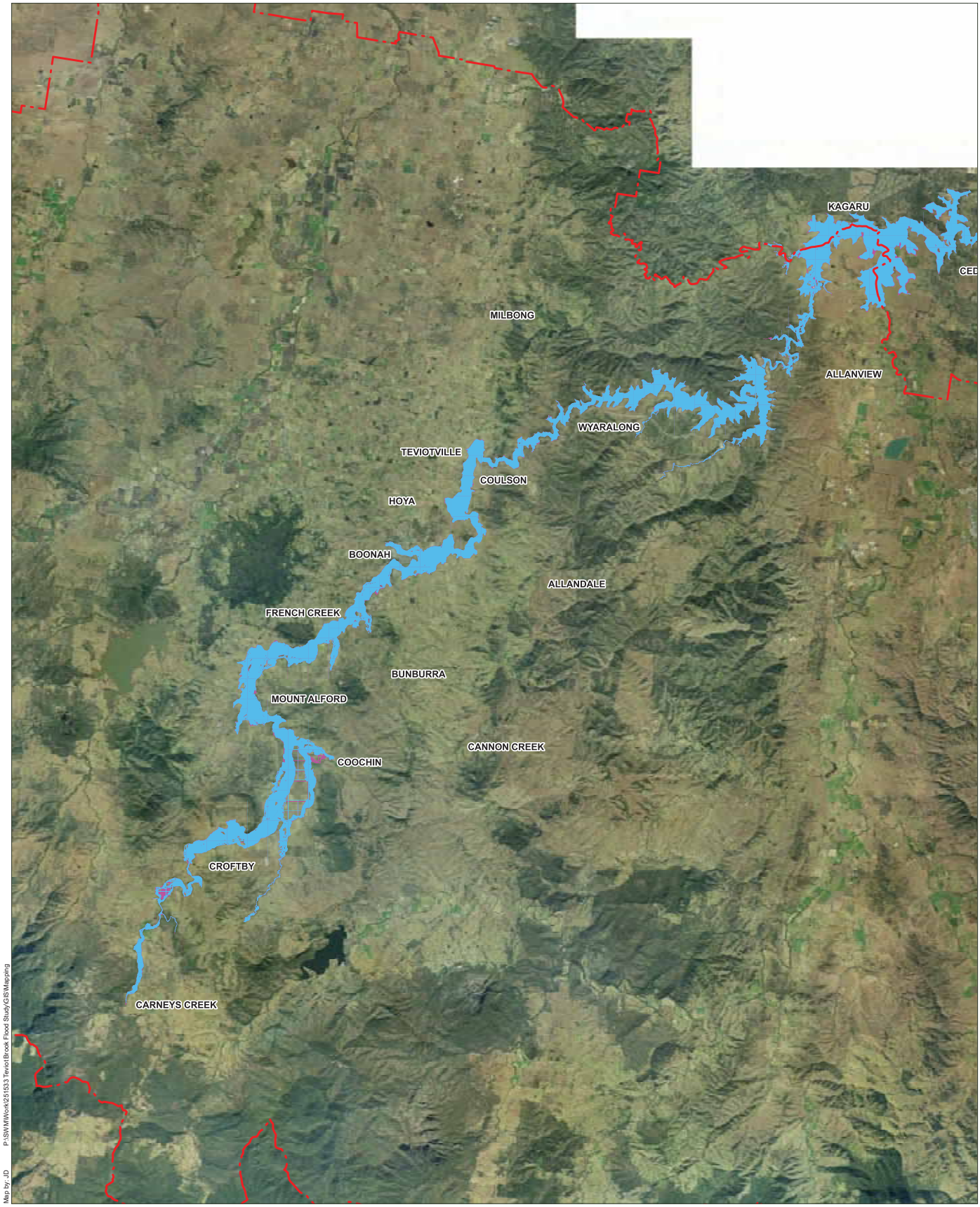
0 5,000 m 10,000 m

Date: 29/06/2016 Version: 0 Job No: 251533

Projection: MGA Zone 55

Teviot Brook Flood Study **Figure B2 - b**

Climate Change Scenario 8.5 - 1% Afflux Map



Map by: JD P:\SW\MWork\251533 Teviot Brook Flood Study\GIS\Mapping

Legend

- SRRC Boundary
- Existing Scenario Inundation Extents
- Climate Change Scenario 4.5 Inundation Extent

Notes:

A3 scale 1:200,000

0 5,000 m 10,000 m

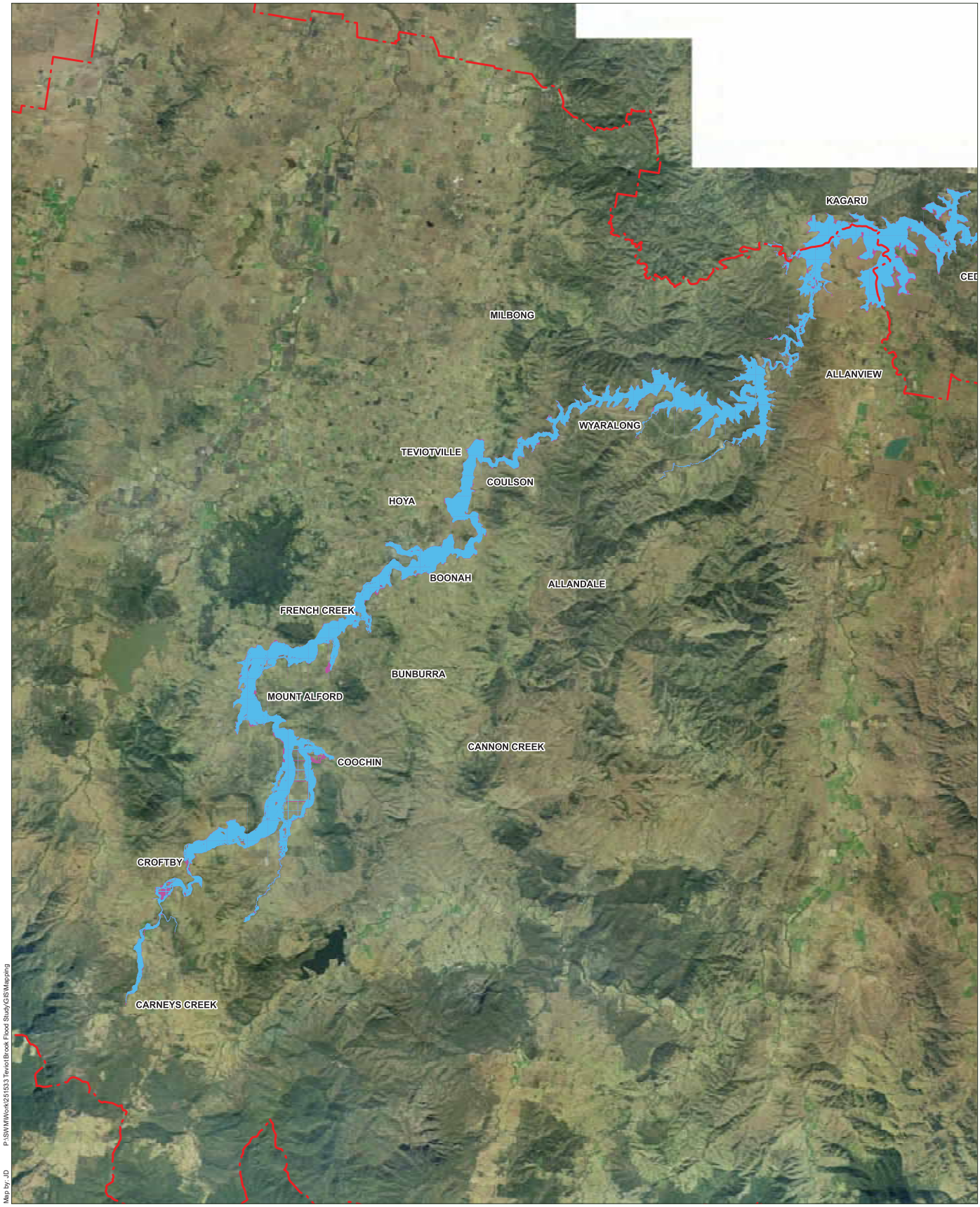
Date: 29/06/2016 Version: 0 Job No: 251533

Projection: MGA Zone 56

Teviot Brook Flood Study

Figure B3 - a

Climate Change Scenario 4.5 - 1% Inundation Extent



Map by: JD P:\SW\MWork\251533 Teviot Brook Flood Study\GIS\Mapping

Legend

- SRRC Boundary
- Existing Scenario Inundation Extents
- Climate Change Scenario 8.5 Inundation Extent

Notes:

A3 scale 1:200,000

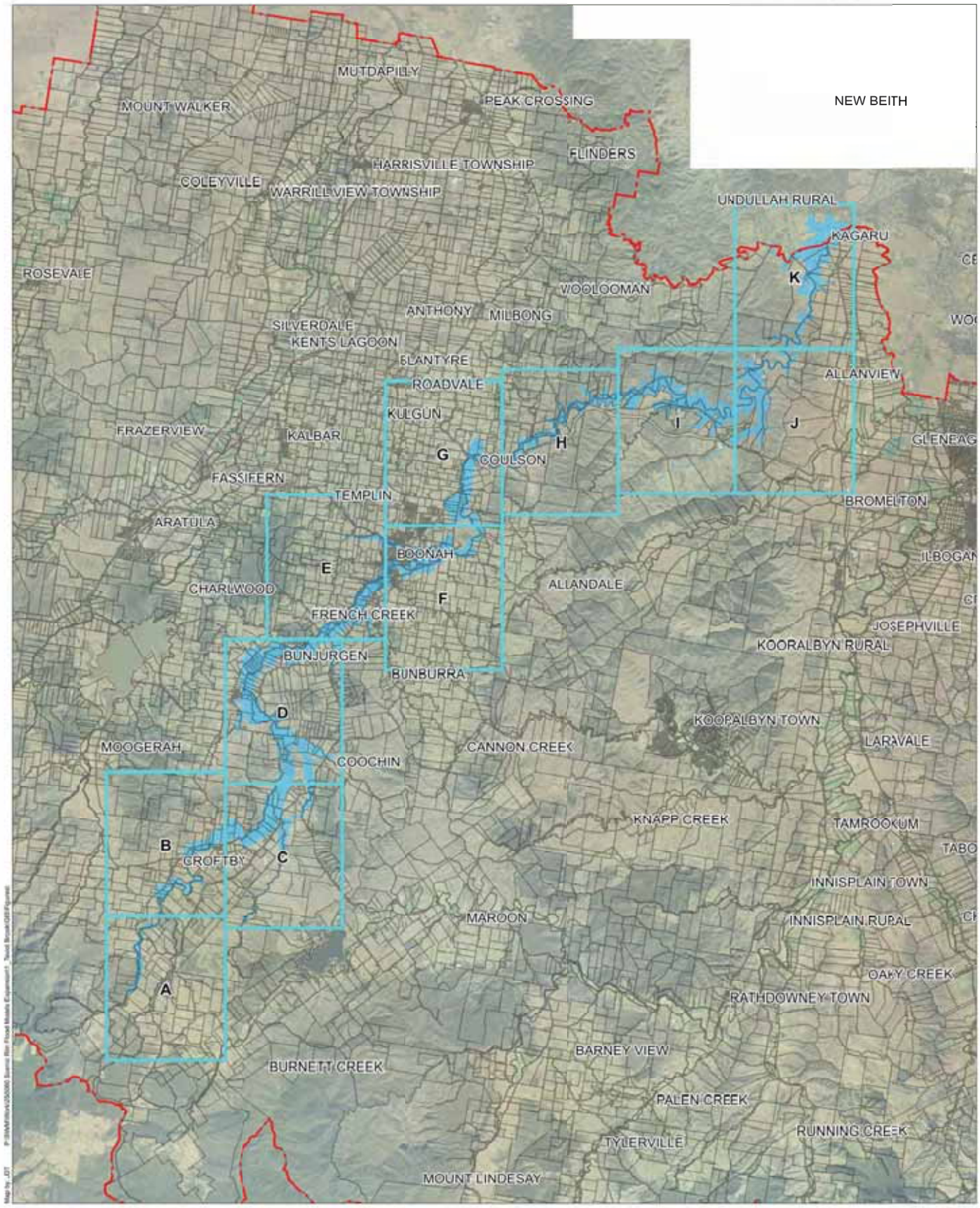
0 5,000 m 10,000 m

Date: 29/06/2016 Version: 0 Job No: 251533

Projection: MGA Zone 56

Teviot Brook 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)

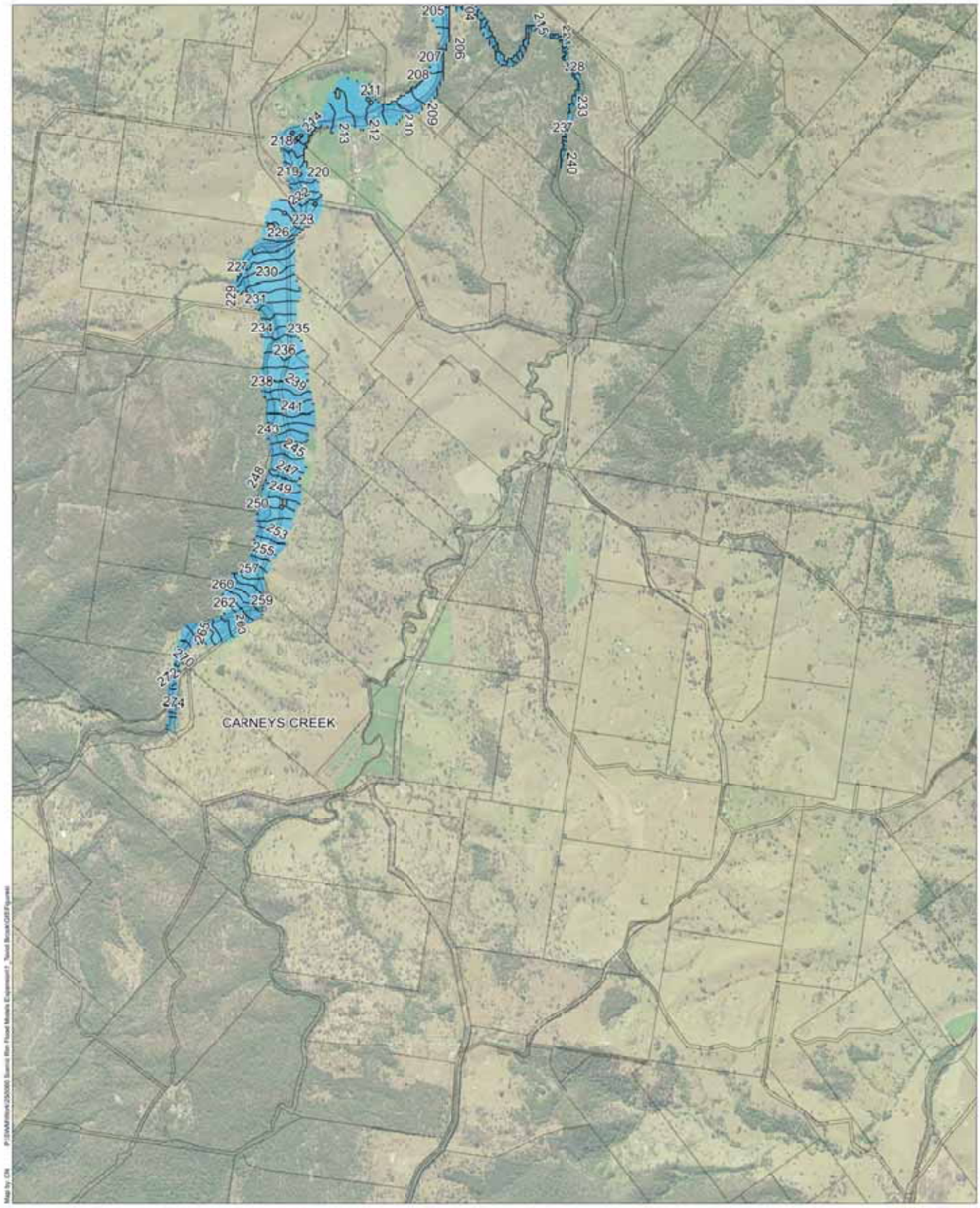
Notes:

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

Date: 24/10/2017 Version: 0 Job No: 255060

Teviot Brook 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:

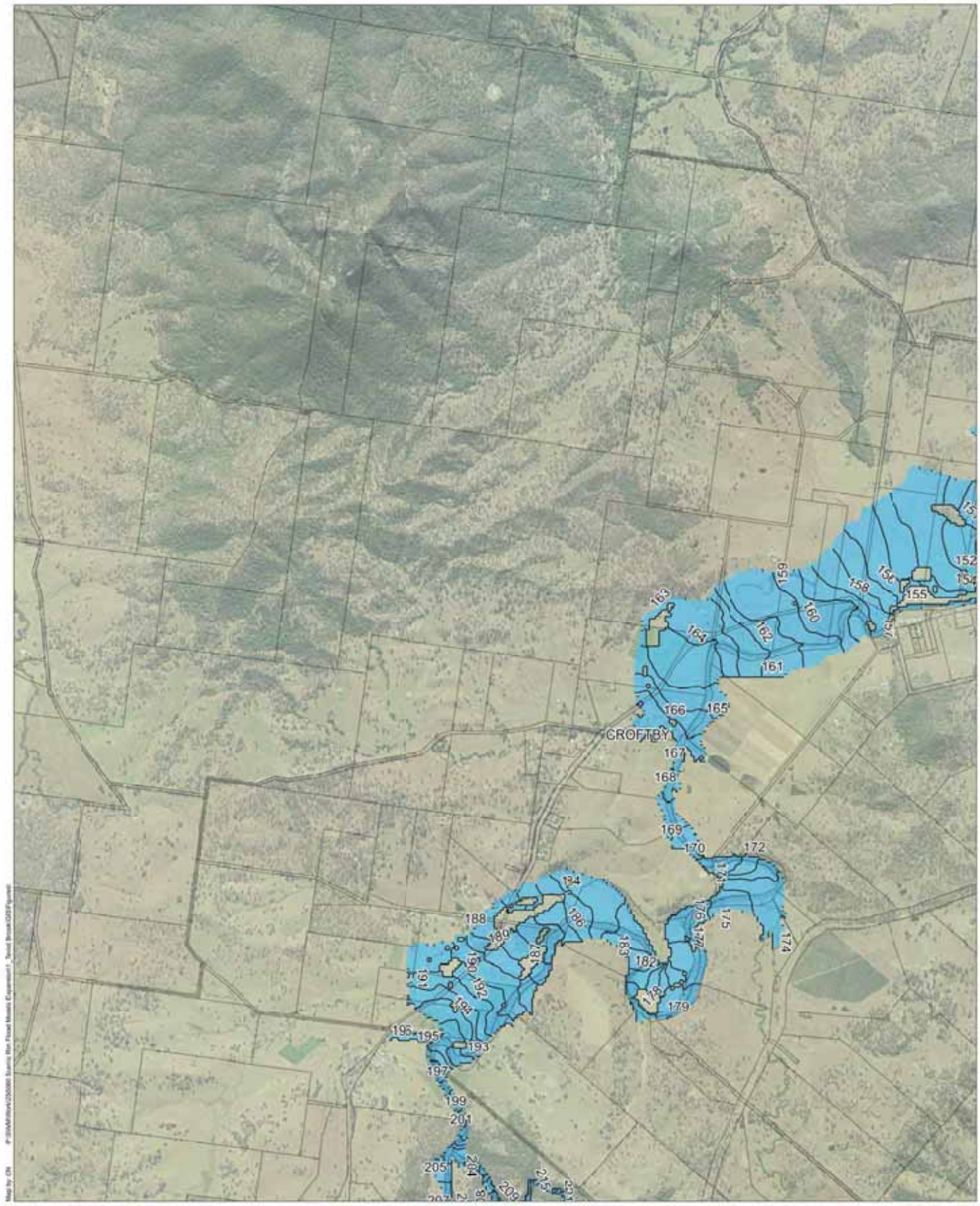
1:25,000

0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Teviot Brook Flood Study **Figure B4-a**

1% AEP Event -Climate Change Scenario 4.5 Inundation Extent



Legend

SRRC Boundary

Cadastral Boundary

Inundation Extent

Peak Water level Contour (mAHD)

Notes:

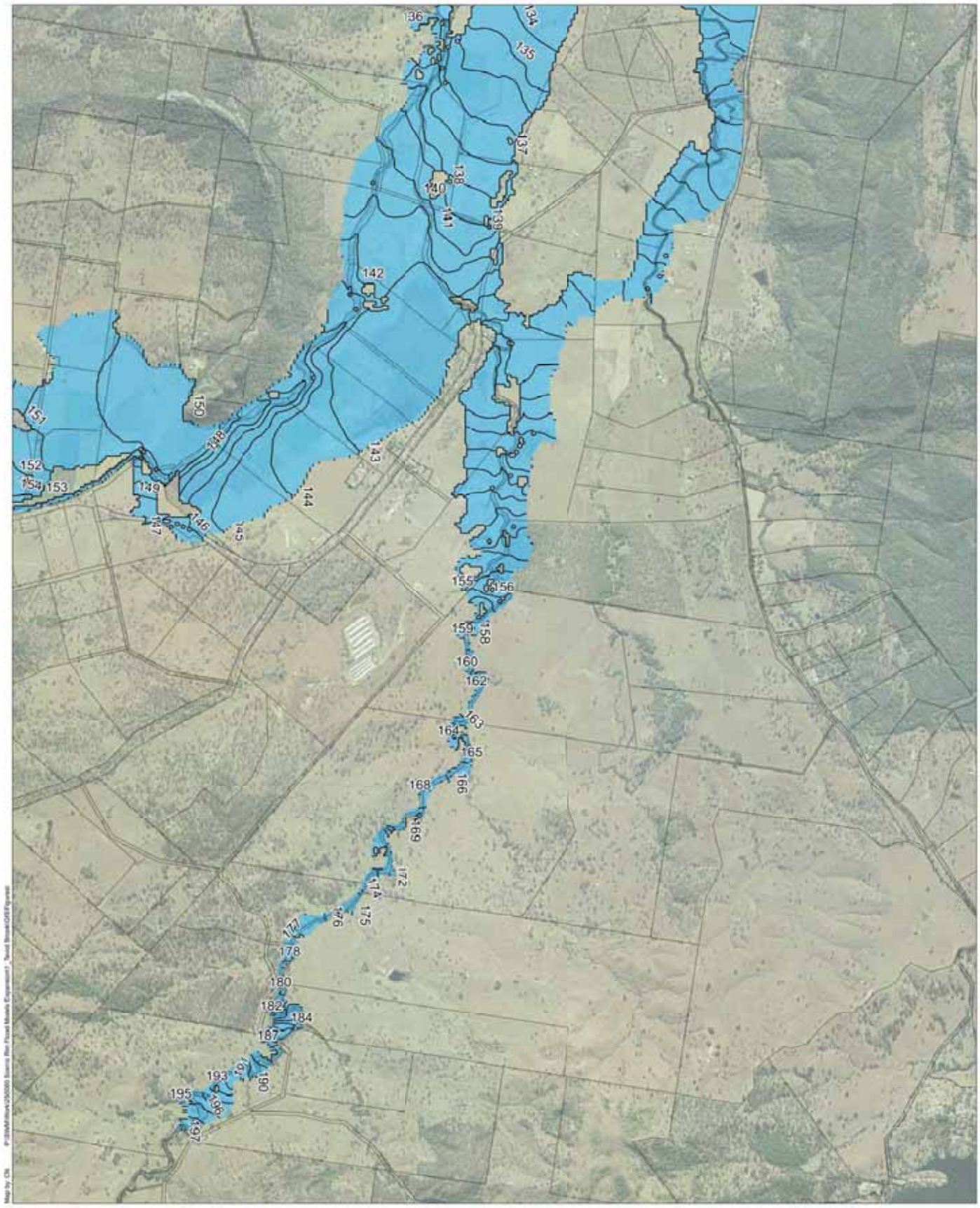
1:25,000

0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Teviot Brook Flood Study Figure B4-b

1% AEP Event -Climate Change Scenario 4.5 Inundation Extent



Legend

- SRRC Boundary
- Cadastral Boundary
- Inundation Extent
- Peak Water level Contour (mAHD)

Notes:

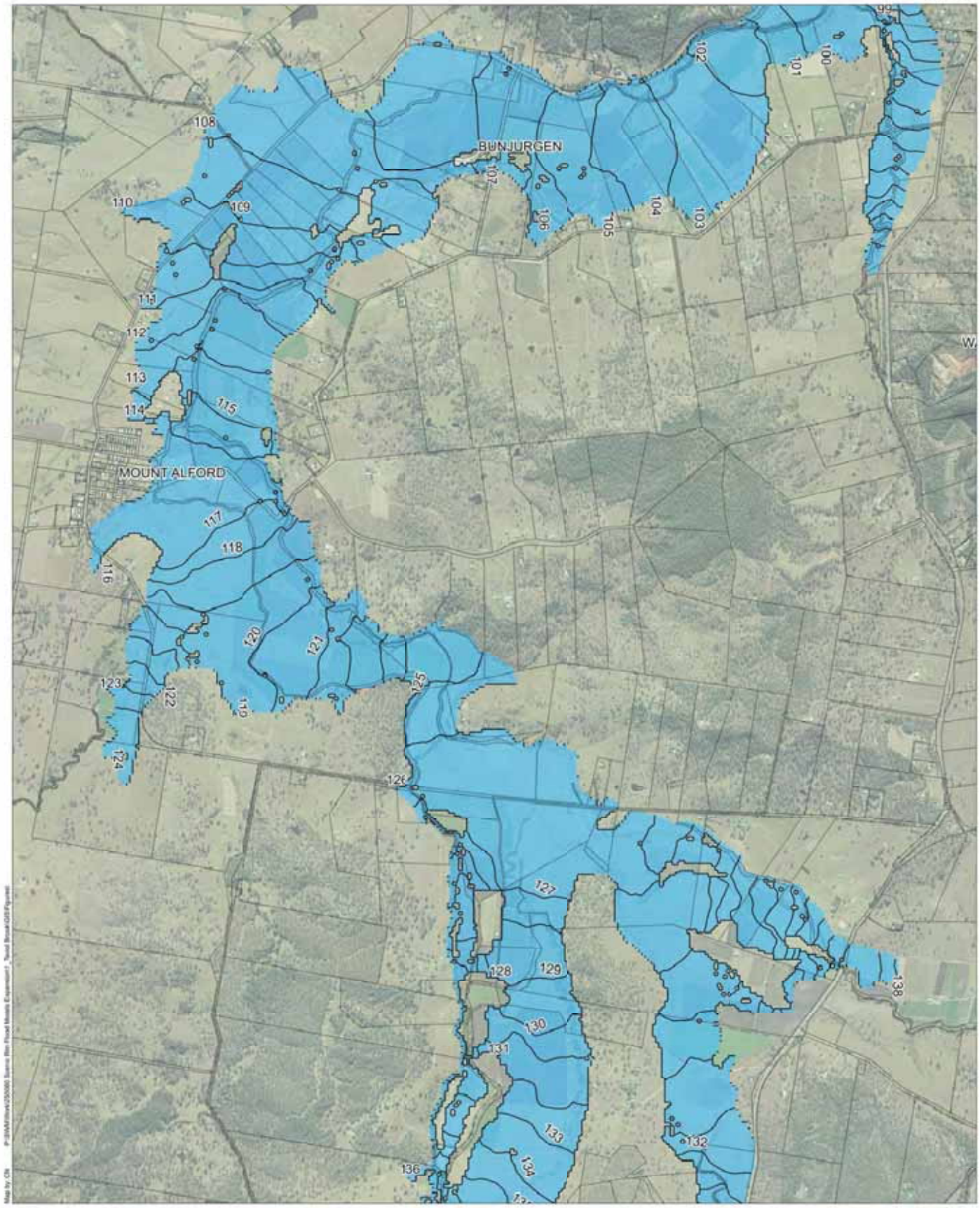
1:25,000

0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Teviot Brook Flood Study **Figure B4-c**

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

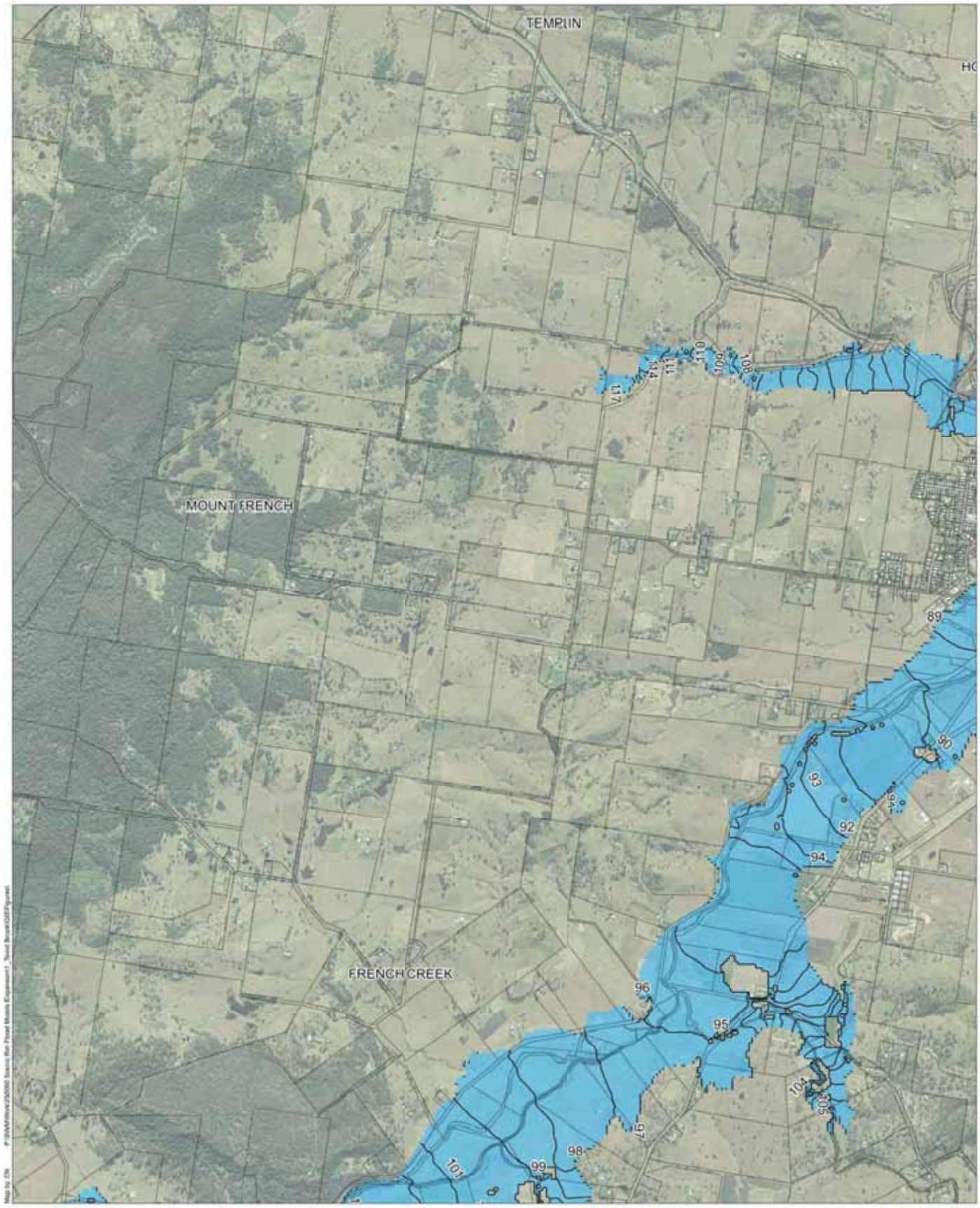
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 55

Teviot Brook Flood Study **Figure B4-d**

1% AEP Event -Climate Change Scenario 4.5 Inundation Extent



Legend

SRRC Boundary

Cadastral Boundary

Inundation Extent

Peak Water level Contour (mAHD)

Notes:

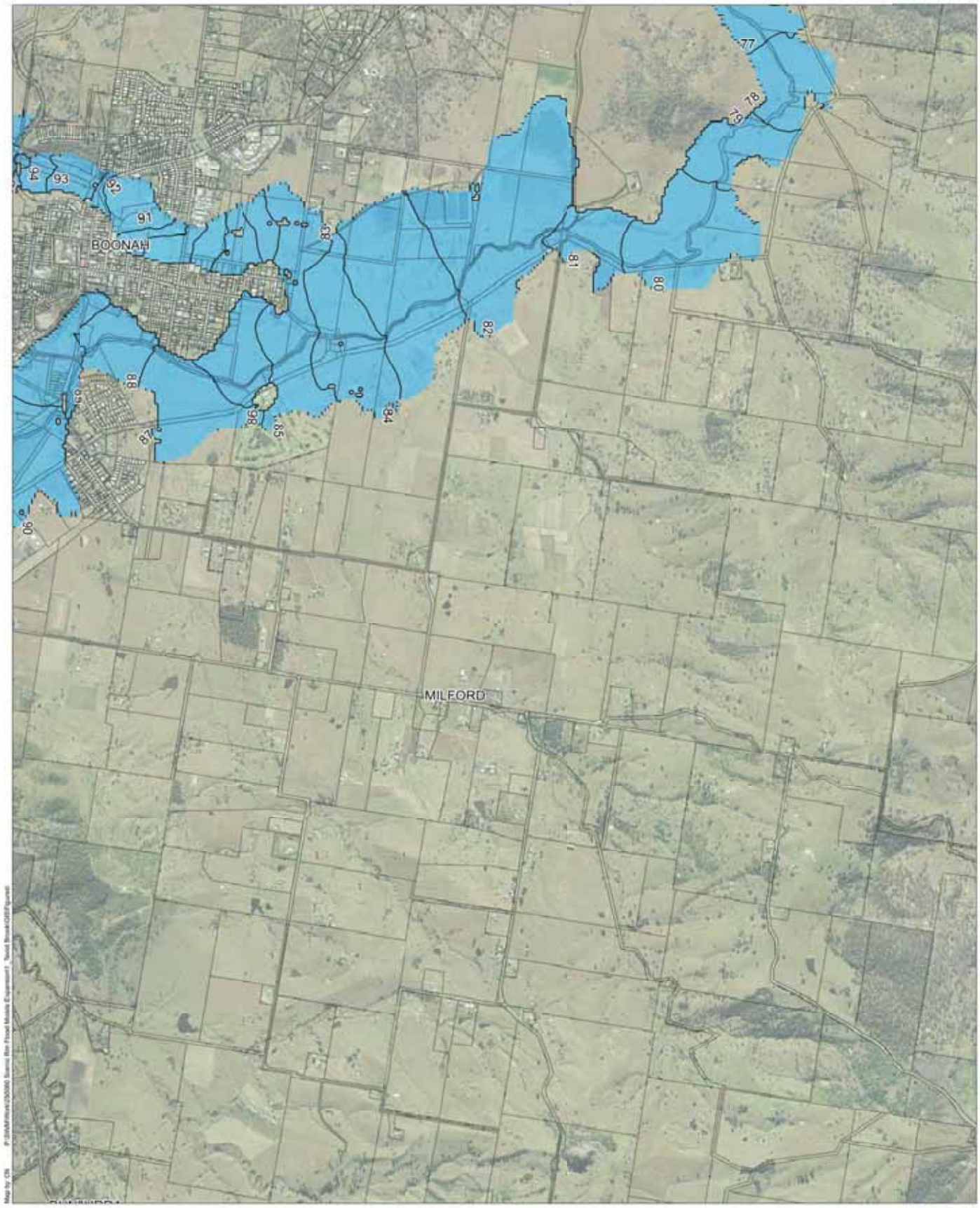
1:25,000

0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Teviot Brook Flood Study Figure B4-e

1% AEP Event -Climate Change Scenario 4.5 Inundation Extent



Legend

SRRC Boundary

Cadastral Boundary

Inundation Extent

Peak Water level Contour (mAHD)

Notes:

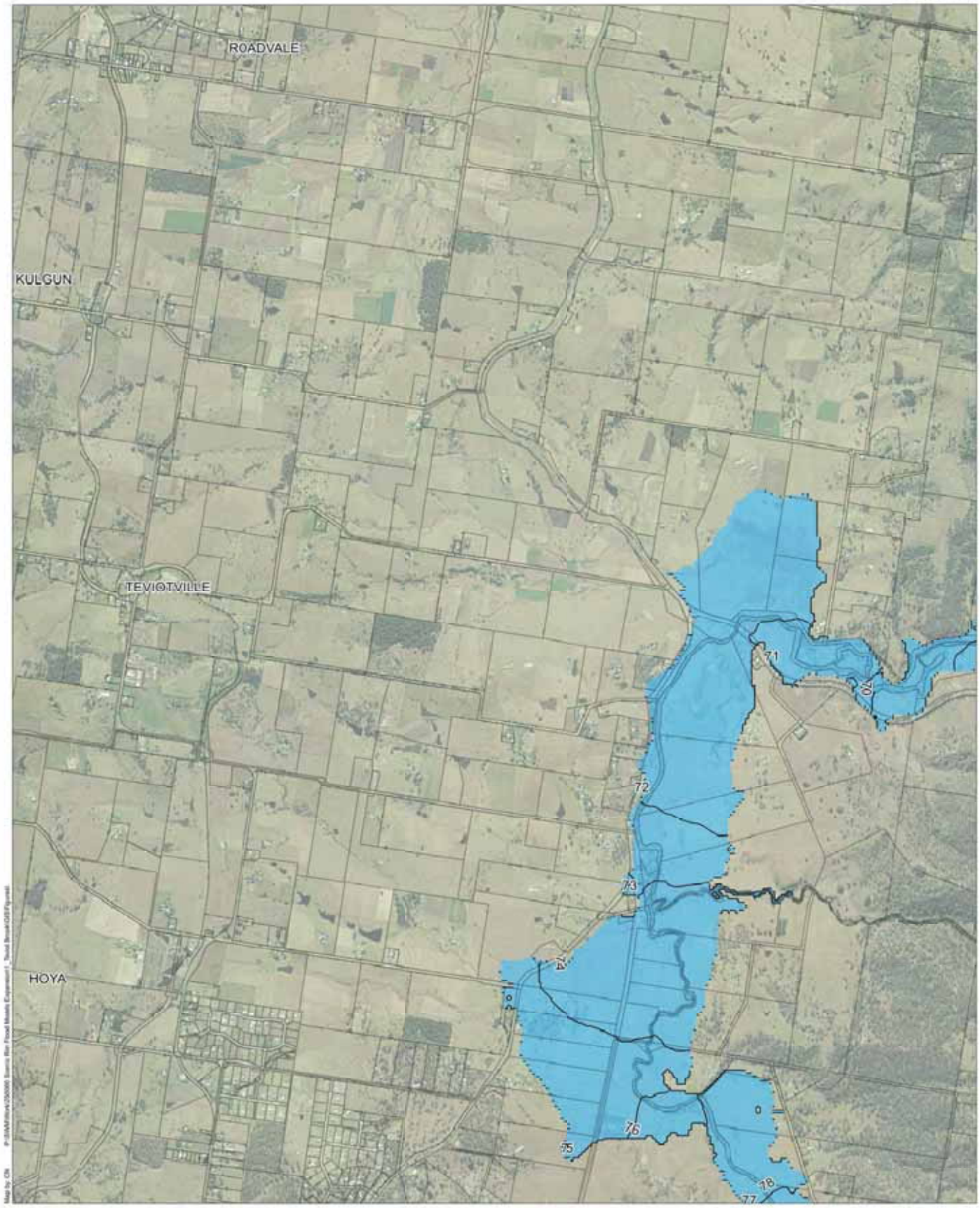
1:25,000

0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Teviot Brook Flood Study Figure B4-f

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

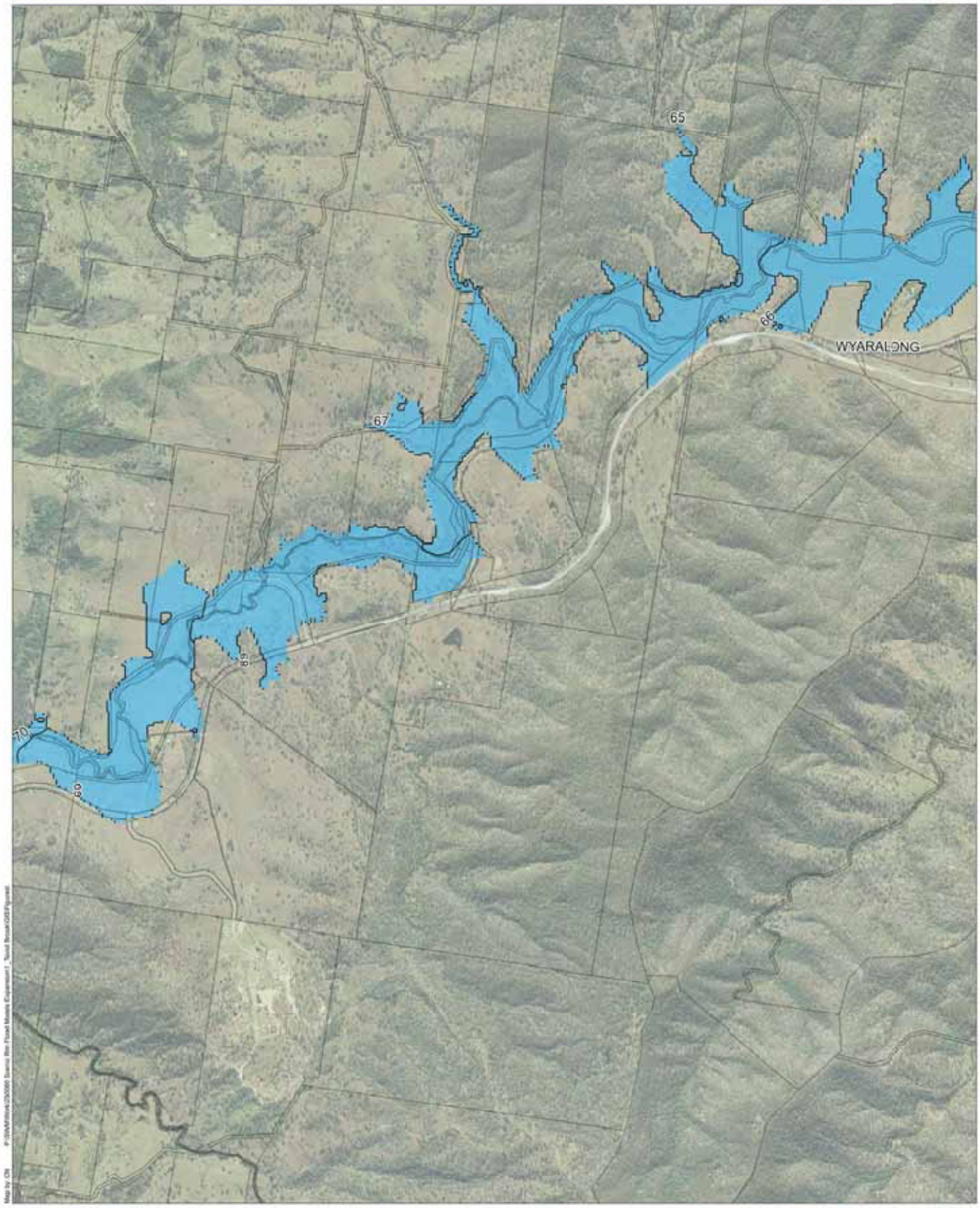
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 55

Teviot Brook Flood Study Figure B4-g

1% AEP Event -Climate Change Scenario 4.5 Inundation Extent



Legend

SRRC Boundary

Cadastral Boundary

Inundation Extent

Peak Water level Contour (mAHD)

Notes:

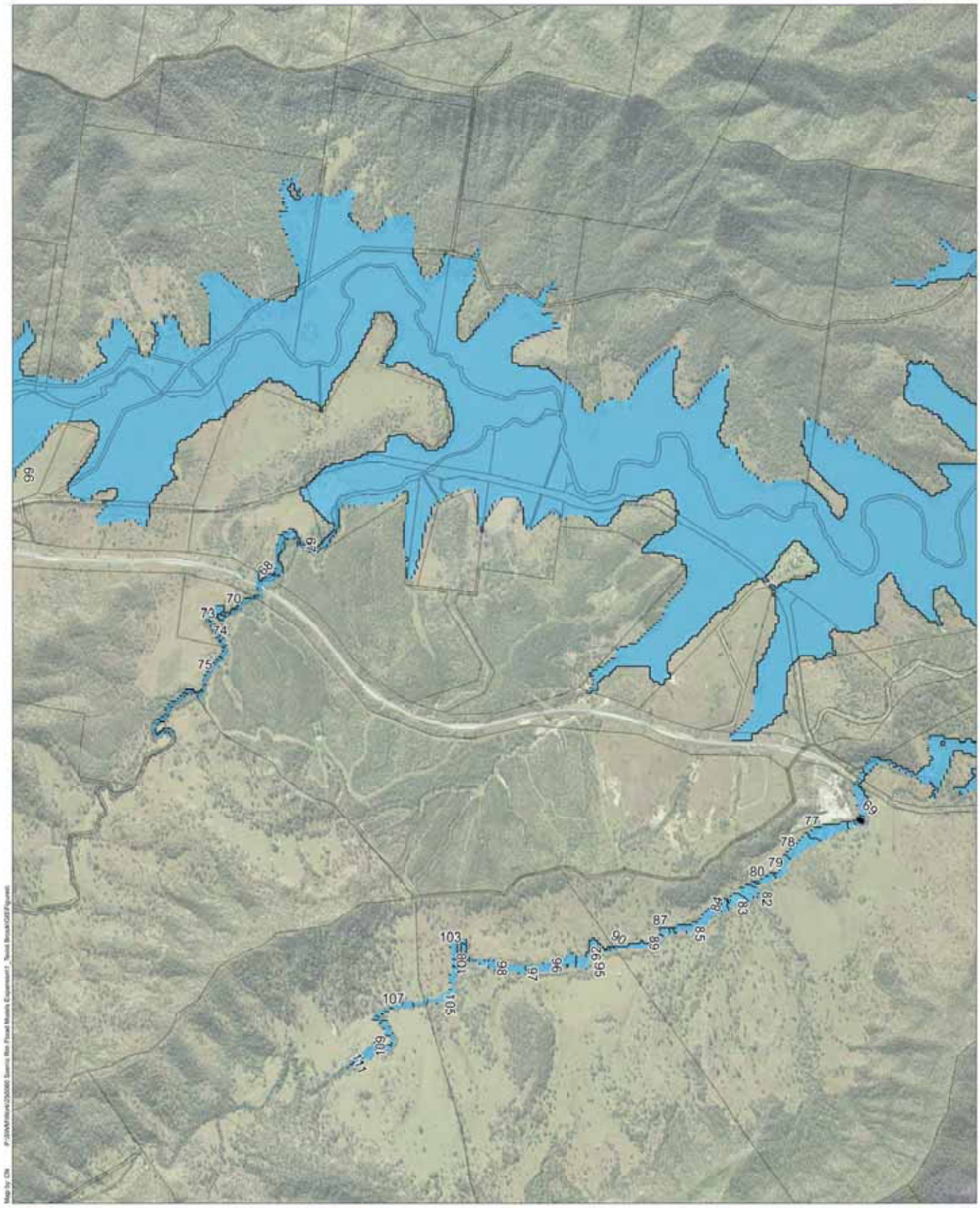
1:25,000

0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Teviot Brook Flood Study Figure B4-h

1% AEP Event -Climate Change Scenario 4.5 Inundation Extent



Legend

- SRRC Boundary
- Cadastral Boundary
- Inundation Extent
- Peak Water level Contour (mAHD)

Notes:

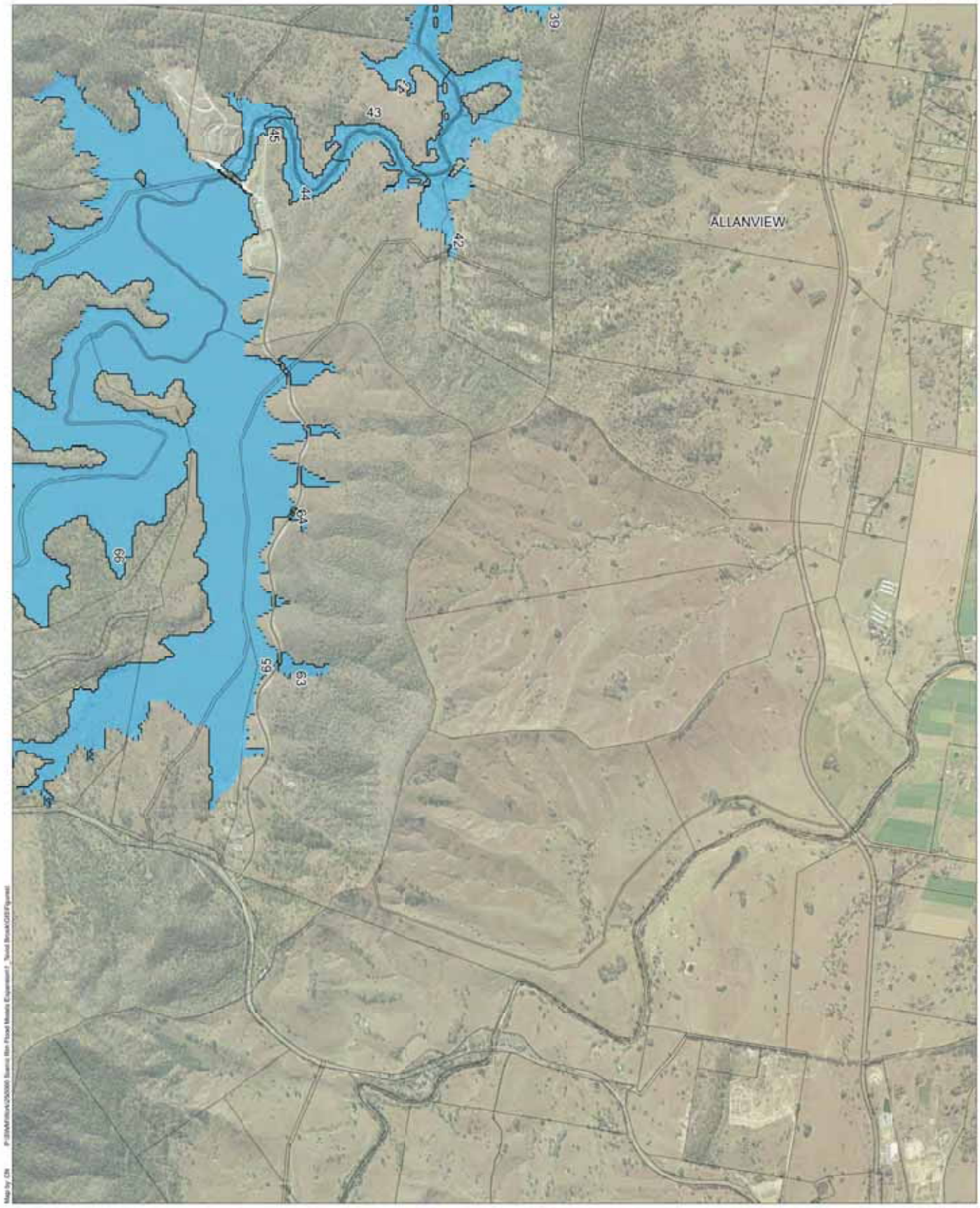
1:25,000

0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Teviot Brook Flood Study **Figure B4-i**

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

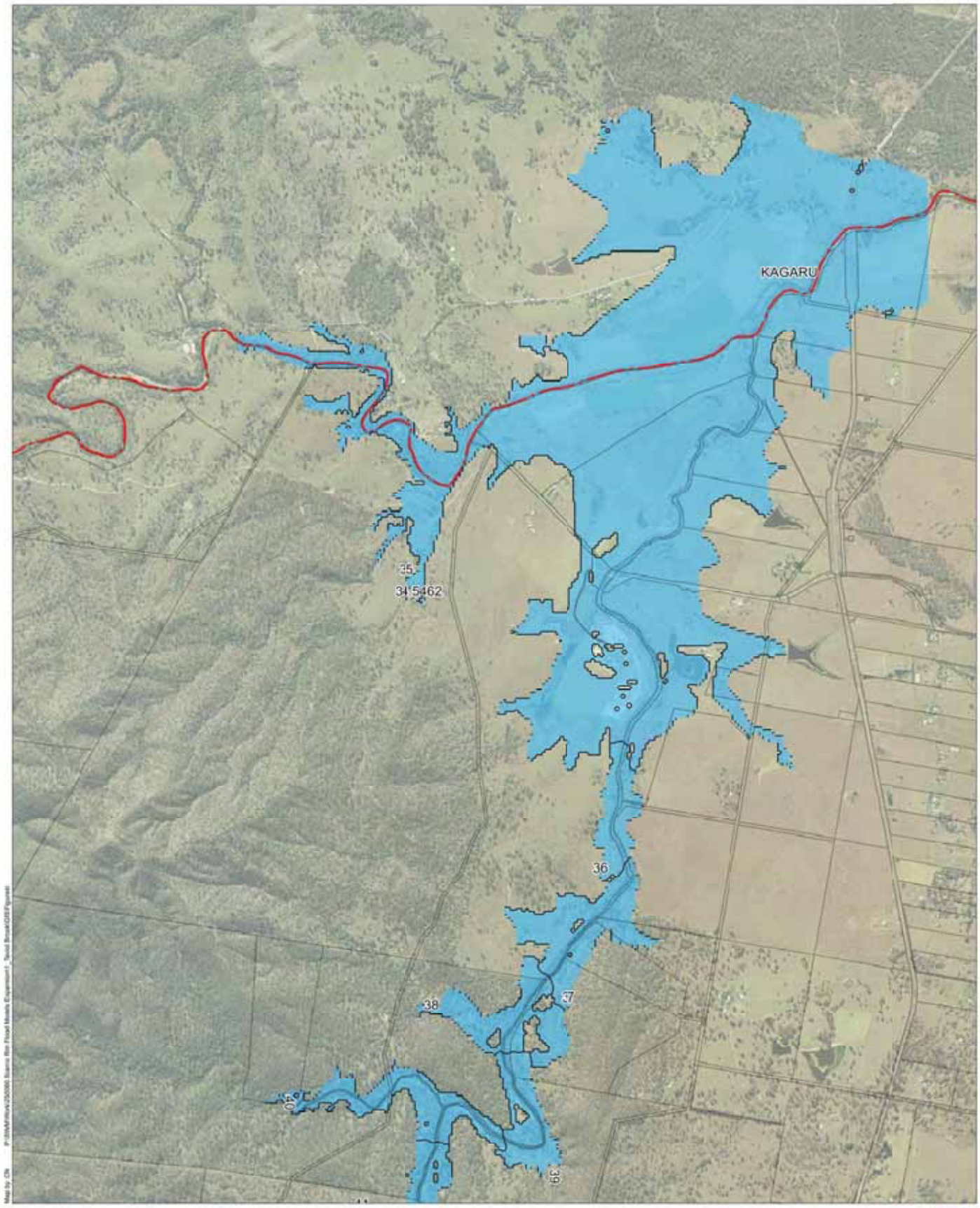
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Teviot Brook Flood Study Figure B4-j

1% AEP Event -Climate Change Scenario 4.5 Inundation Extent

aurecon



Legend

SRRC Boundary

Cadastral Boundary

Inundation Extent

Peak Water level Contour (mAHD)

Notes:

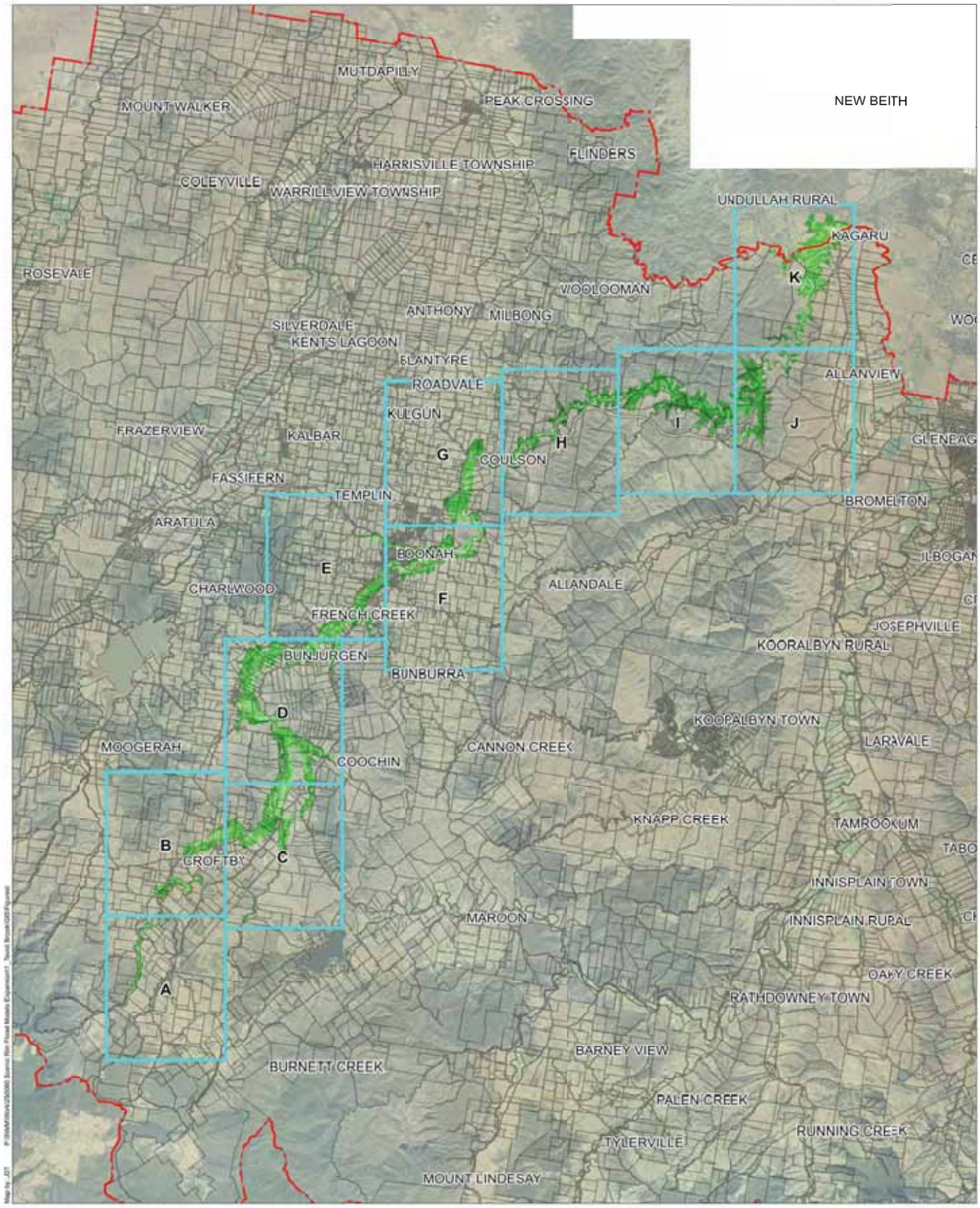
1:25,000

0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Teviot Brook Flood Study Figure B4-k

1% AEP Event -Climate Change Scenario 4.5 Inundation Extent



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:

1:100,000

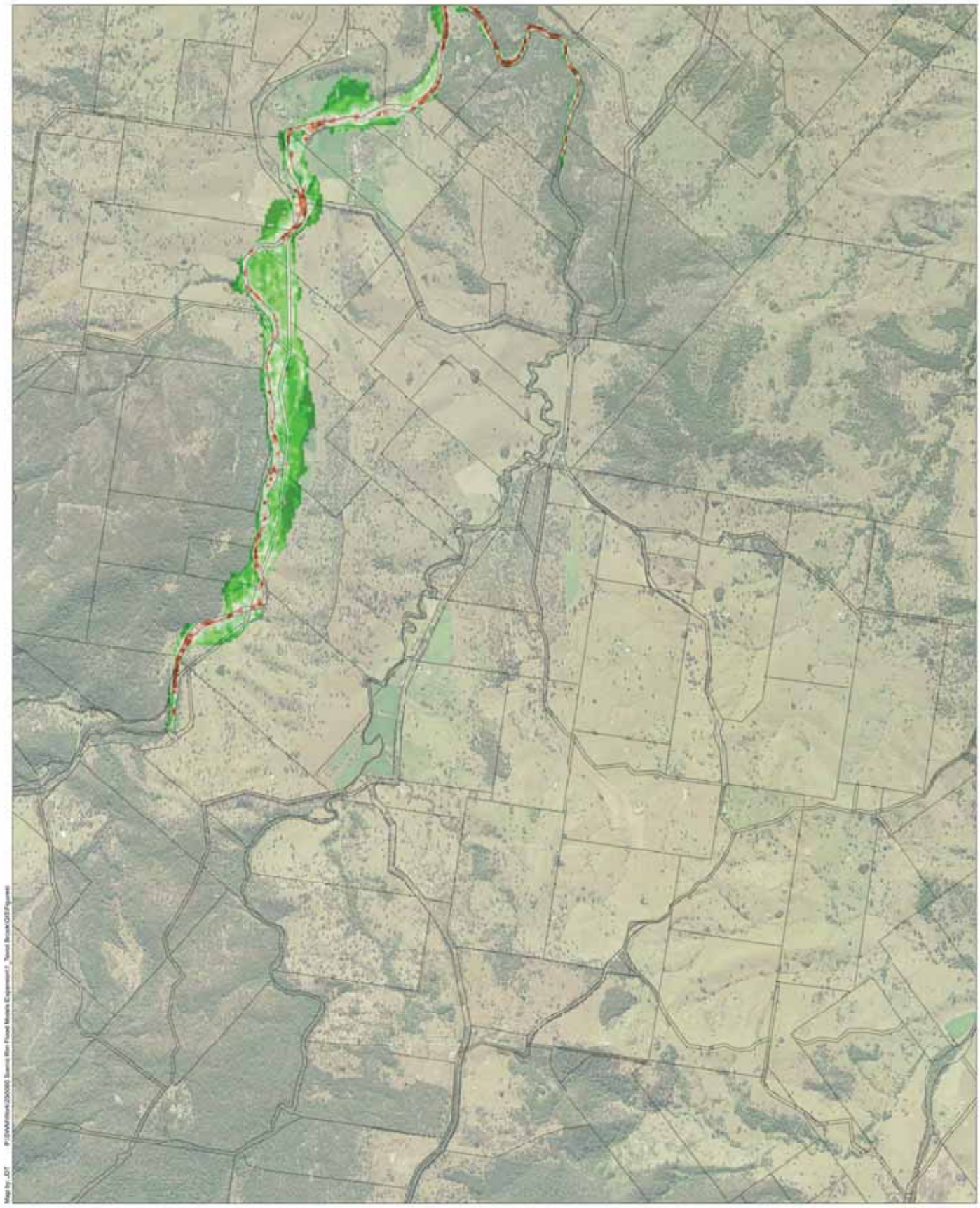
0 2,500 m 5,000 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Teviot Brook Flood Study **Figure B5**

1% AEP Event Climate Change Scenario 4.5- Peak Velocities



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

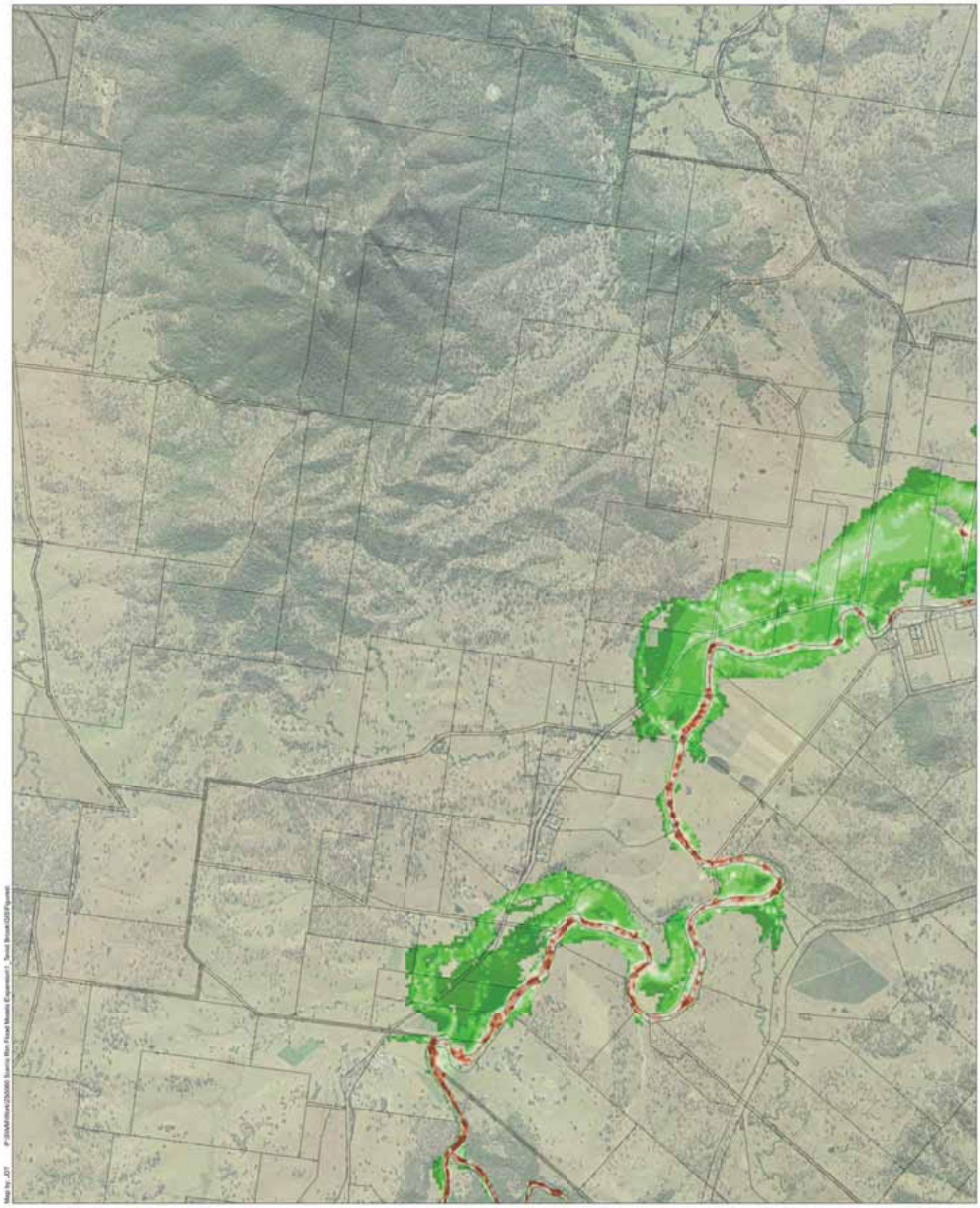
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 55

Teviot Brook Flood Study **Figure B5-a**

1% AEP Event Climate Change Scenario 4.5- Peak Velocities



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

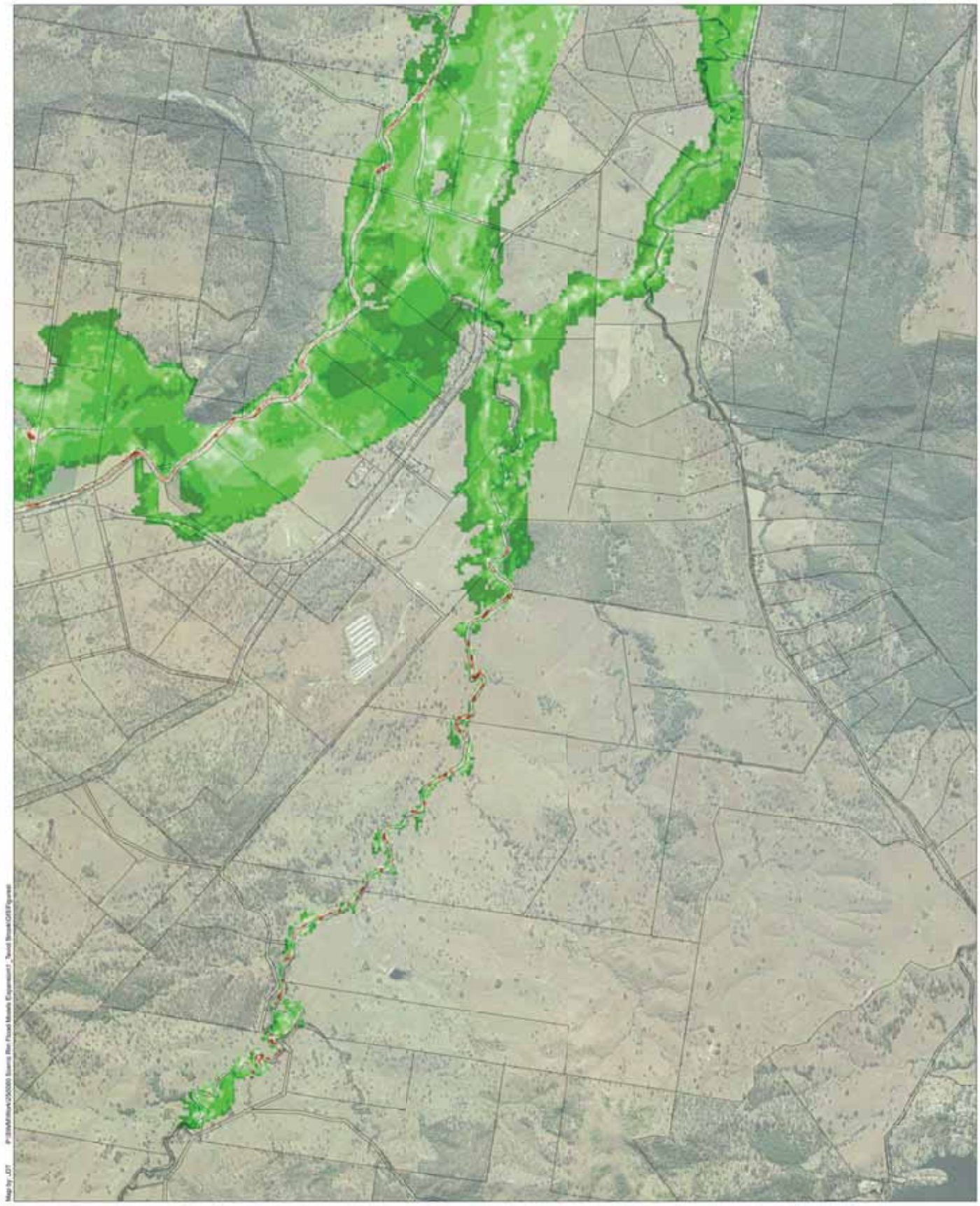
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 55

Teviot Brook Flood Study **Figure B5-b**

1% AEP Event Climate Change Scenario 4.5- Peak Velocities



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

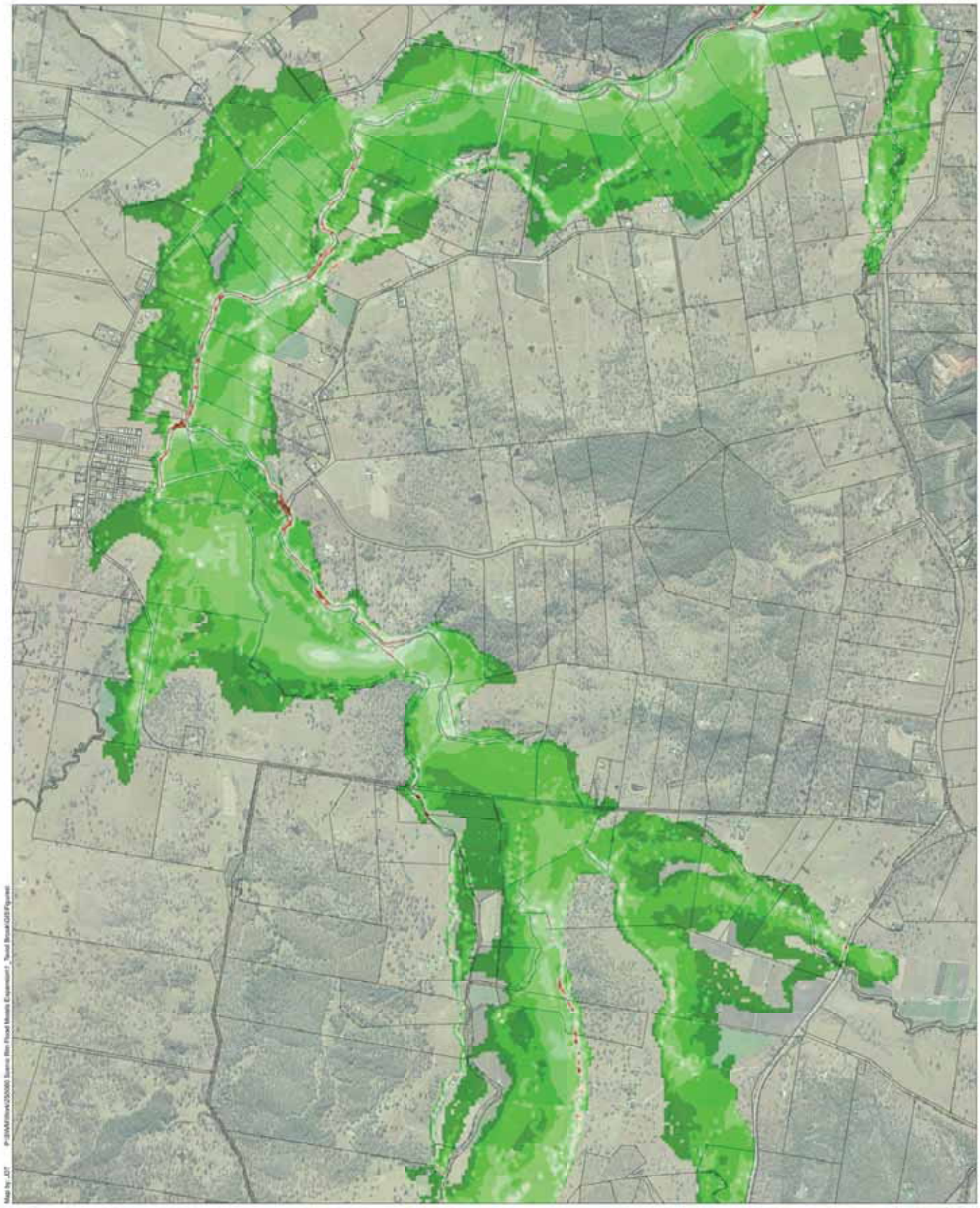
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 55

Teviot Brook Flood Study **Figure B5-c**

1% AEP Event Climate Change Scenario 4.5- Peak Velocities



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

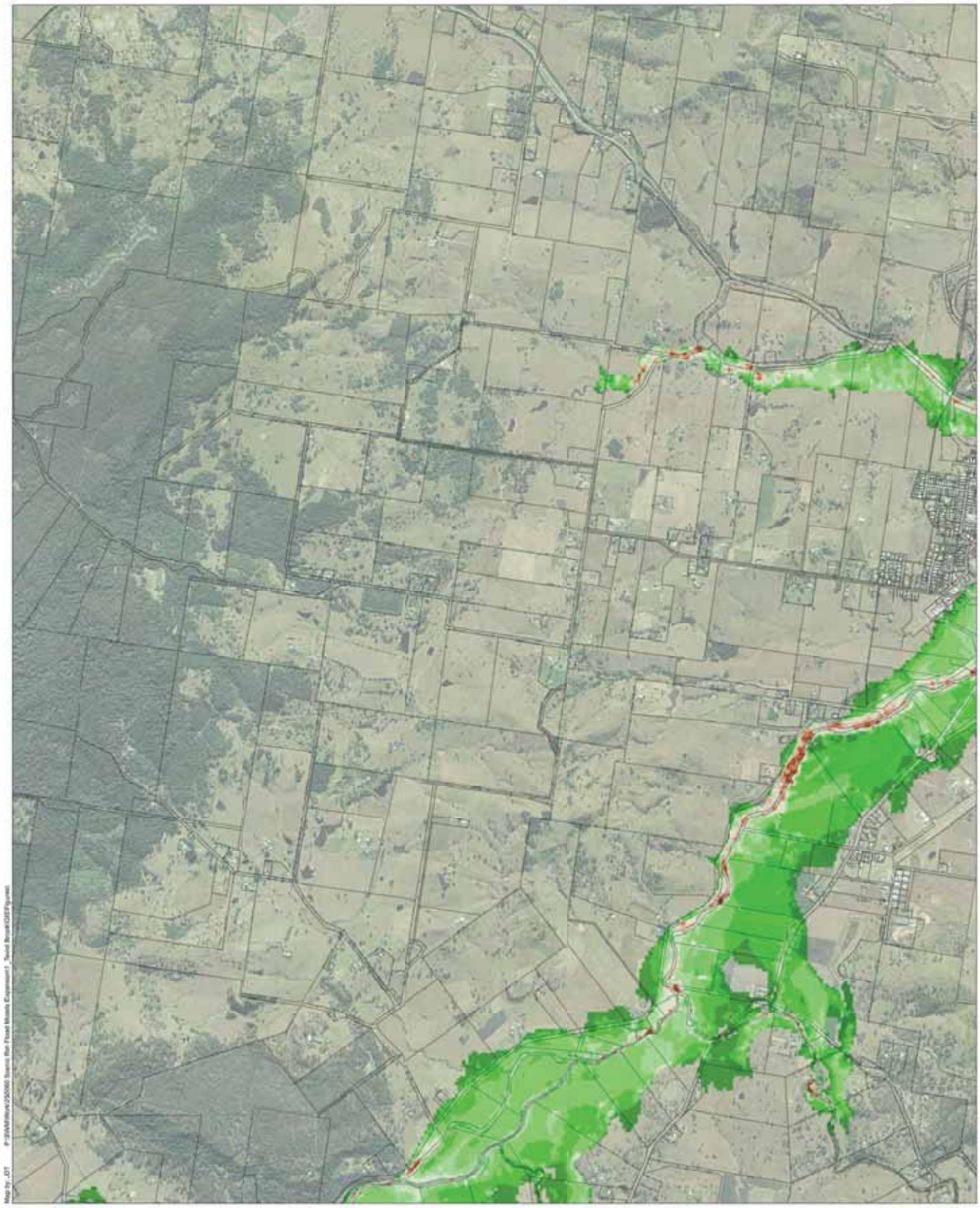
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 55

Teviot Brook Flood Study **Figure B5-d**

1% AEP Event Climate Change Scenario 4.5- Peak Velocities



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

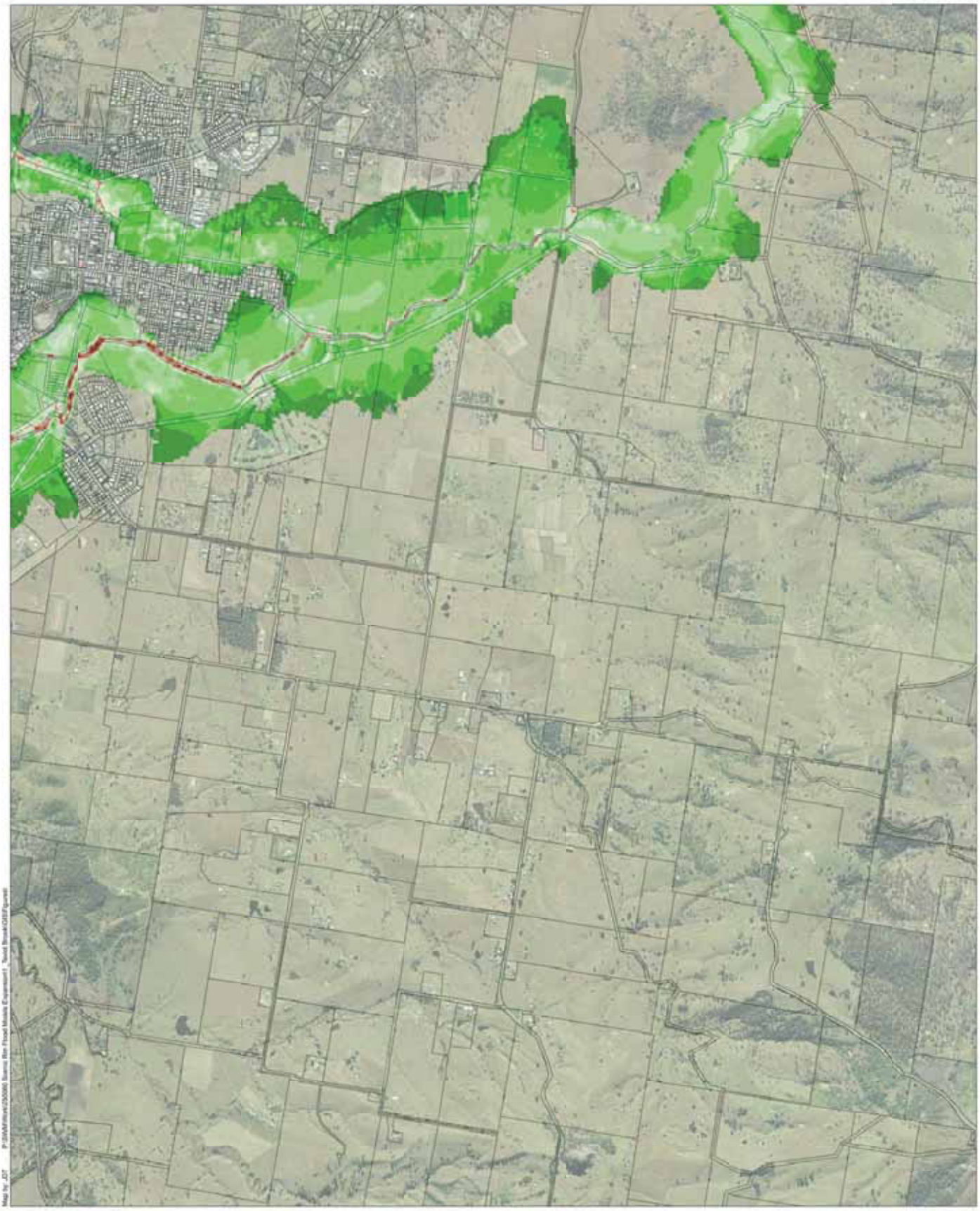
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 55

Teviot Brook Flood Study **Figure B5-e**

1% AEP Event Climate Change Scenario 4.5- Peak Velocities



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

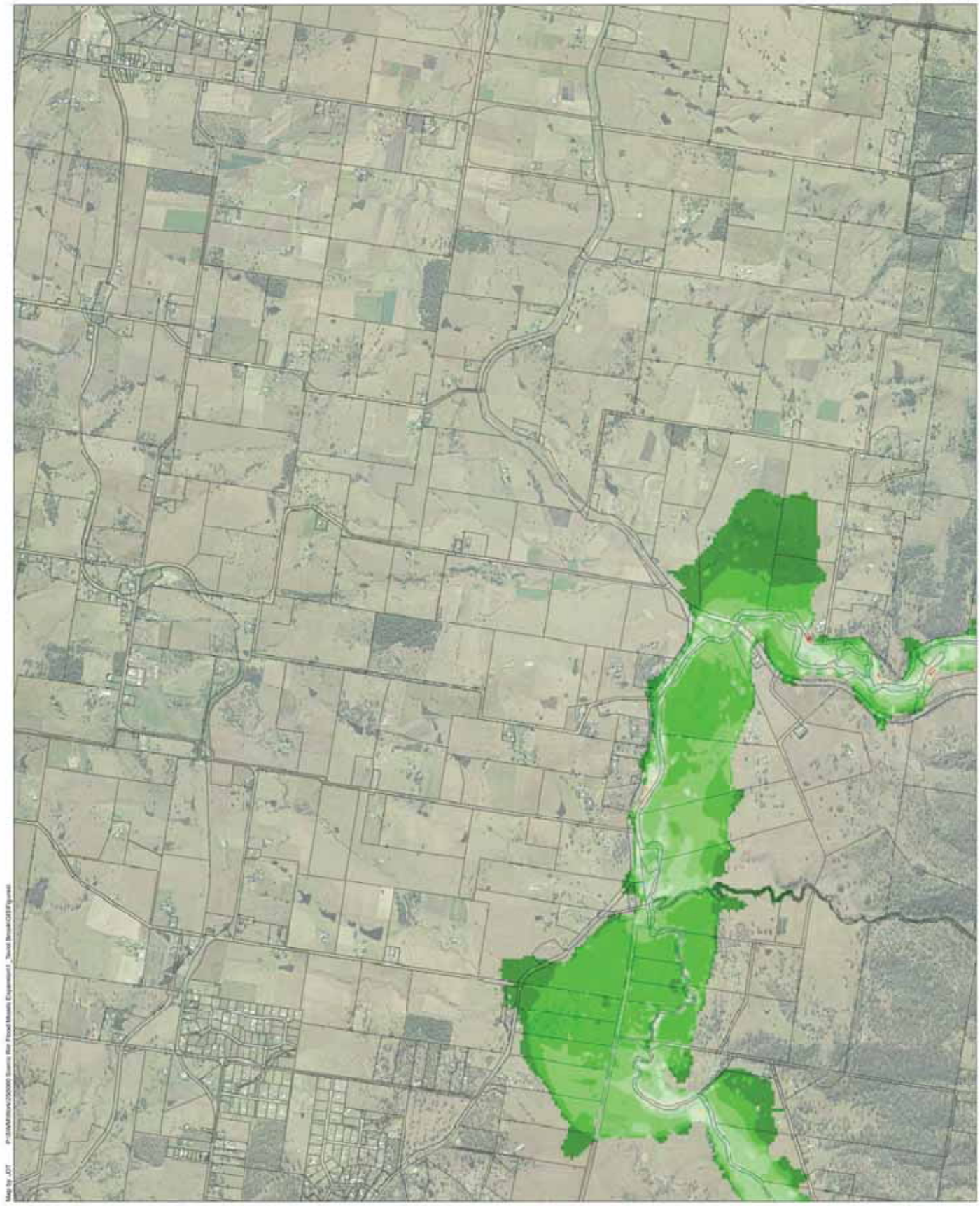
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 55

Teviot Brook Flood Study **Figure B5-f**

1% AEP Event Climate Change Scenario 4.5- Peak Velocities



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

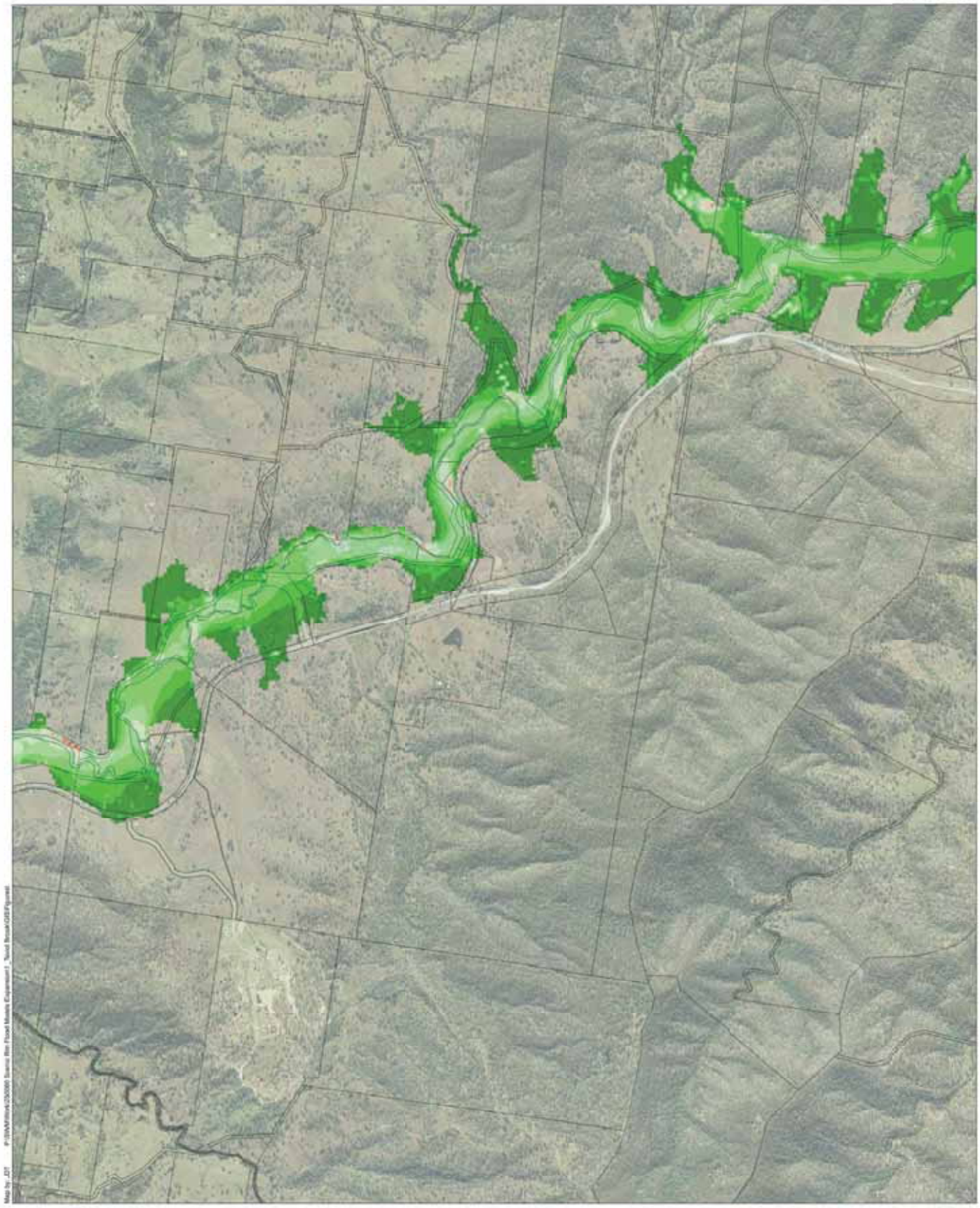
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 55

Teviot Brook Flood Study **Figure B5-g**

1% AEP Event Climate Change Scenario 4.5- Peak Velocities



Legend

SRRC

Cadastral

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

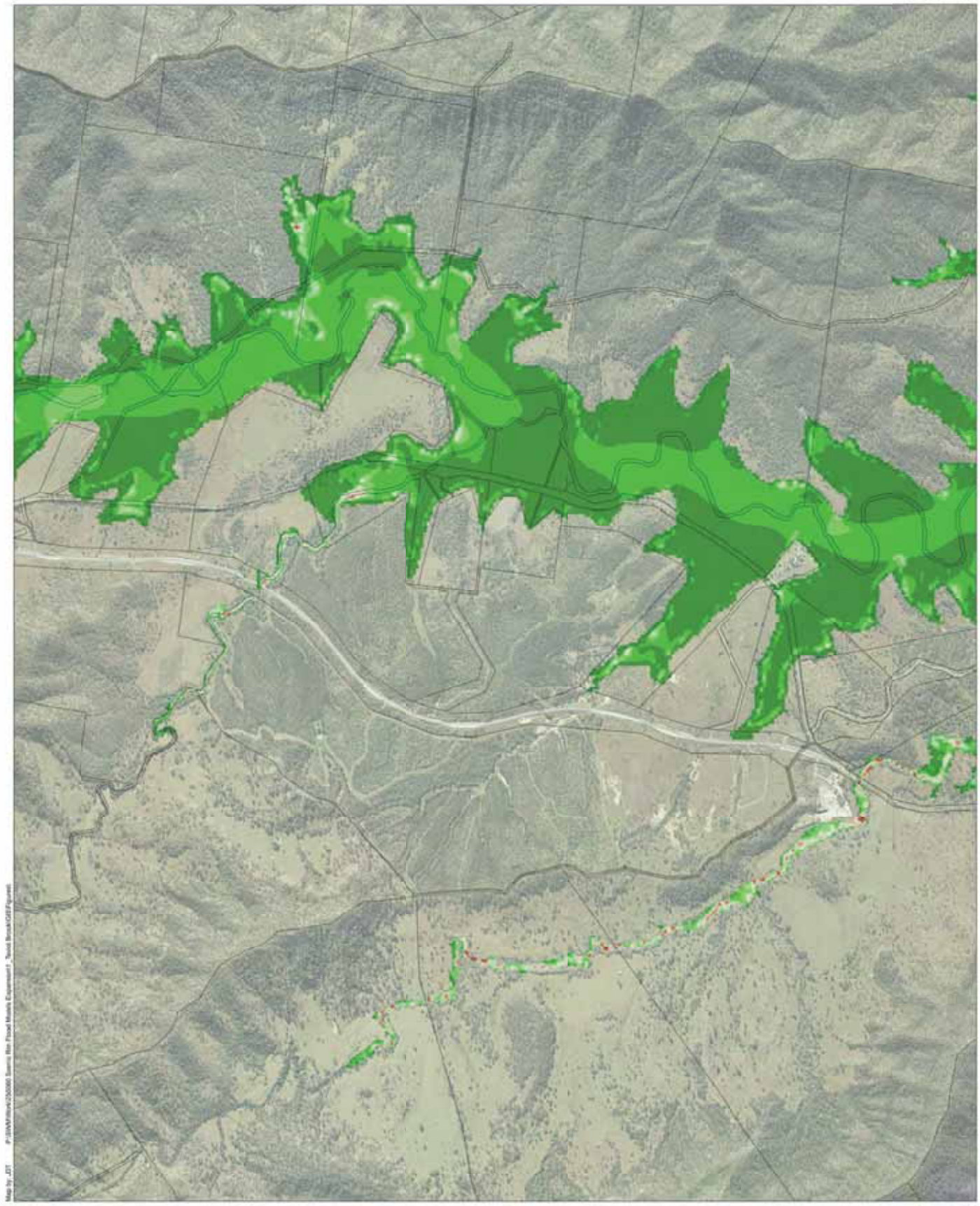
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 55

Teviot Brook Flood Study **Figure B5-h**

1% AEP Event Climate Change Scenario 4.5- Peak Velocities



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

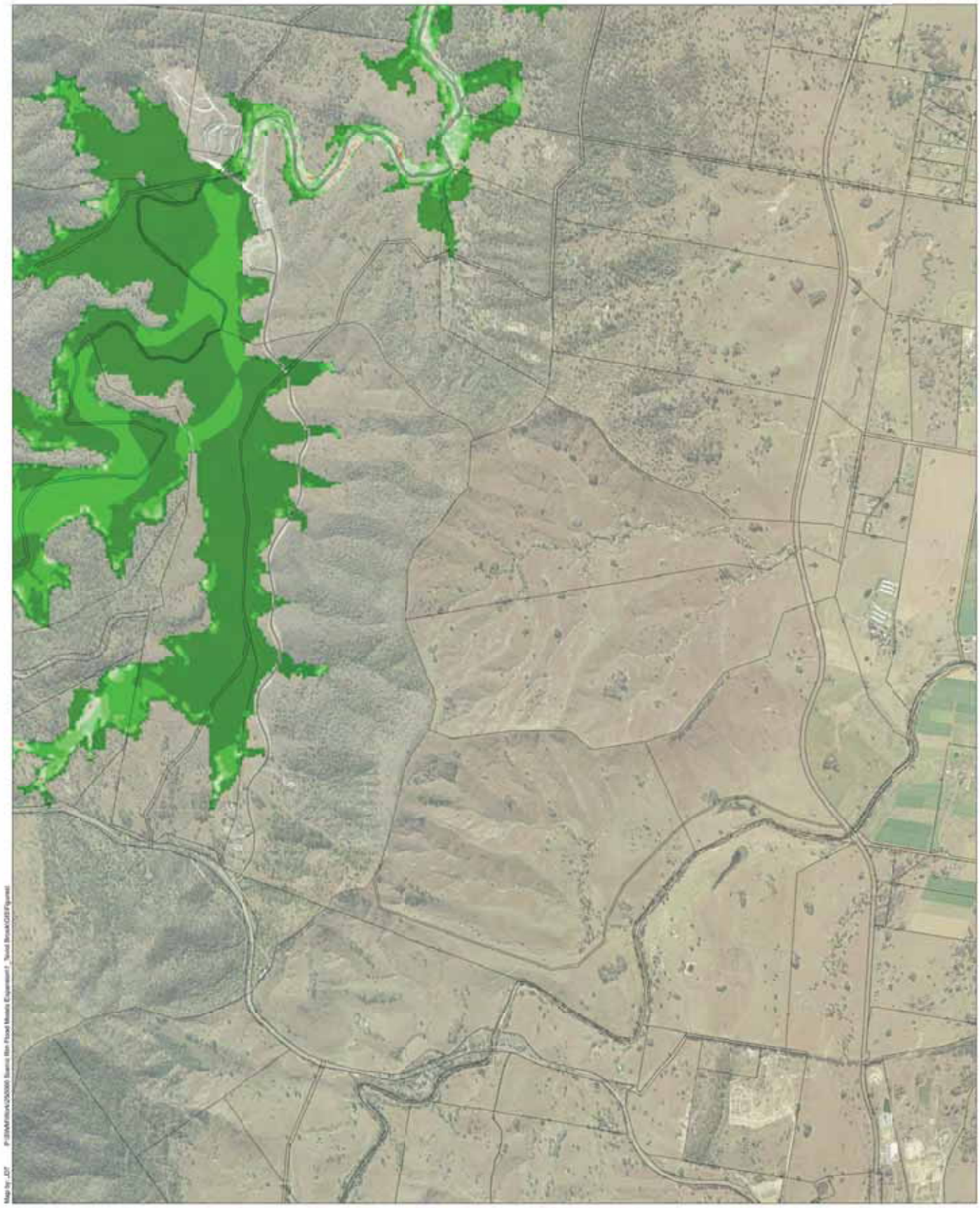
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 55

Teviot Brook Flood Study **Figure B5-i**

1% AEP Event Climate Change Scenario 4.5- Peak Velocities



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

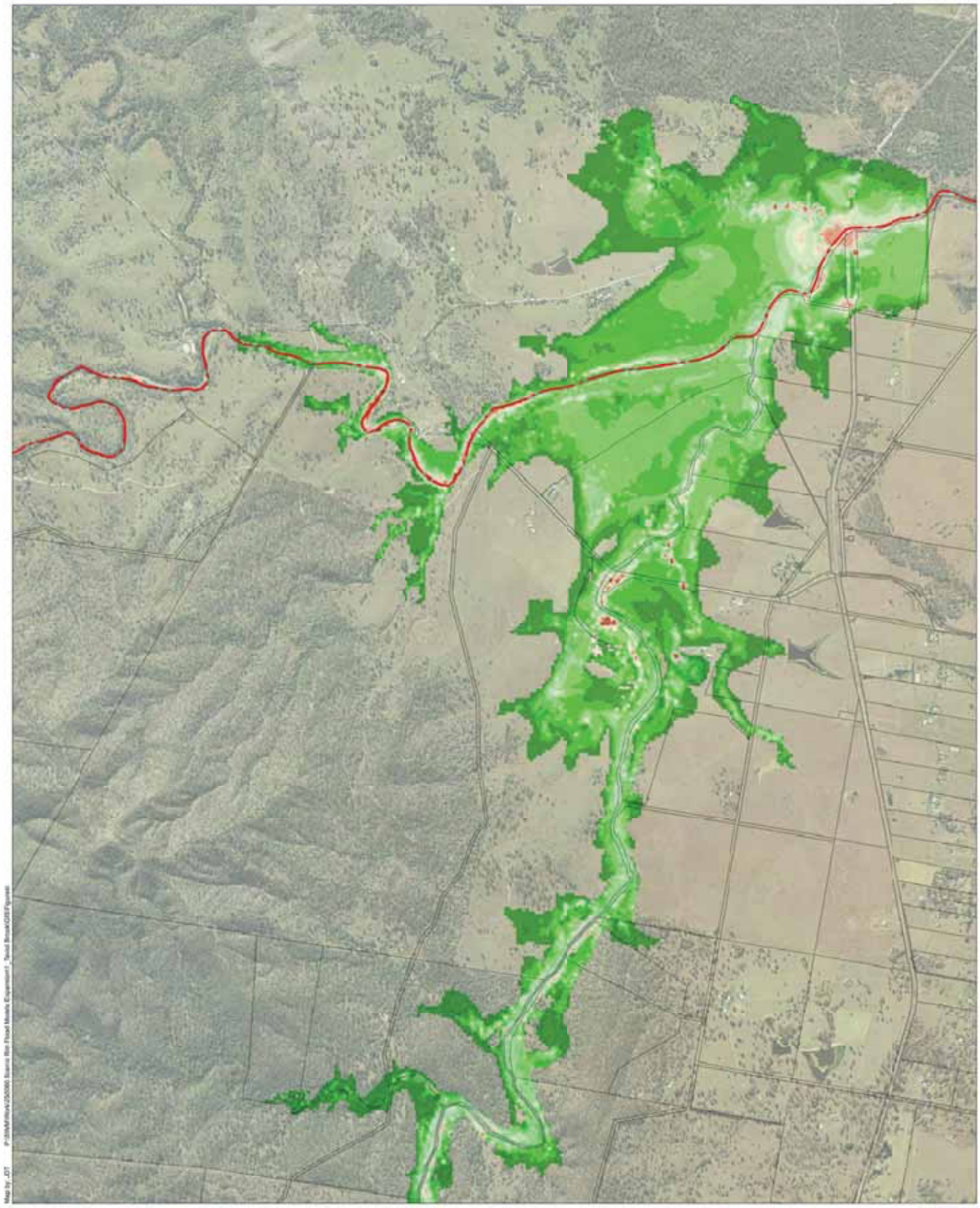
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 55

Teviot Brook Flood Study **Figure B5-j**

1% AEP Event Climate Change Scenario 4.5- Peak Velocities



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

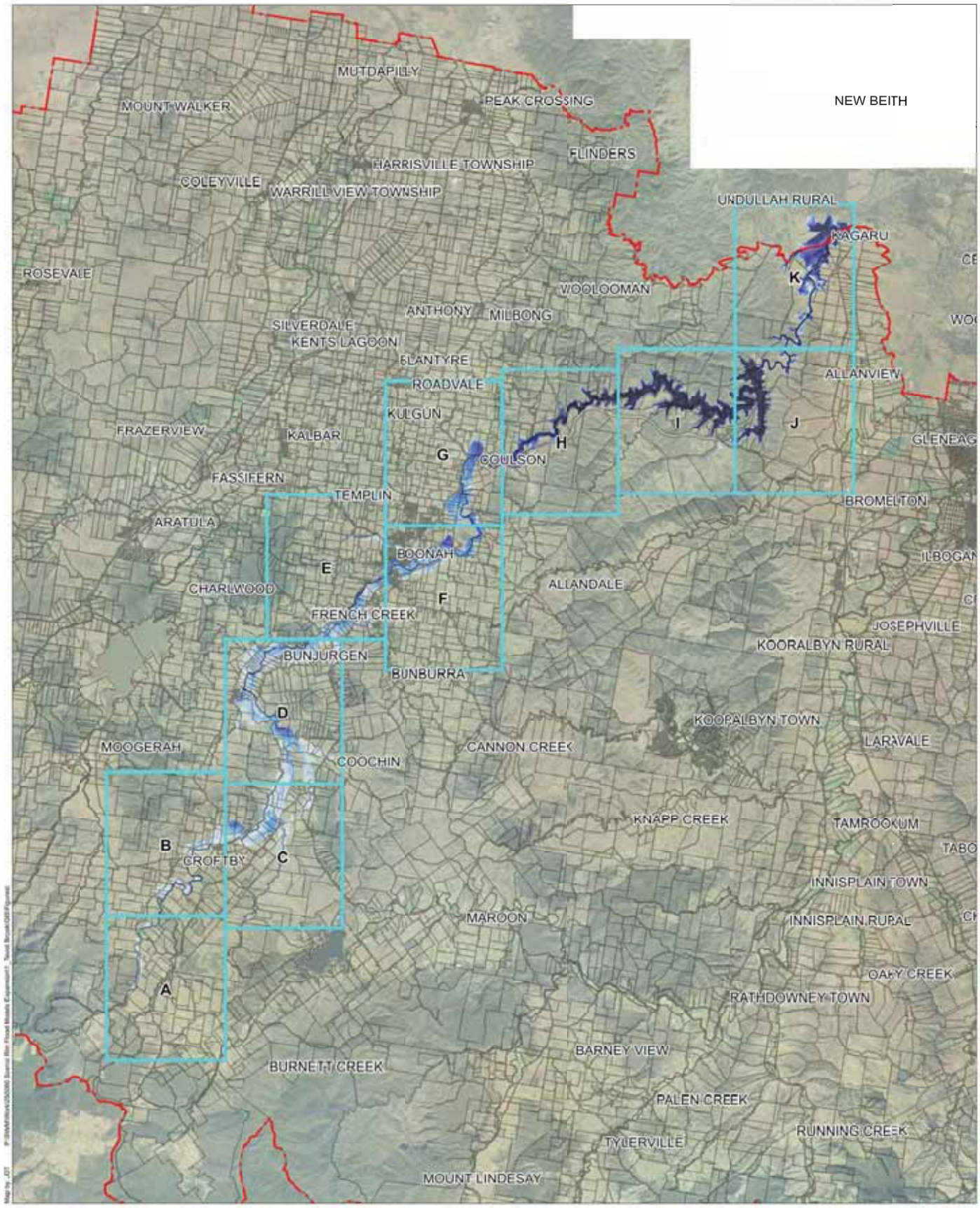
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 55

Teviot Brook Flood Study **Figure B5-k**

1% AEP Event Climate Change Scenario 4.5- Peak Velocities



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:

1:100,000

0 2,500 m 5,000 m

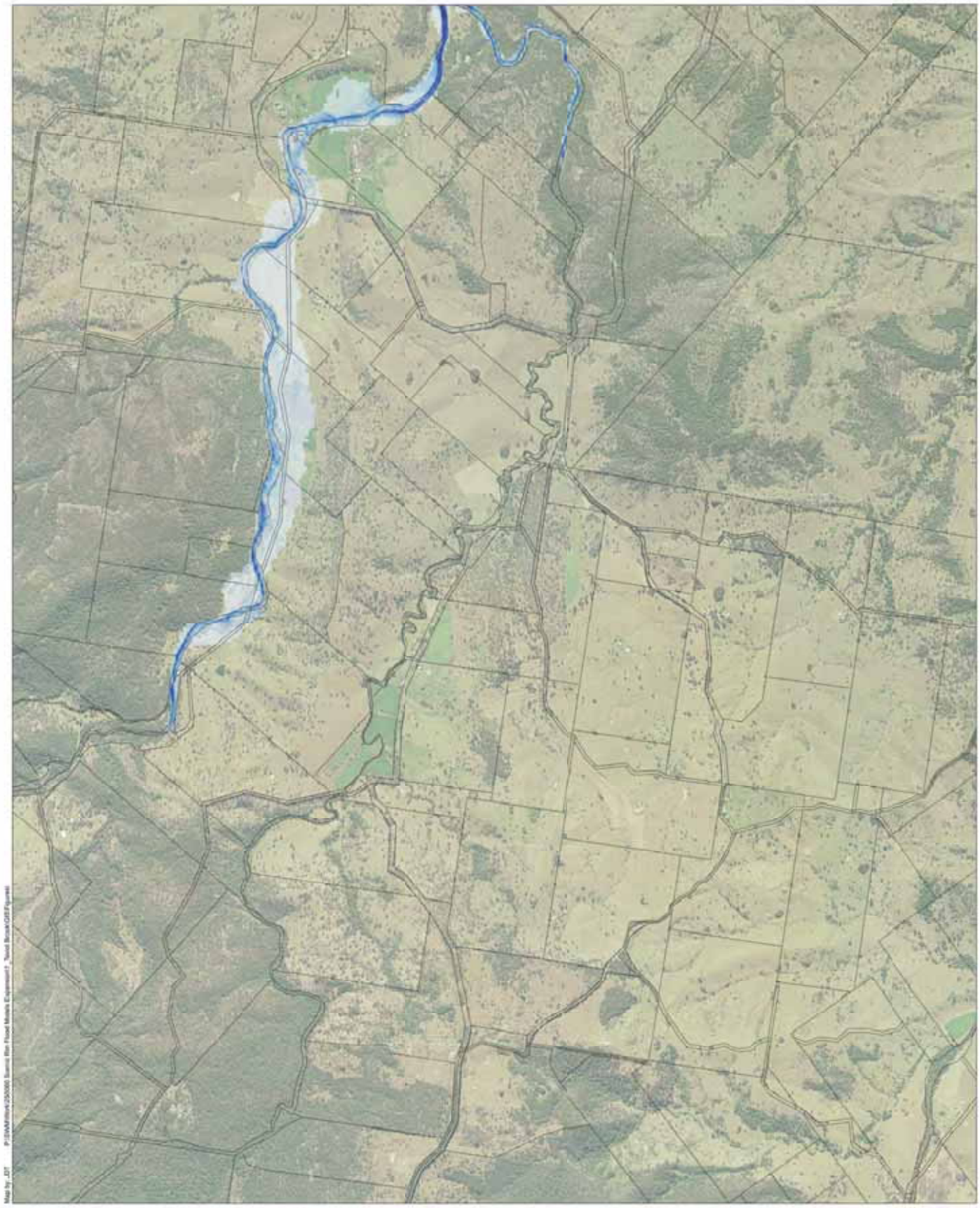
Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Teviot Brook Flood Study **Figure B6**

1% AEP Event Climate Change Scenario 4.5 - 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

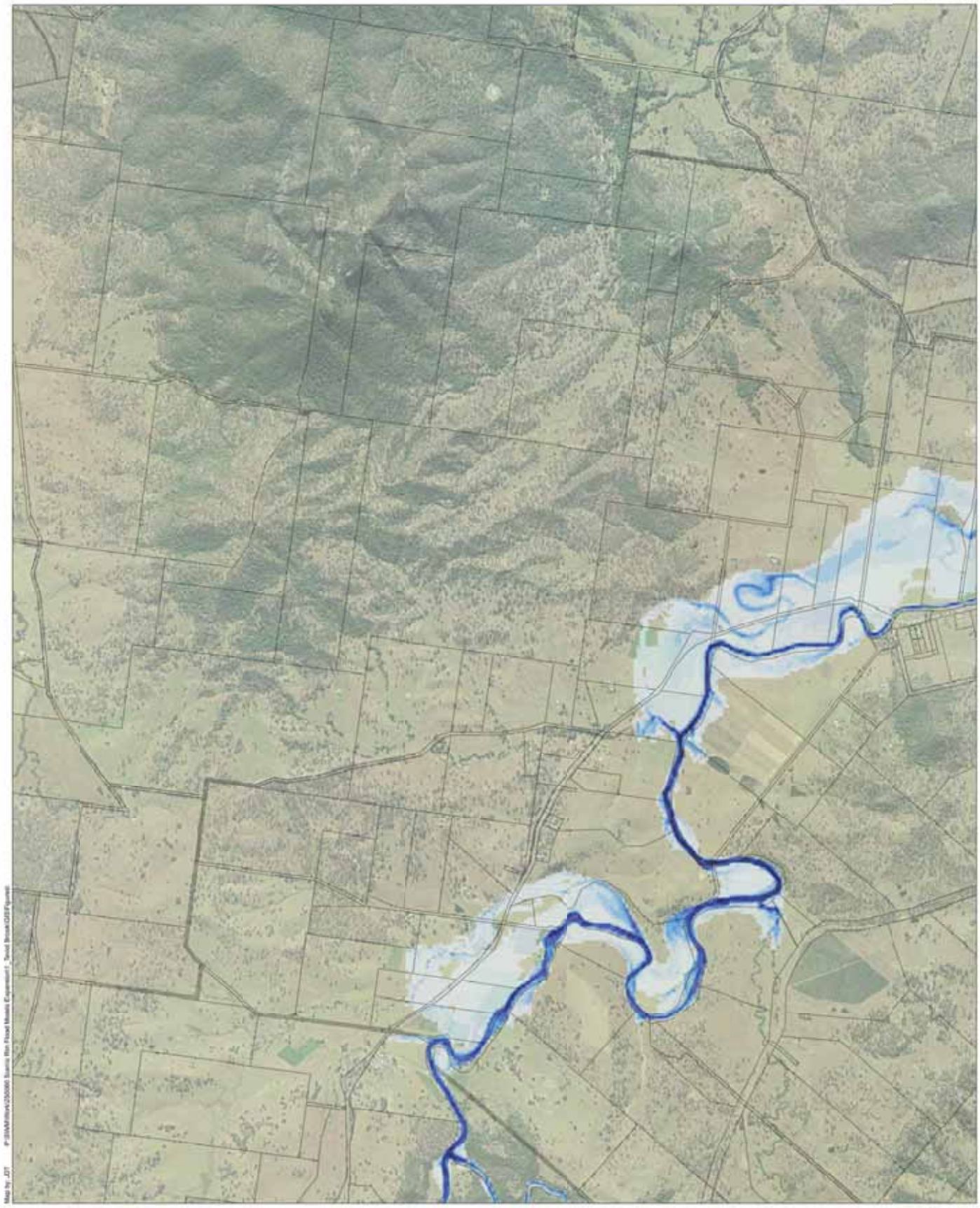
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 55

Teviot Brook Flood Study **Figure B6-a**

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



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

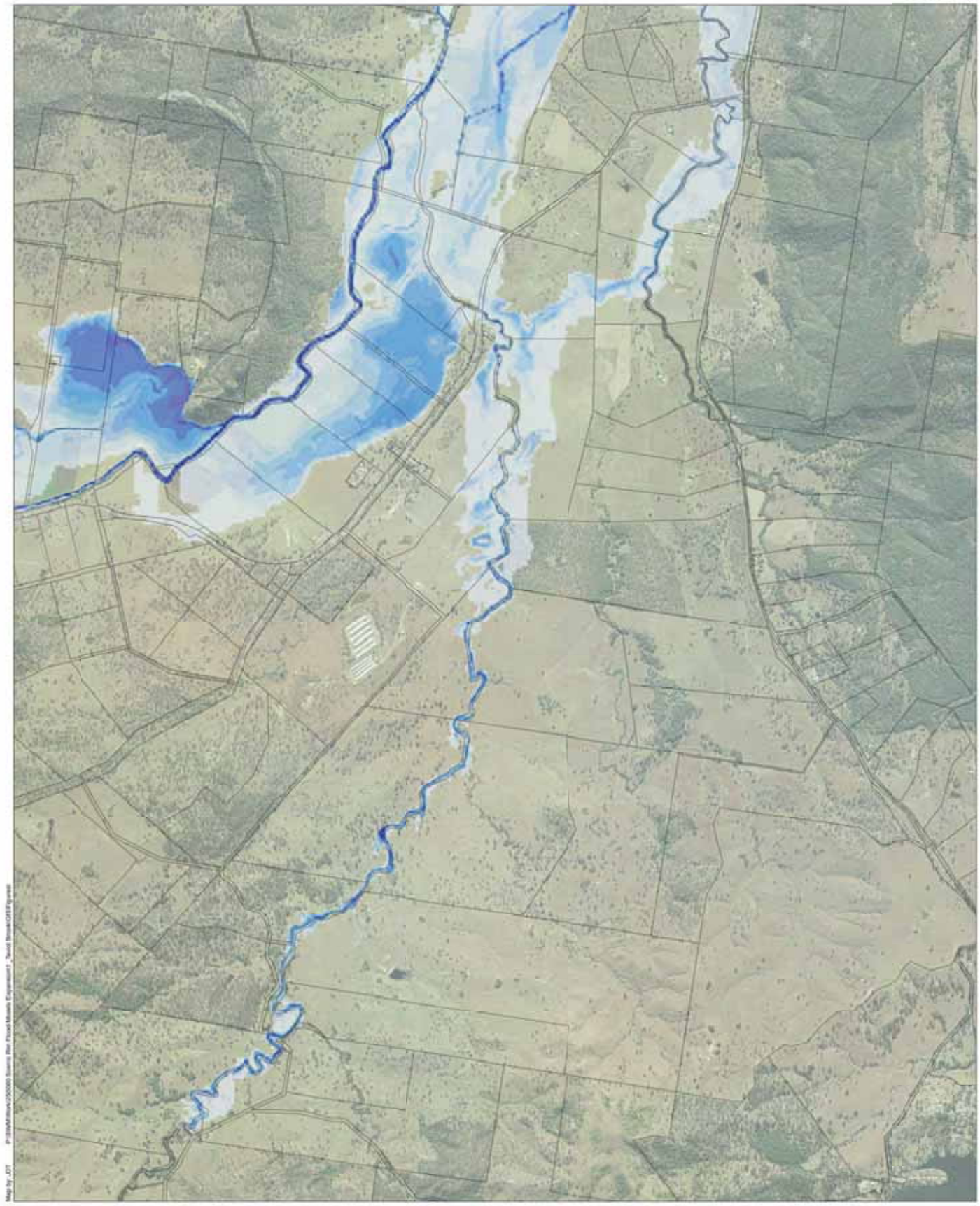
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 55

Teviot Brook Flood Study **Figure B6-b**

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



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

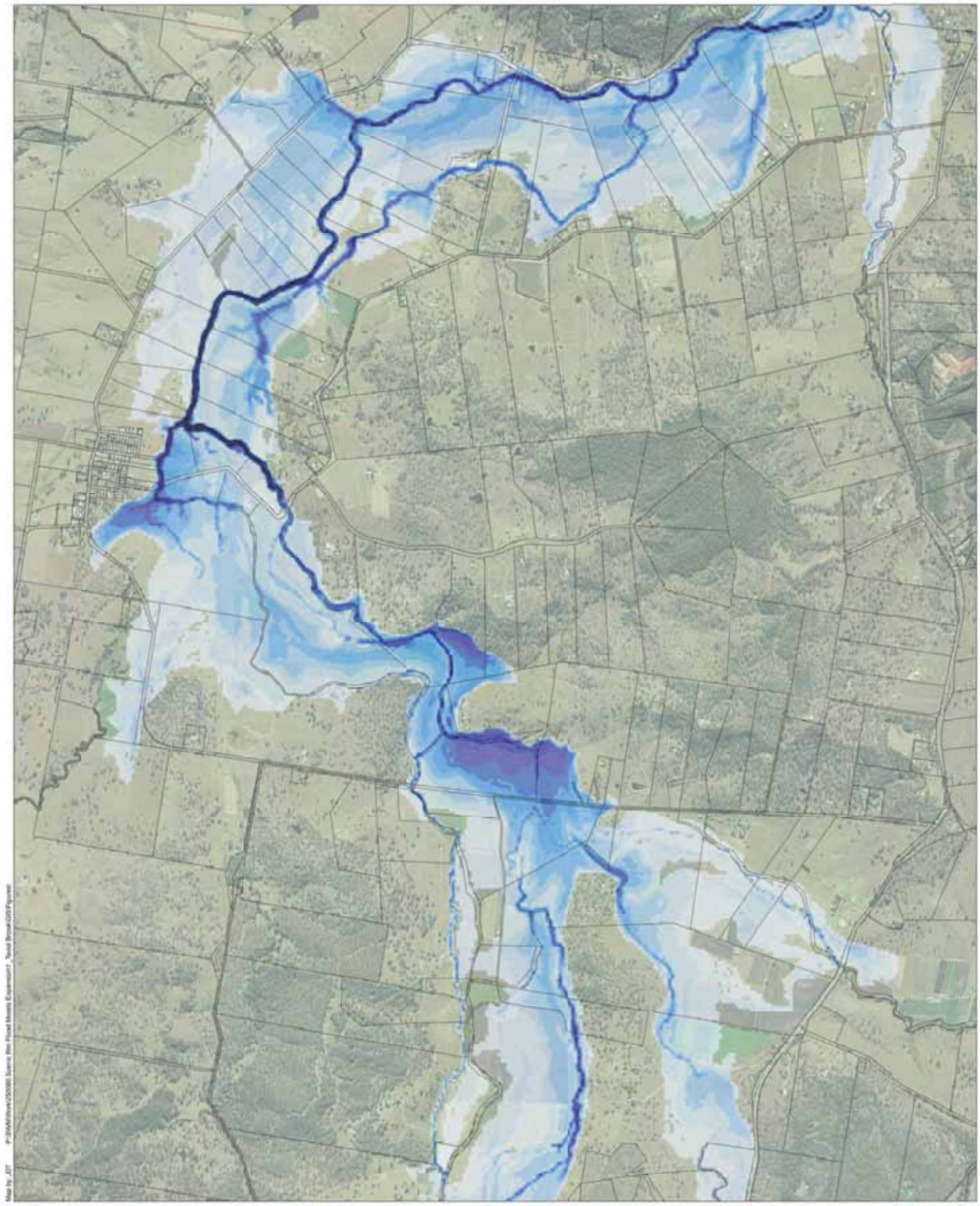
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 55

Teviot Brook Flood Study **Figure B6-c**

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



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

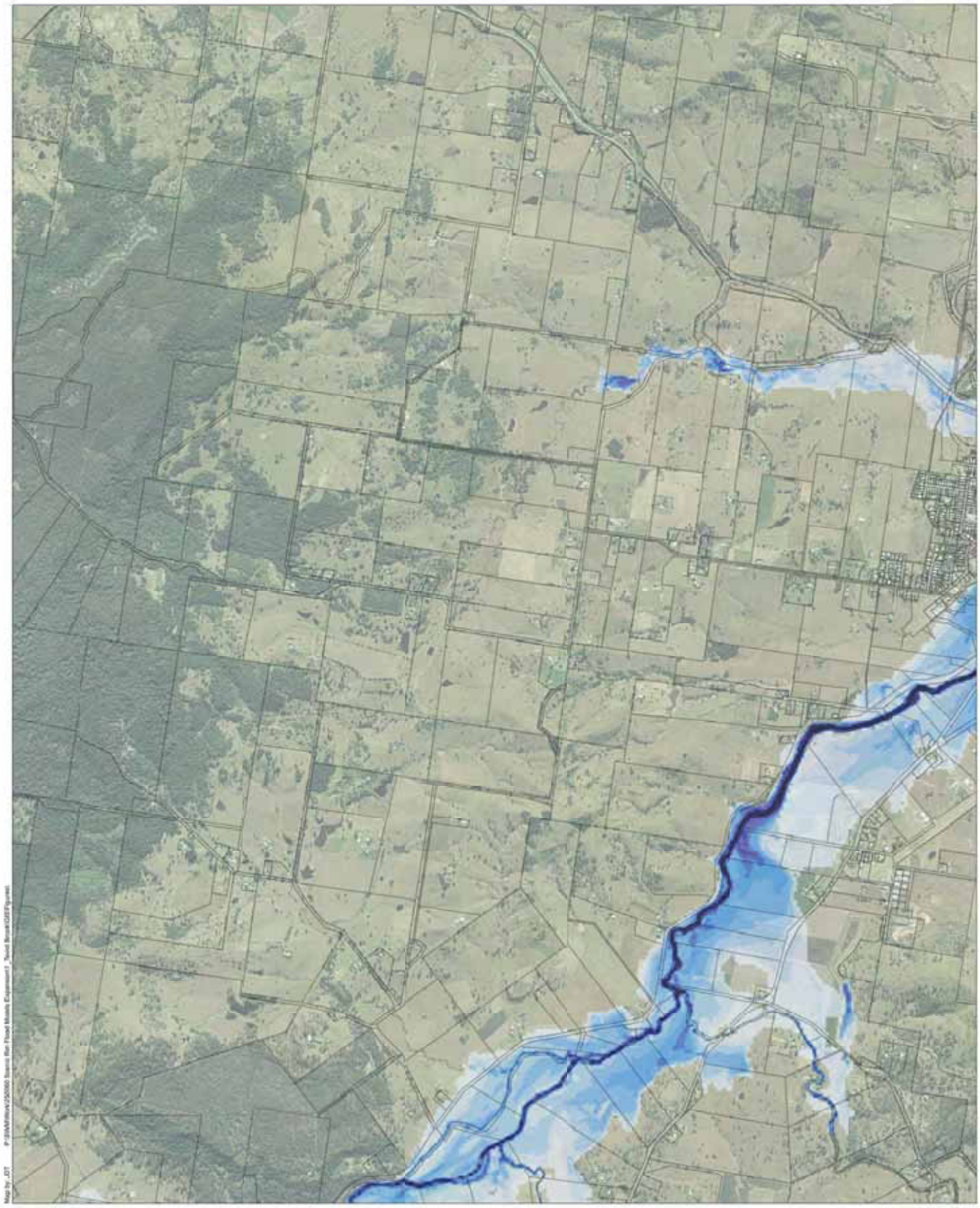
Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 55

Teviot Brook Flood Study **Figure B6-d**

1% AEP Event Climate Change Scenario 4.5 - 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

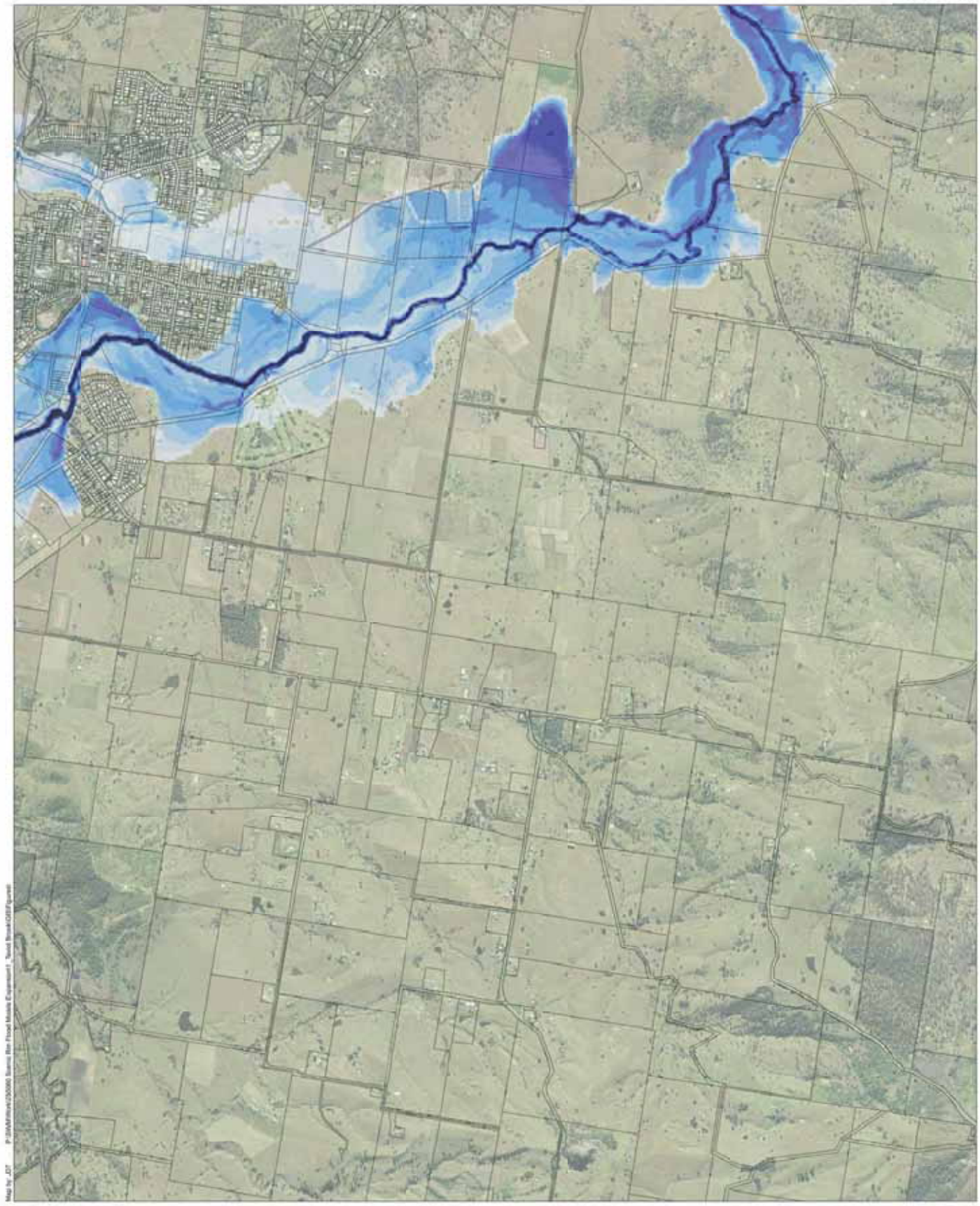
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 55

Teviot Brook Flood Study Figure B6-e

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



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

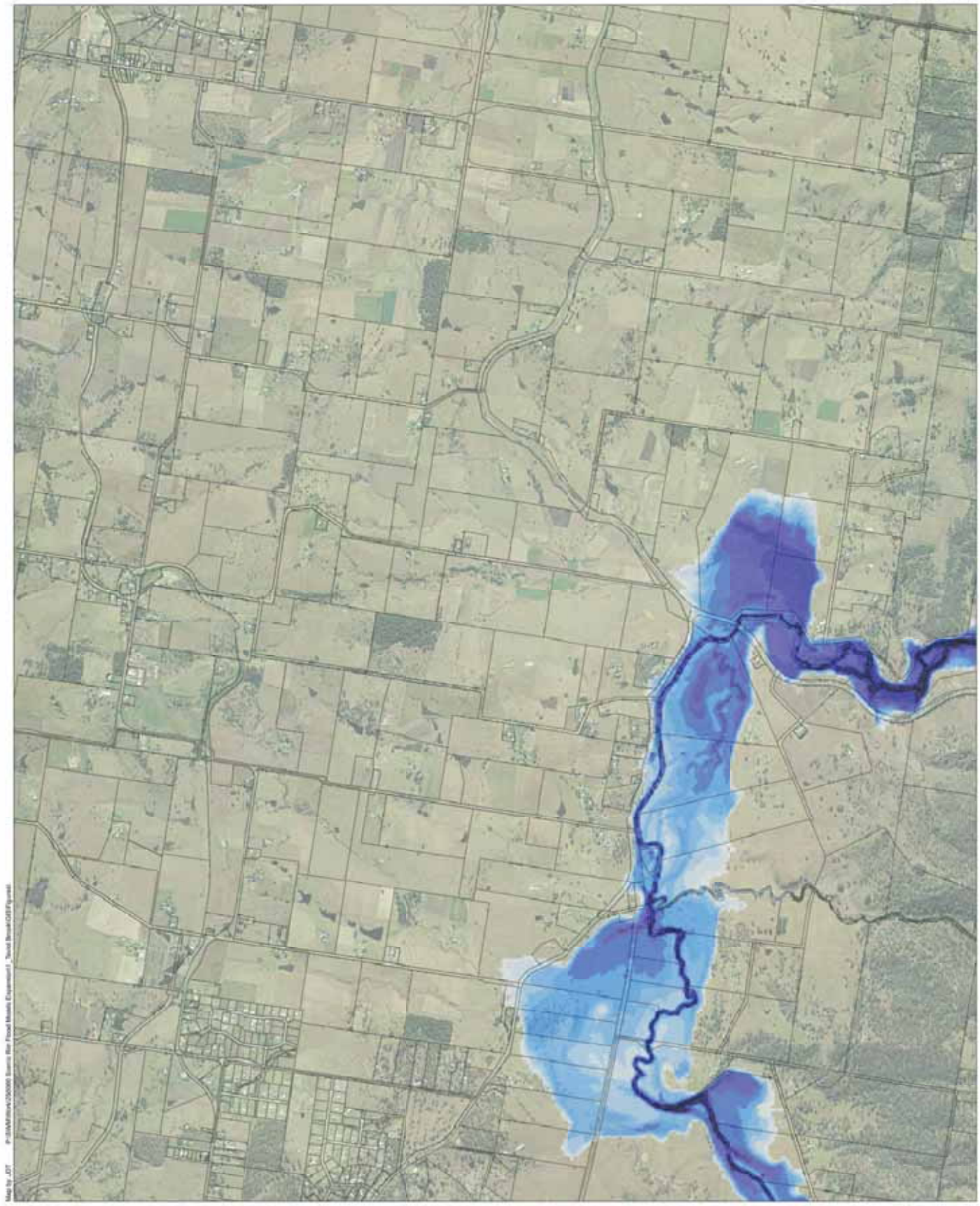
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 55

Teviot Brook Flood Study **Figure B6-f**

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



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

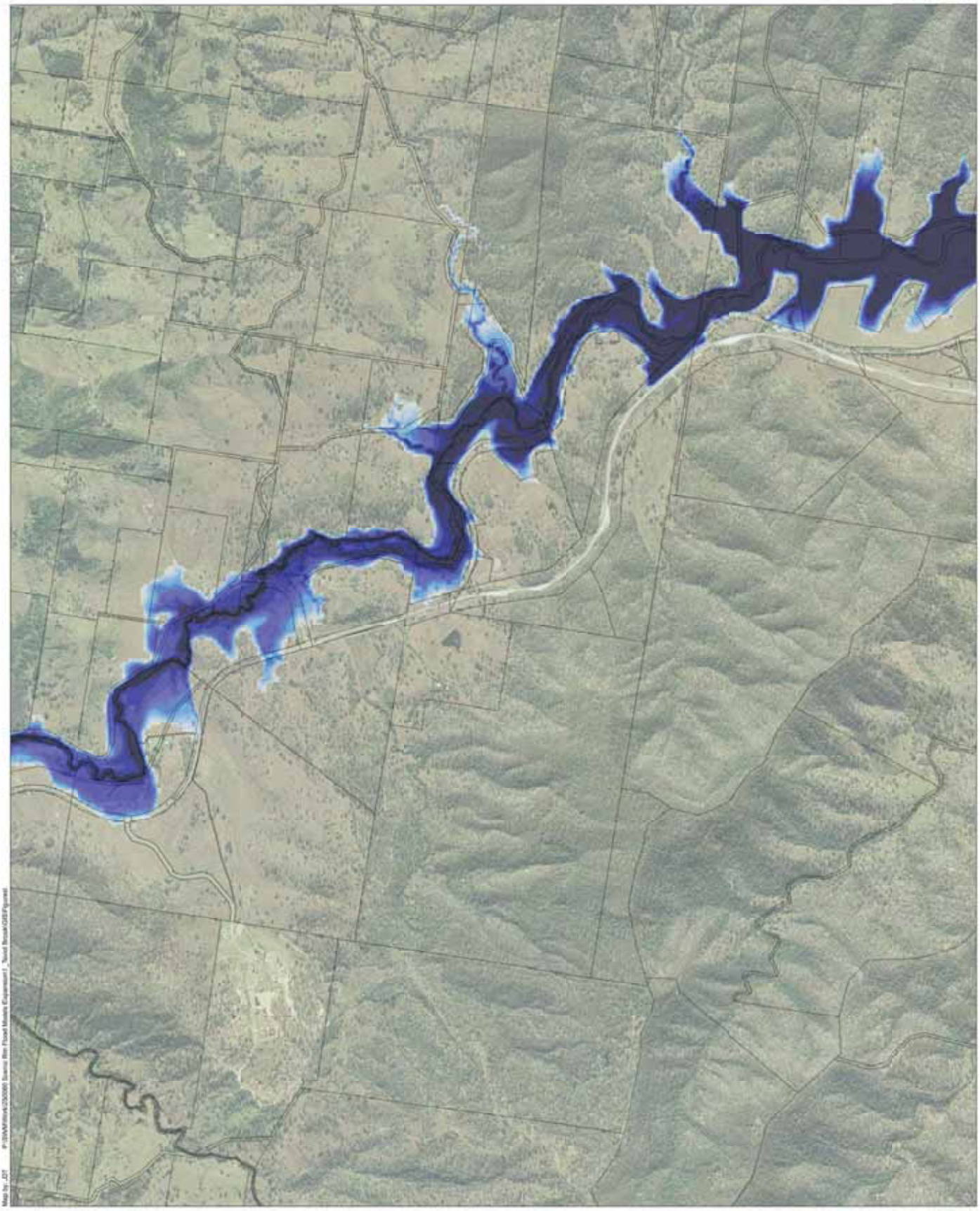
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 55

Teviot Brook Flood Study **Figure B6-g**

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



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

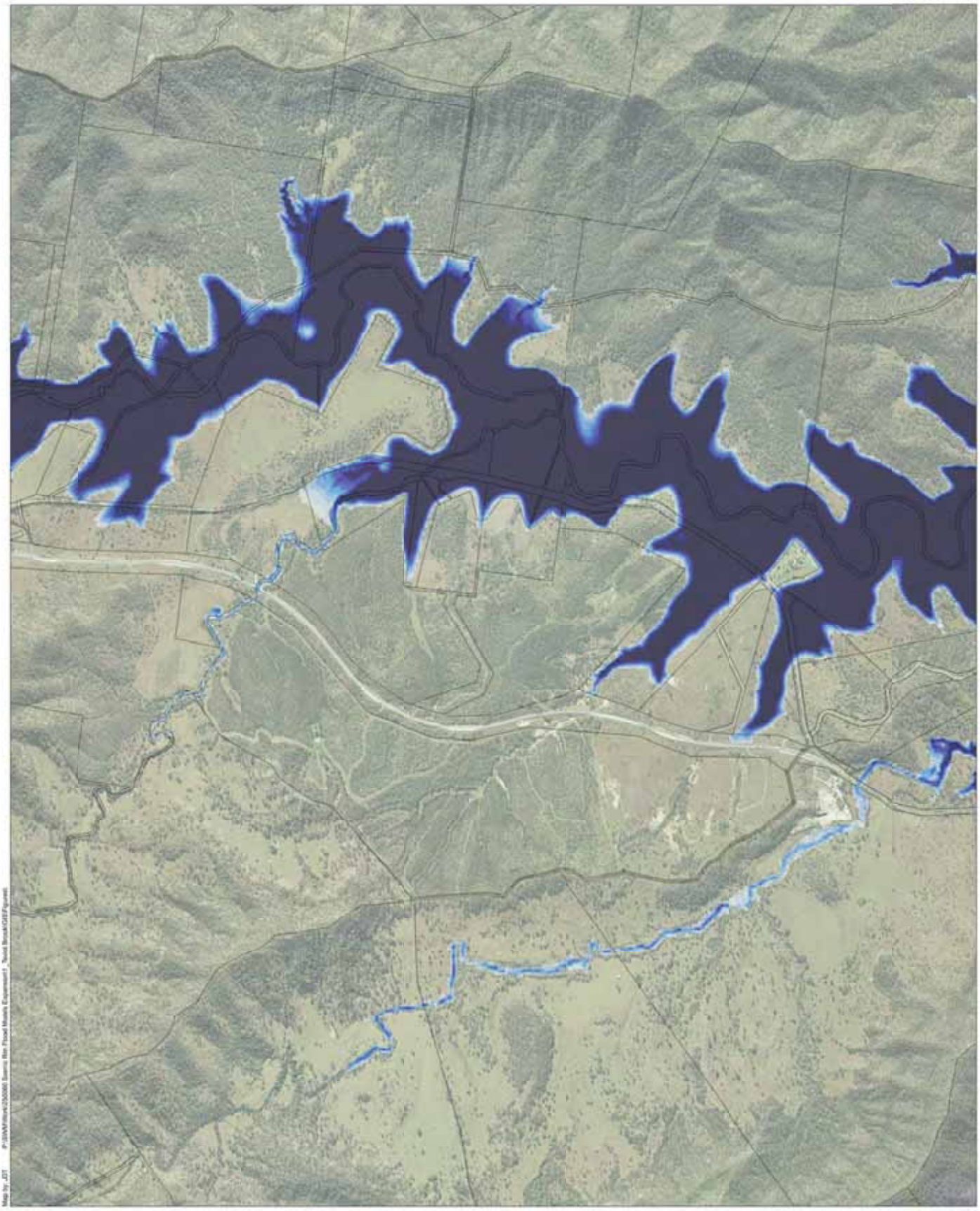
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 55

Teviot Brook Flood Study **Figure B6-h**

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



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

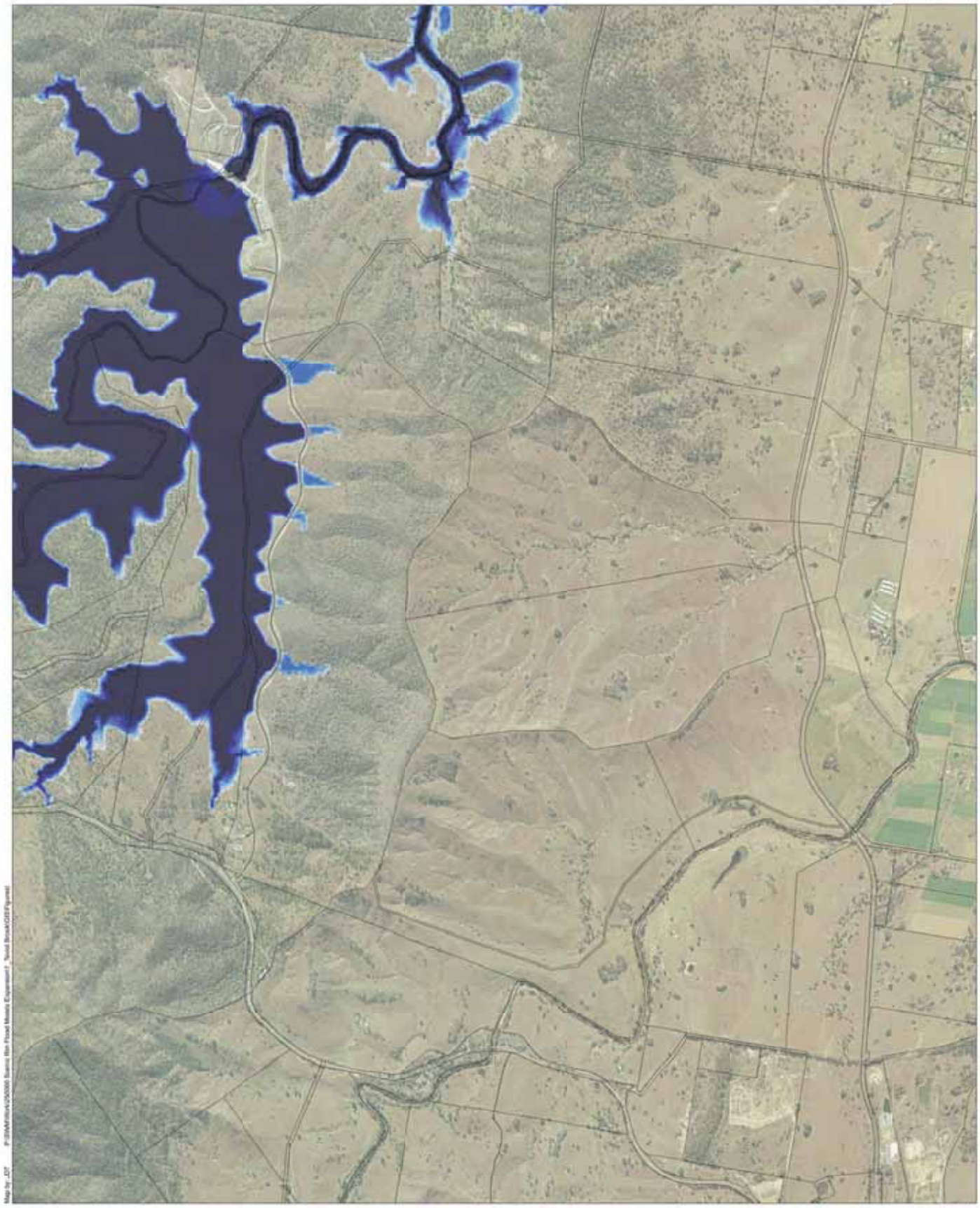
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 55

Teviot Brook Flood Study **Figure B6-i**

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



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

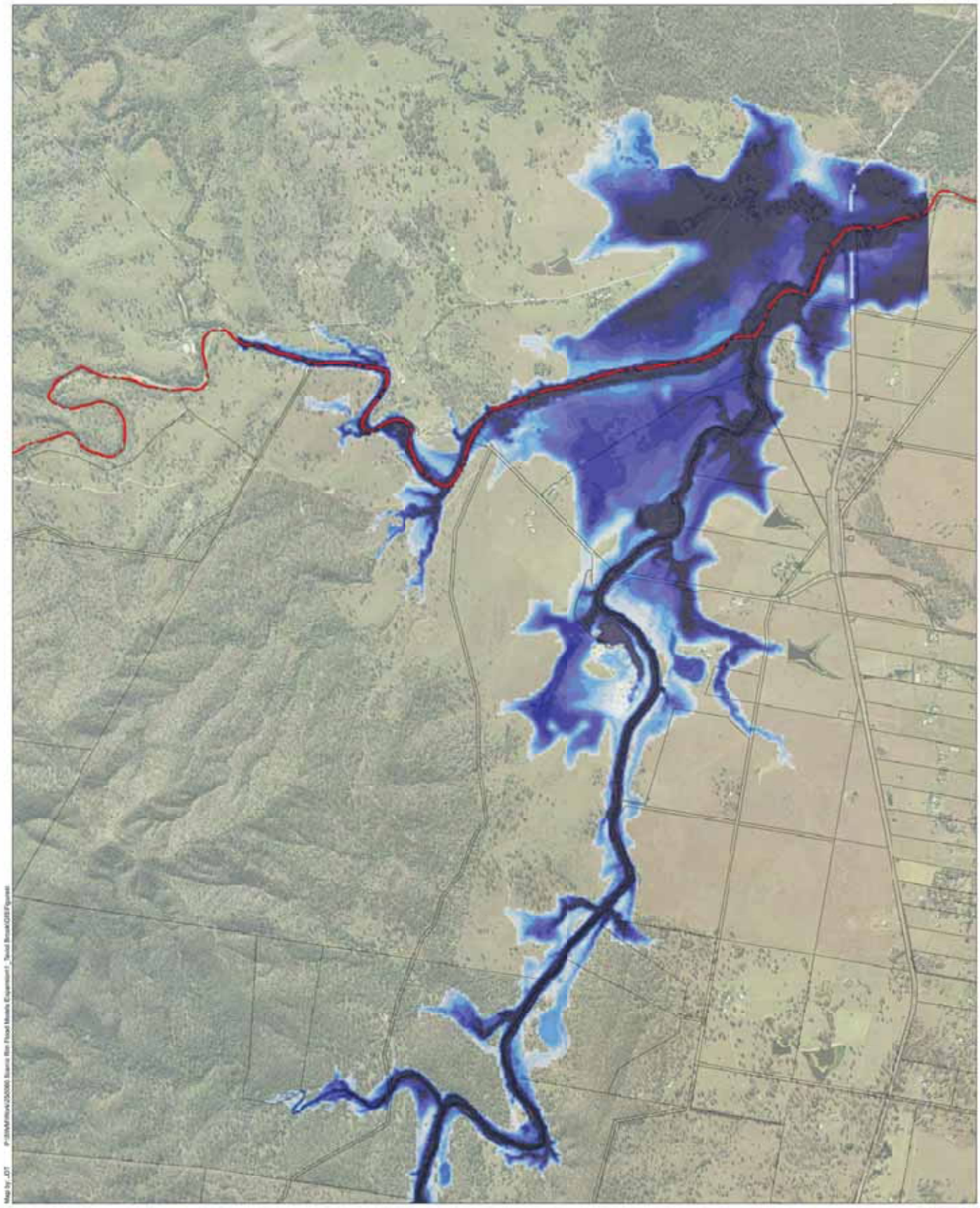
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 55

Teviot Brook Flood Study **Figure B6-j**

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



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

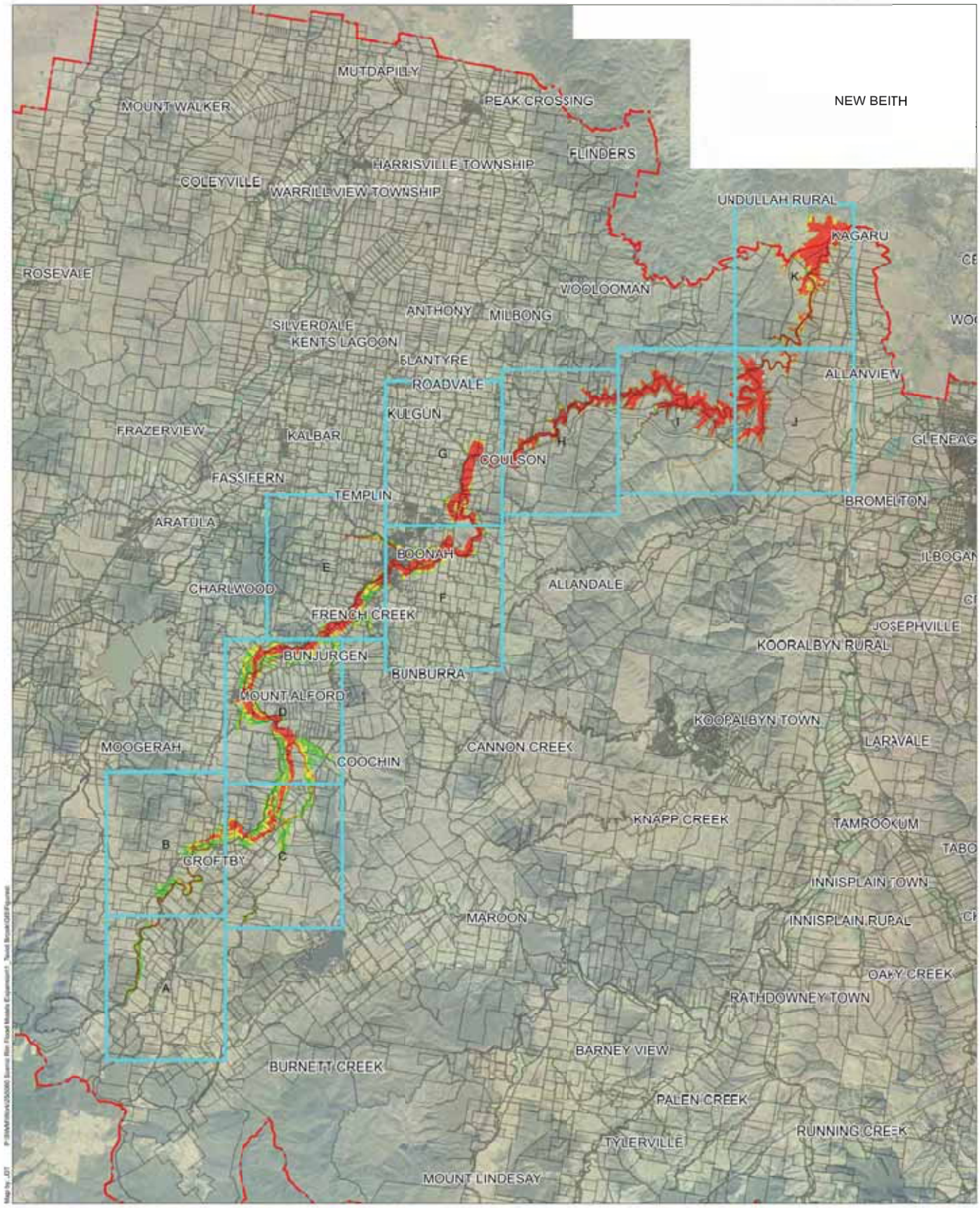
Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 55

Teviot Brook Flood Study **Figure B6-k**

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

aurecon



Legend

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

Notes:

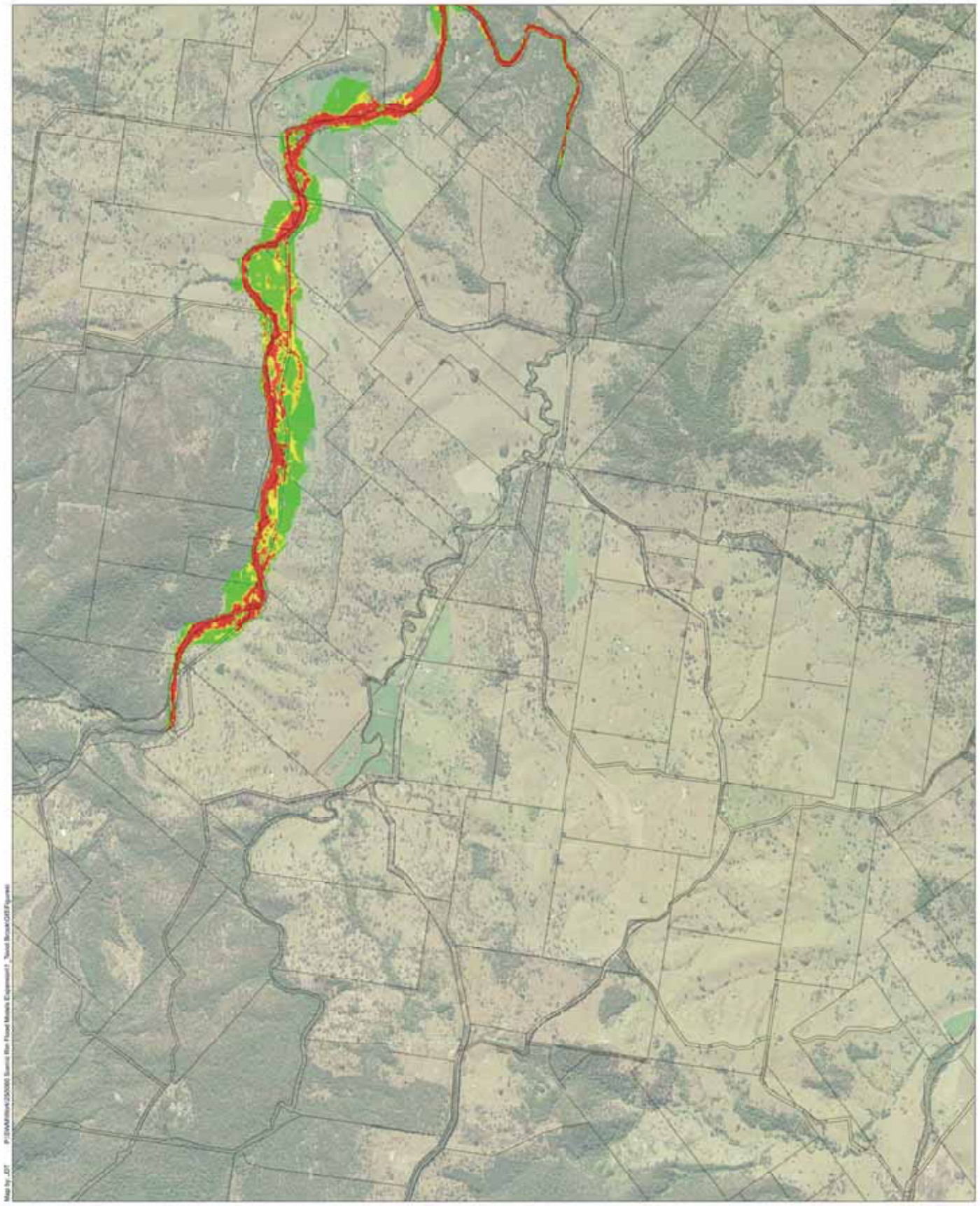
1:100,000
0 2,500 m 5,000 m

Date: 24/10/2017 Version: 0 Job No: 255060

Teviot Brook Flood Study Figure B7

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

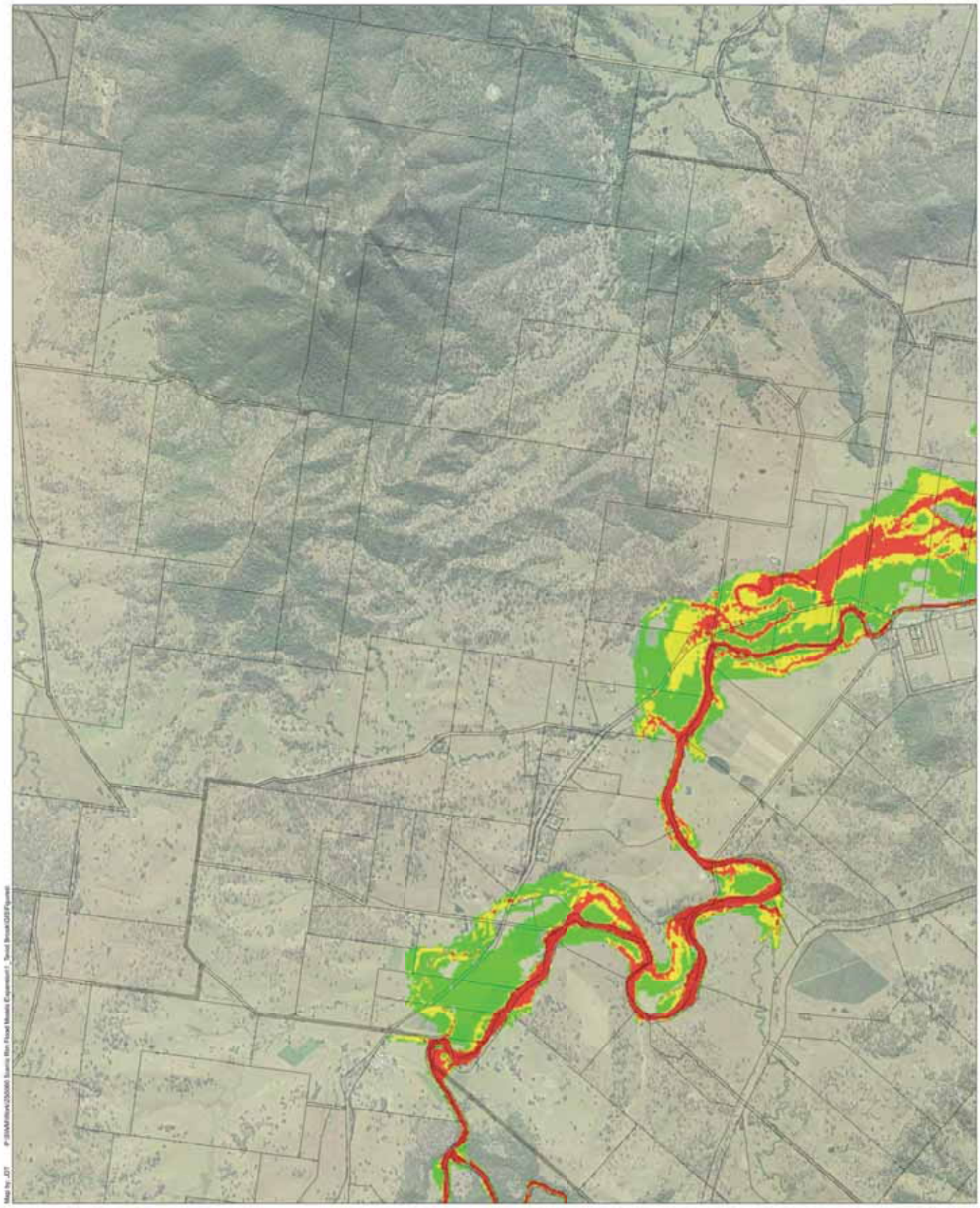
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 55

Teviot Brook Flood Study Figure B7-a

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

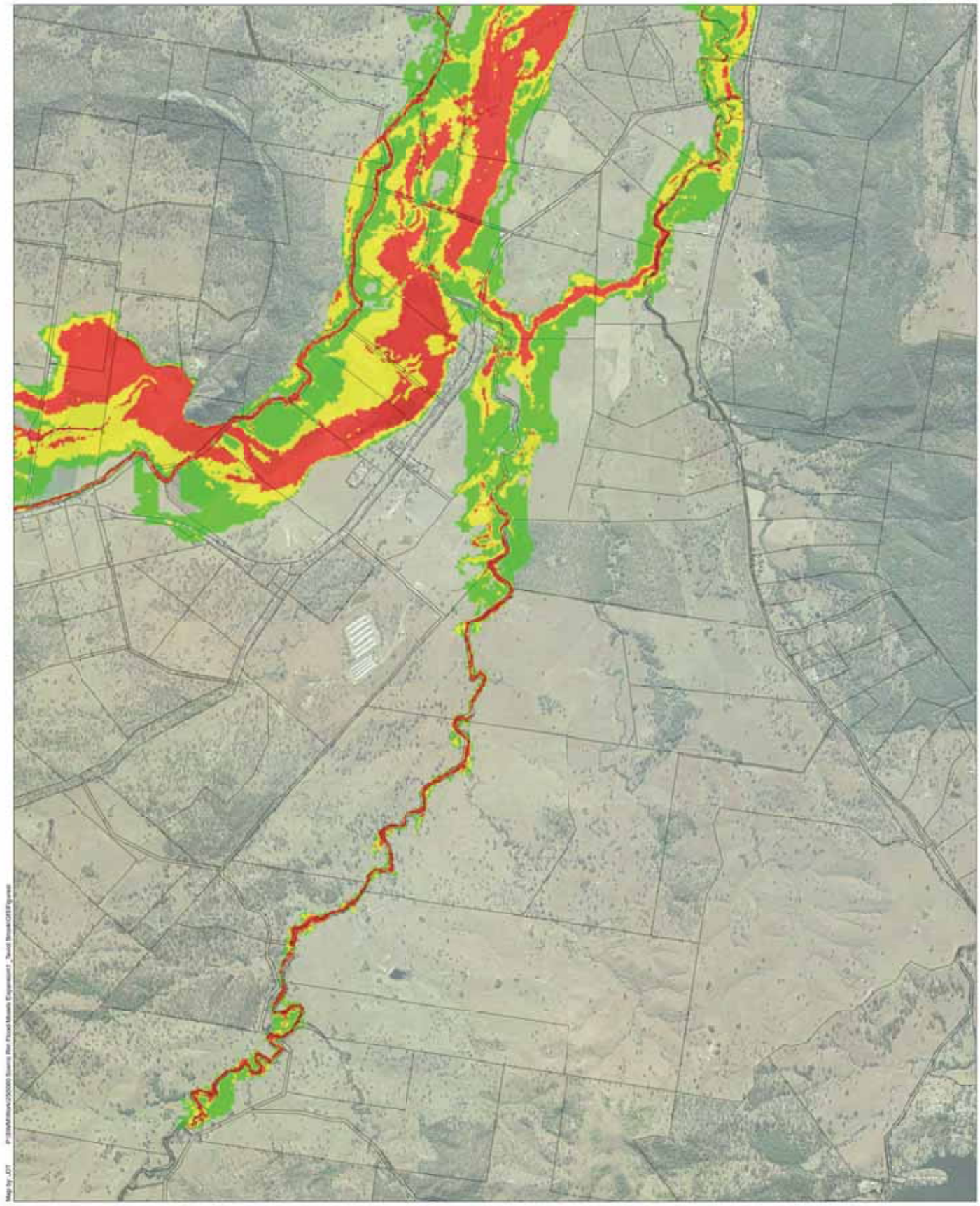
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Teviot Brook 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

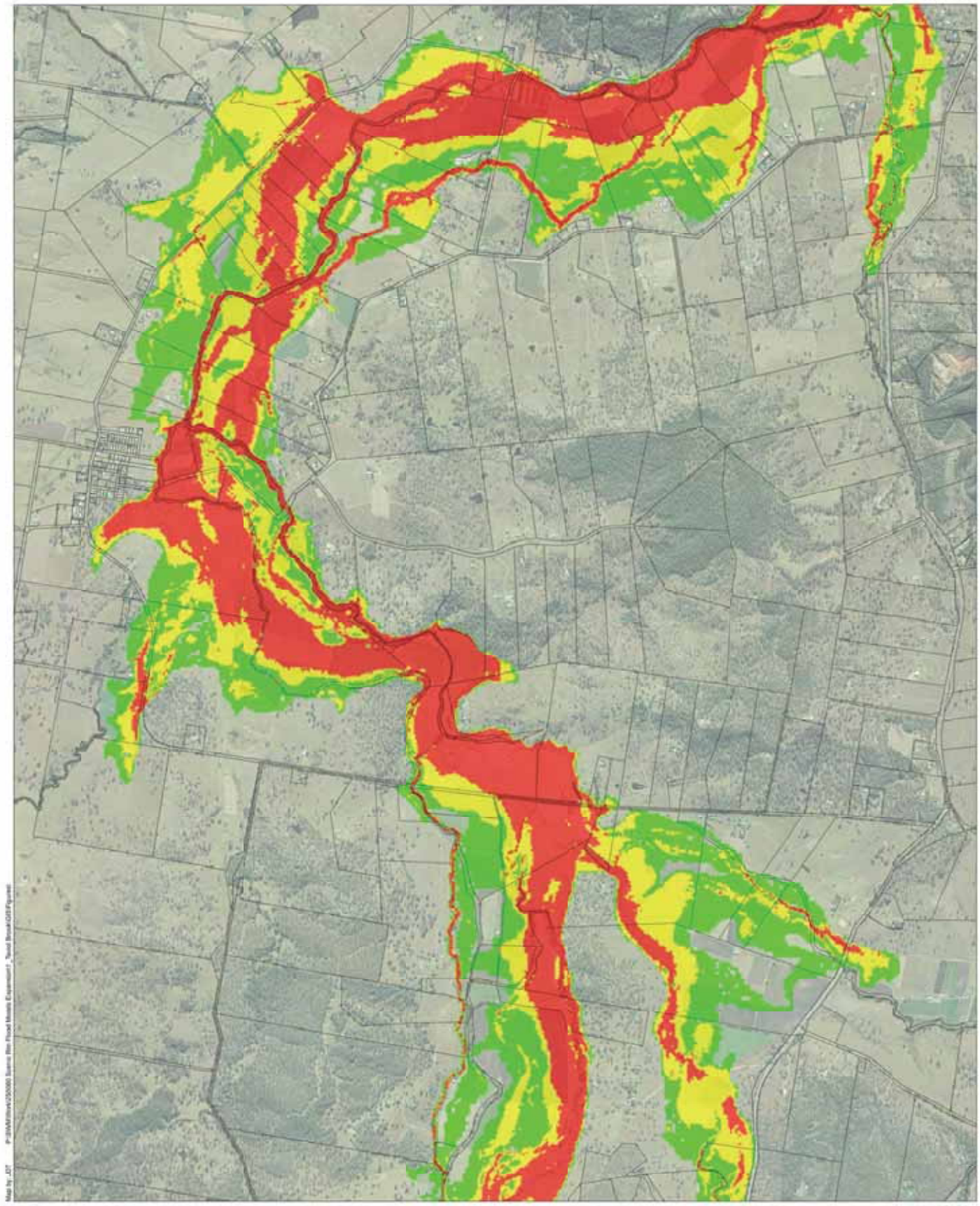
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 55

Teviot Brook Flood Study Figure B7-c

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

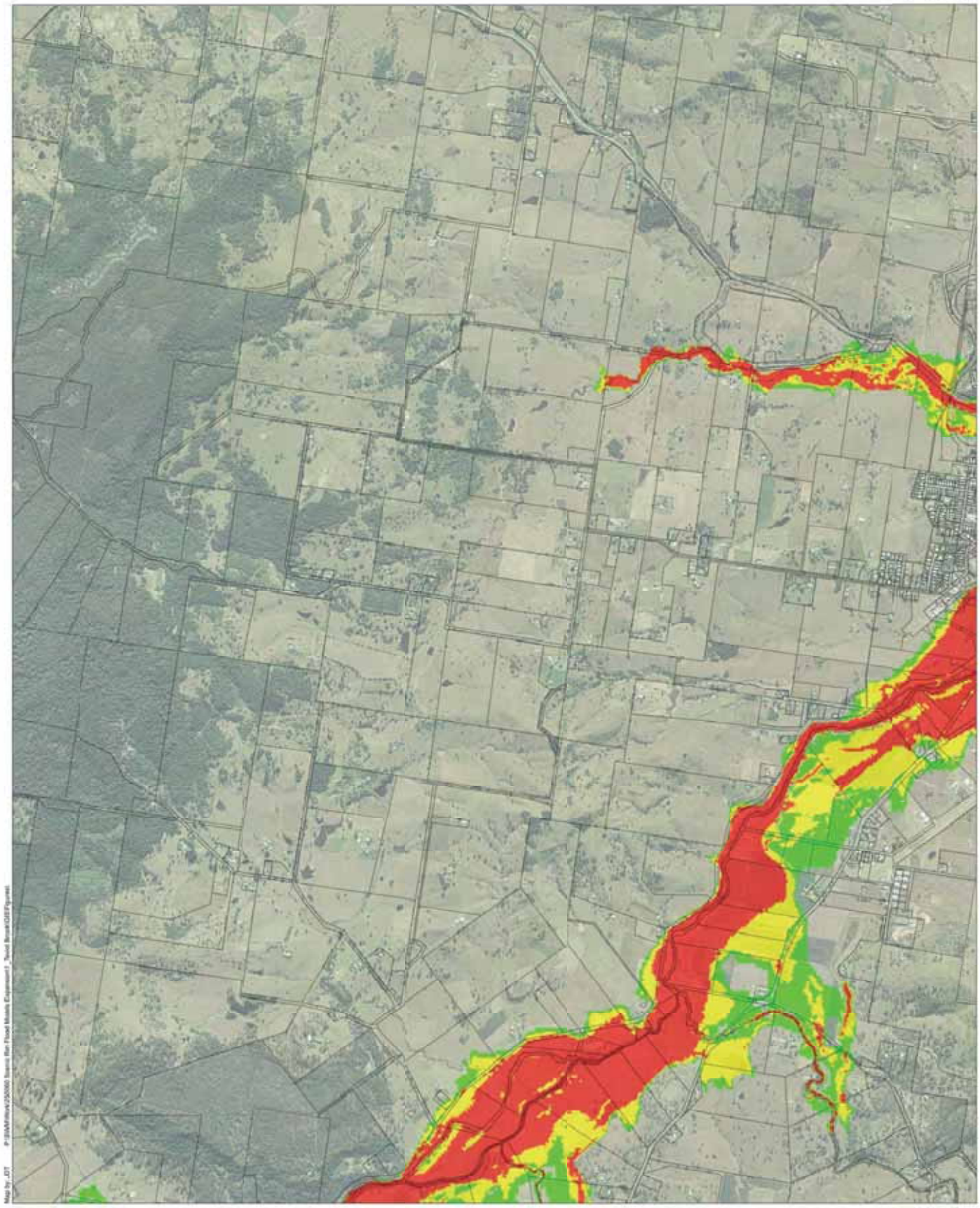
Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 55

Teviot Brook Flood Study **Figure B7-d**

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

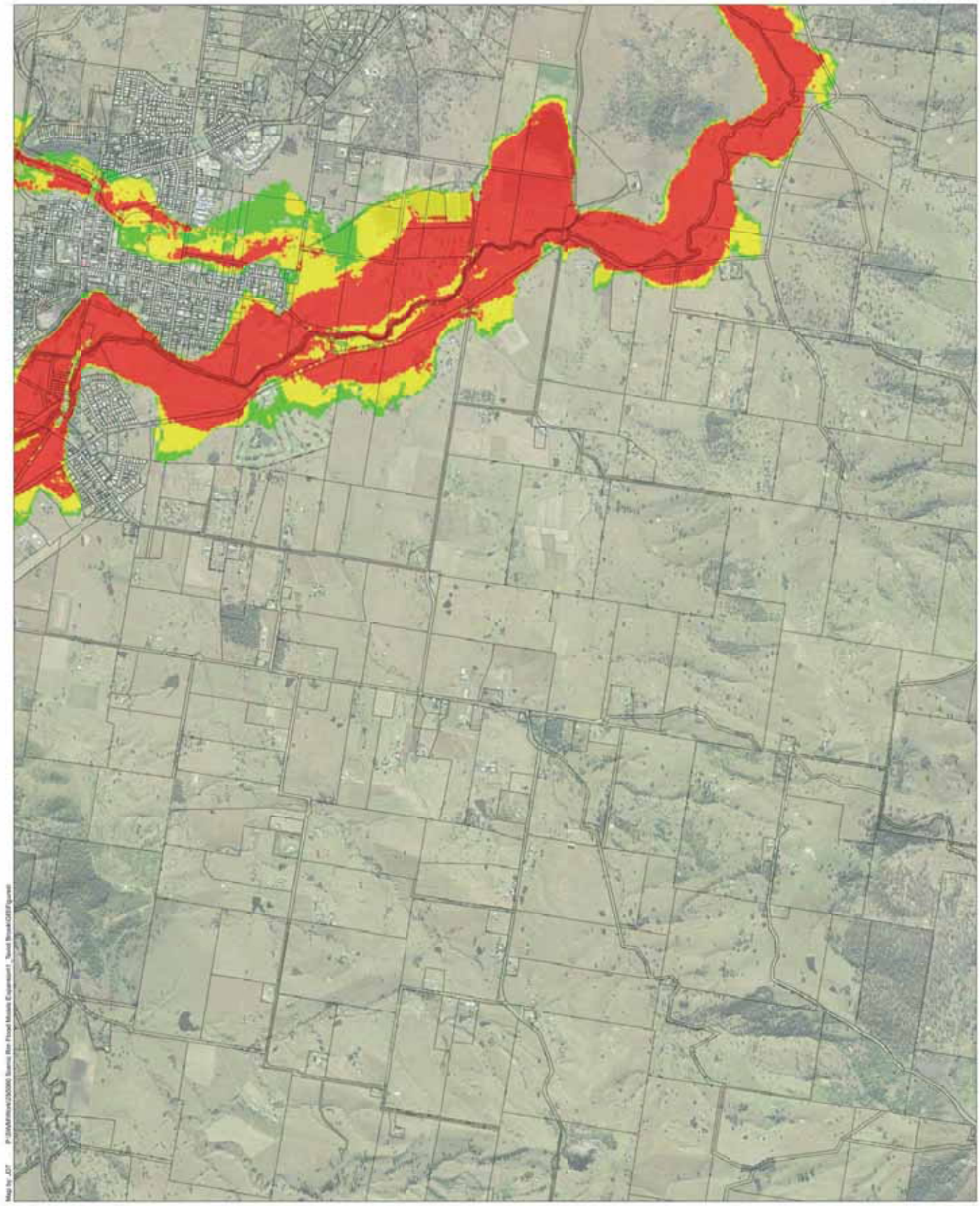
Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 55

Teviot Brook Flood Study Figure B7-e

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

aurecon



Legend

SRRC Boundary

Cadastral Boundary

Low Hazard

Medium Hazard

High Hazard

Notes:

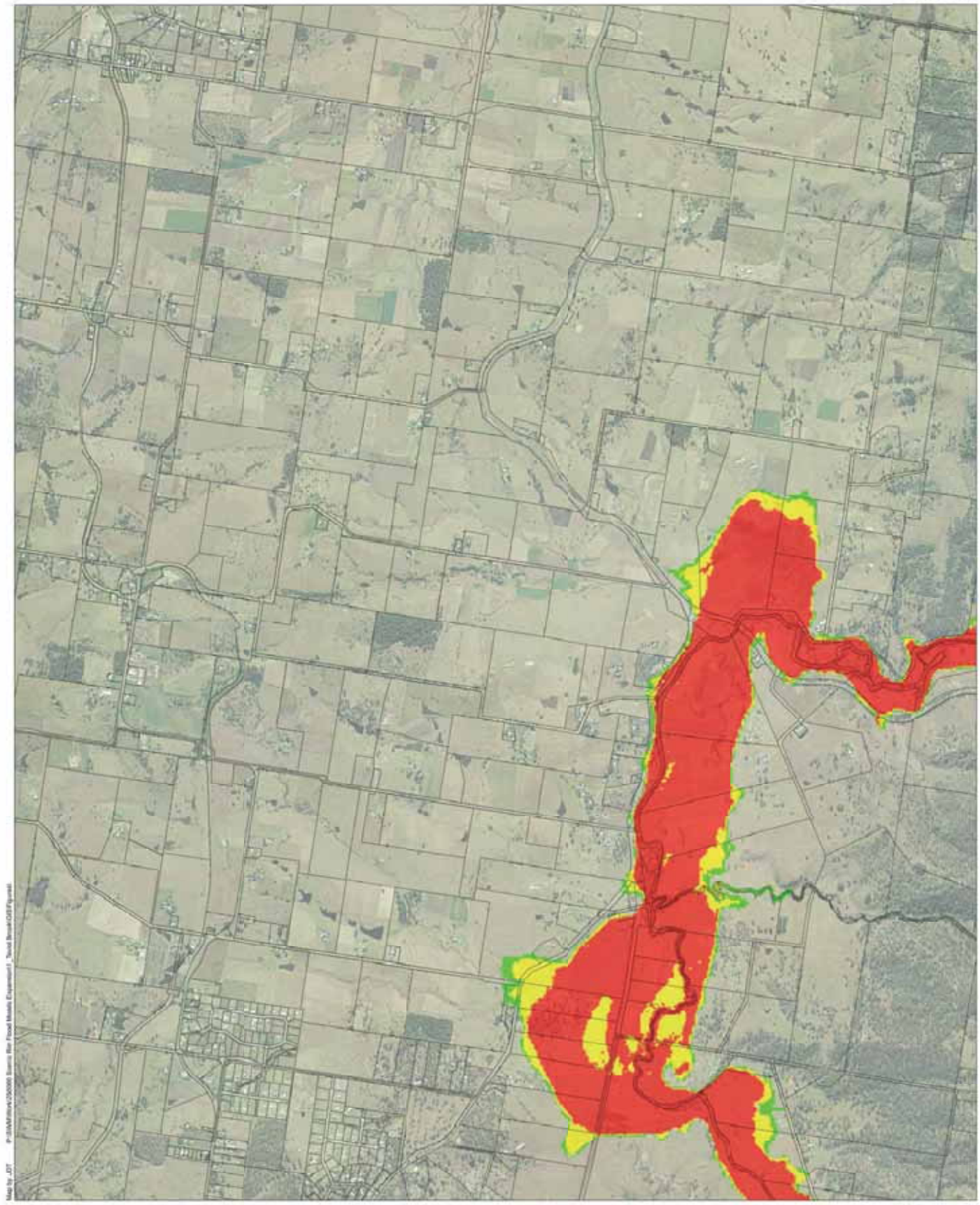
1:25,000

0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Teviot Brook Flood Study Figure B7-f

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

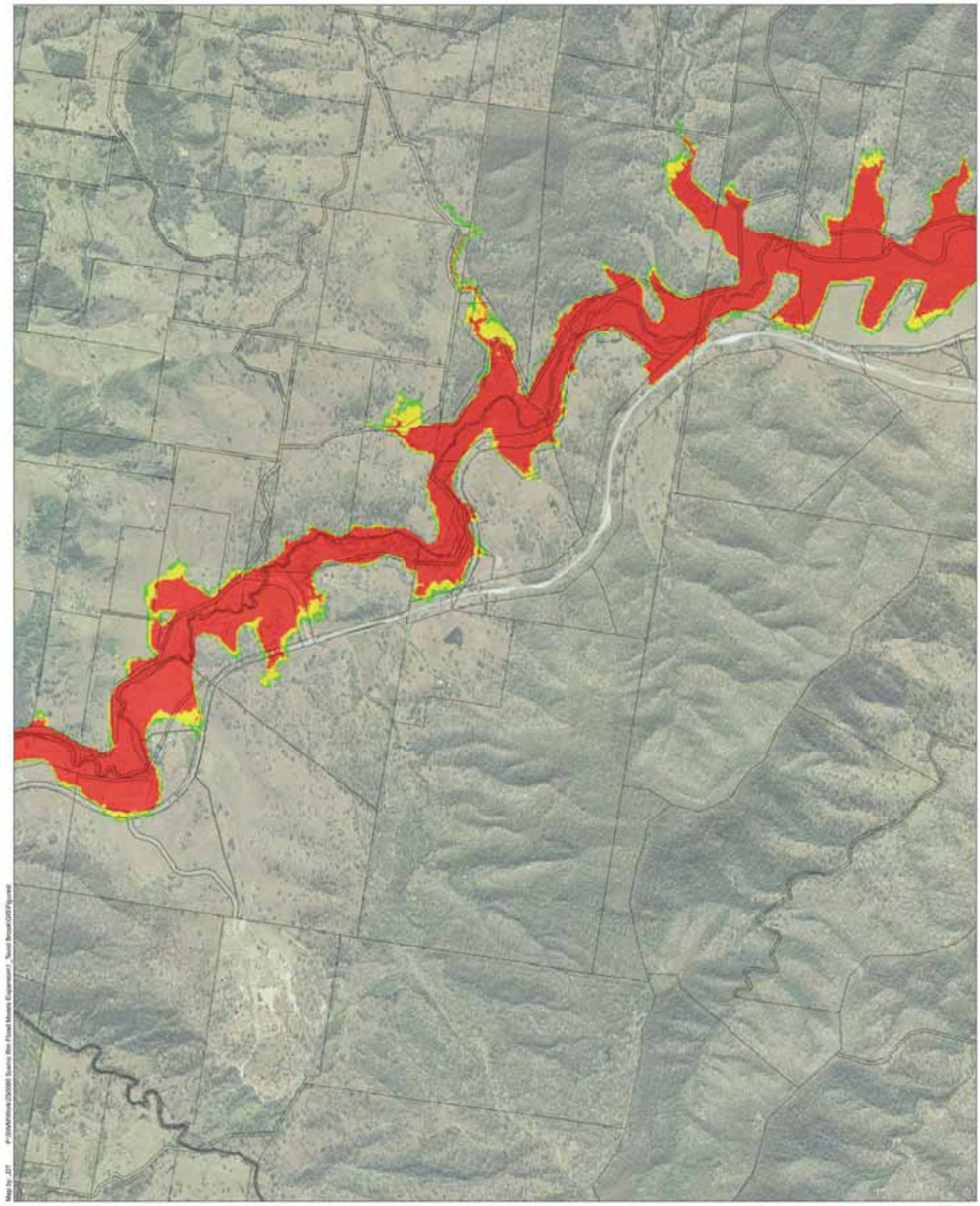
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 55

Teviot Brook Flood Study **Figure B7-g**

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

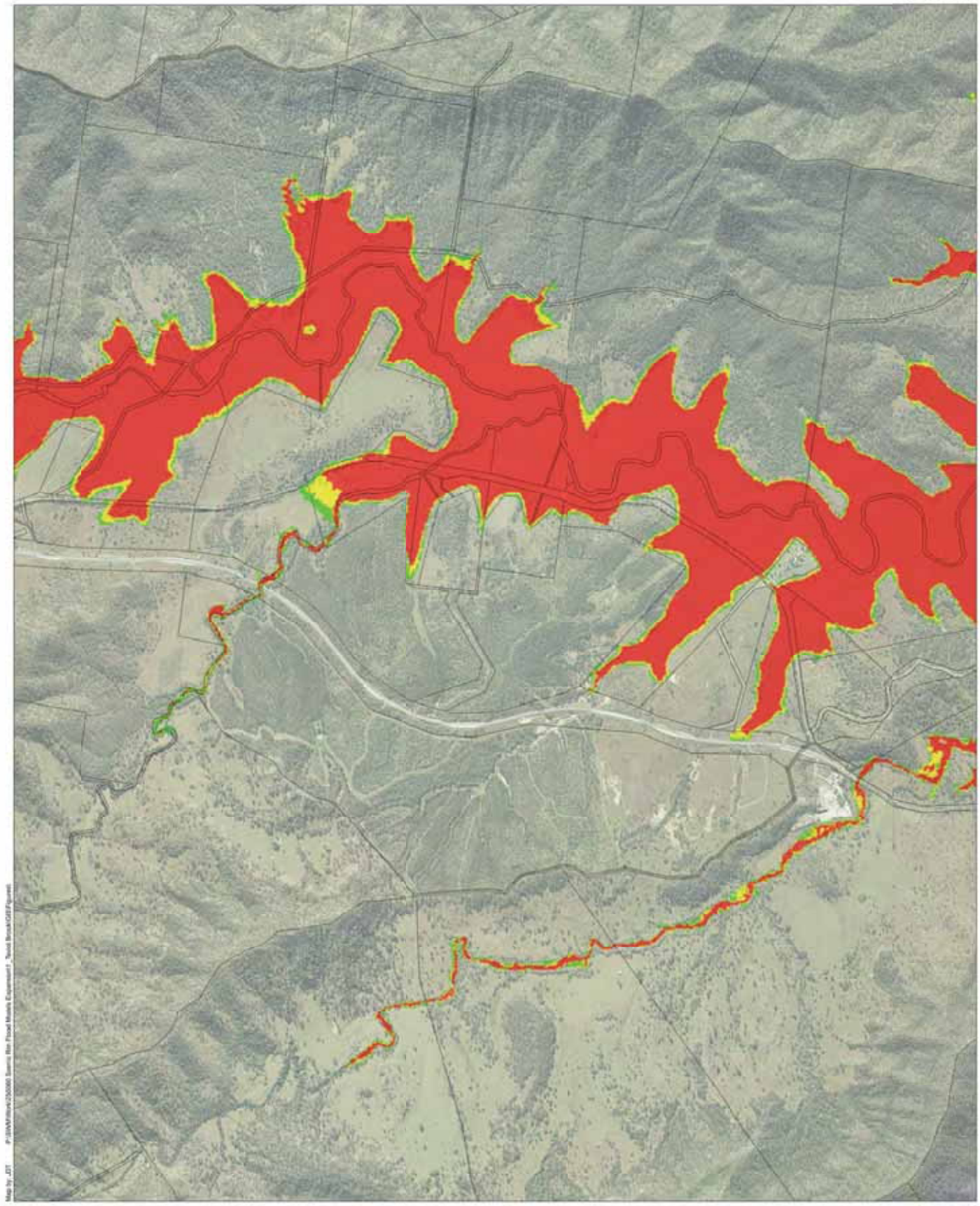
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 55

Teviot Brook Flood Study **Figure B7-h**

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

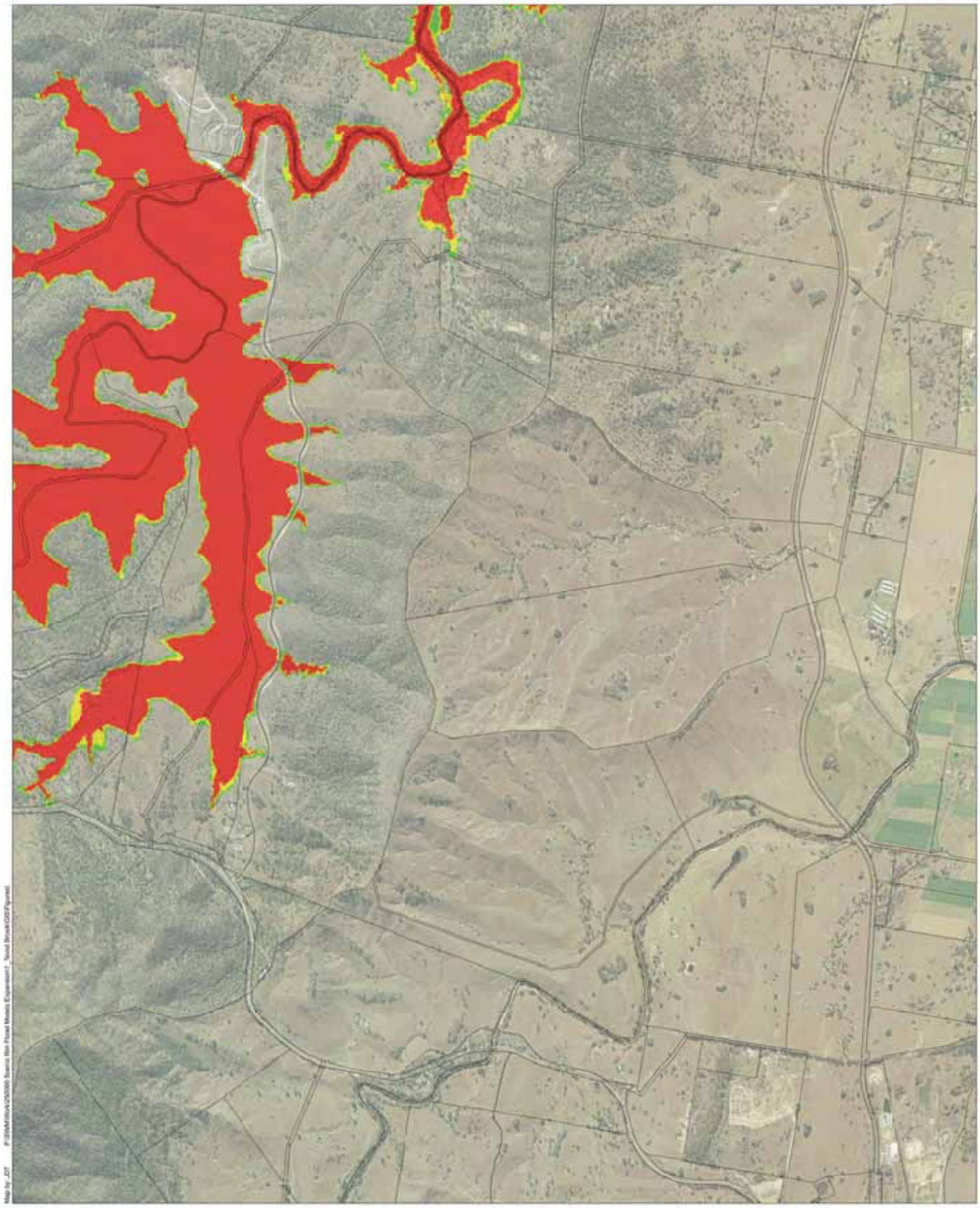
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 55

Teviot Brook Flood Study Figure B7-i

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



Legend

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

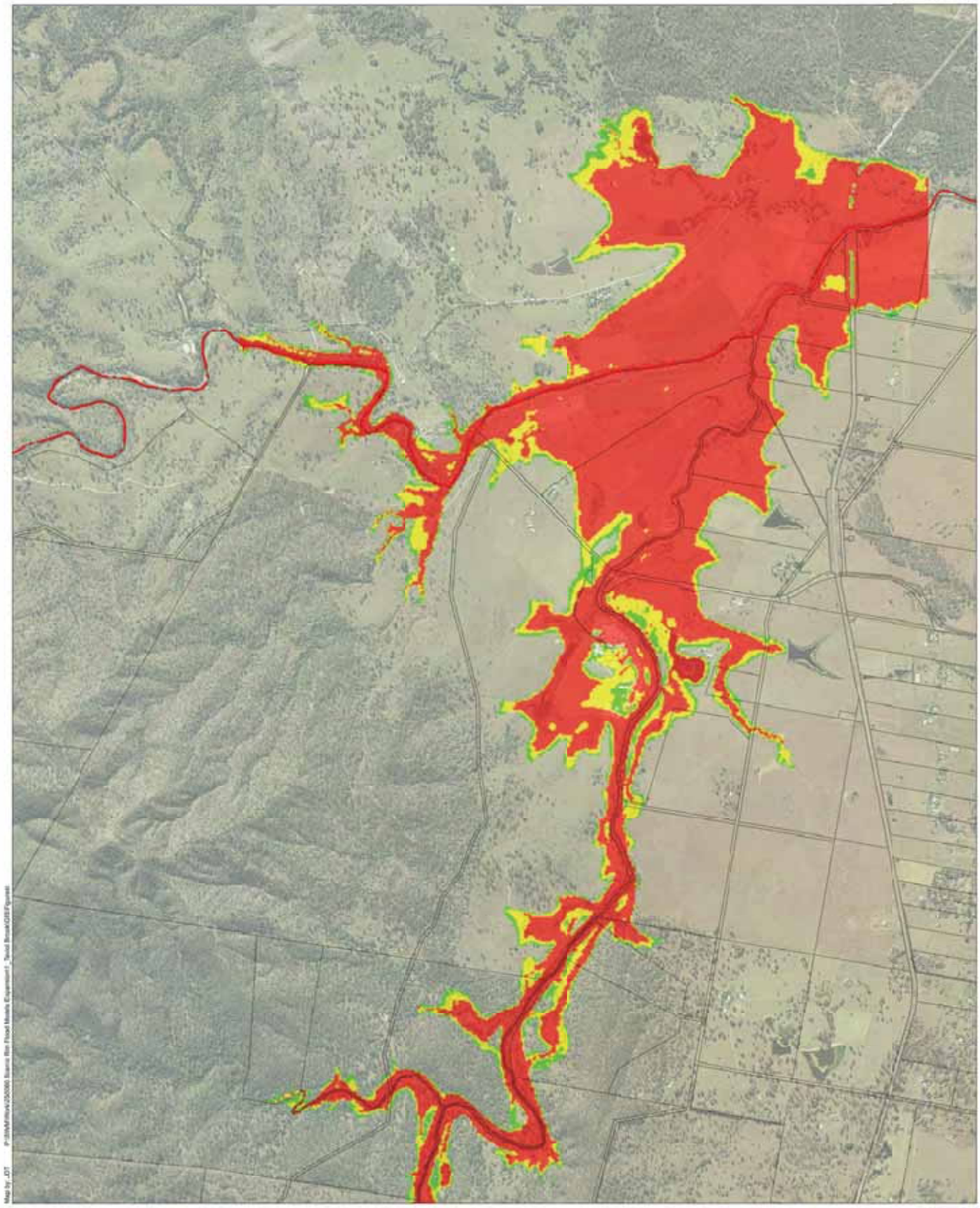
Notes:

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

Date: 24/10/2017 Version: 0 Job No: 255060

Teviot Brook Flood Study **Figure B7-j**

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

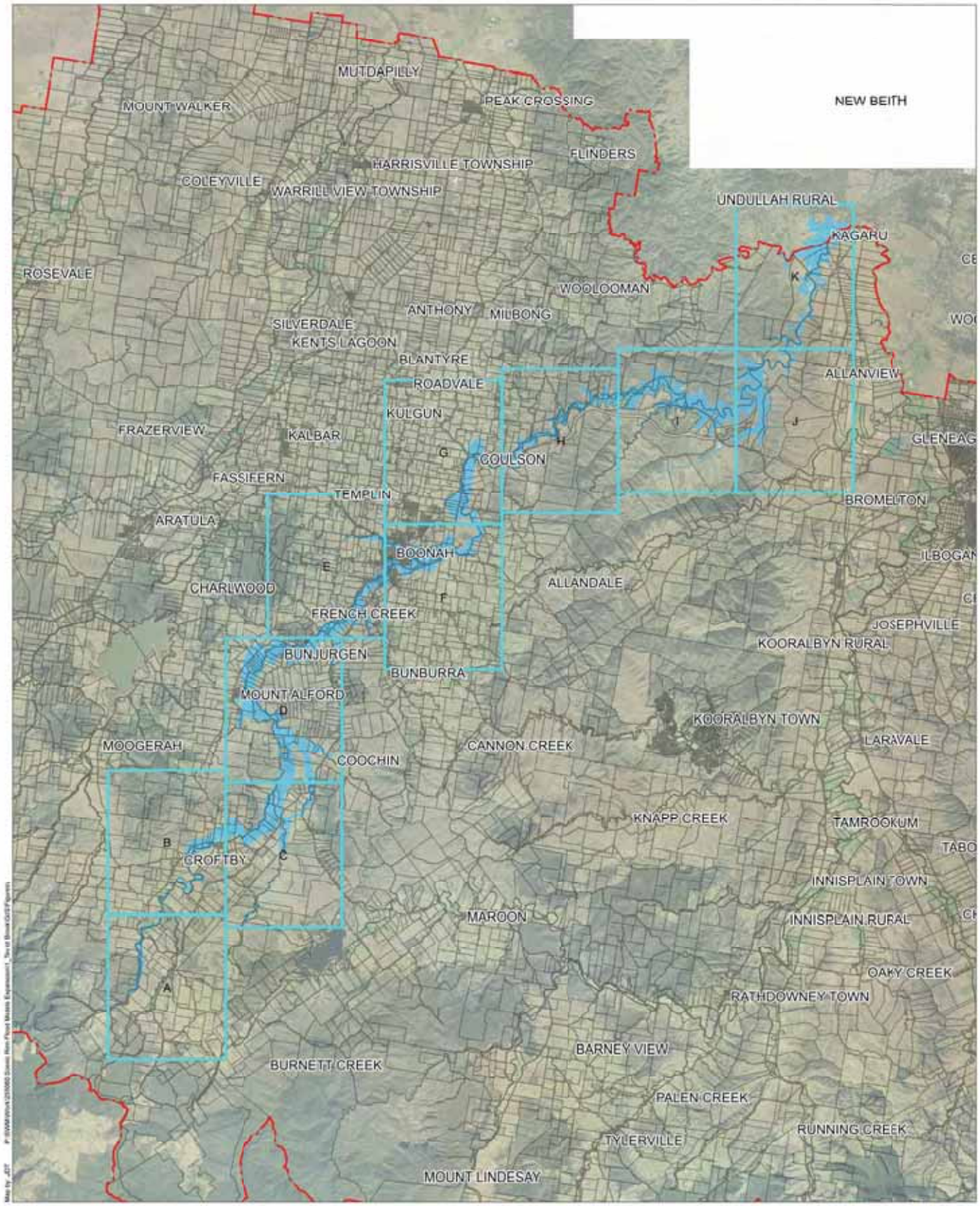
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 55

Teviot Brook Flood Study Figure B7-k

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



Legend

SRRC Boundary

Cadastral Boundary

Inundation Extent

Peak Water level Contour (mAHD)

1:100,000

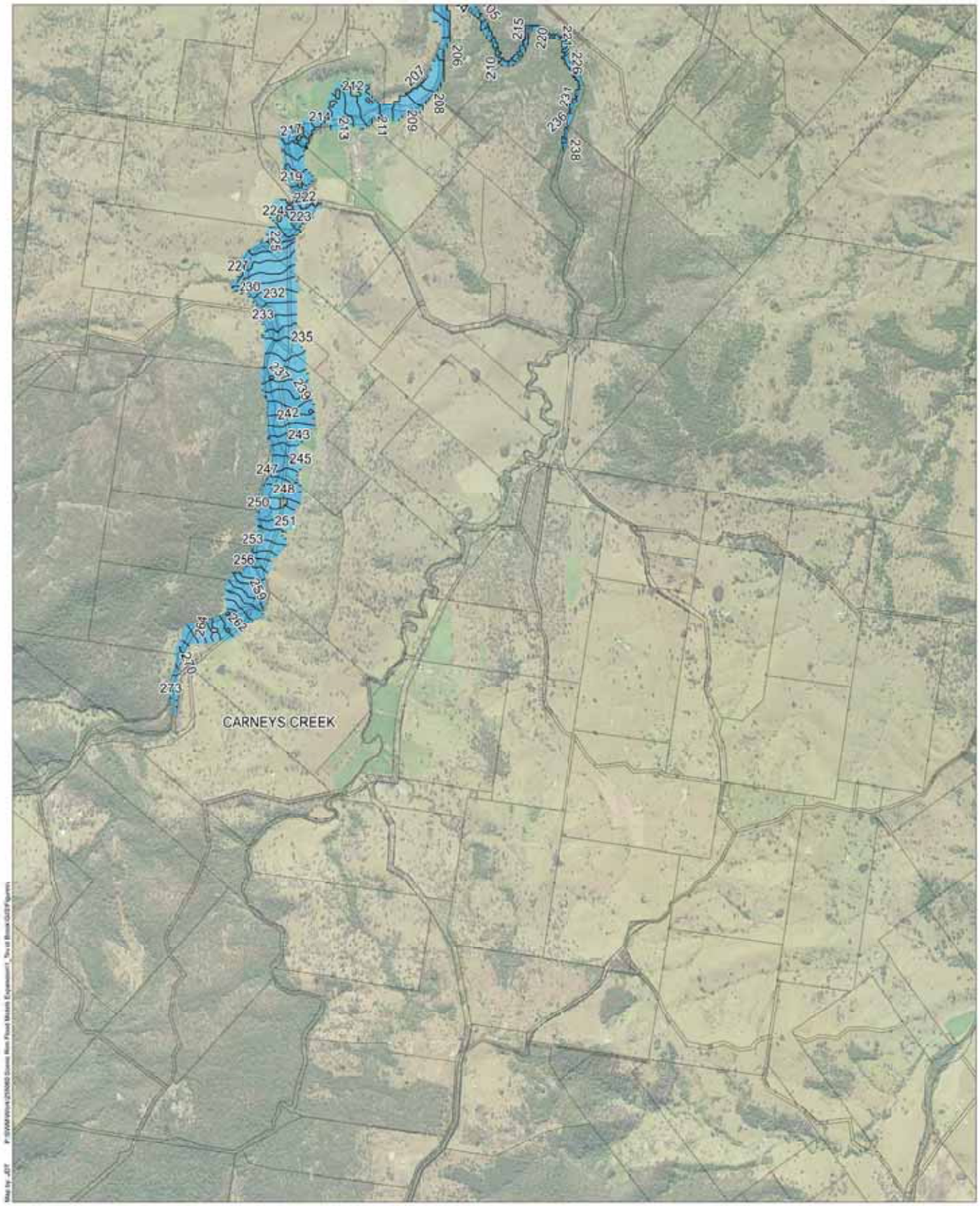
0 2,500 m 5,000 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

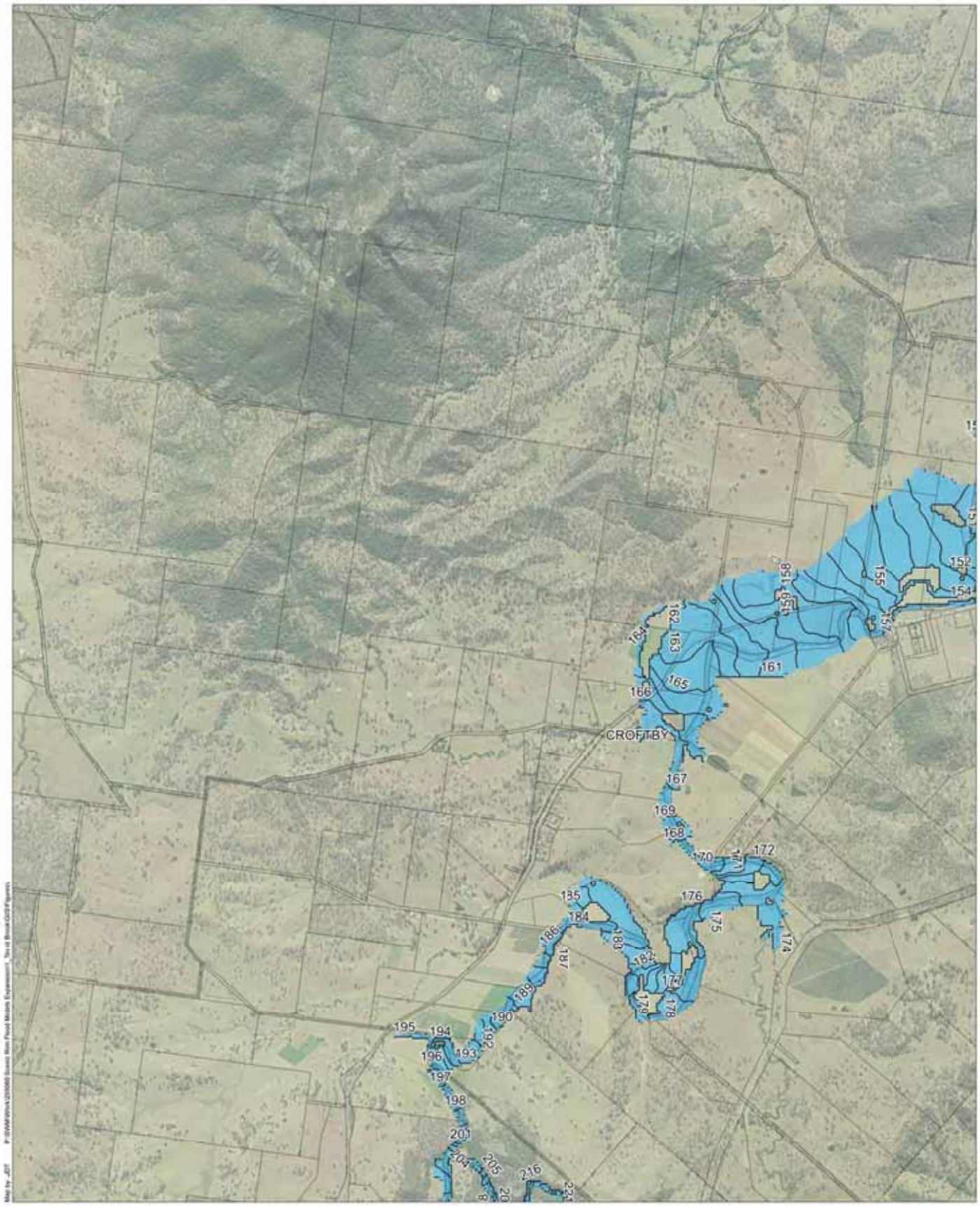
Teviot Brook Flood Study **Figure C1**

2% AEP Event - Inundation Extent



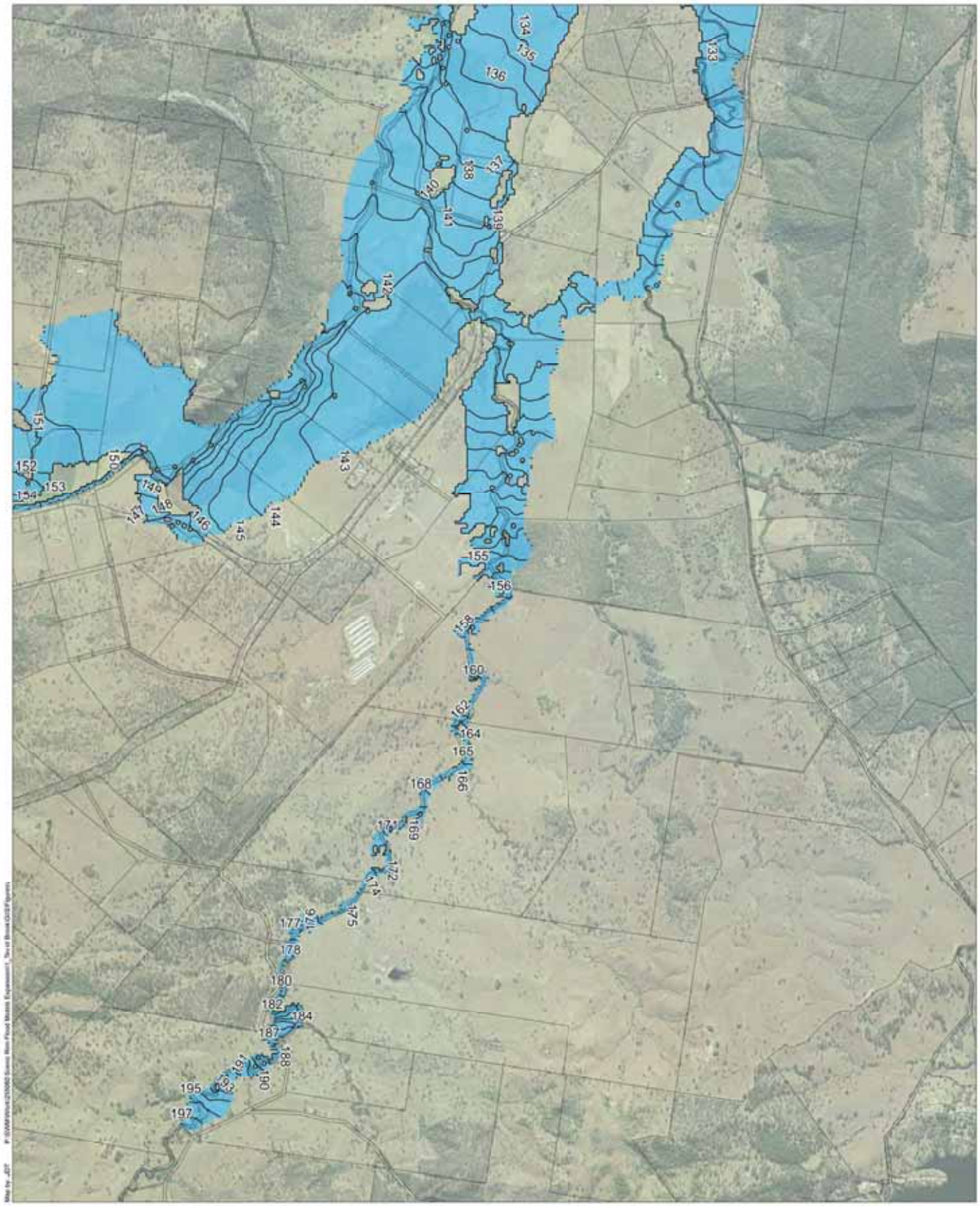
Teviot Brook Flood Study **Figure C1-a**

2% AEP Event - Inundation Extent



Teviot Brook Flood Study **Figure C1-b**

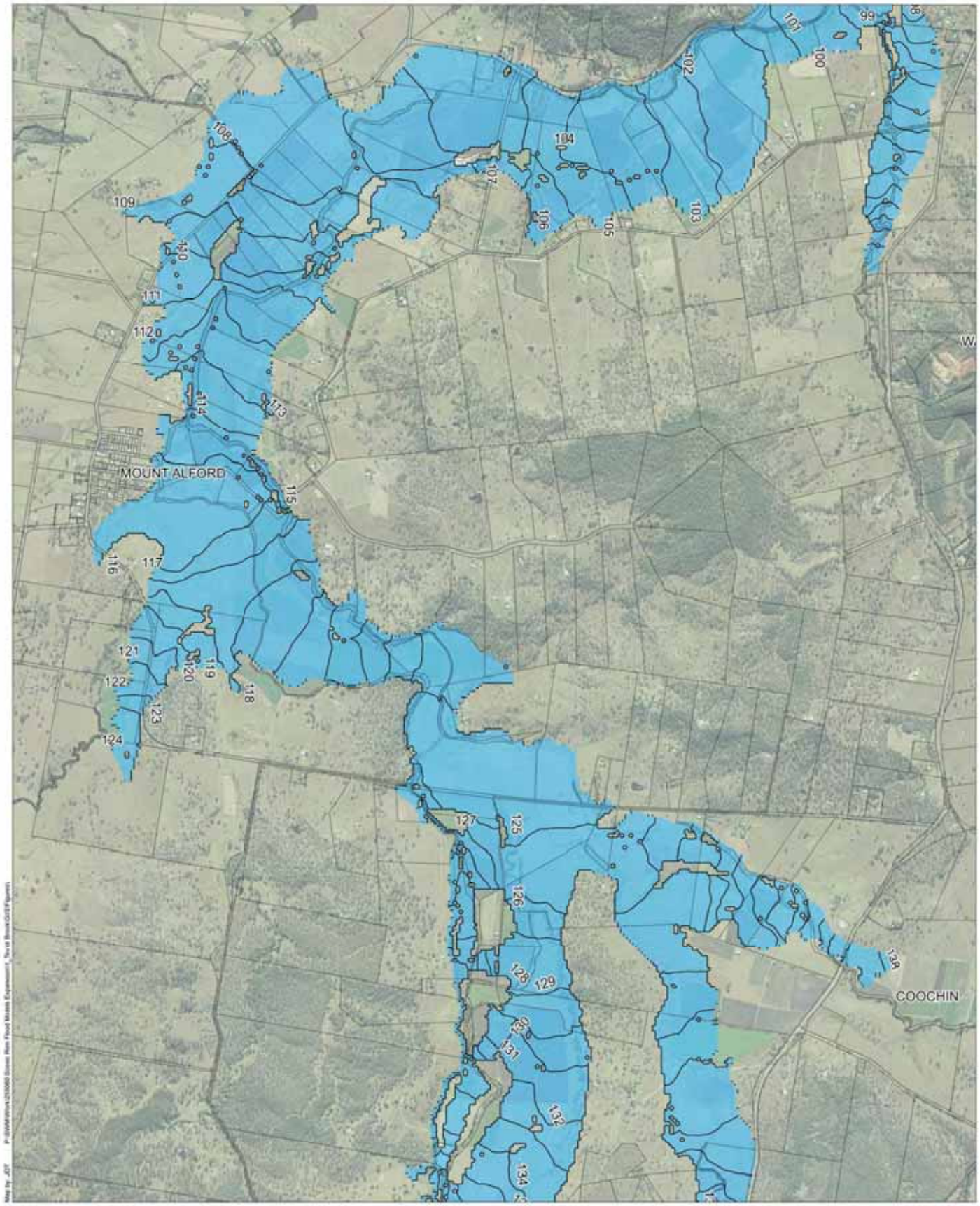
2% AEP Event - Inundation Extent



Teviot Brook 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

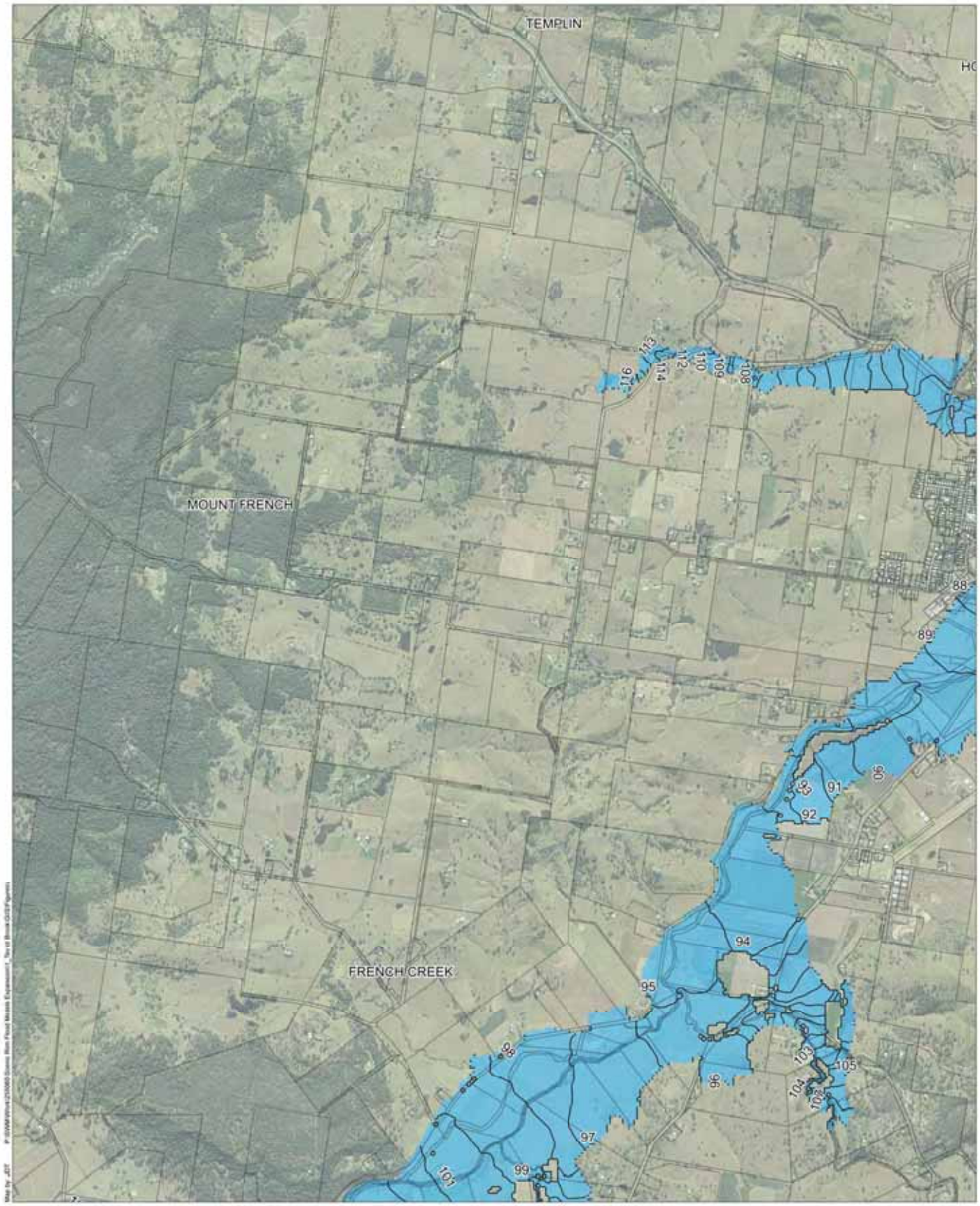
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

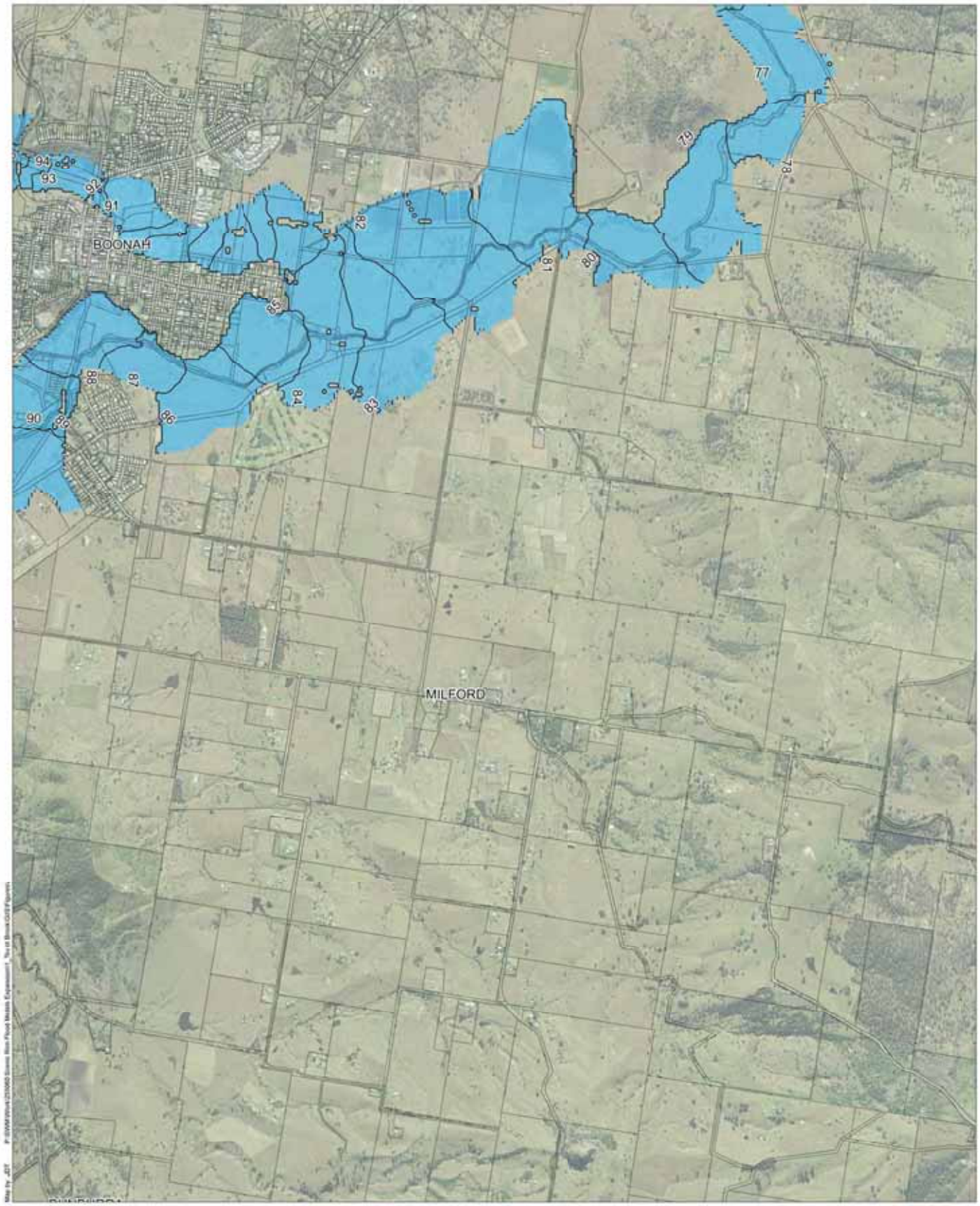
Teviot Brook Flood Study Figure C1-d

2% AEP Event - Inundation Extent



Teviot Brook Flood Study **Figure C1-e**

2% AEP Event - Inundation Extent

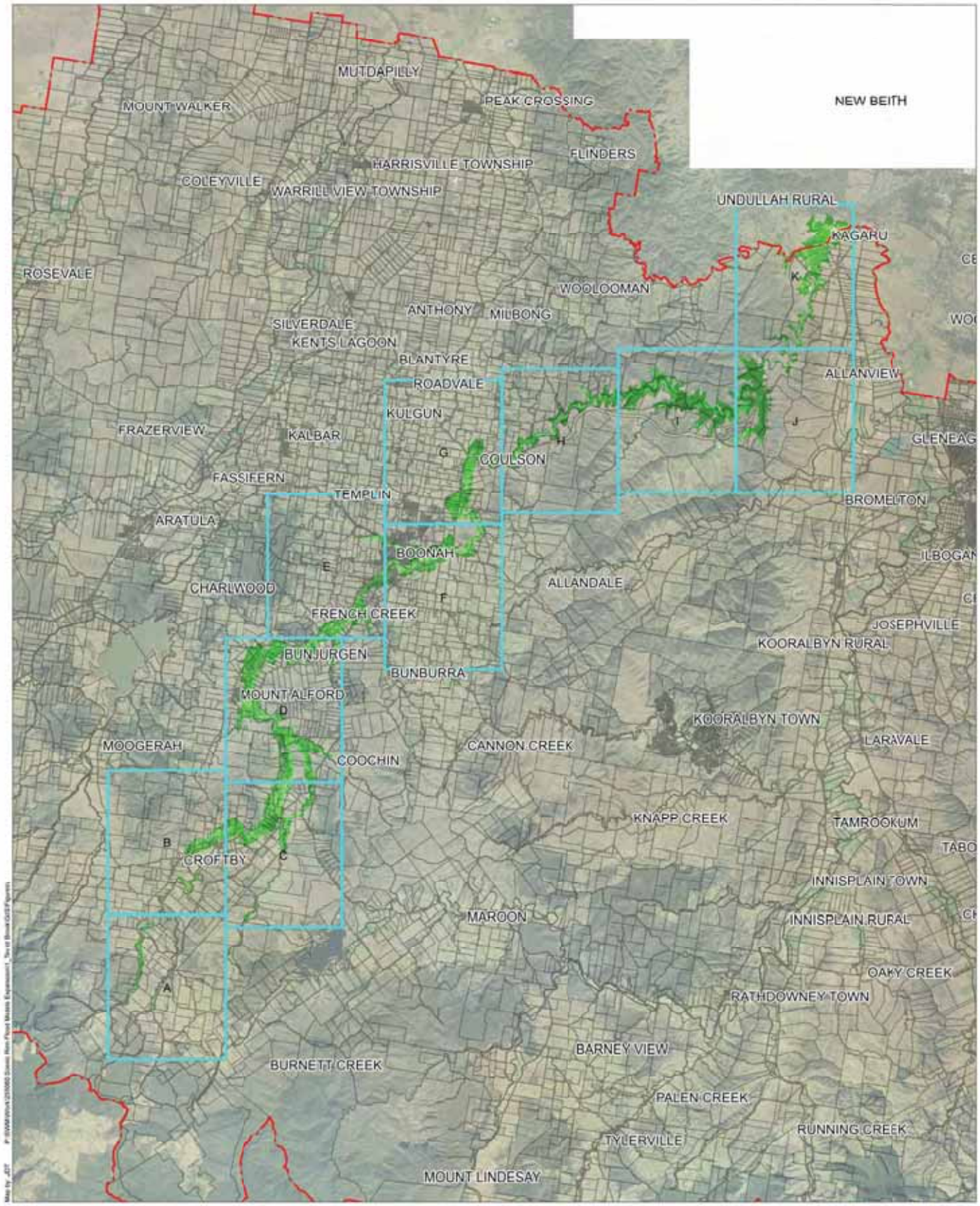


1:25,000
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060
Projection: MGA Zone 56

Teviot Brook Flood Study Figure C1-f

2% AEP Event - Inundation Extent



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:

1:100,000

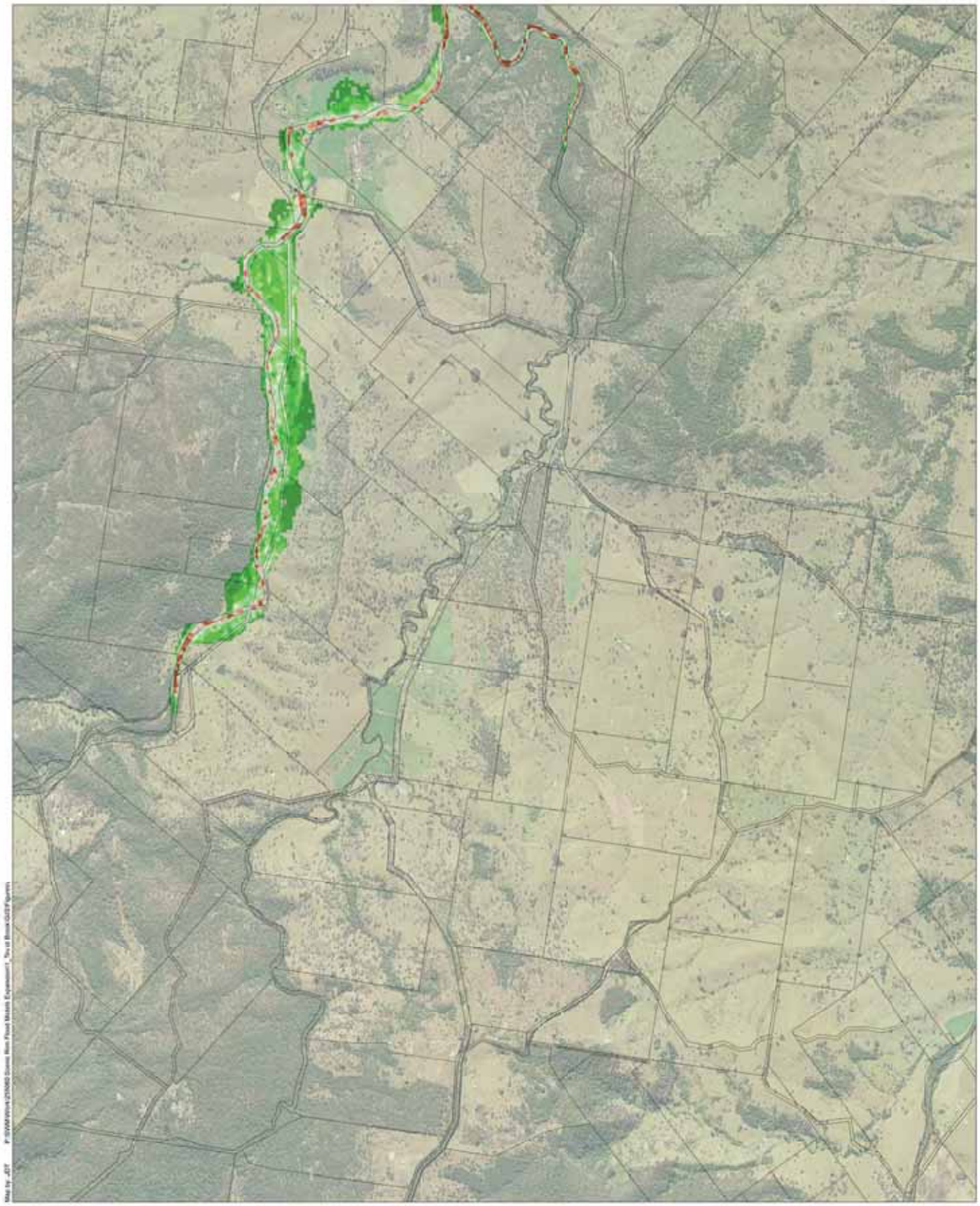
0 2,500 m 5,000 m

Date: 24/10/2017 Version: 0 Job No: 235080

Projection: MGA Zone 56

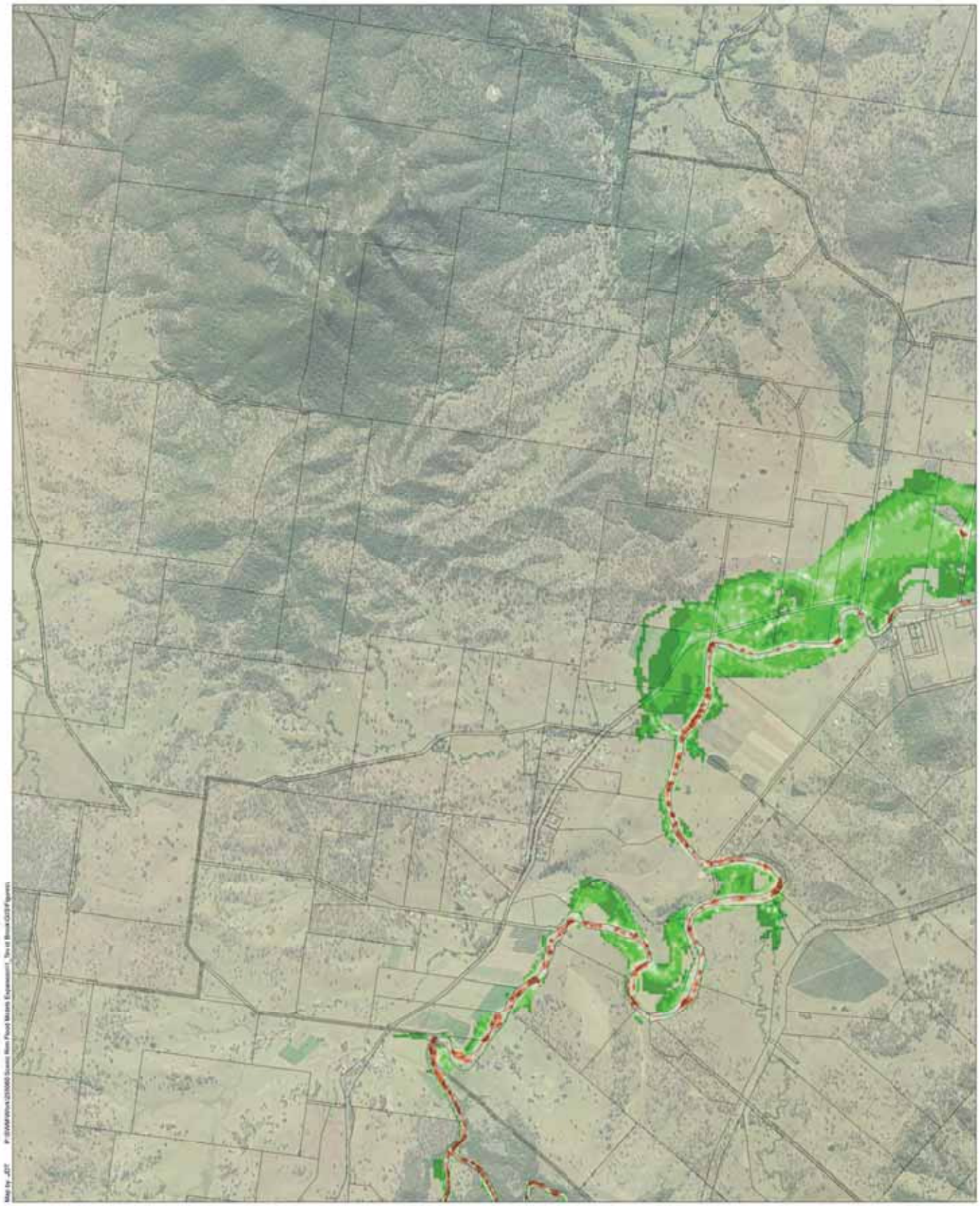
Teviot Brook Flood Study Figure C2

2% AEP Event - Peak Velocities



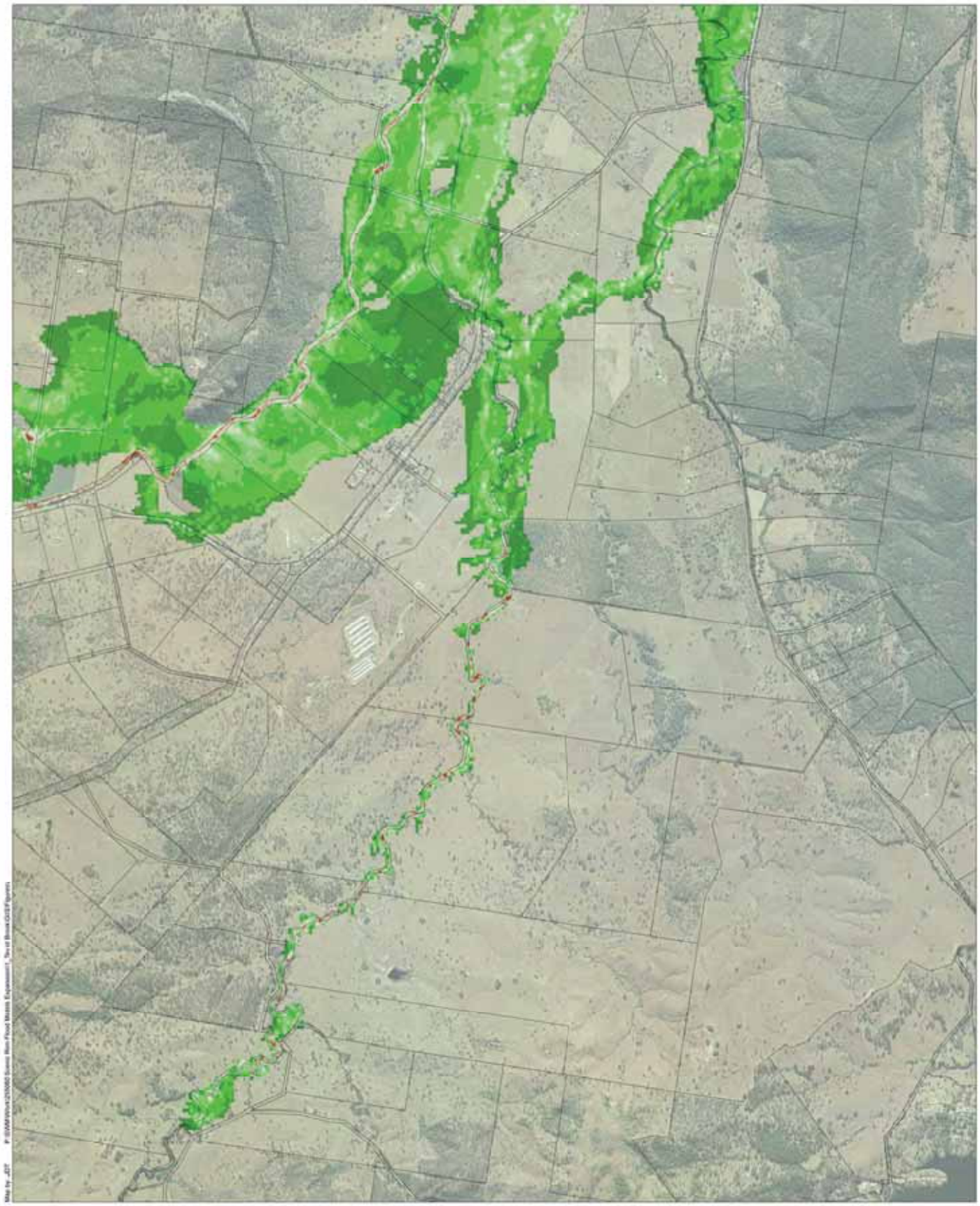
Teviot Brook Flood Study **Figure C2-a**

2% AEP Event - Peak Velocities



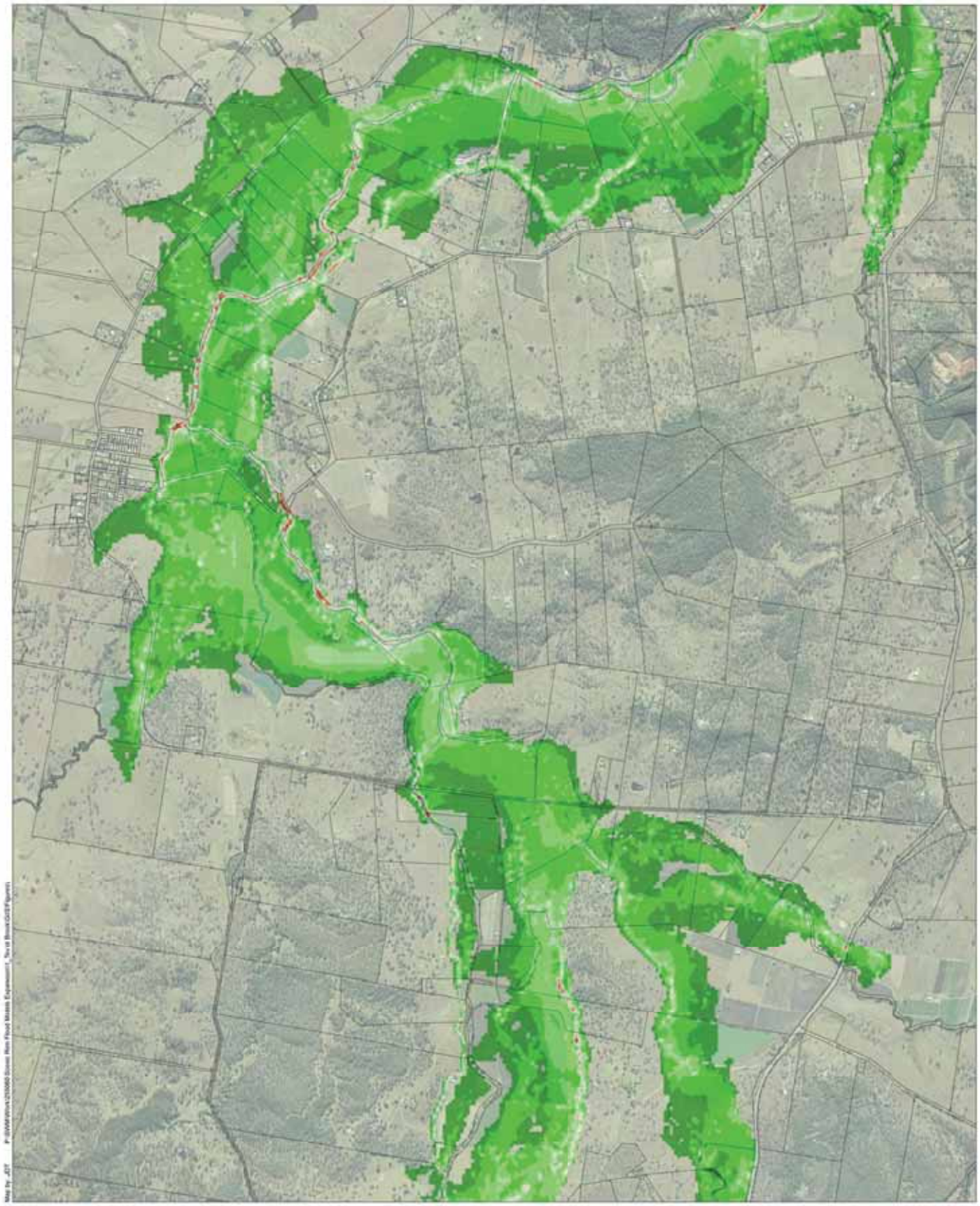
Teviot Brook Flood Study **Figure C2-b**

2% AEP Event - Peak Velocities



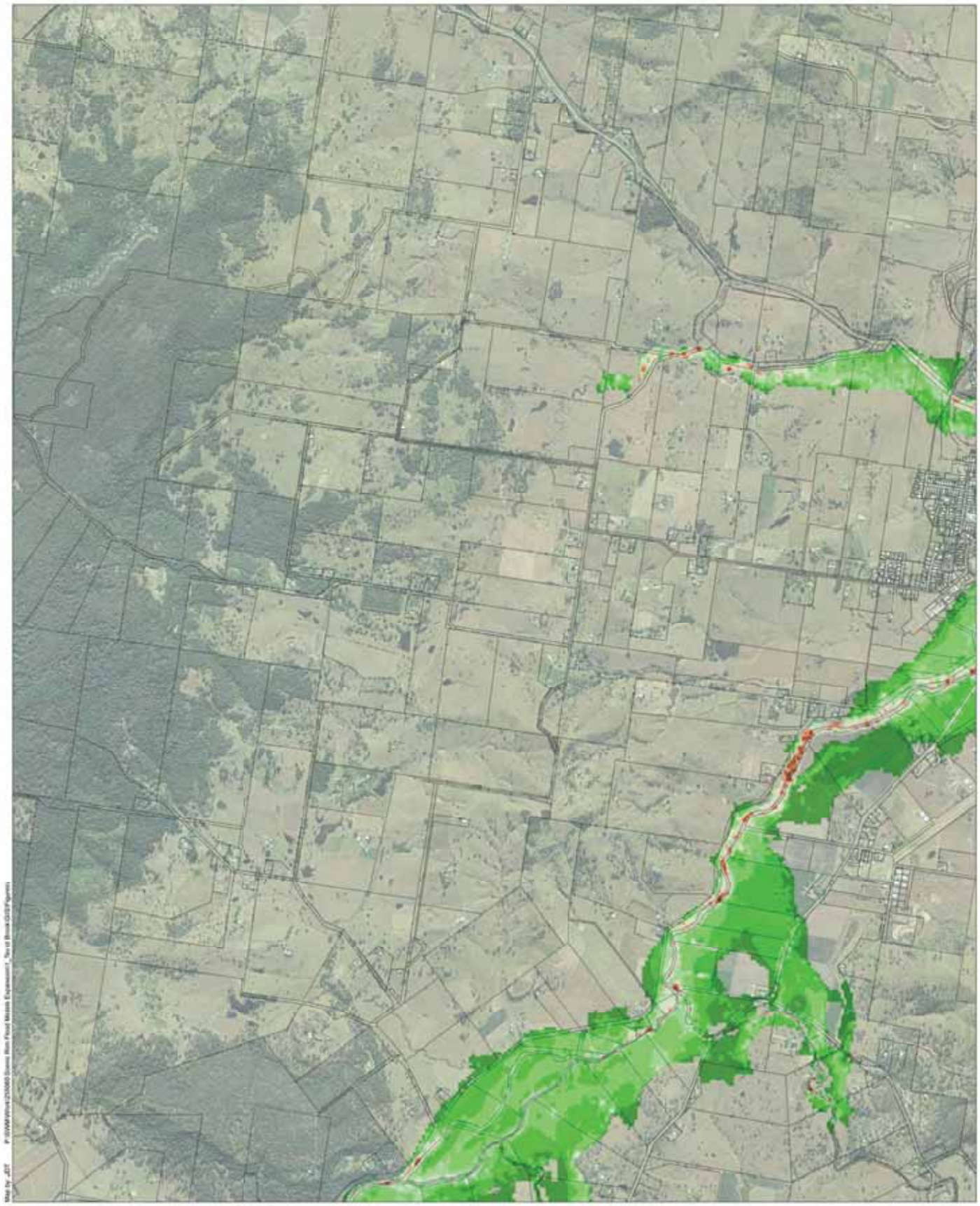
Teviot Brook Flood Study **Figure C2-c**

2% AEP Event - Peak Velocities



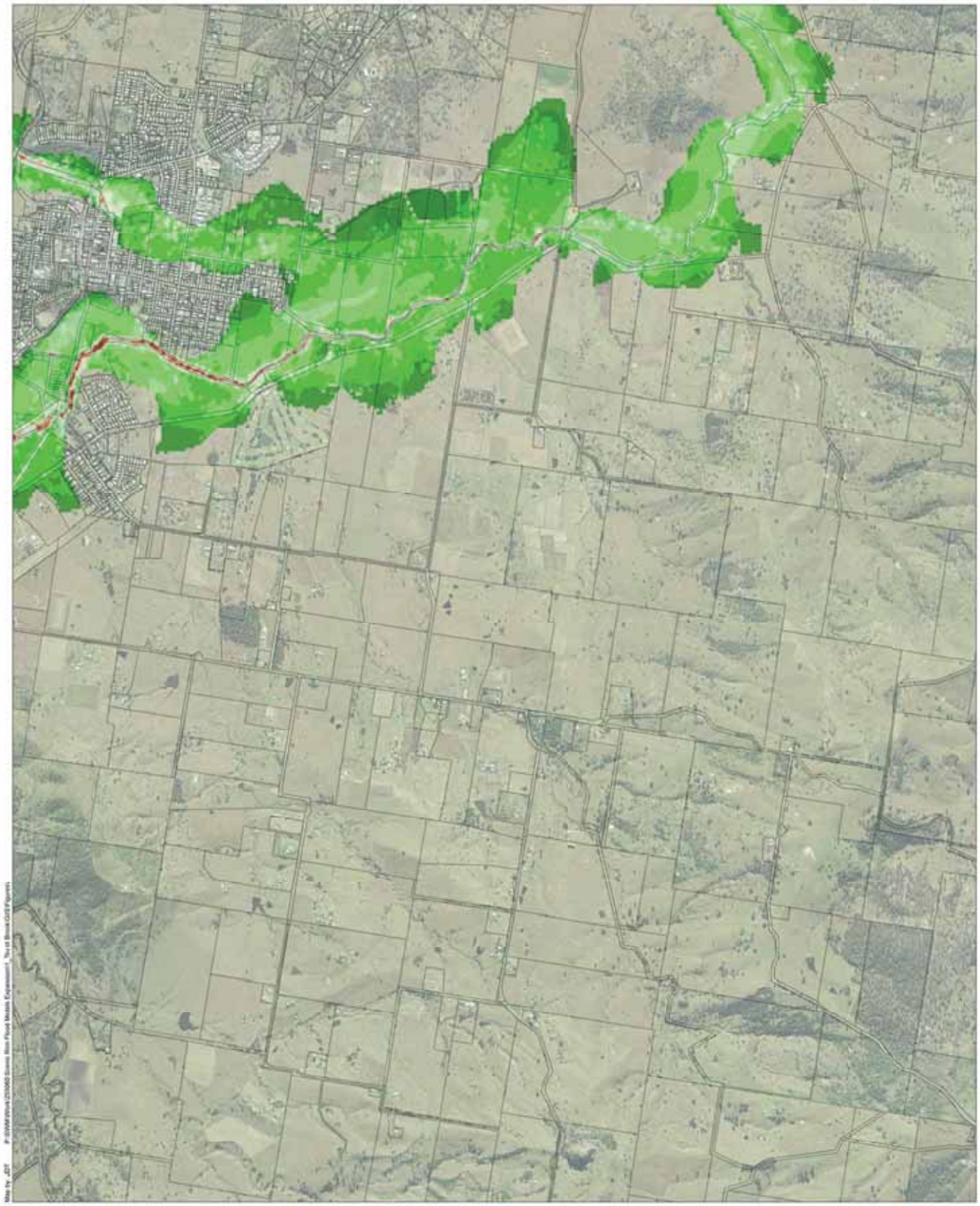
Teviot Brook Flood Study **Figure C2-d**

2% AEP Event - Peak Velocities



Teviot Brook Flood Study **Figure C2-e**

2% AEP Event - Peak Velocities



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

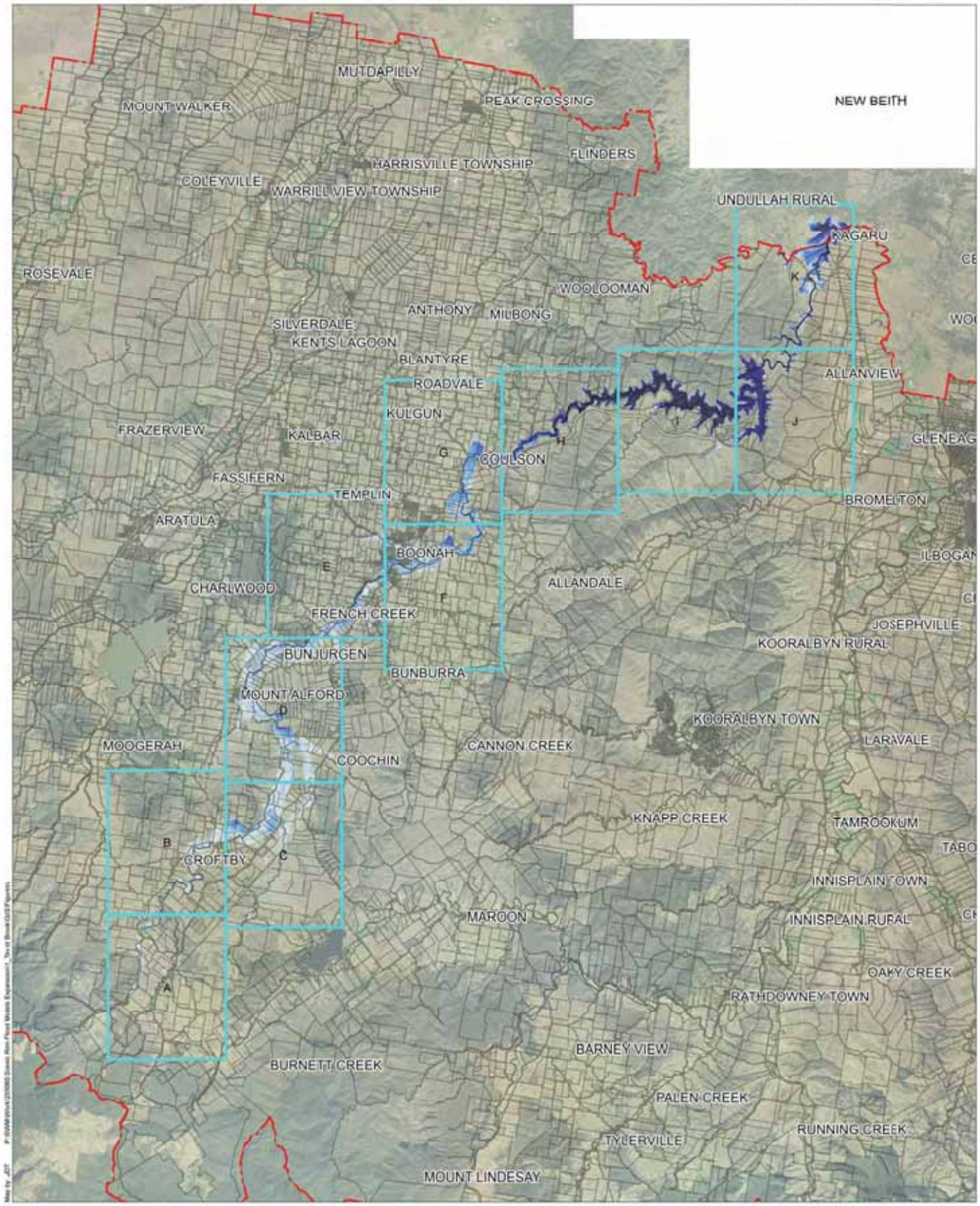
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 235060

Projection: MGA Zone 56

Teviot Brook Flood Study **Figure C2-f**

2% AEP Event - Peak Velocities



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:

1:100,000

0 2,500 m 5,000 m

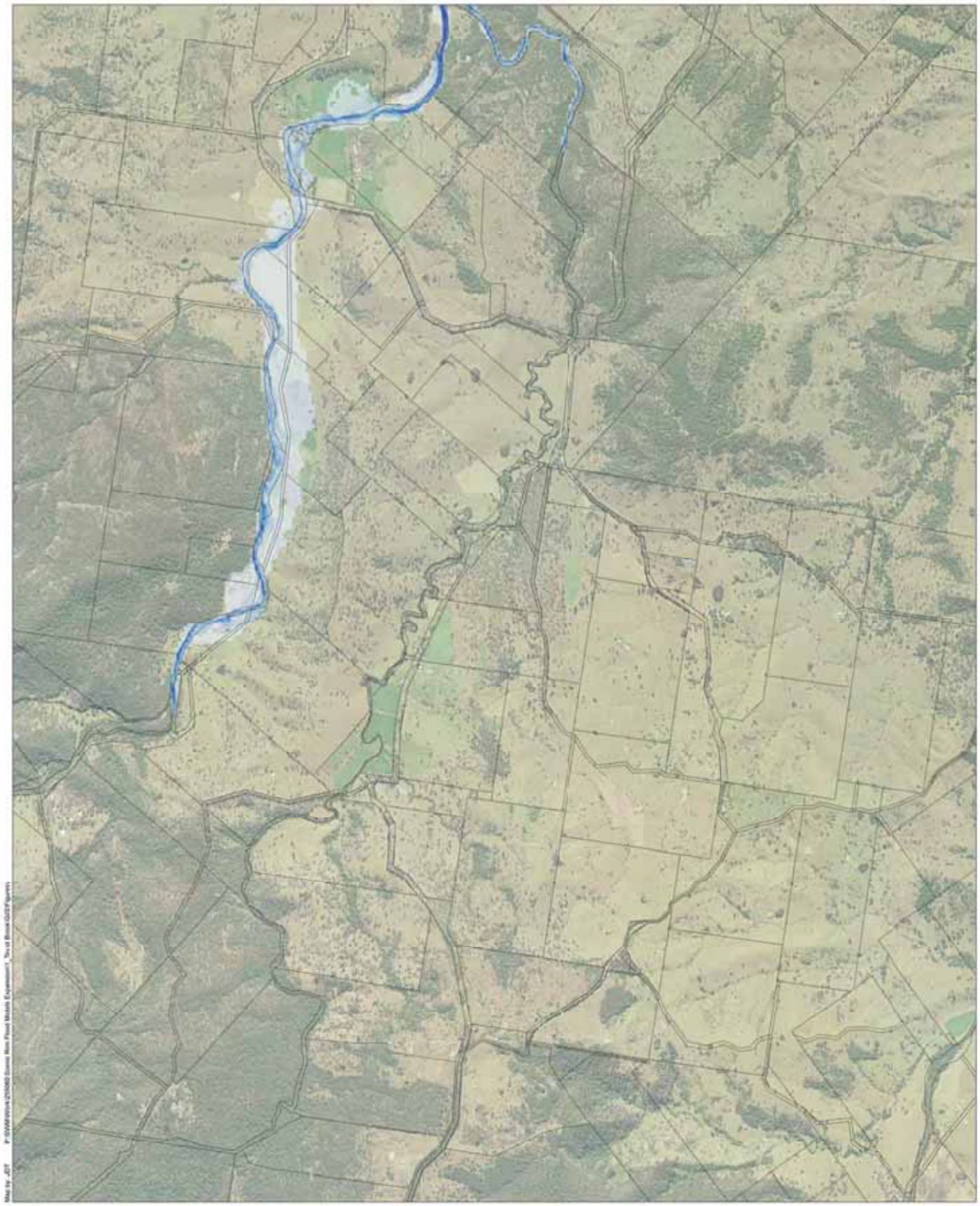
Date: 24/10/2017 Version: 0 Job No: 235060

Projection: MGA Zone 56

Teviot Brook Flood Study Figure C3

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

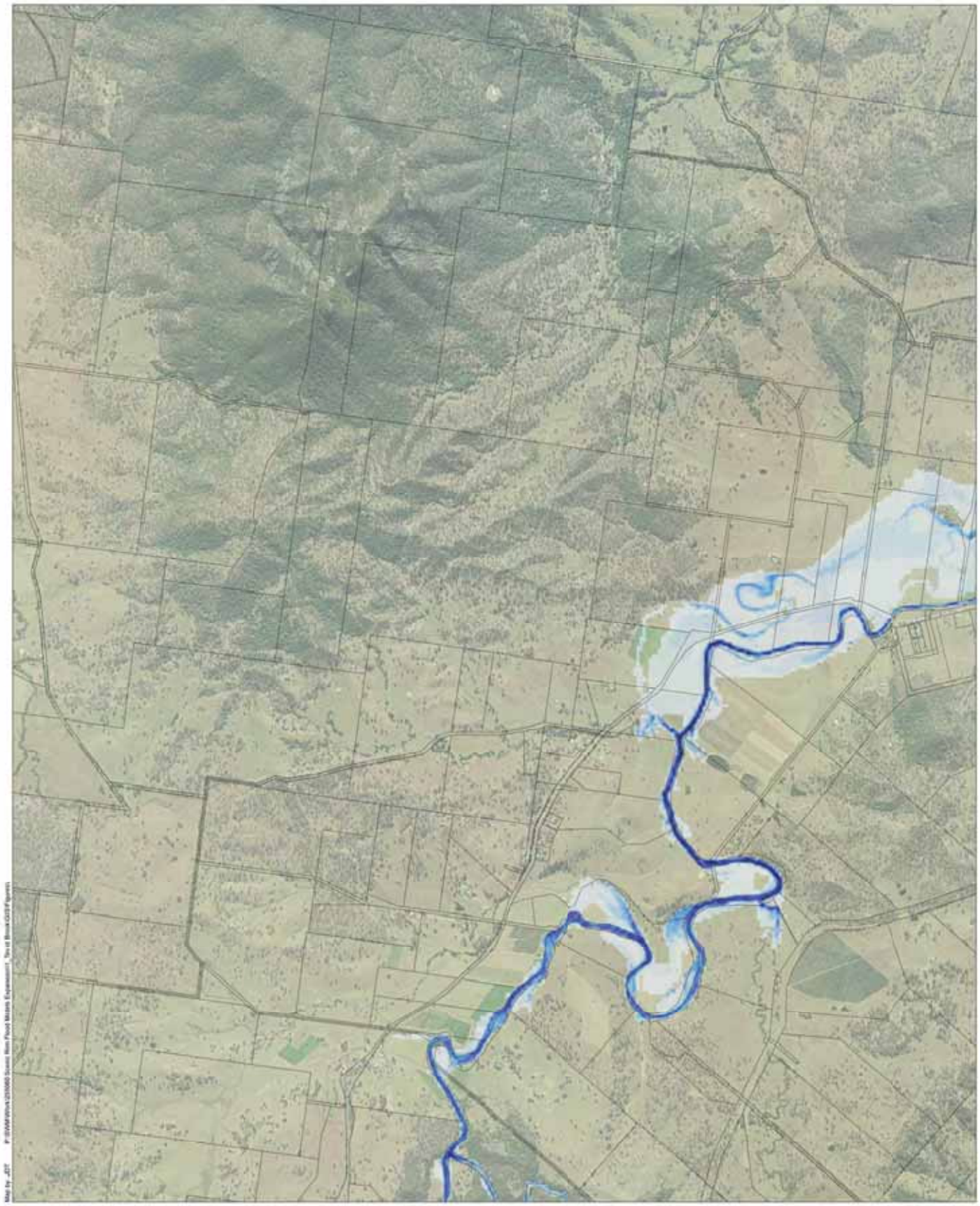
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 235080

Projection: MGA Zone 56

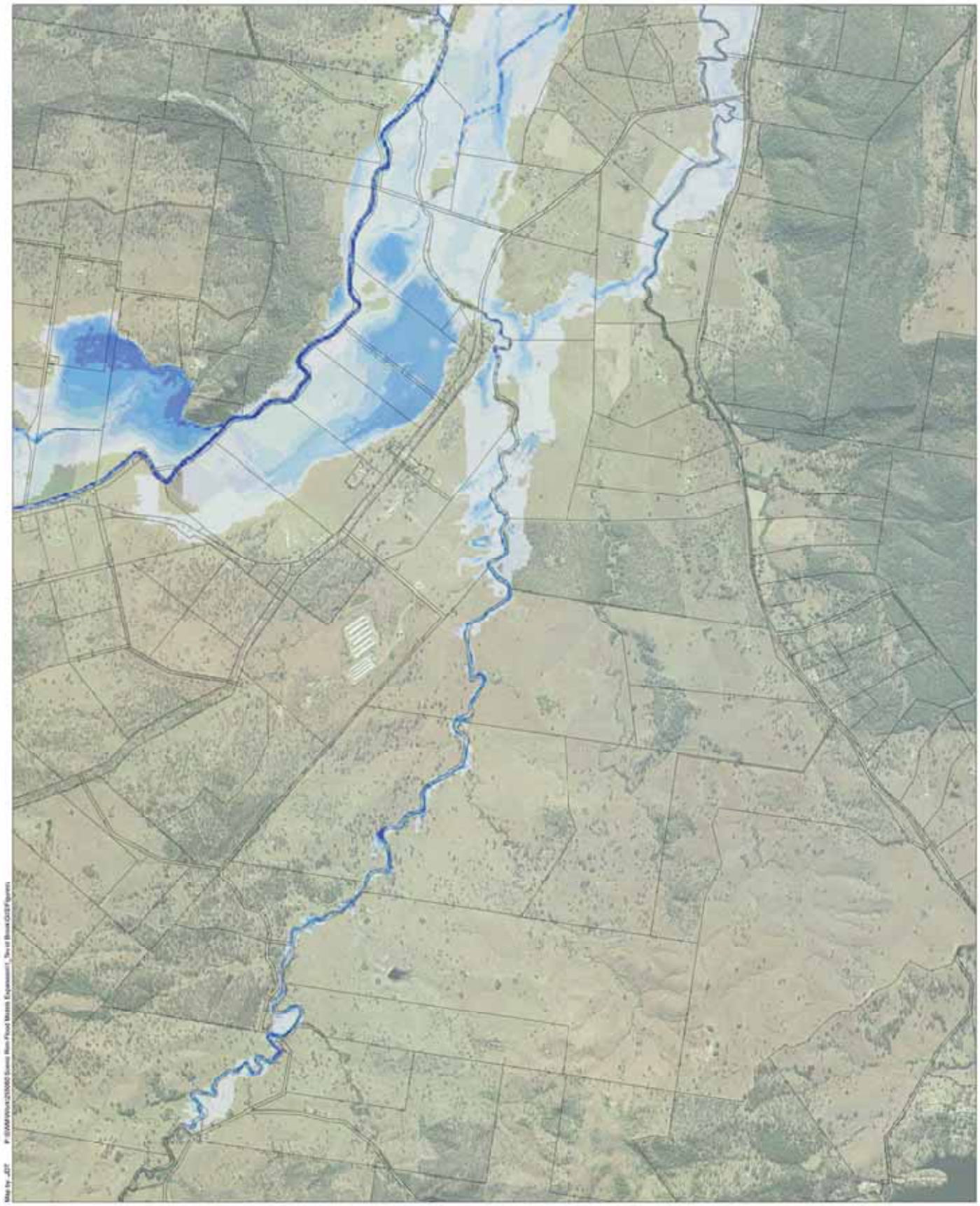
Teviot Brook Flood Study Figure C3-a

2% AEP Event - Peak Depth Map



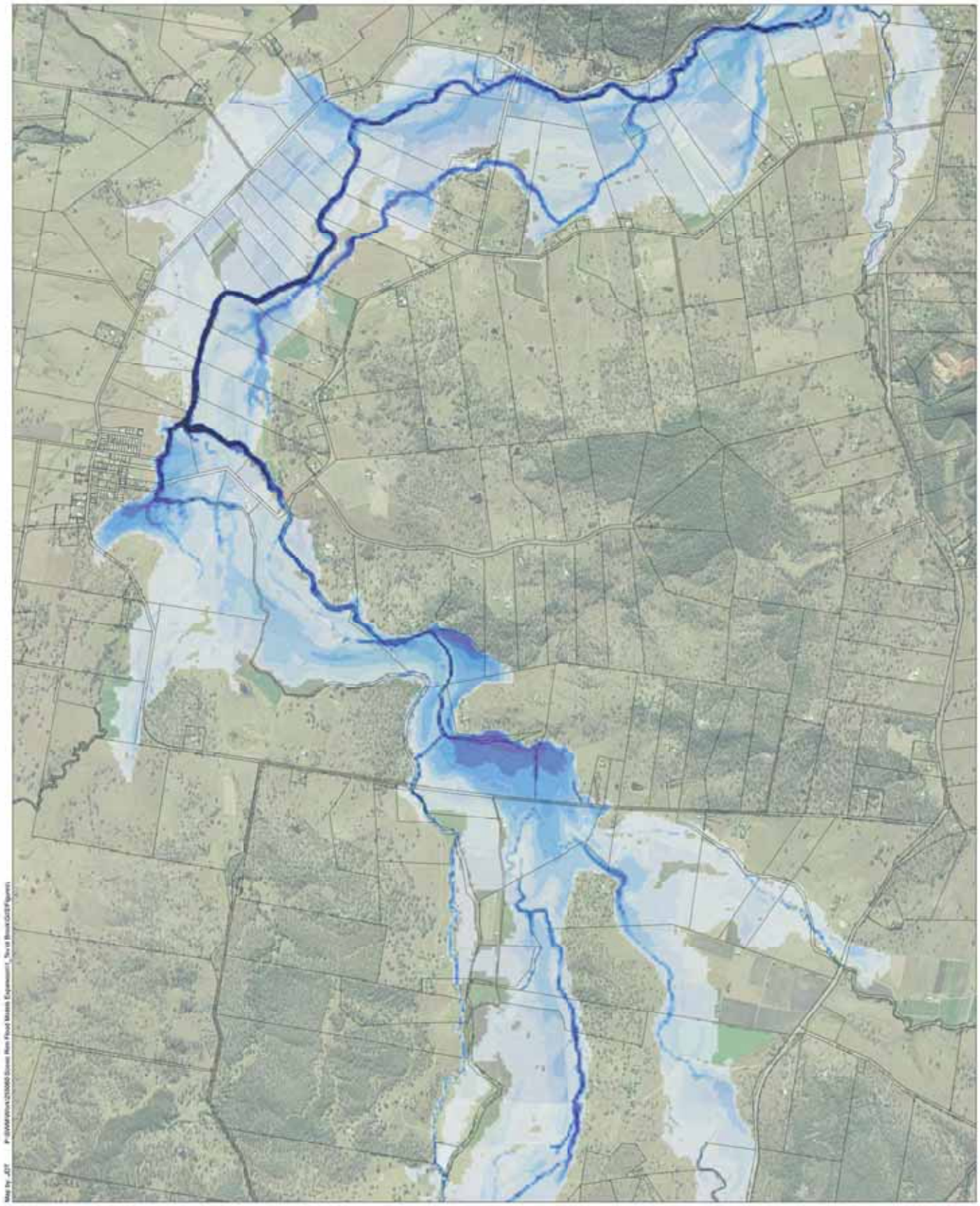
Teviot Brook Flood Study **Figure C3-b**

2% AEP Event - Peak Depth Map



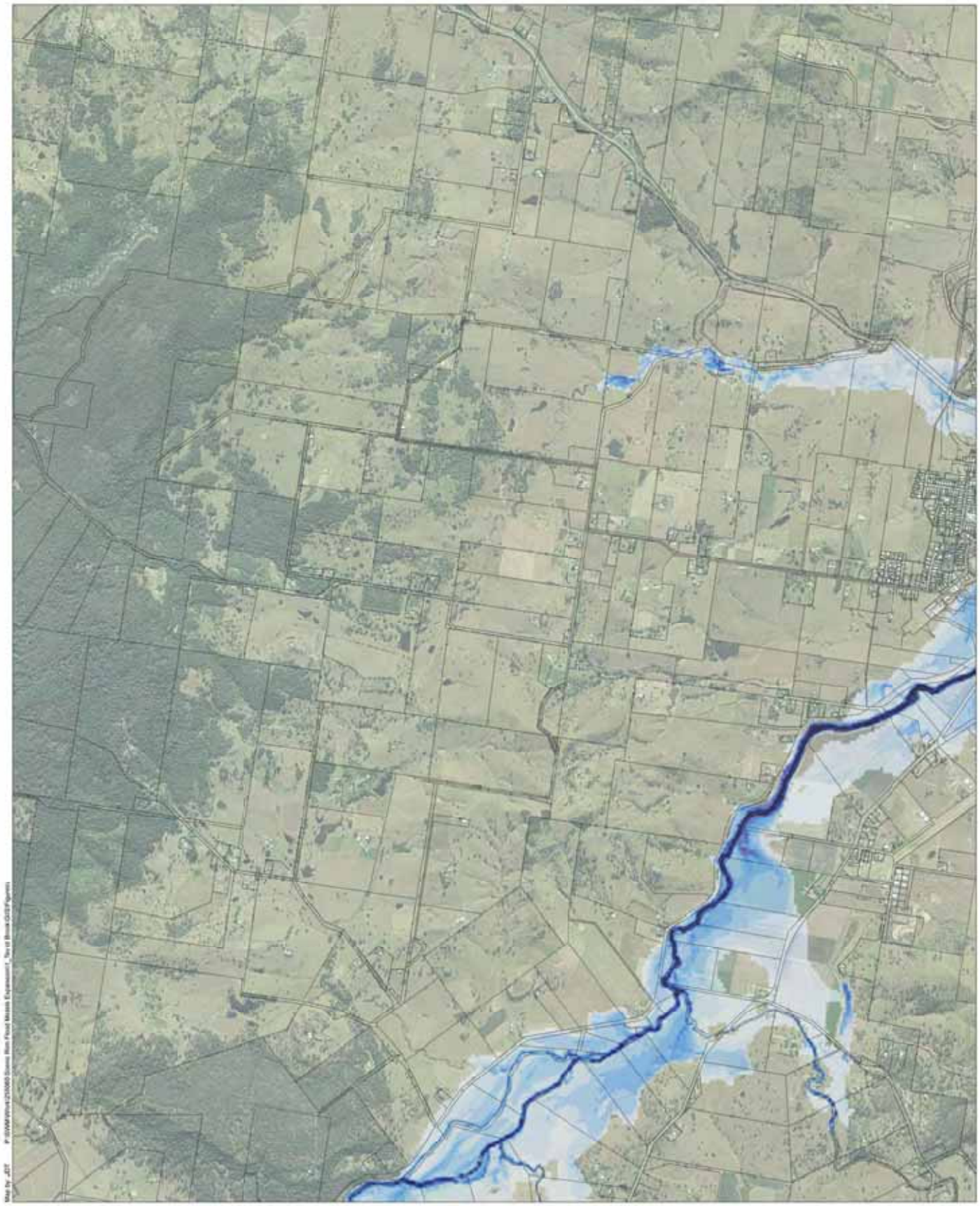
Teviot Brook Flood Study **Figure C3-c**

2% AEP Event - Peak Depth Map



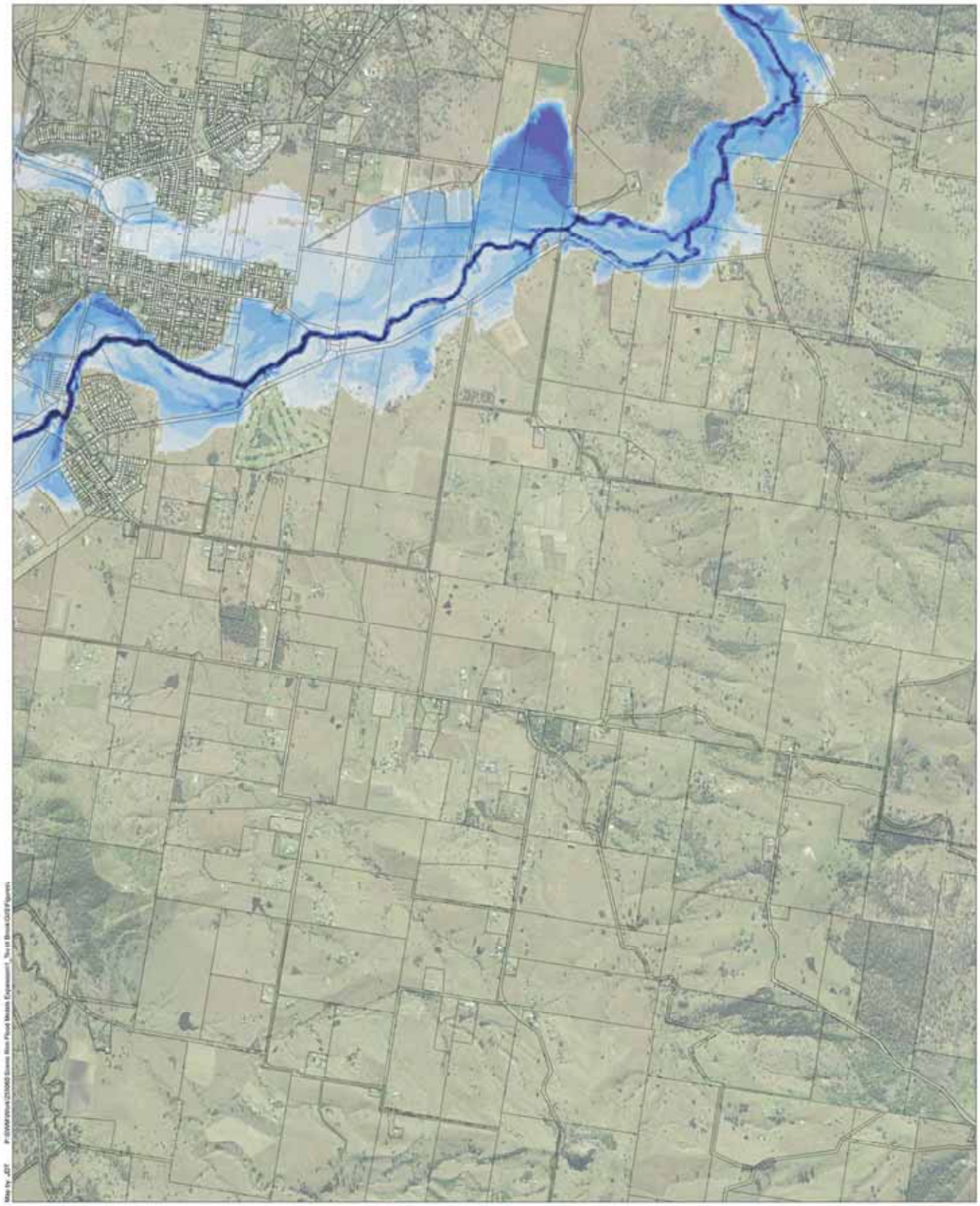
Teviot Brook Flood Study **Figure C3-d**

2% AEP Event - Peak Depth Map



Teviot Brook Flood Study **Figure C3-e**

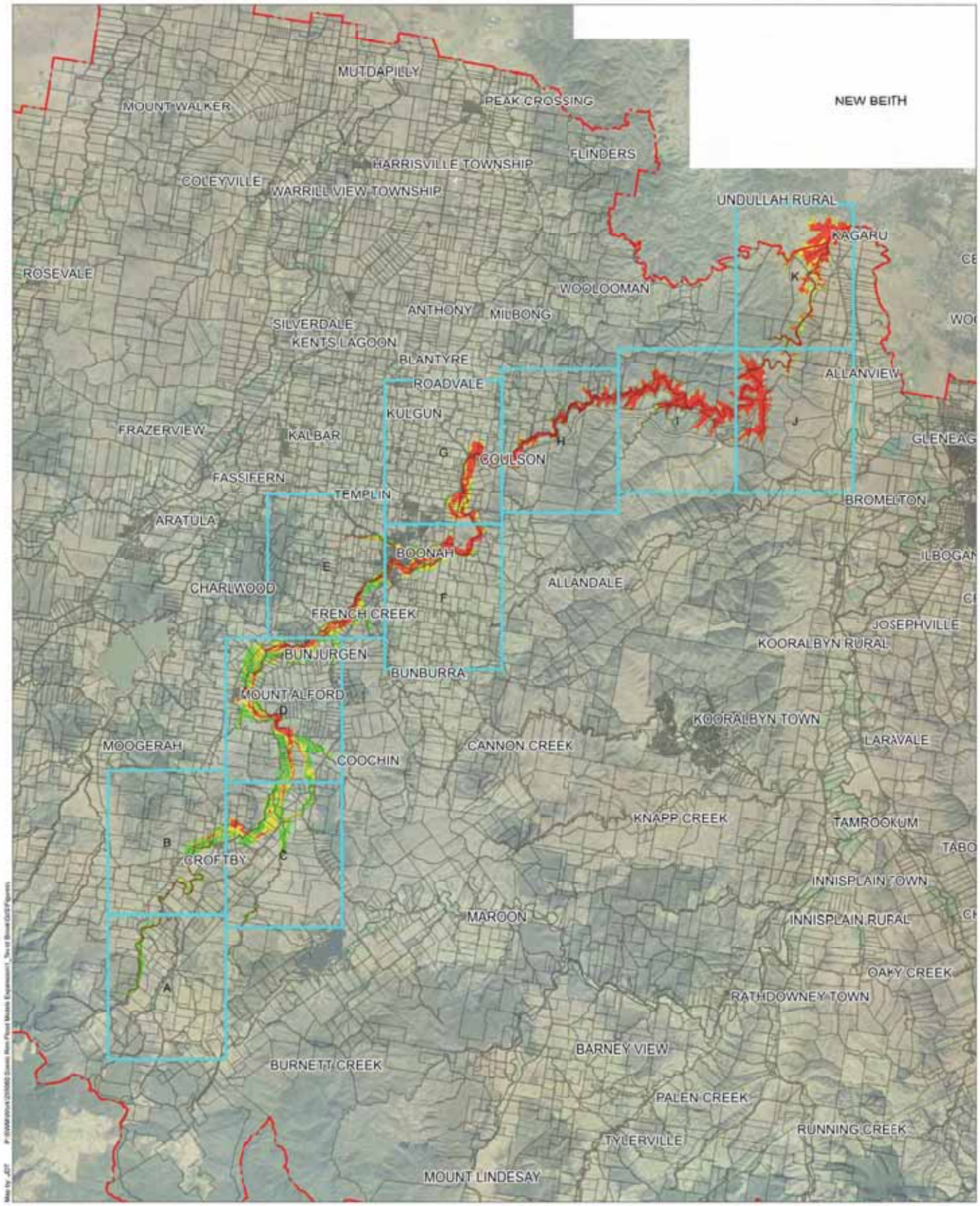
2% AEP Event - Peak Depth Map



Teviot Brook Flood Study **Figure C3-f**

2% AEP Event - Peak Depth Map

aurecon



Legend

SRRC Boundary

Cadastral Boundary

Low Hazard

Medium Hazard

High Hazard

1:100,000

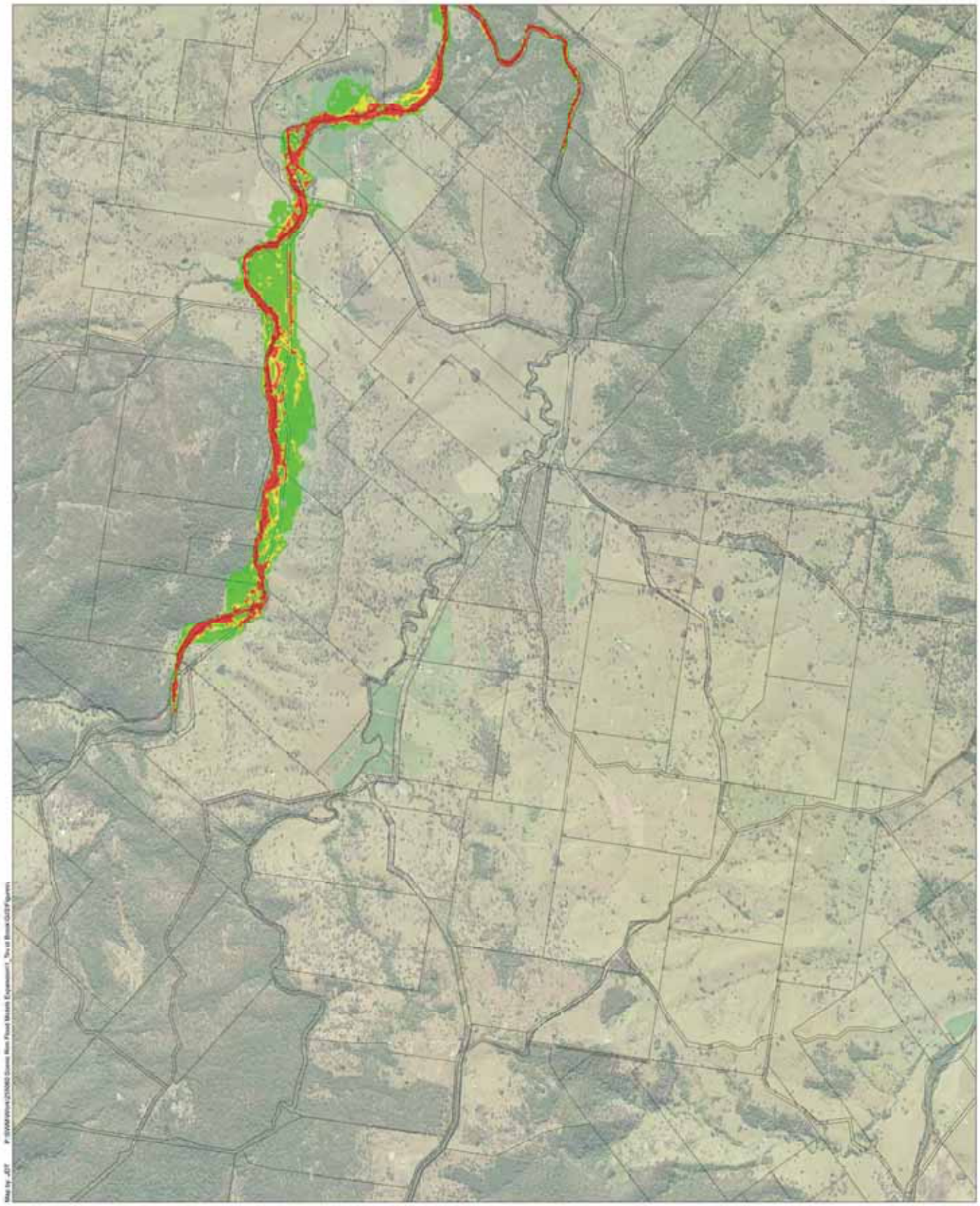
0 2,500 m 5,000 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Teviot Brook Flood Study Figure C4

2% AEP Event - Peak Hazard Map

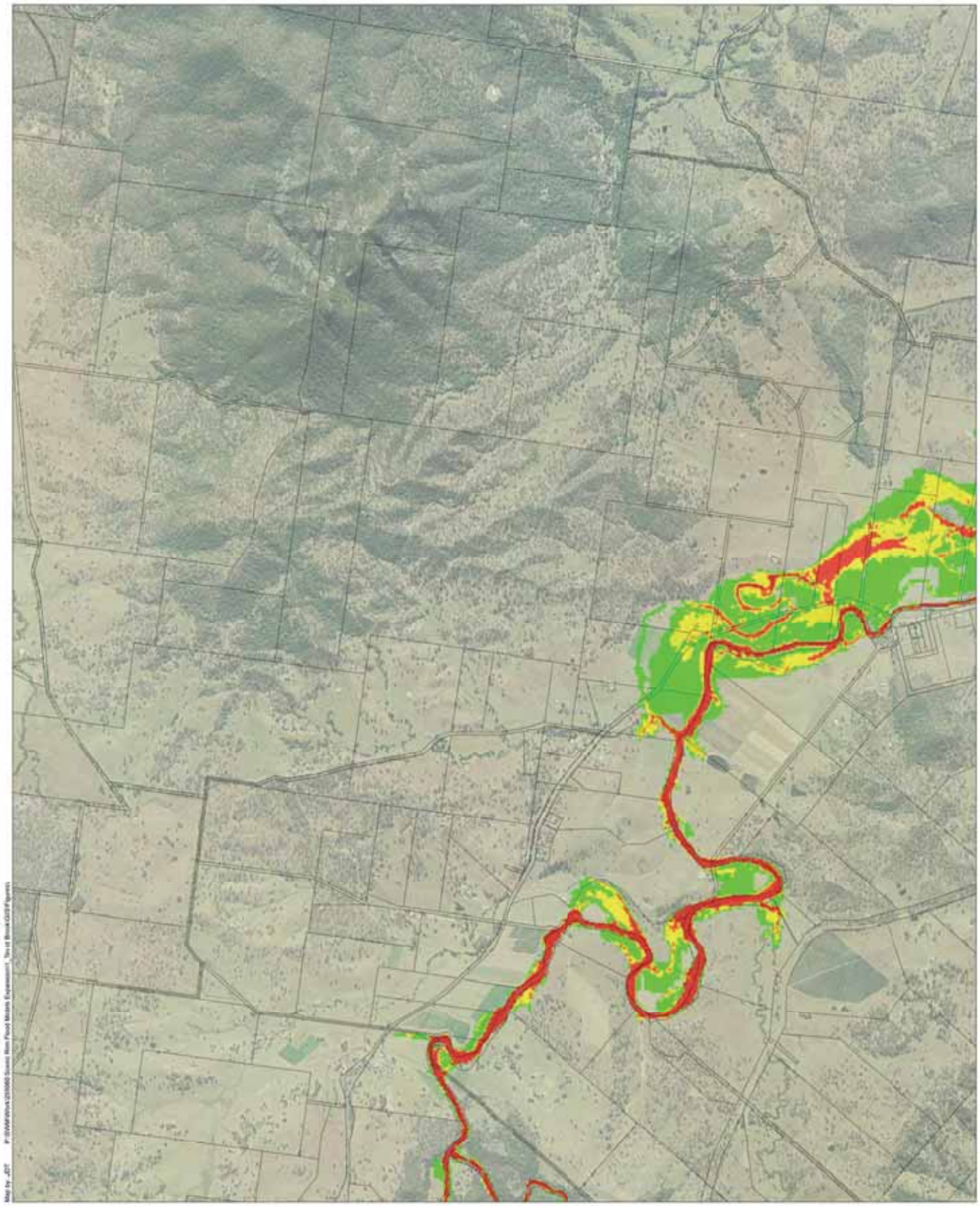


1:25,000
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060
Projection: MGA Zone 56

Teviot Brook Flood Study Figure C4-a

2% AEP Event - Peak Hazard Map

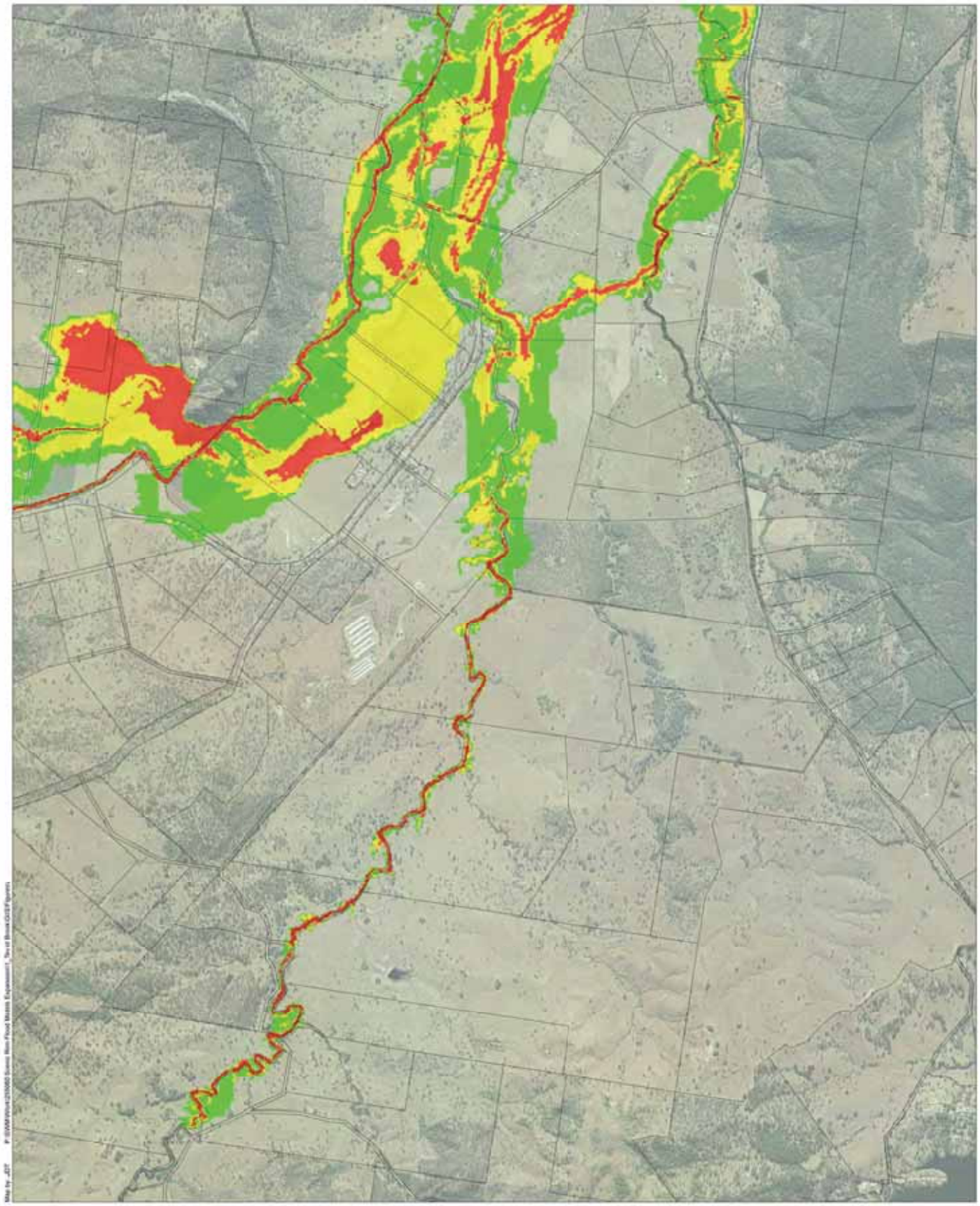


1:25,000
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060
Projection: MGA Zone 56

Teviot Brook Flood Study Figure C4-b

2% AEP Event - Peak Hazard Map



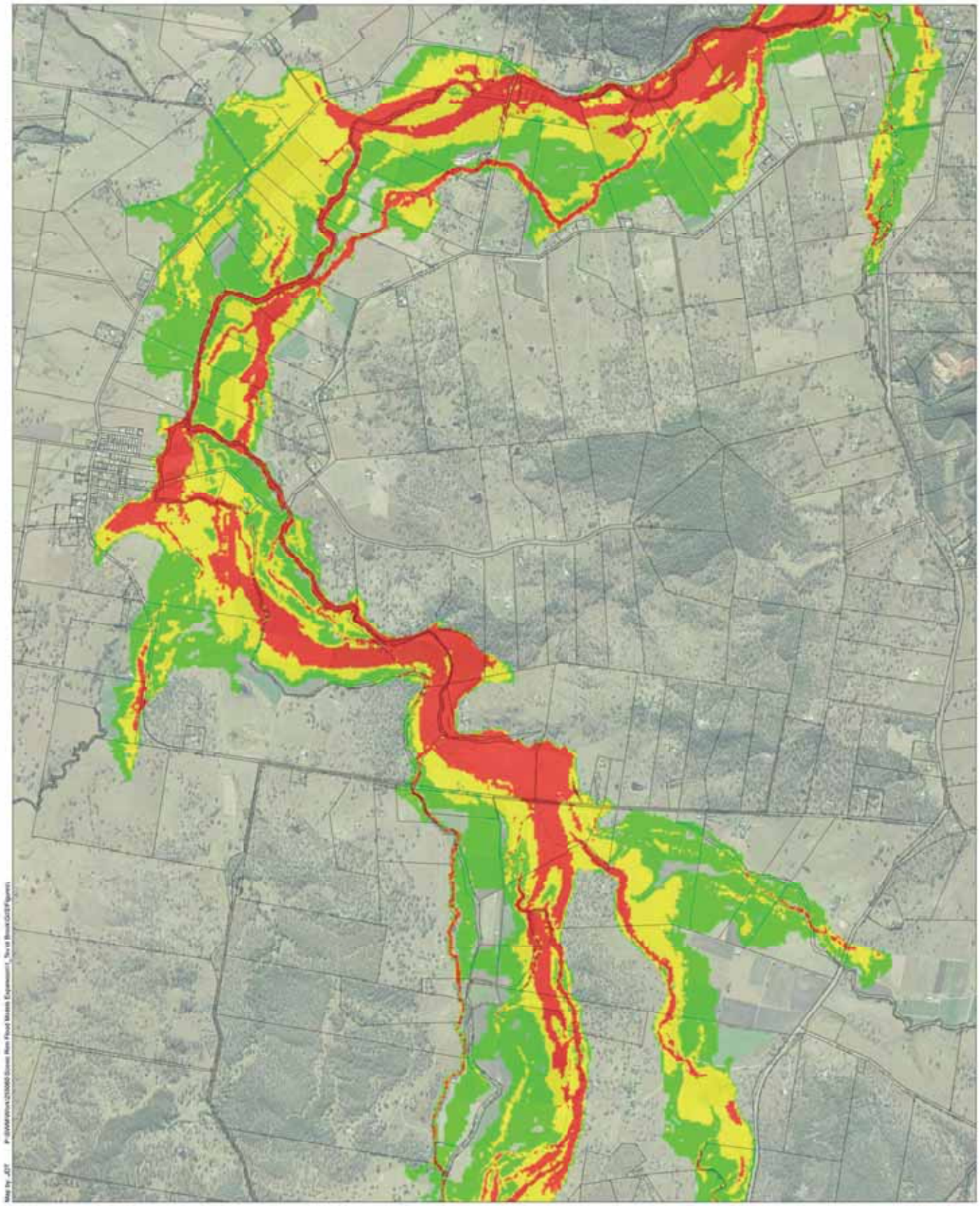
1:25,000
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060
Projection: MGA Zone 56

Teviot Brook Flood Study Figure C4-c

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

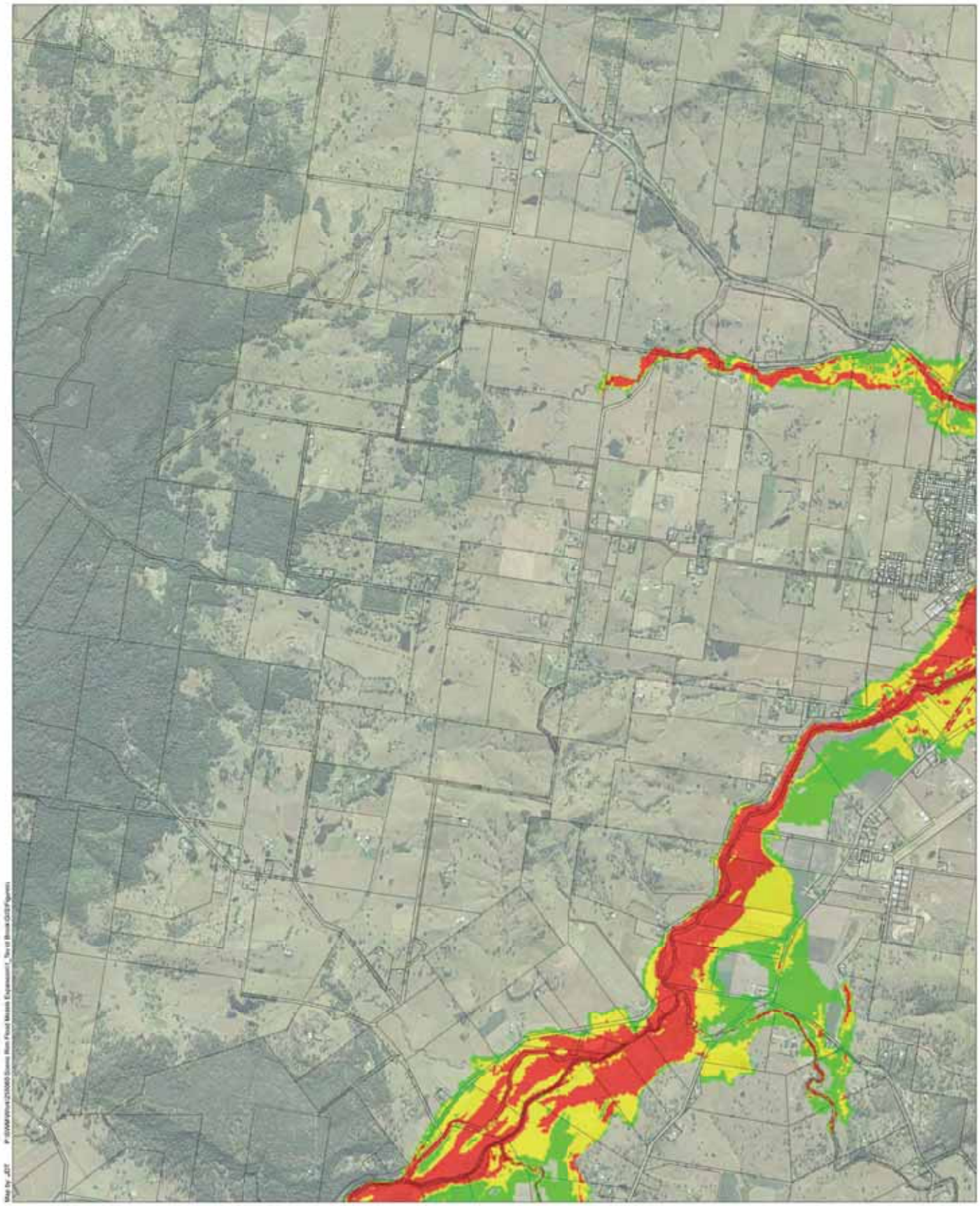
Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Teviot Brook Flood Study Figure C4-d

2% AEP Event - Peak Hazard Map

aurecon



Legend

SRRC Boundary

Cadastral Boundary

Low Hazard

Medium Hazard

High Hazard

Notes:

1:25,000

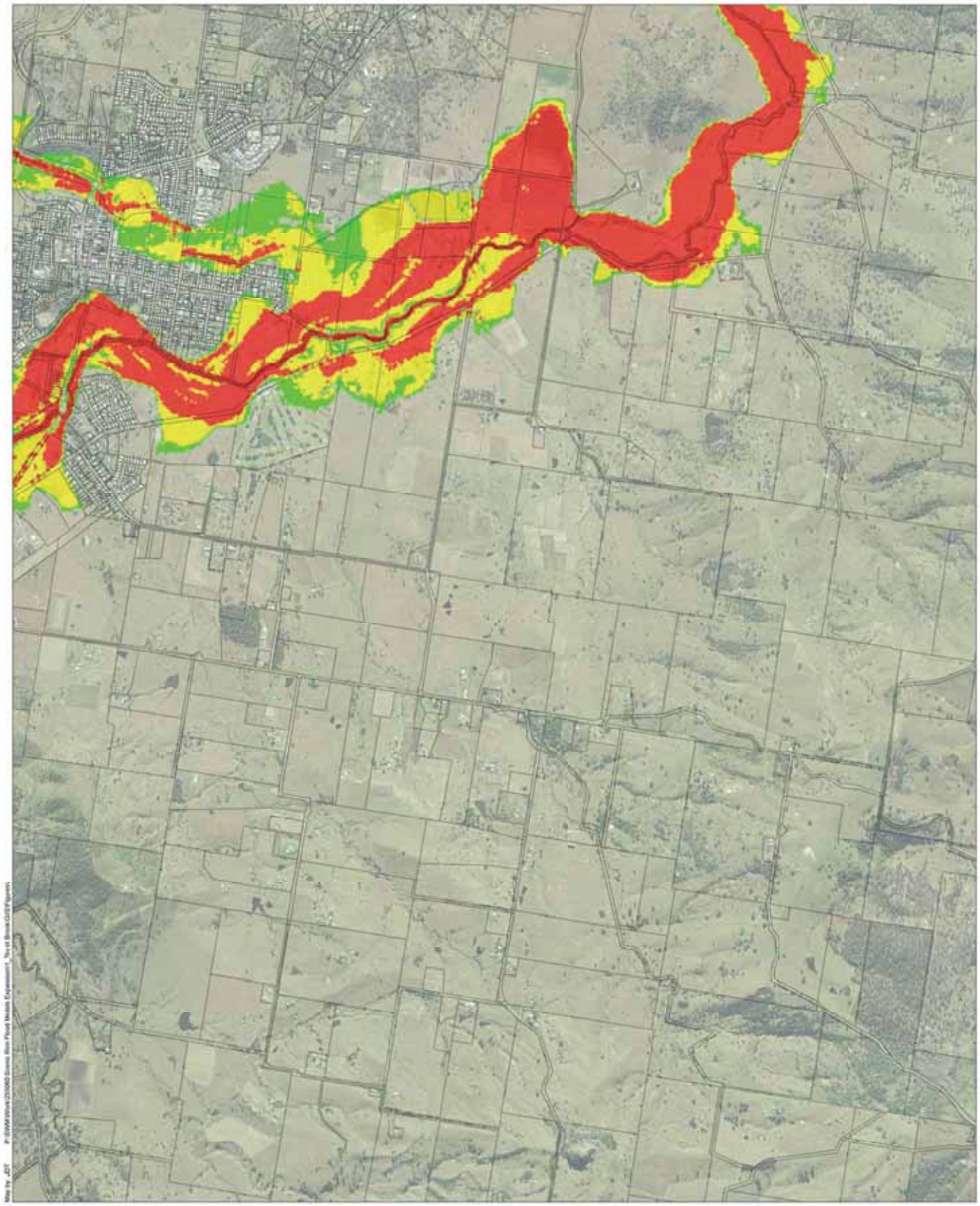
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Teviot Brook Flood Study Figure C4-e

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

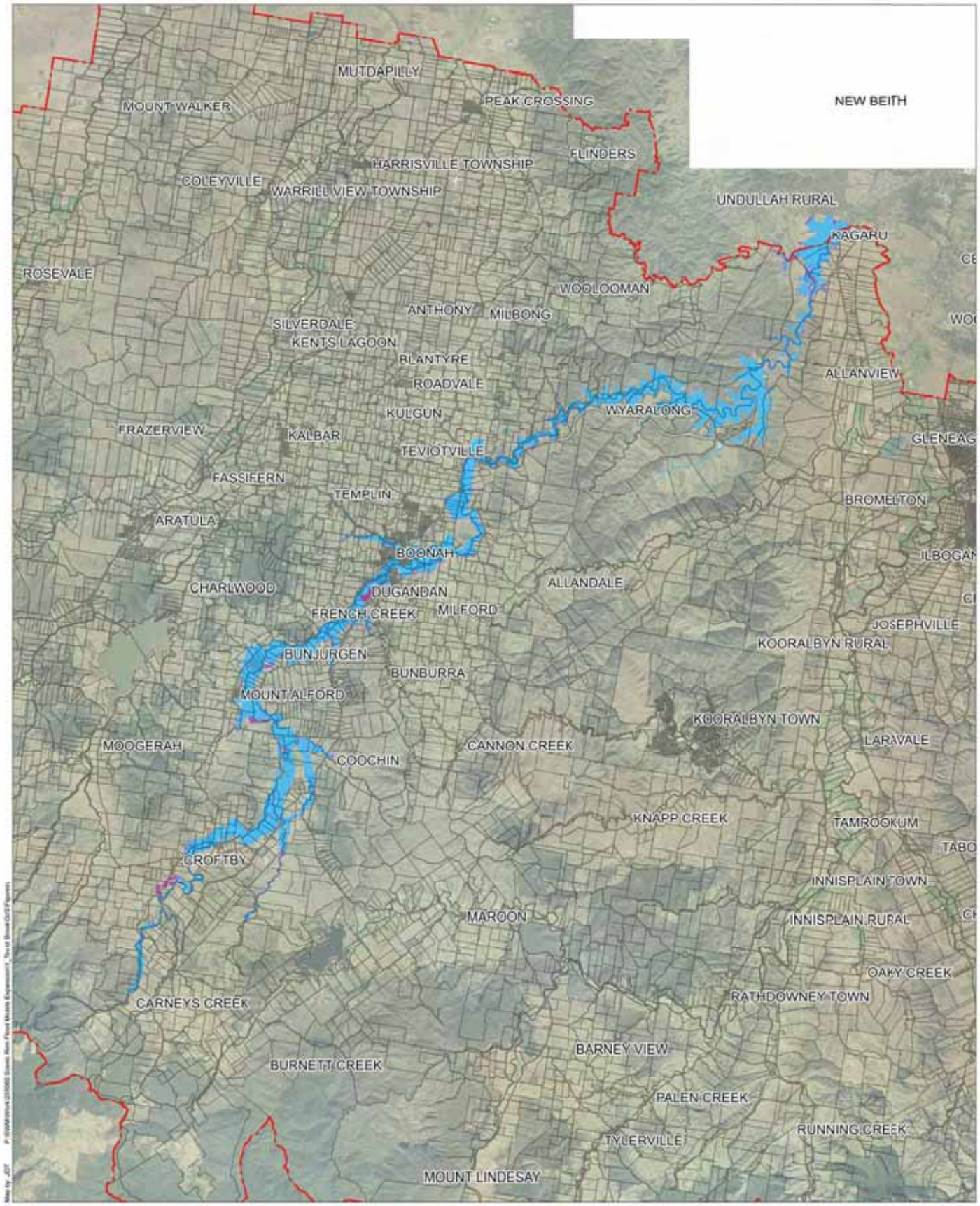
Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Teviot Brook Flood Study **Figure C4-f**

2% AEP Event - Peak Hazard Map

aurecon



Legend

SRRC Boundary

Inundation Extent

Cadastral Boundary

Climate Change Inundation Extent

1:100,000

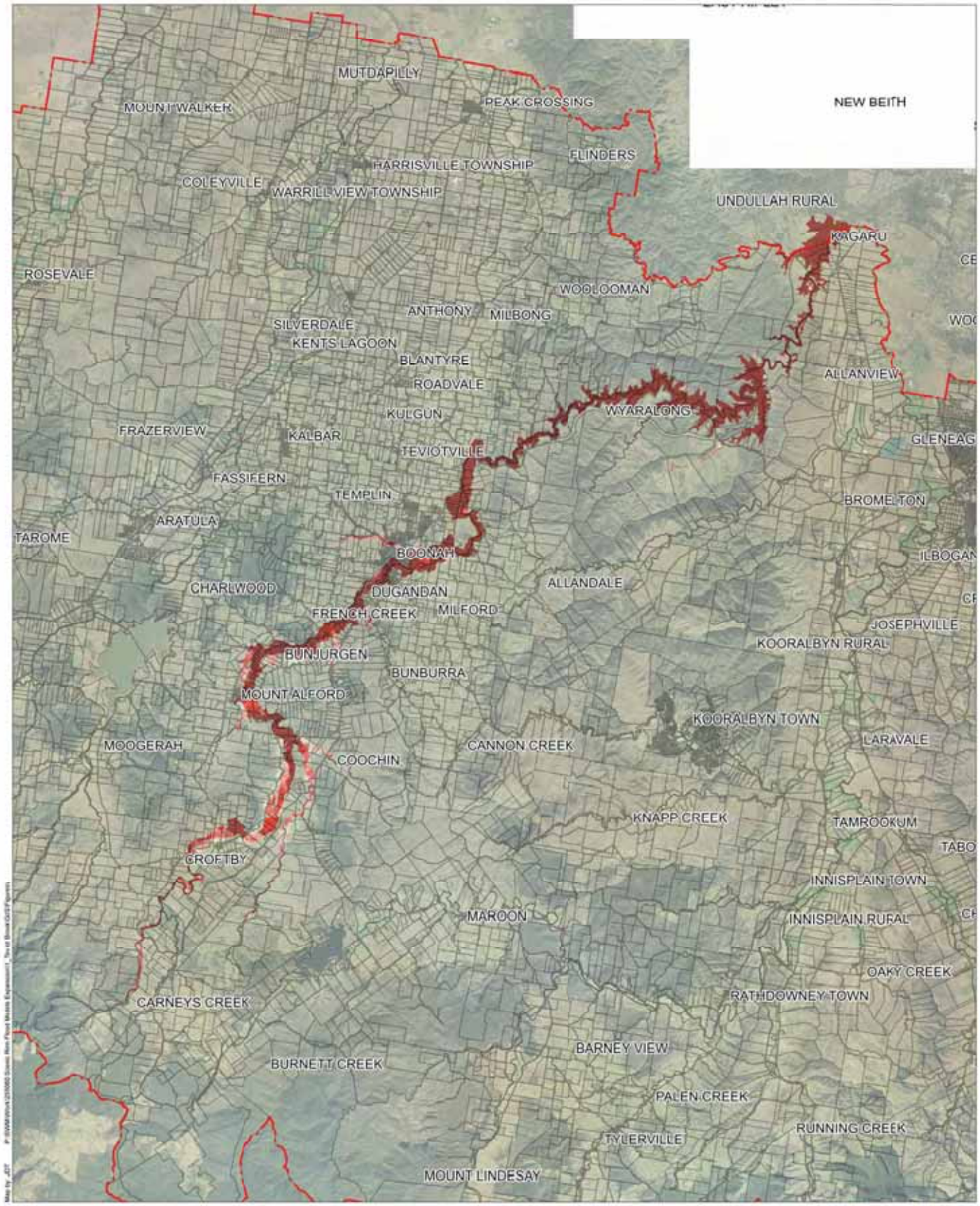
0 2,500 m 5,000 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

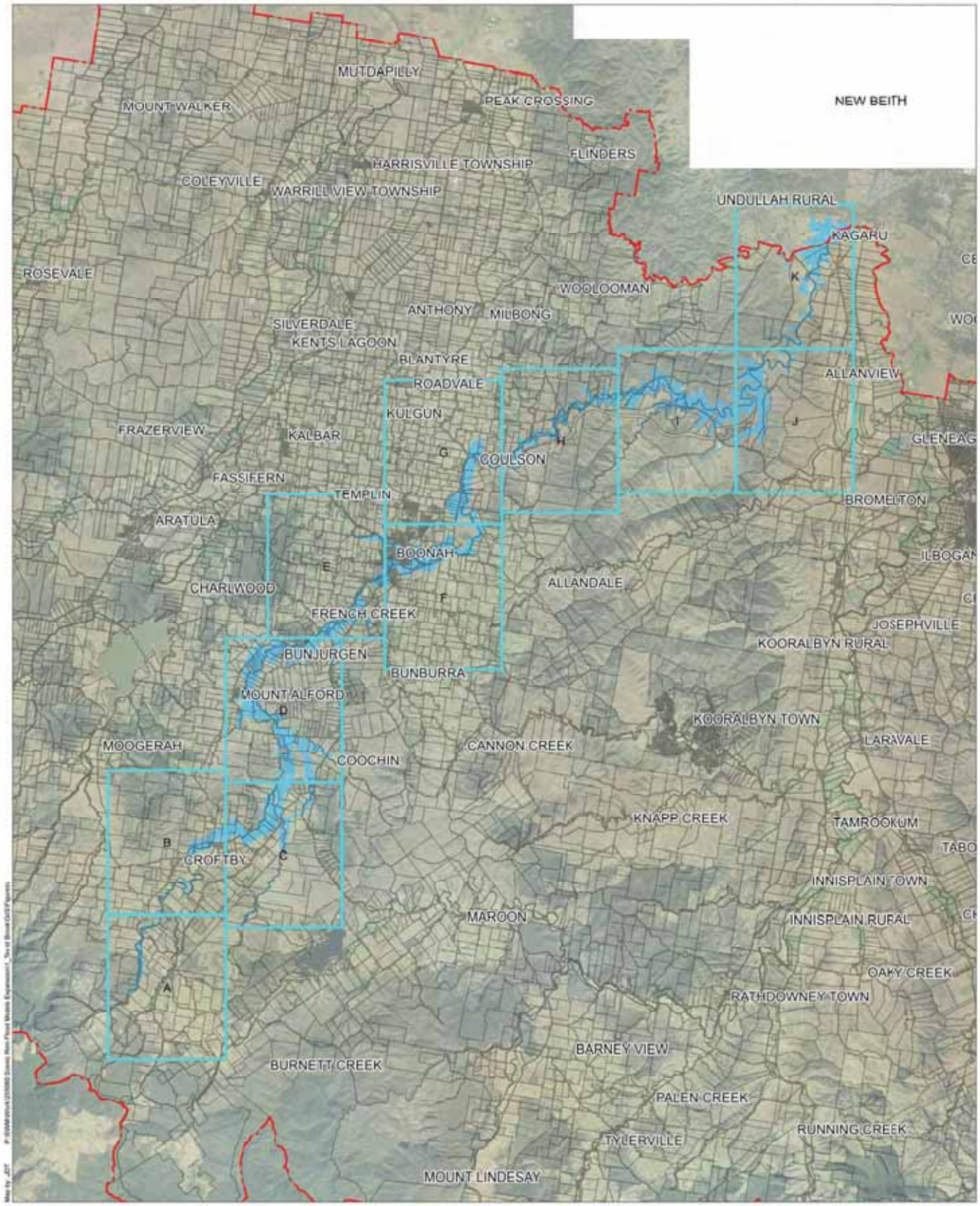
Teviot Brook Flood Study Figure C5 - a

2% AEP Event - Climate Change Inundation Extent



Teviot Brook Flood Study **Figure C5 - b**

Climate Change Scenario 4.5 - 2% AEP Event Afflux Map



Legend

SRRC Boundary

Cadastral Boundary

Inundation Extent

Peak Water level Contour (mAHD)

1:100,000

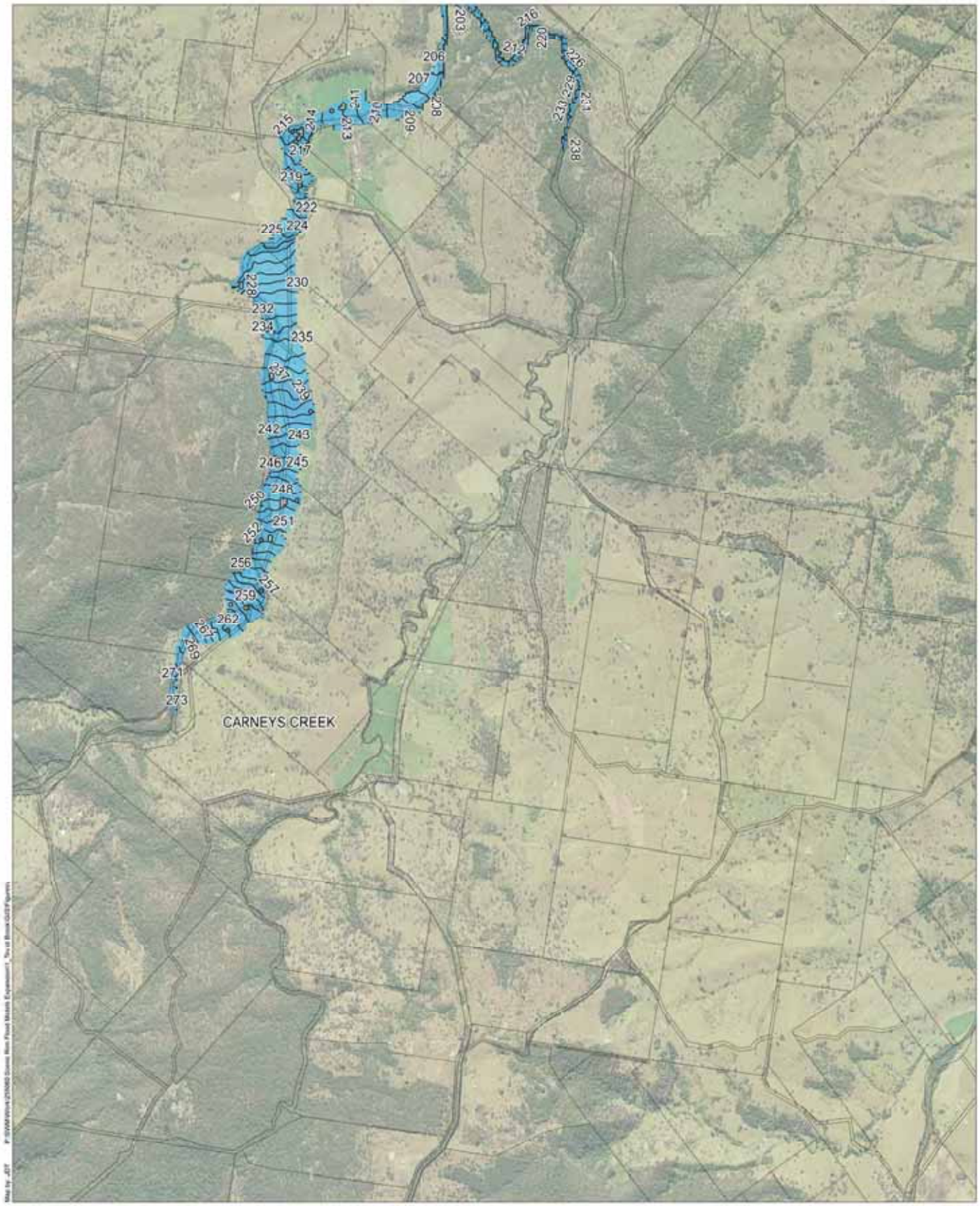
0 2,500 m 5,000 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

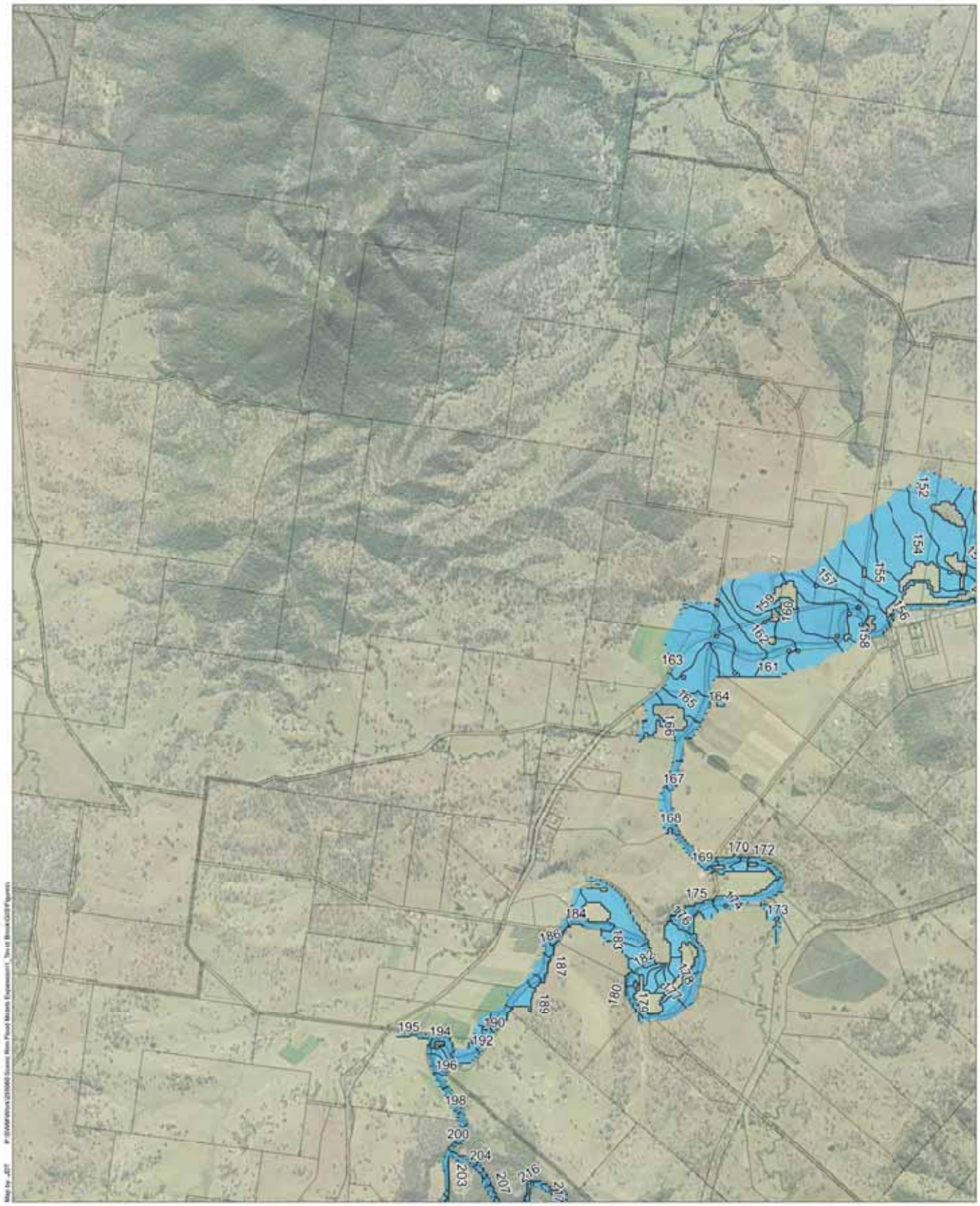
Teviot Brook Flood Study **Figure D1**

5% AEP Event - Inundation Extent



Teviot Brook Flood Study **Figure D1-a**

5% AEP Event - Inundation Extent



Legend

SRRC Boundary

Cadastral Boundary

Inundation Extent

Peak Water level Contour (mAHD)

Notes:

1:25,000

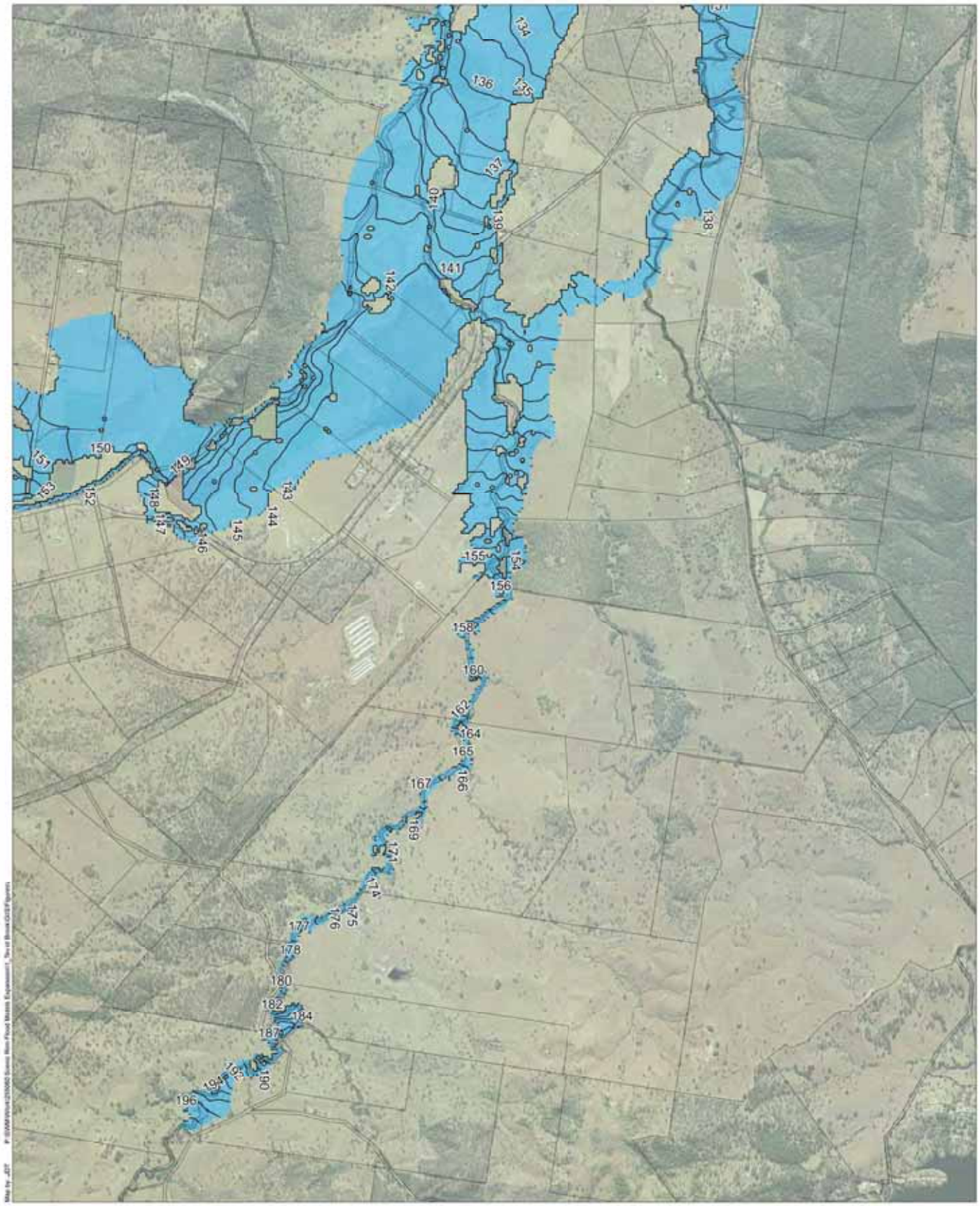
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Teviot Brook Flood Study **Figure D1-b**

5% 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

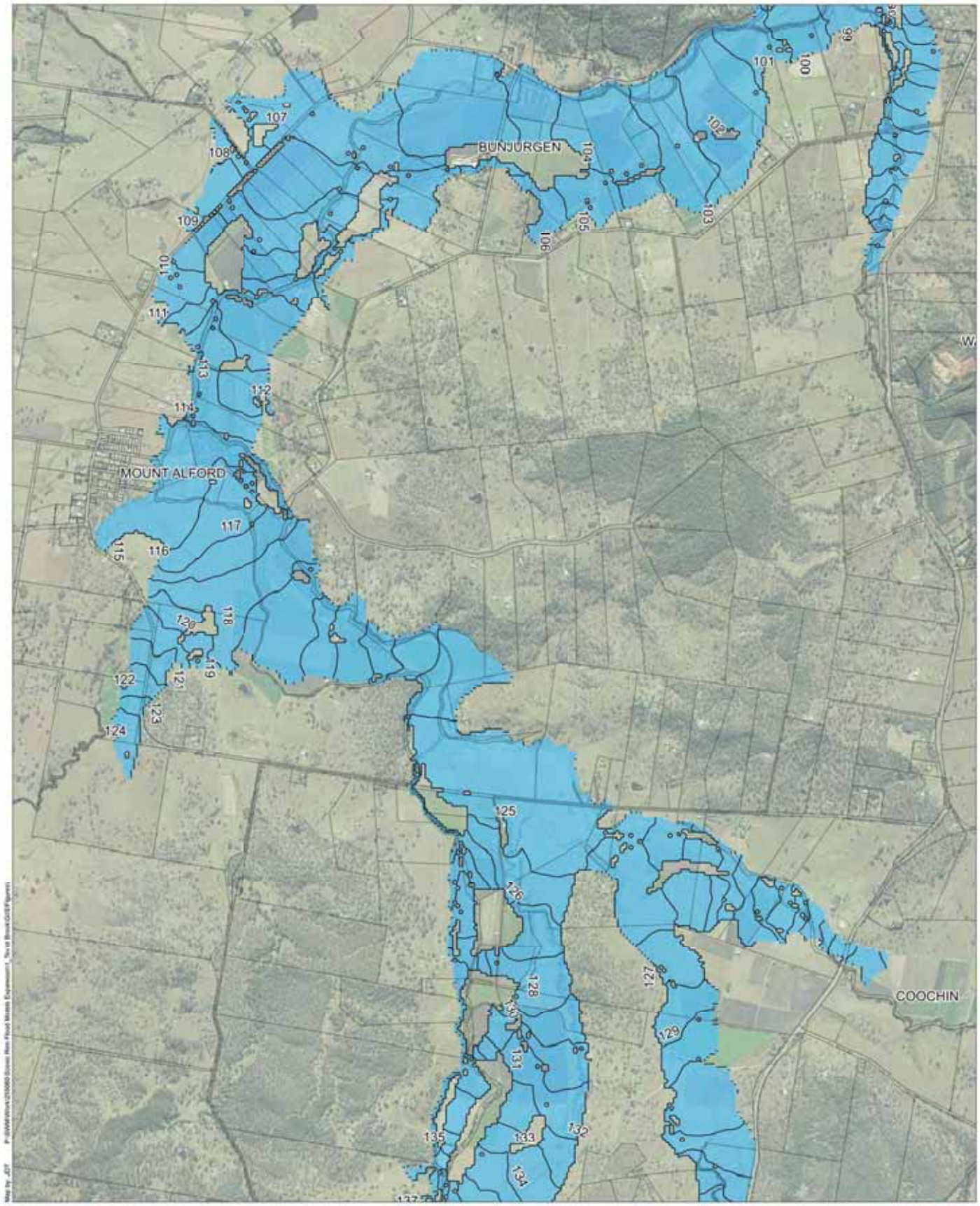
Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Teviot Brook Flood Study **Figure D1-c**

5% AEP Event - Inundation Extent

aurecon



Legend

SRRC Boundary

Cadastral Boundary

Inundation Extent

Peak Water level Contour (mAHD)

1:25,000

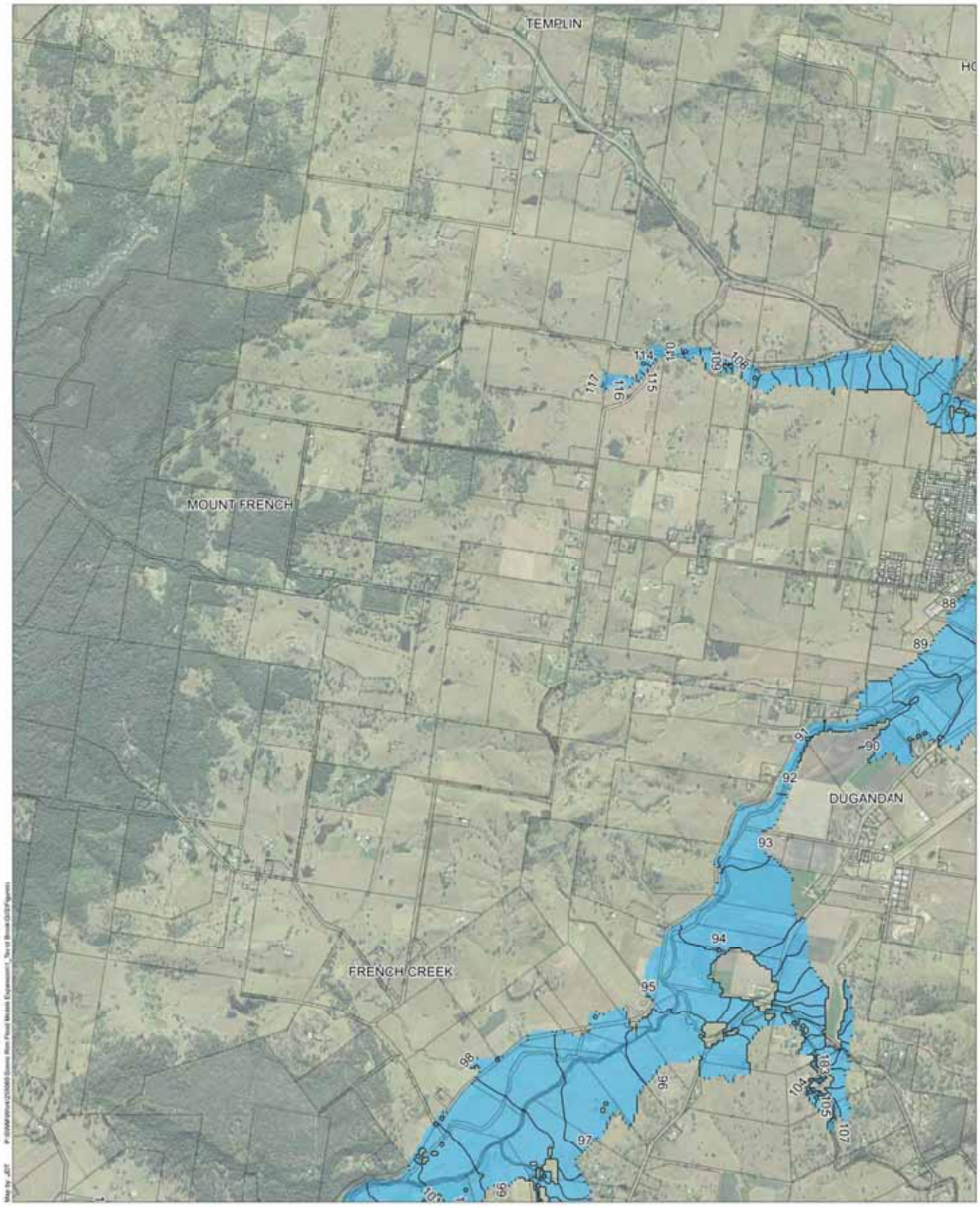
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

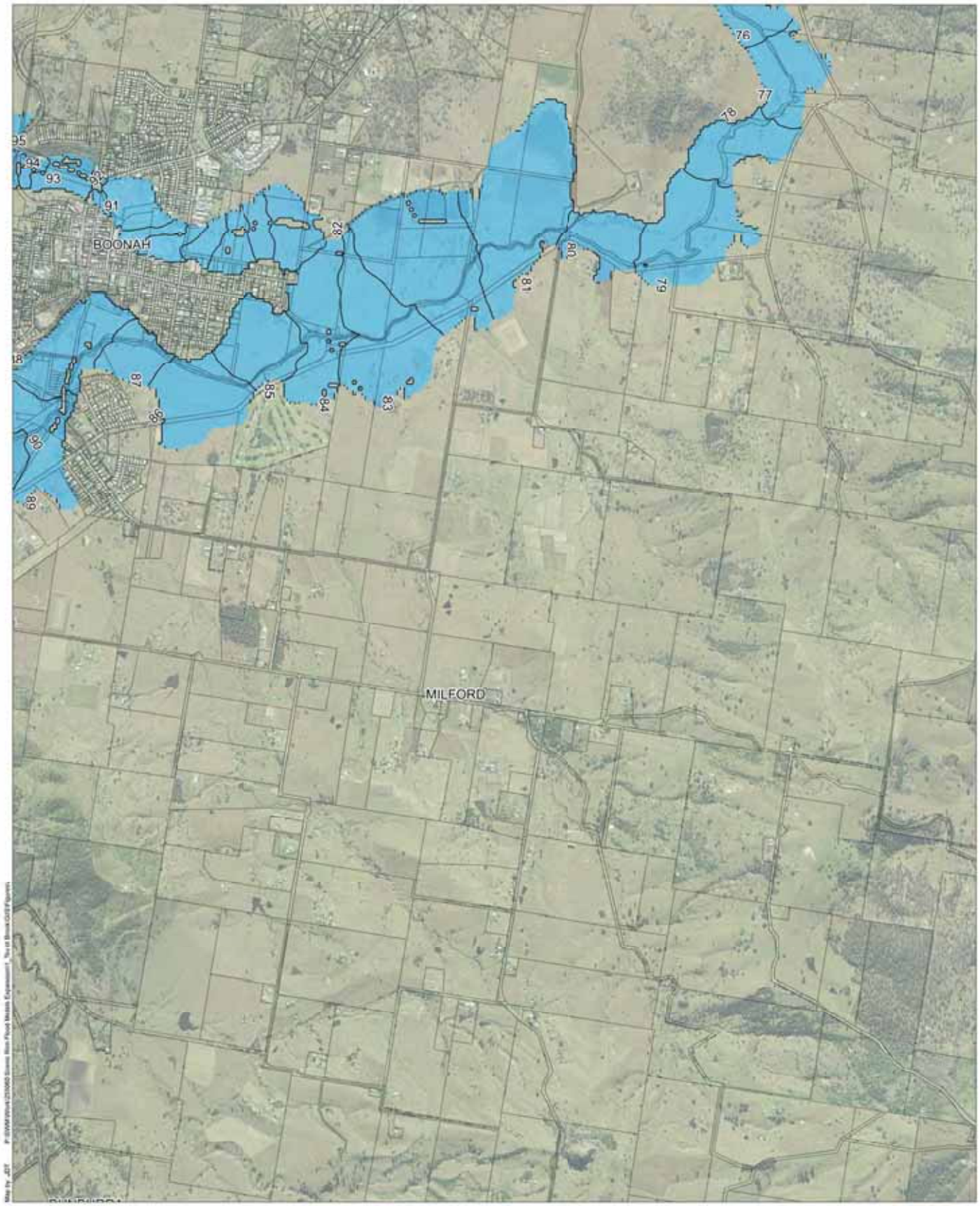
Teviot Brook Flood Study **Figure D1-d**

5% AEP Event - Inundation Extent



Teviot Brook Flood Study **Figure D1-e**

5% AEP Event - Inundation Extent



Legend

SRRC Boundary

Cadastral Boundary

Inundation Extent

Peak Water level Contour (mAHD)

Notes:

1:25,000

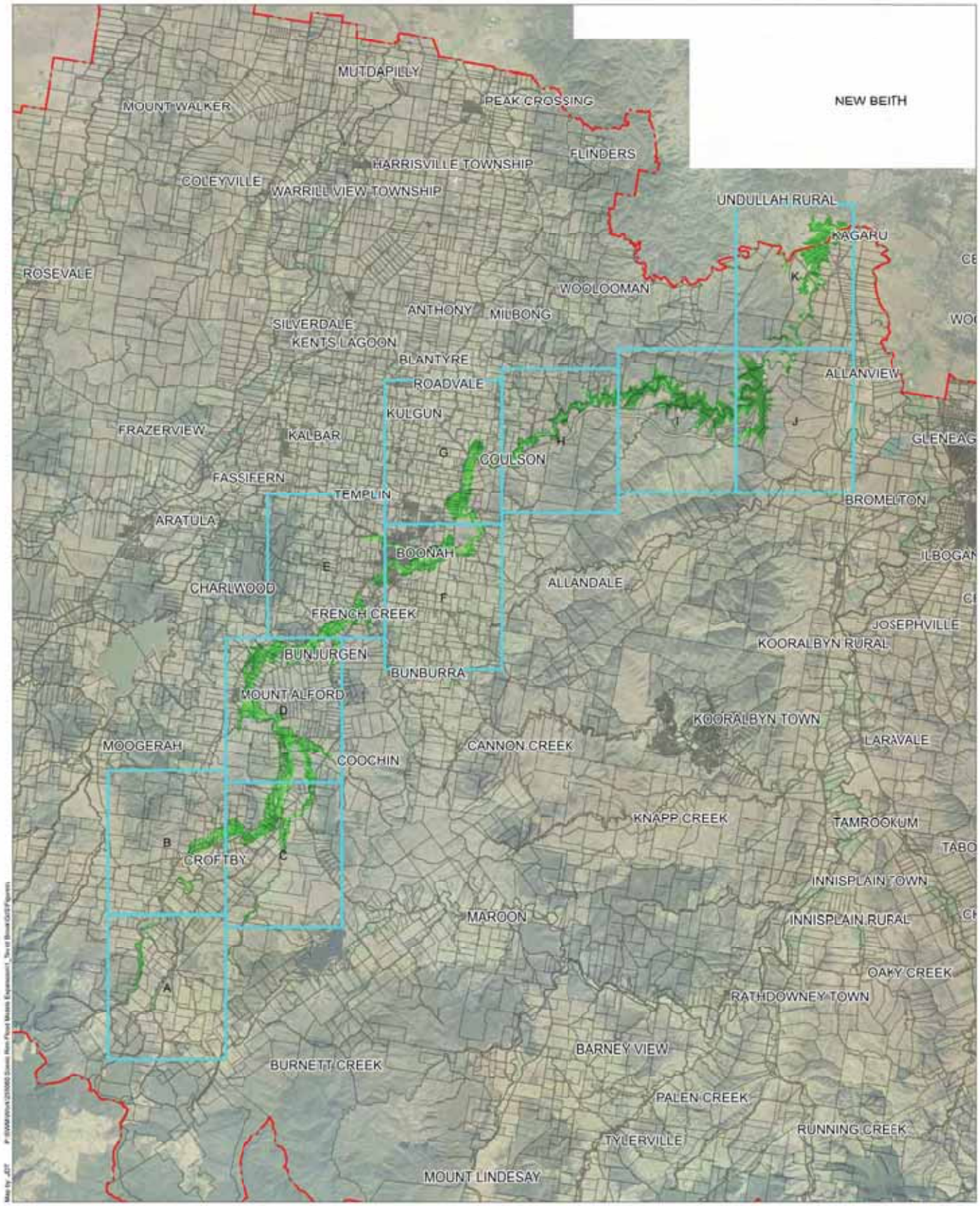
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Teviot Brook Flood Study Figure D1-f

5% AEP Event - Inundation Extent



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:

1:100,000

0 2,500 m 5,000 m

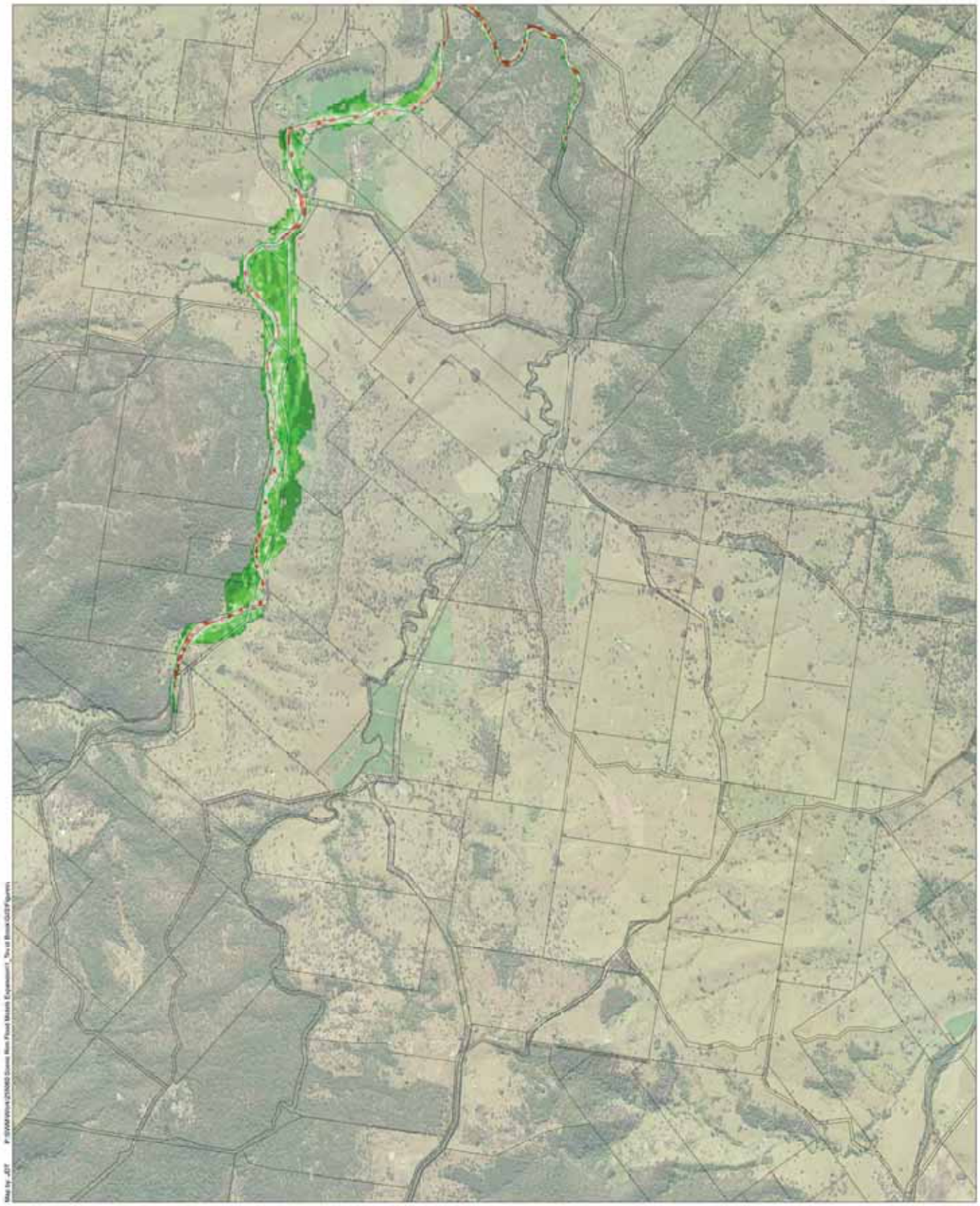
Date: 24/10/2017 Version: 0 Job No: 235080

Projection: MGA Zone 56

Teviot Brook Flood Study Figure D2

5% AEP Event - Peak Velocities

aurecon



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

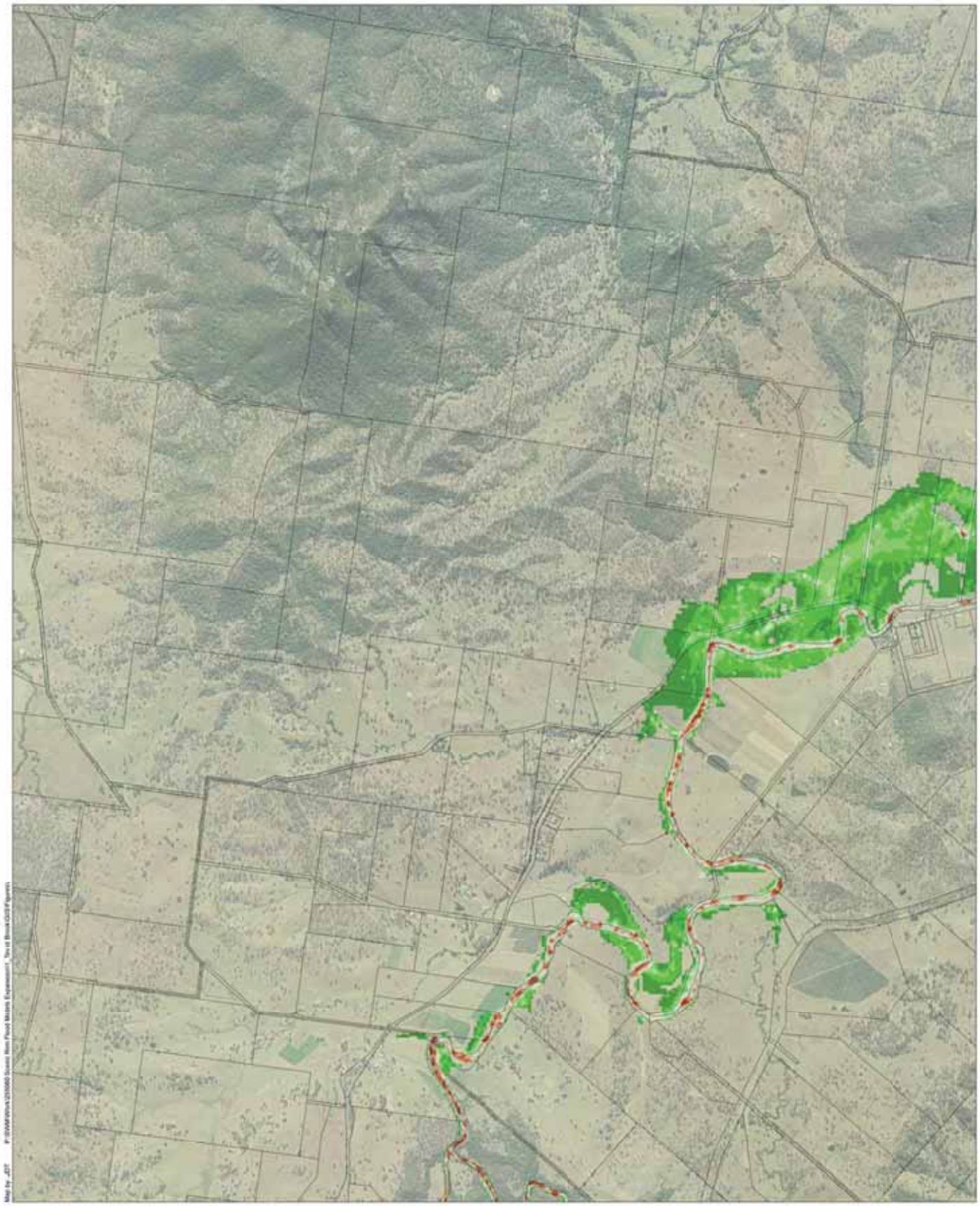
Date: 24/10/2017 Version: 0 Job No: 235080

Projection: MGA Zone 56

Teviot Brook Flood Study Figure D2-a

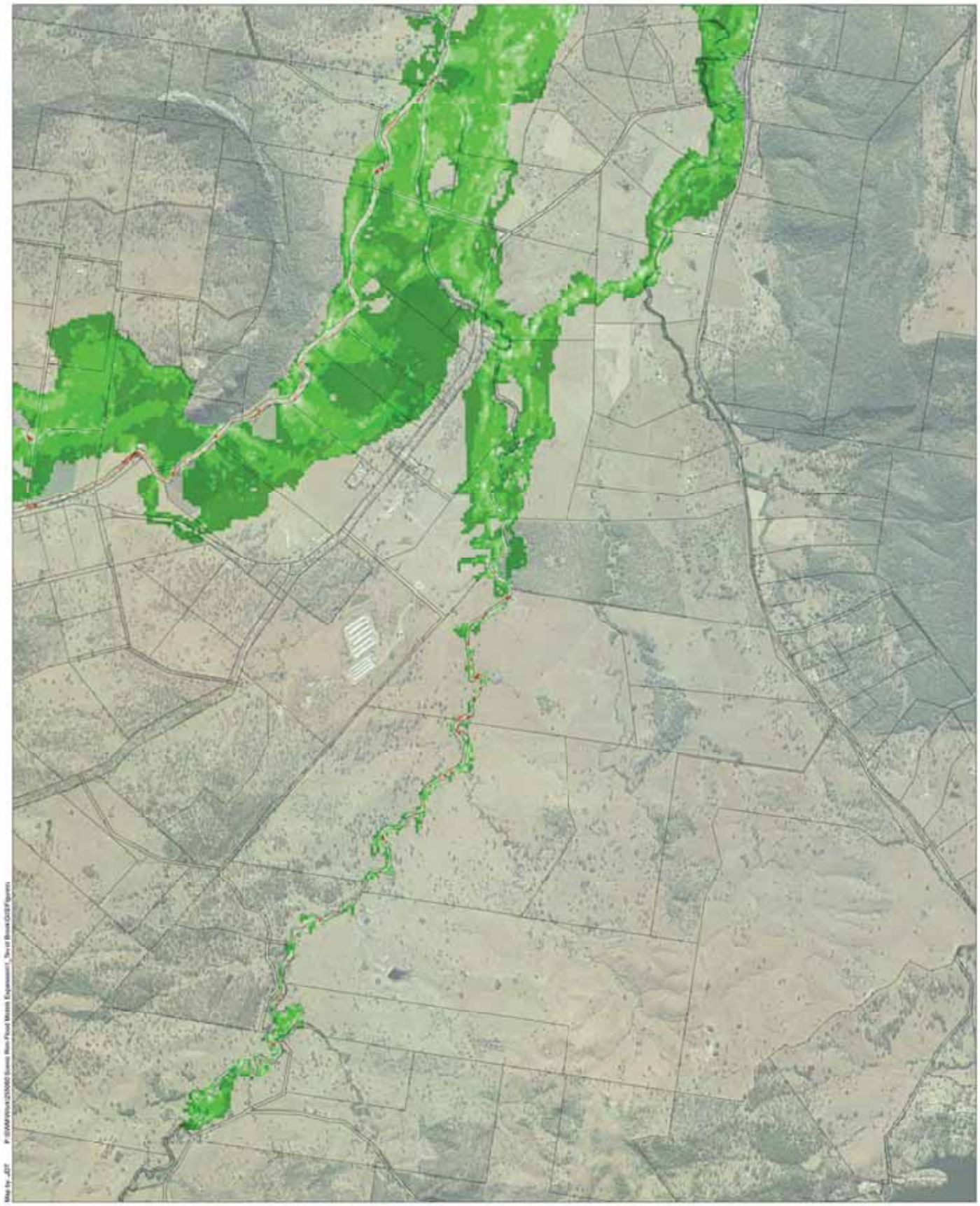
5% AEP Event - Peak Velocities

aurecon



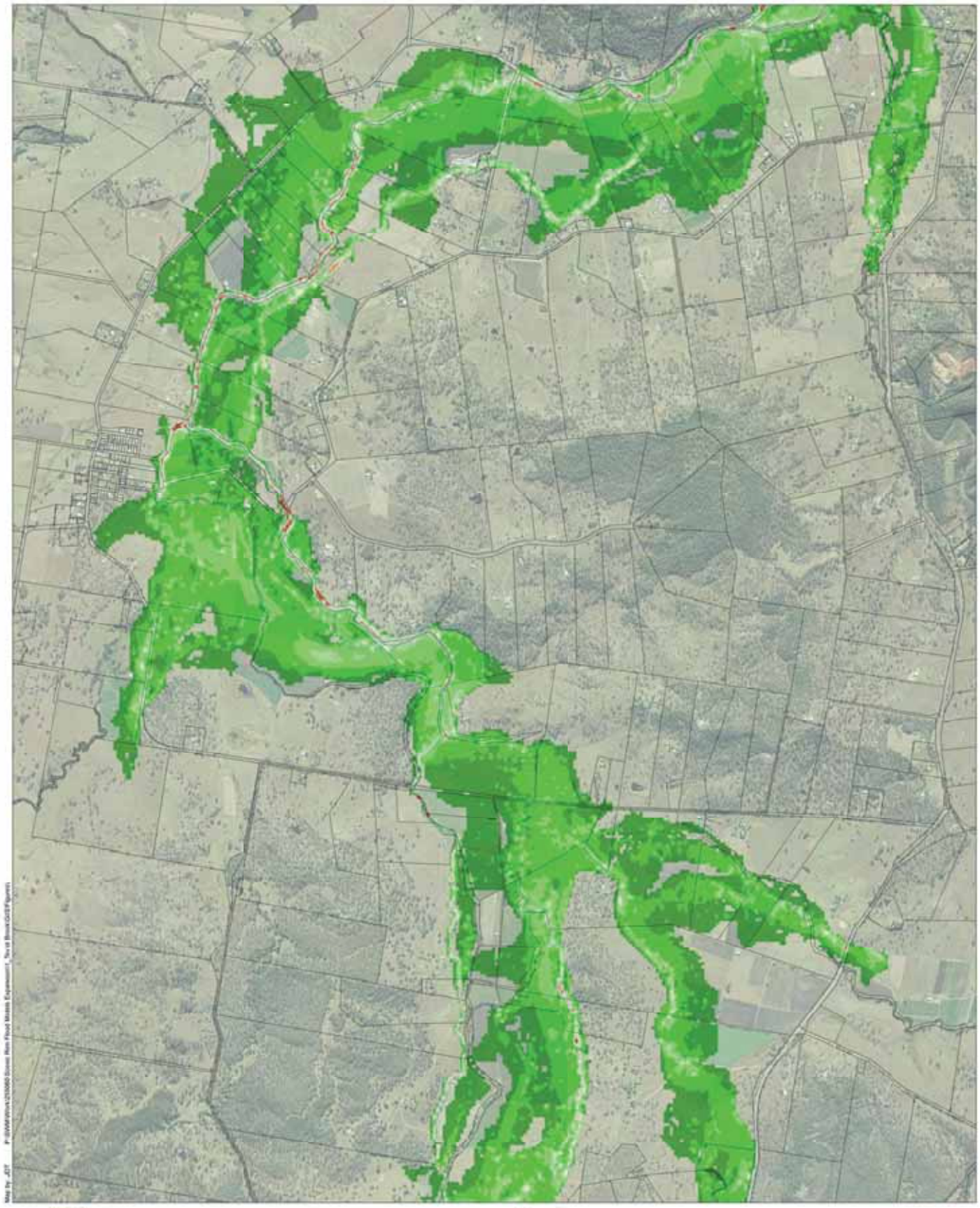
Teviot Brook Flood Study **Figure D2-b**

5% AEP Event - Peak Velocities



Teviot Brook Flood Study **Figure D2-c**

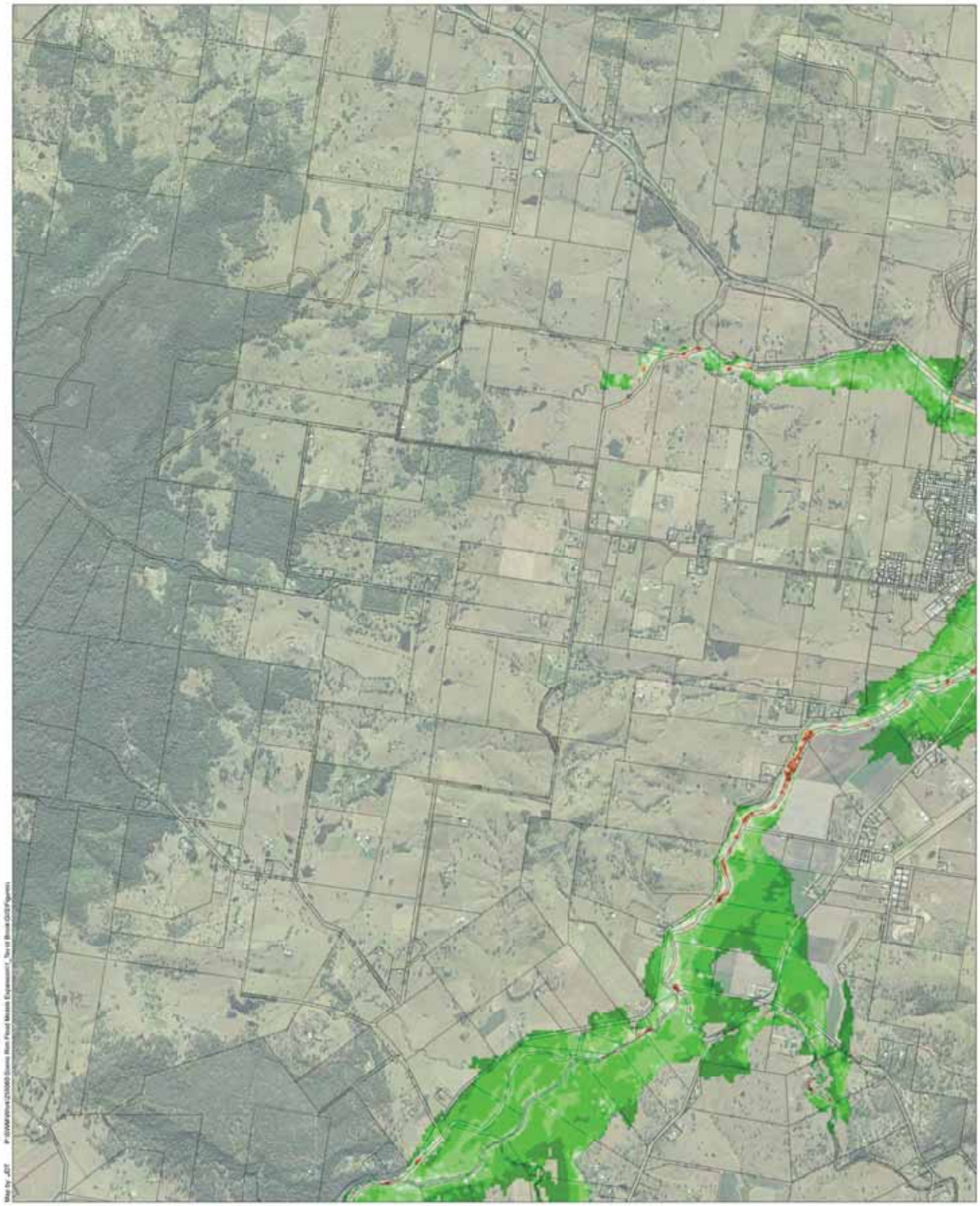
5% AEP Event - Peak Velocities



Teviot Brook Flood Study **Figure D2-d**

5% AEP Event - Peak Velocities

aurecon



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

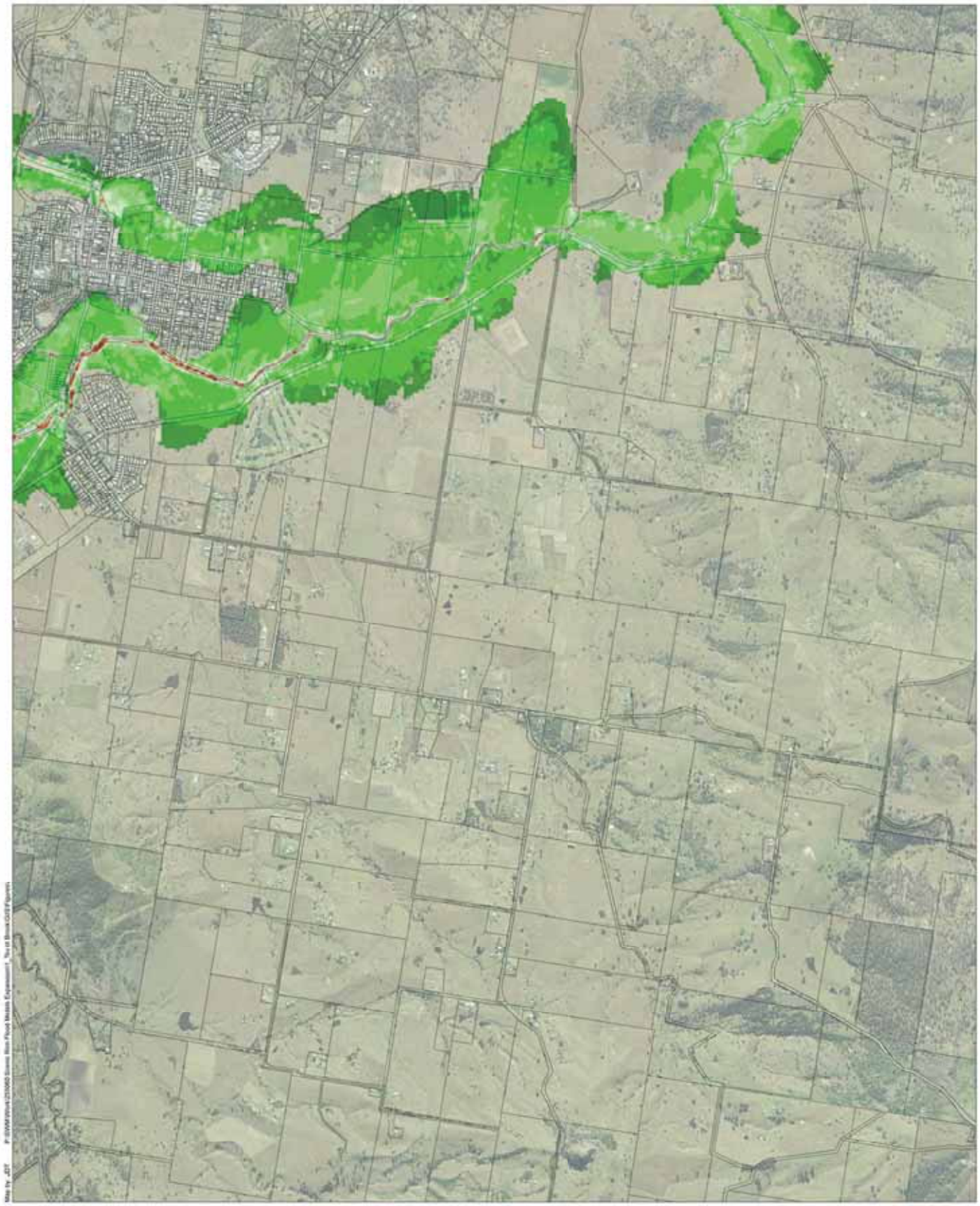
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

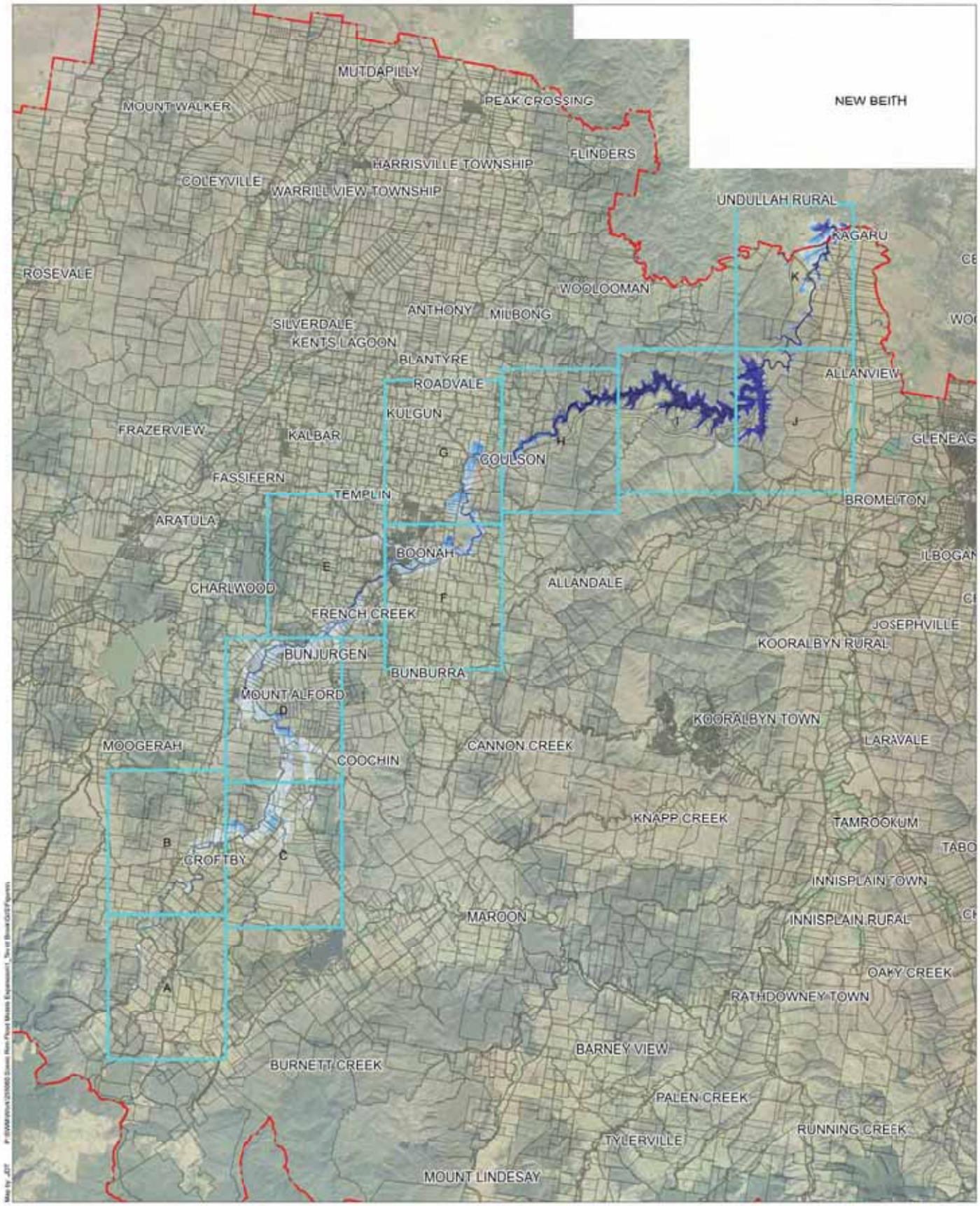
Teviot Brook Flood Study Figure D2-e

5% AEP Event - Peak Velocities



Teviot Brook Flood Study **Figure D2-f**

5% AEP Event - Peak Velocities



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:

1:100,000

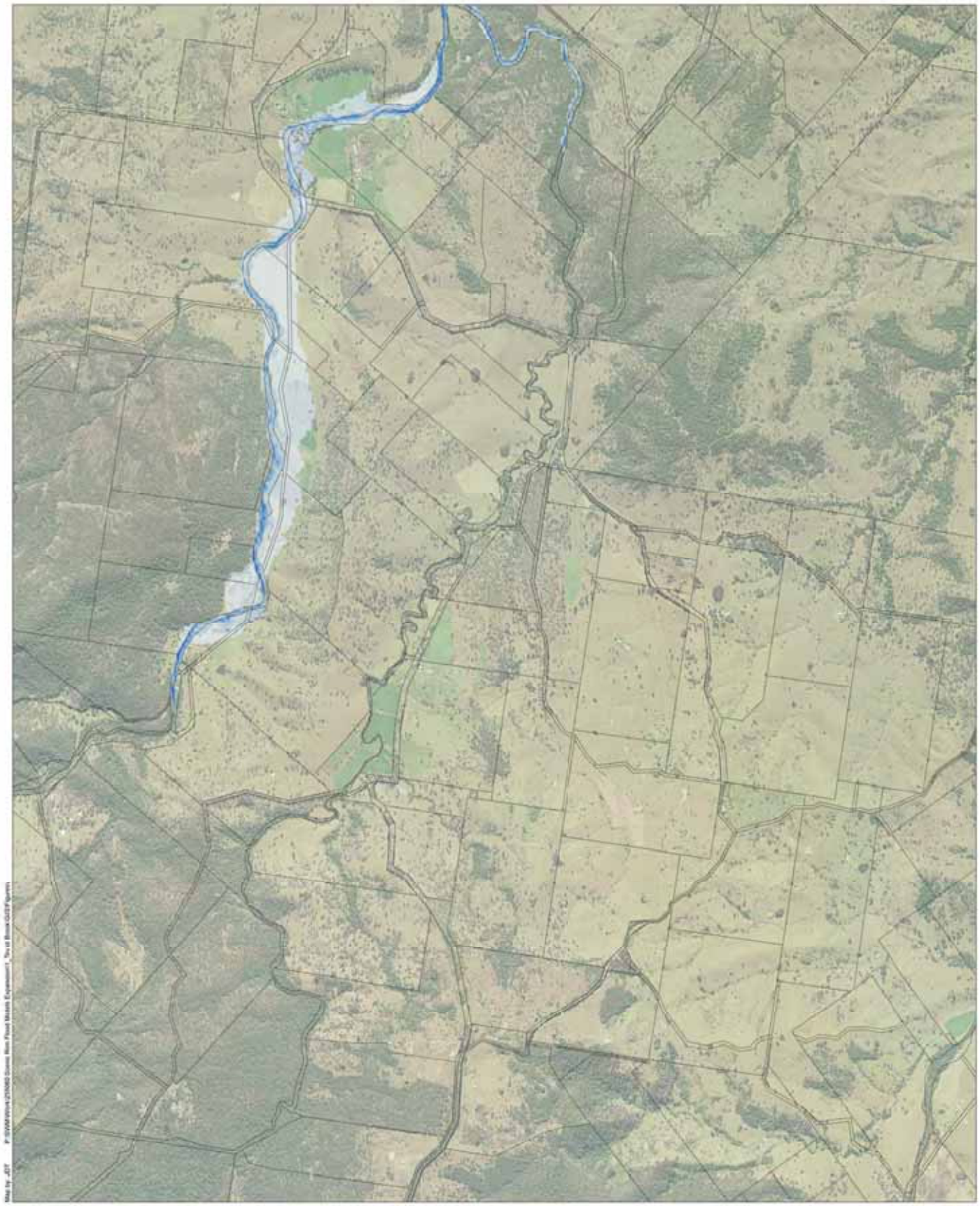
0 2,500 m 5,000 m

Date: 24/10/2017 Version: 0 Job No: 235060

Projection: MGA Zone 56

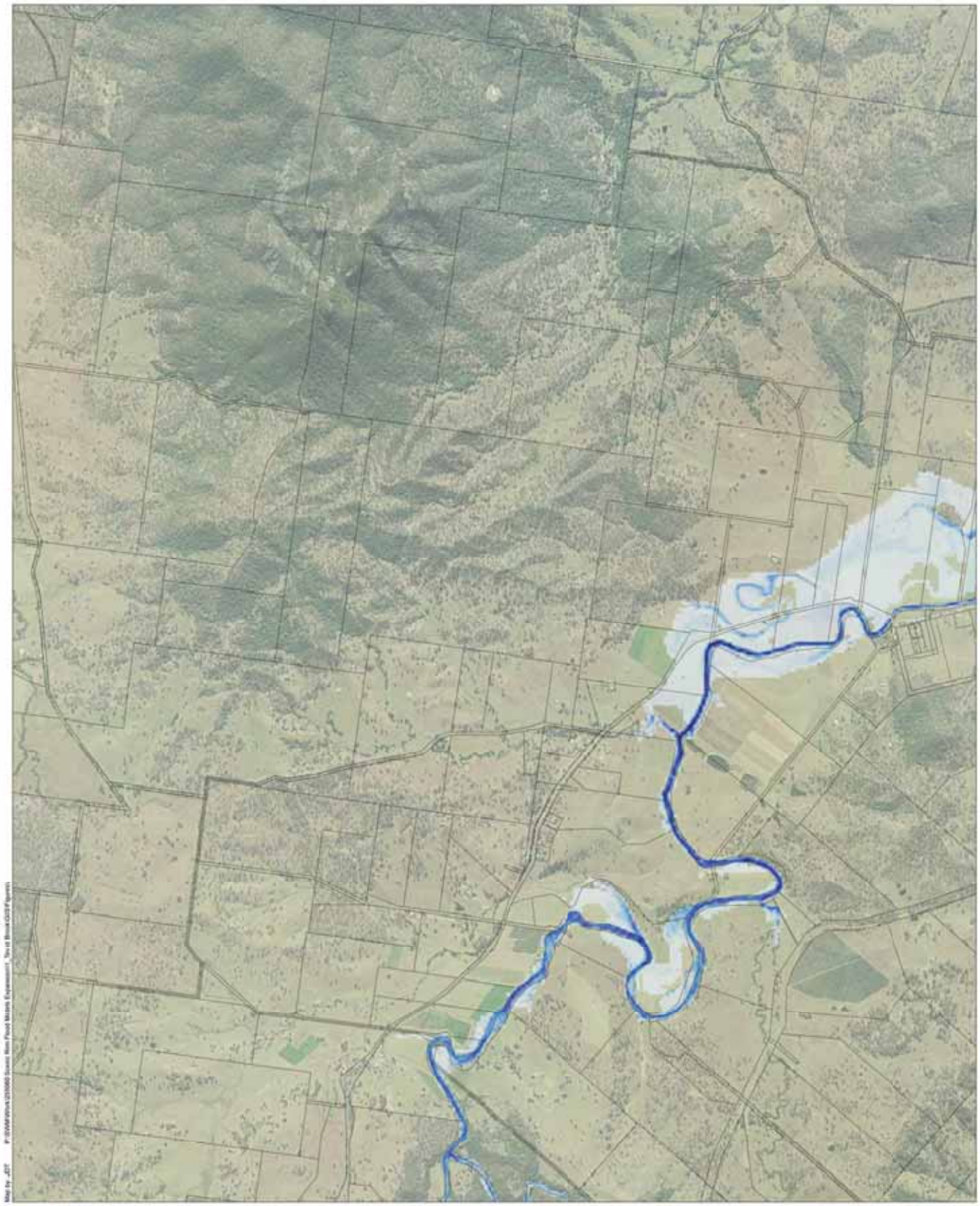
Teviot Brook Flood Study Figure D3

5% AEP Event - Peak Depth Map



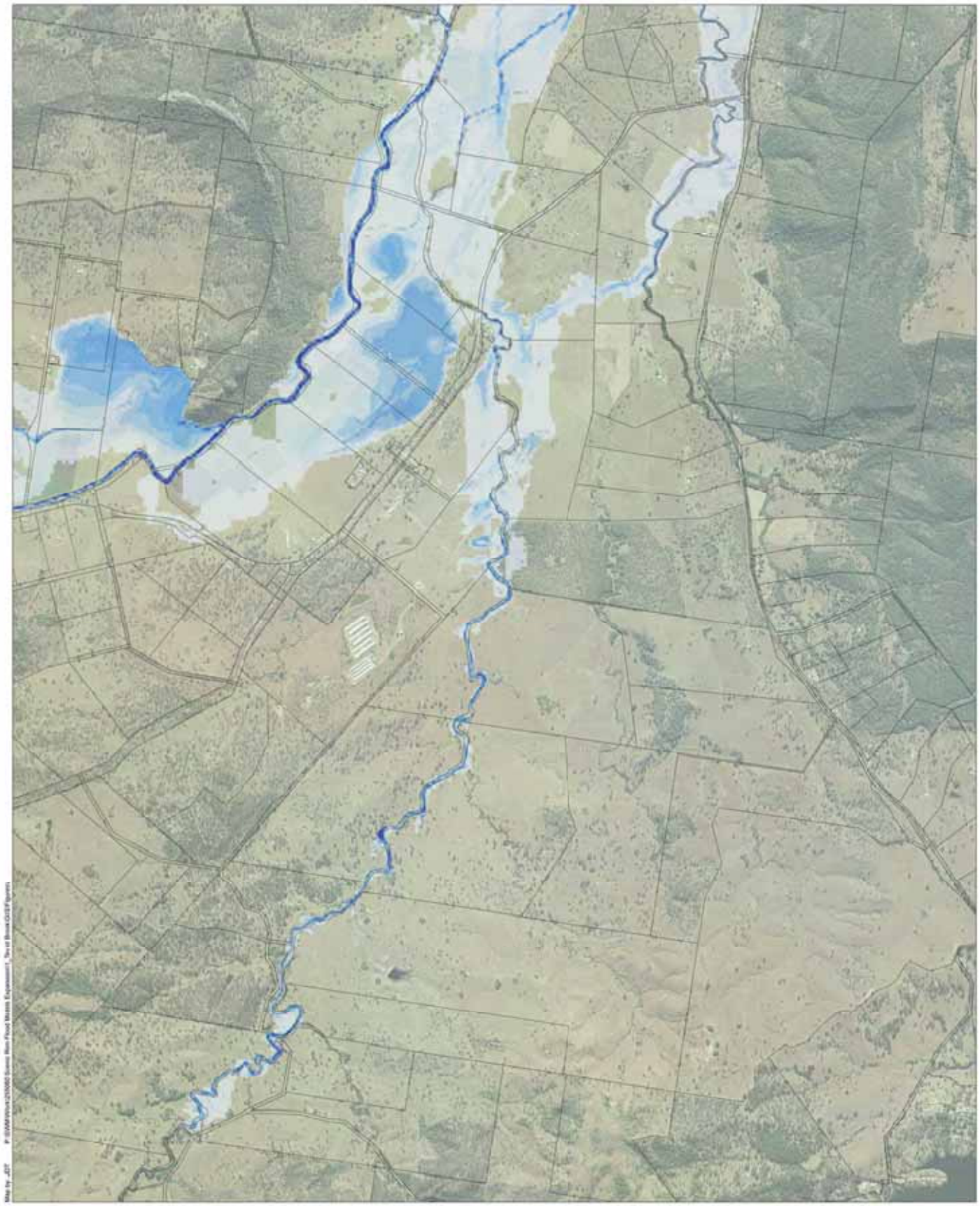
Teviot Brook Flood Study **Figure D3-a**

5% AEP Event - Peak Depth Map



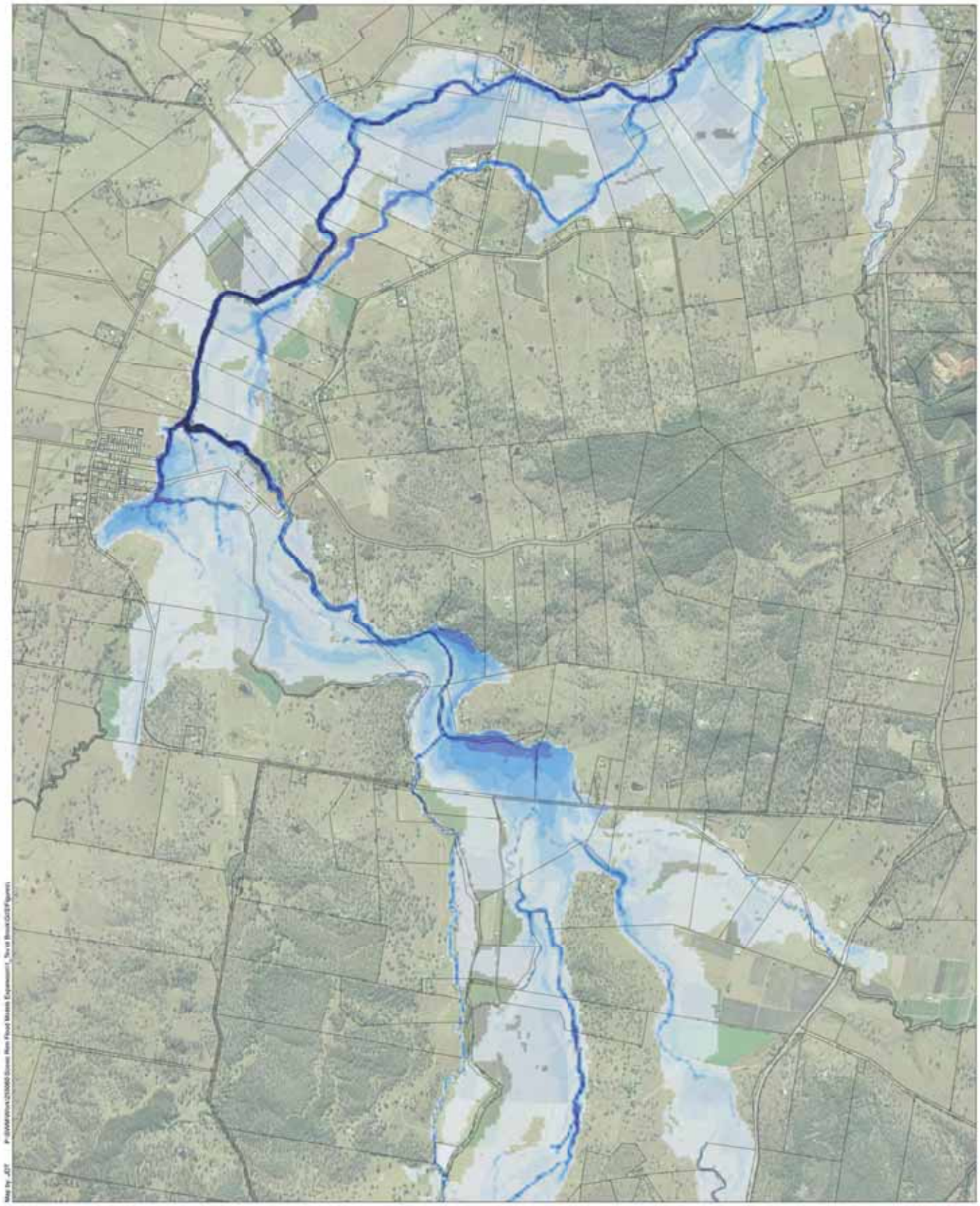
Teviot Brook Flood Study **Figure D3-b**

5% AEP Event - Peak Depth Map



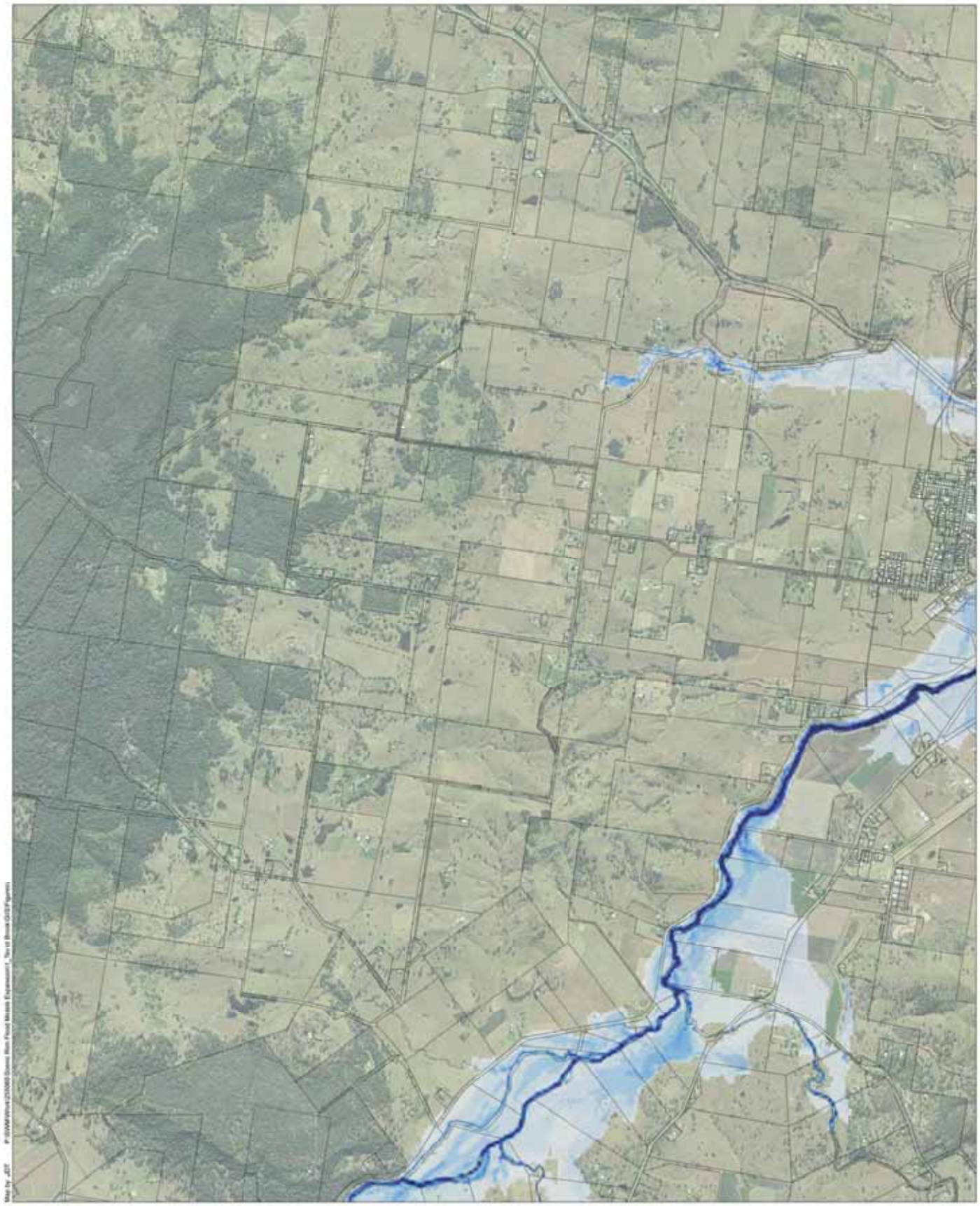
Teviot Brook Flood Study **Figure D3-c**

5% AEP Event - Peak Depth Map



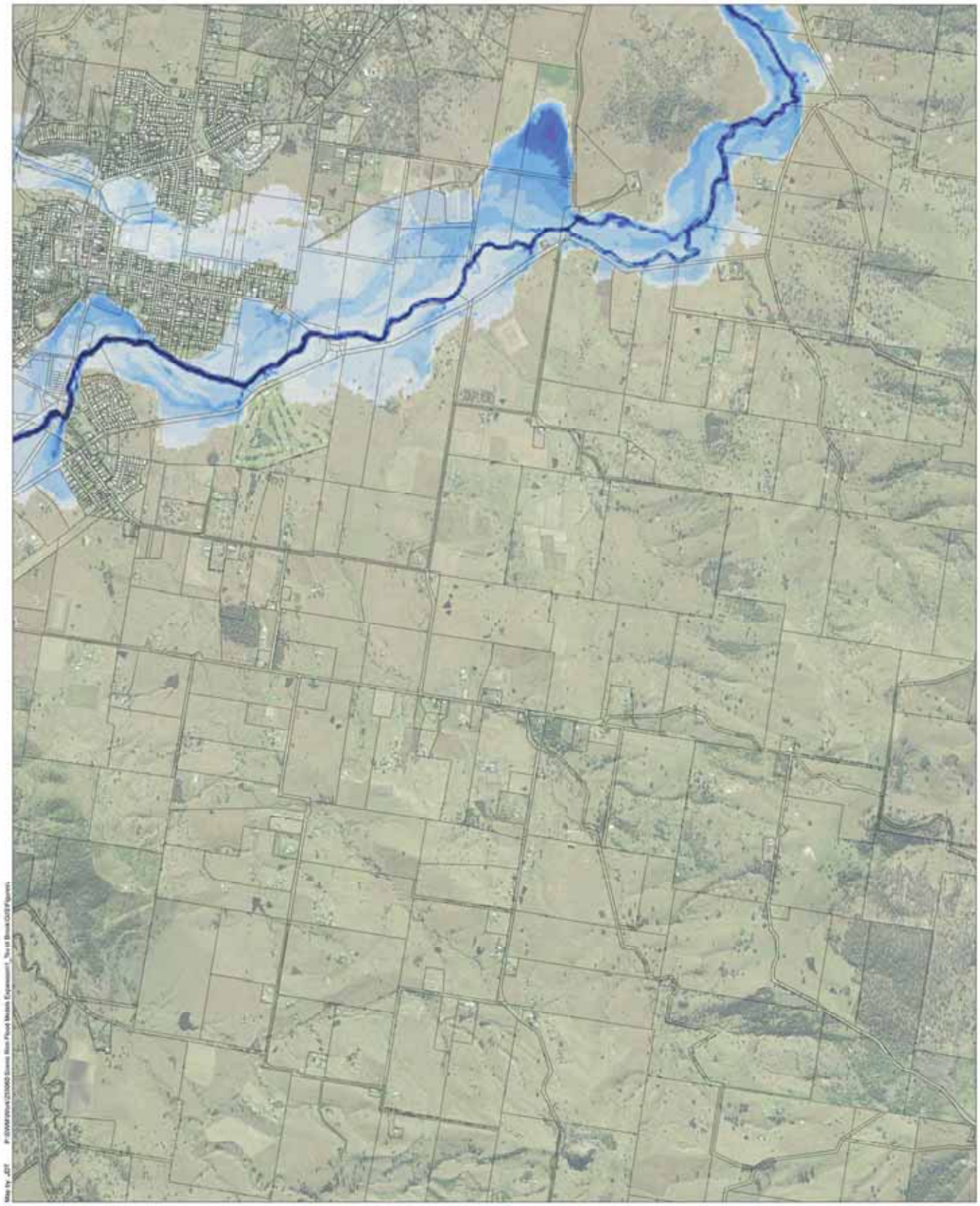
Teviot Brook Flood Study **Figure D3-d**

5% AEP Event - Peak Depth Map



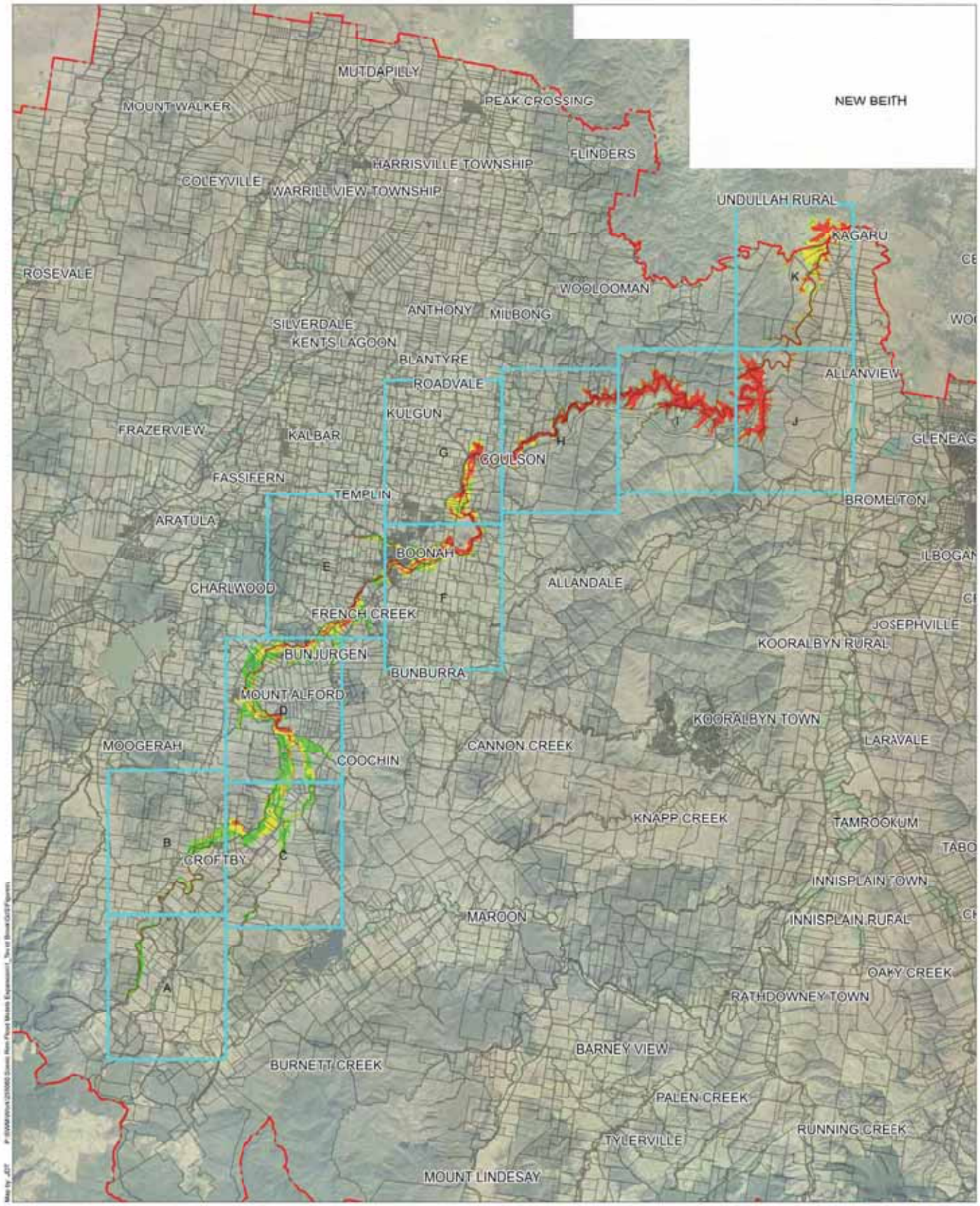
Teviot Brook Flood Study **Figure D3-e**

5% AEP Event - Peak Depth Map



Teviot Brook Flood Study **Figure D3-f**

5% AEP Event - Peak Depth Map



1:100,000

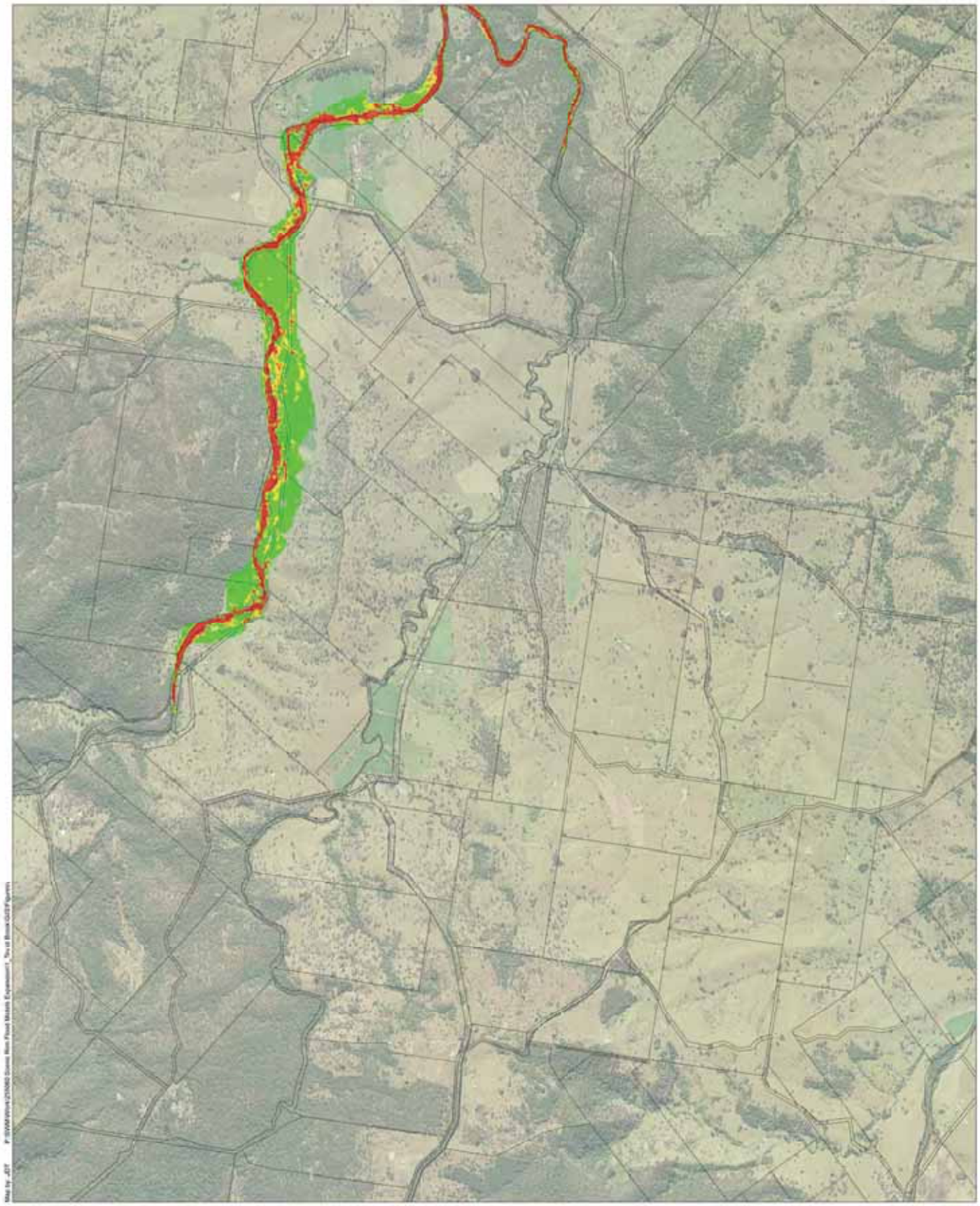
0 2,500 m 5,000 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Teviot Brook Flood Study **Figure D4**

5% AEP Event - Peak Hazard Map

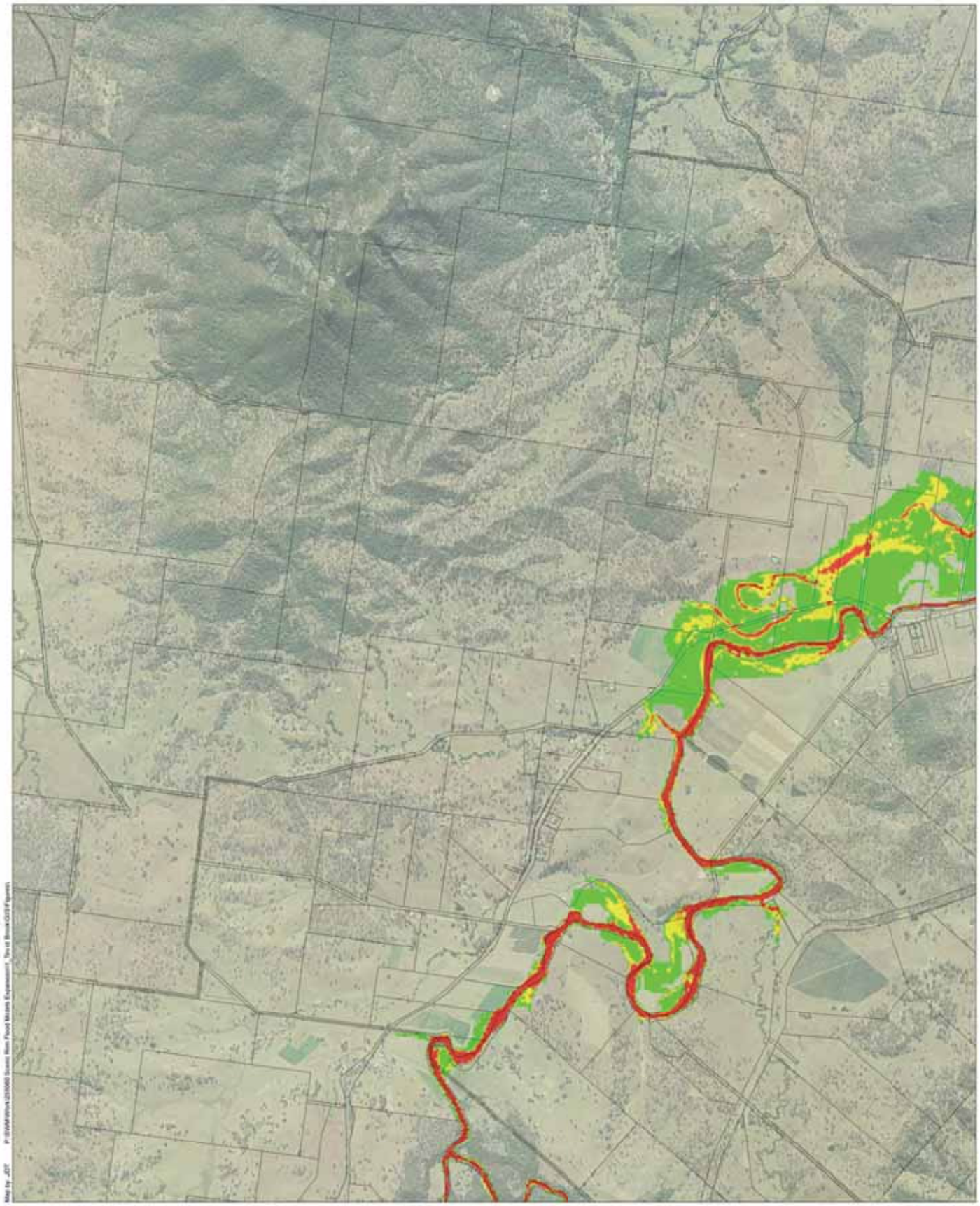


1:25,000
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060
Projection: MGA Zone 56

Teviot Brook Flood Study Figure D4-a

5% AEP Event - Peak Hazard Map



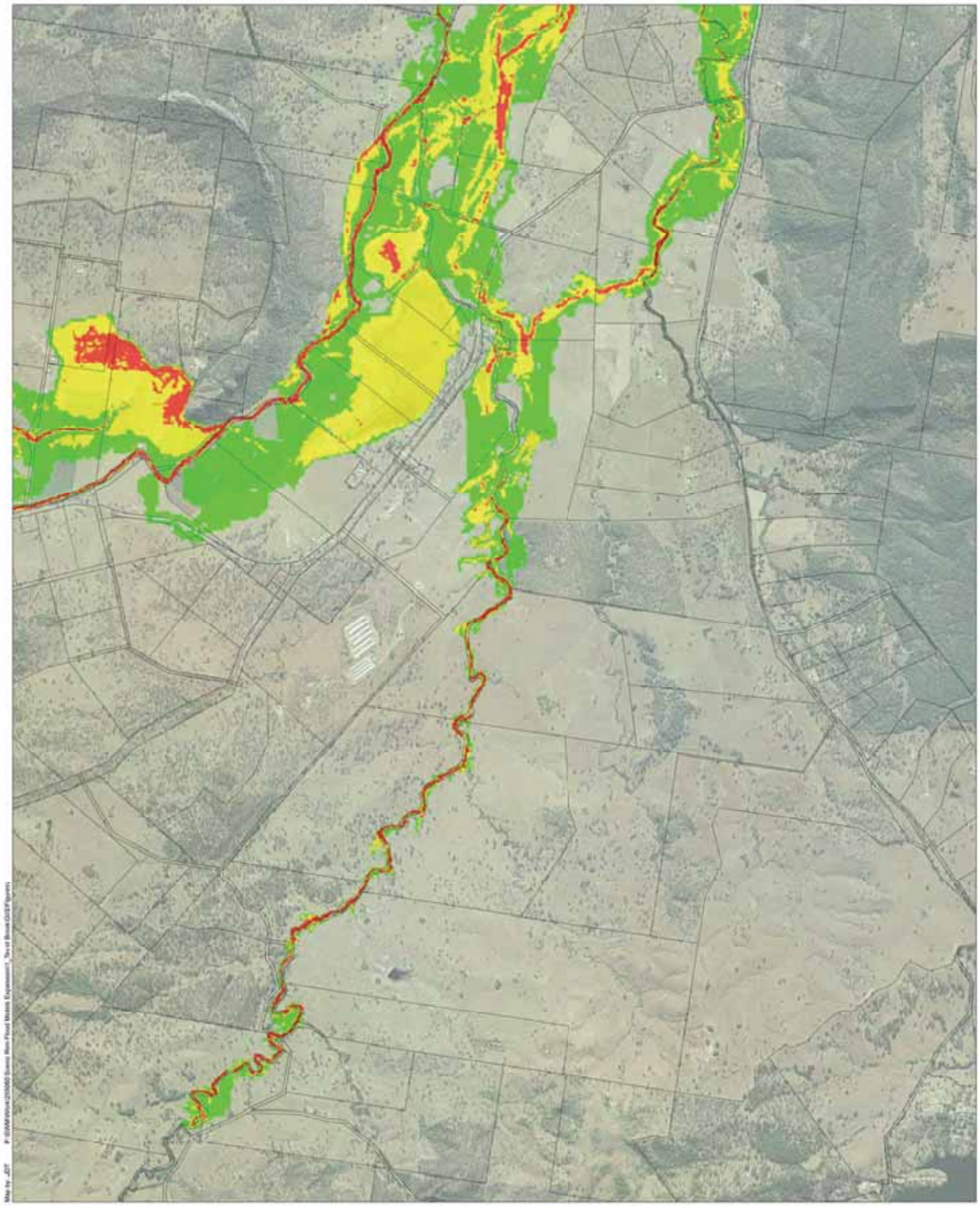
1:25,000
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060
Projection: MGA Zone 56

Teviot Brook Flood Study **Figure D4-b**

5% AEP Event - Peak Hazard Map

aurecon



Legend

SRRC Boundary

Cadastral Boundary

Low Hazard

Medium Hazard

High Hazard

Notes:

1:25,000

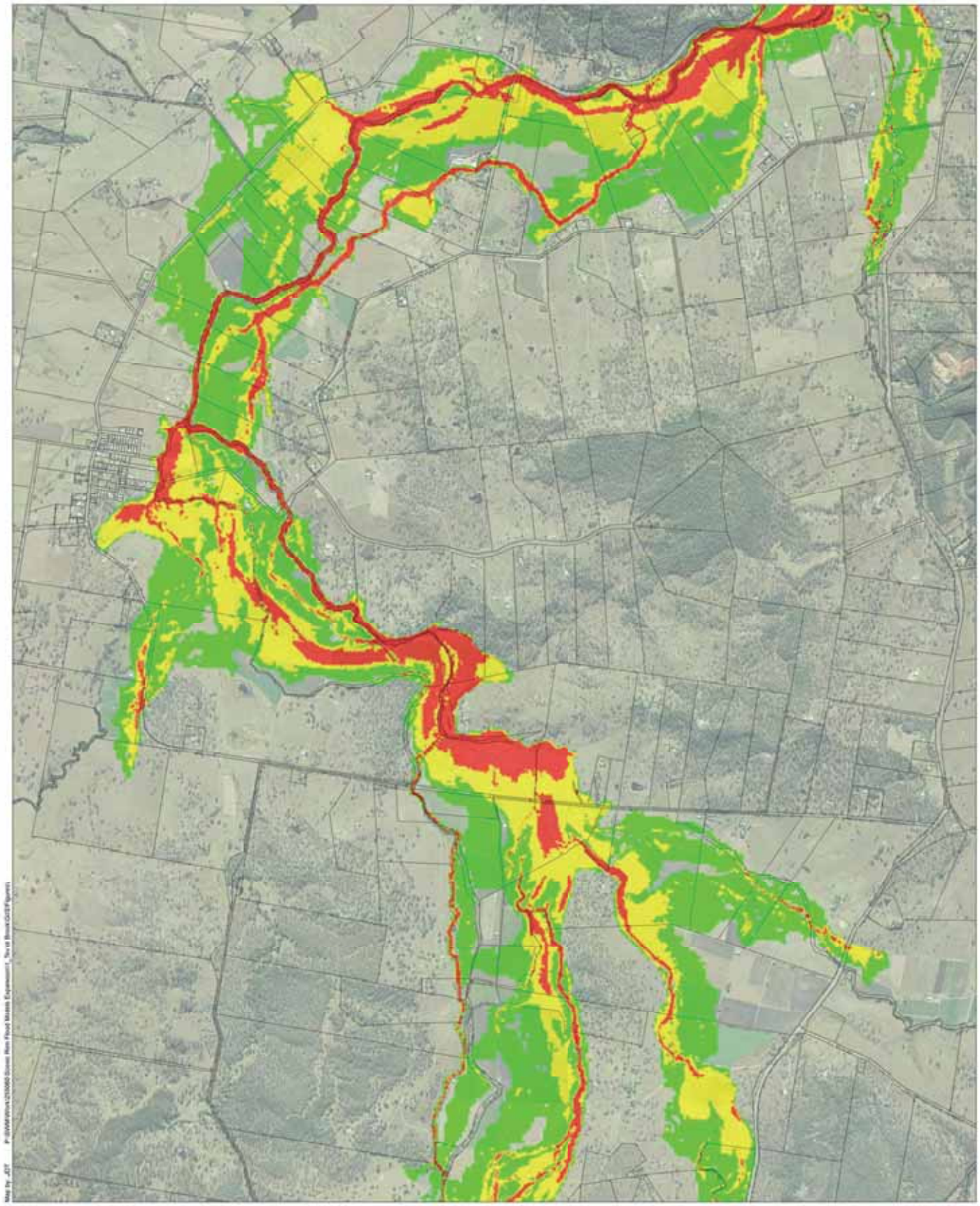
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Teviot Brook Flood Study Figure D4-c

5% AEP Event - Peak Hazard Map

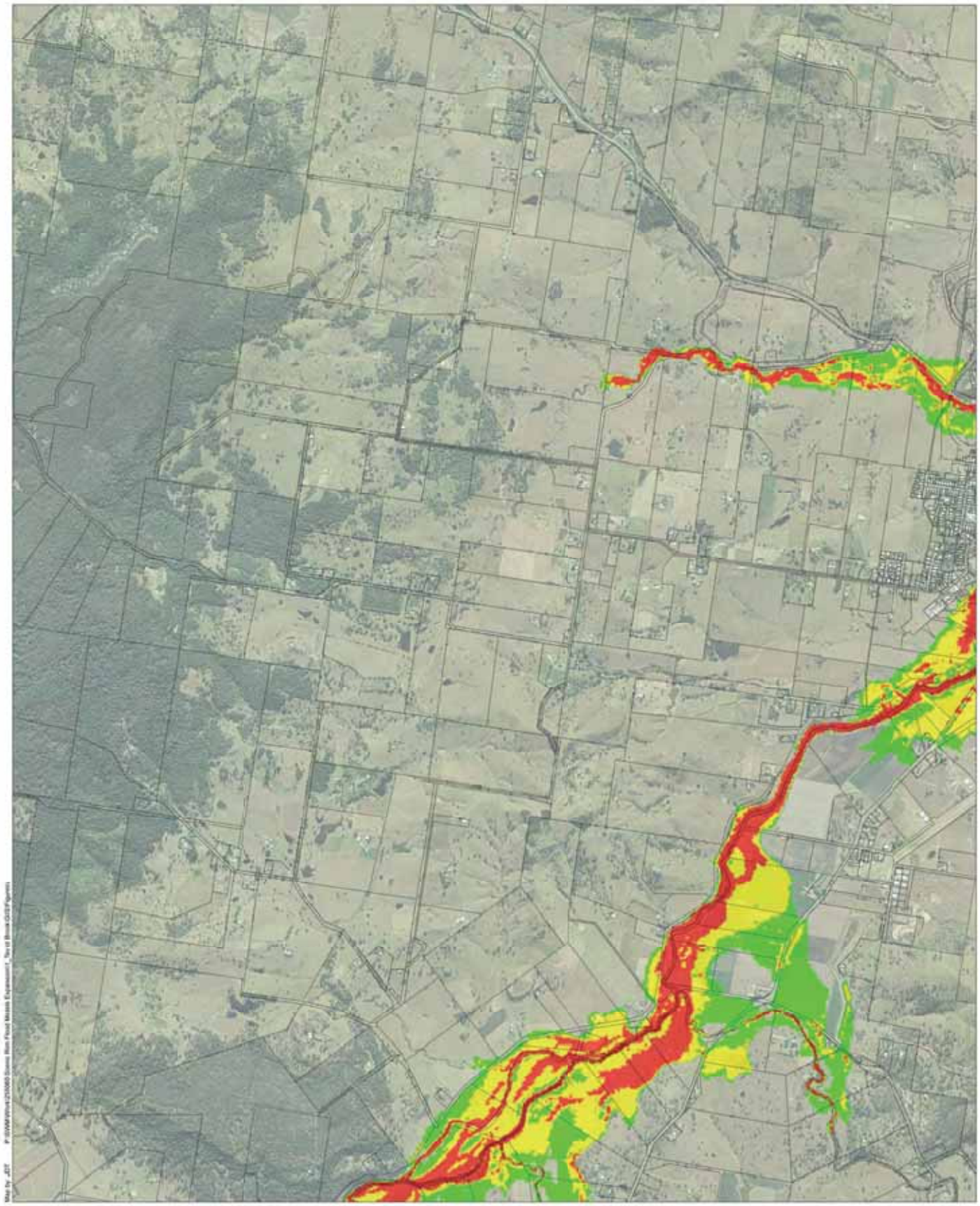


1:25,000
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060
Projection: MGA Zone 56

Teviot Brook Flood Study Figure D4-d

5% AEP Event - Peak Hazard Map

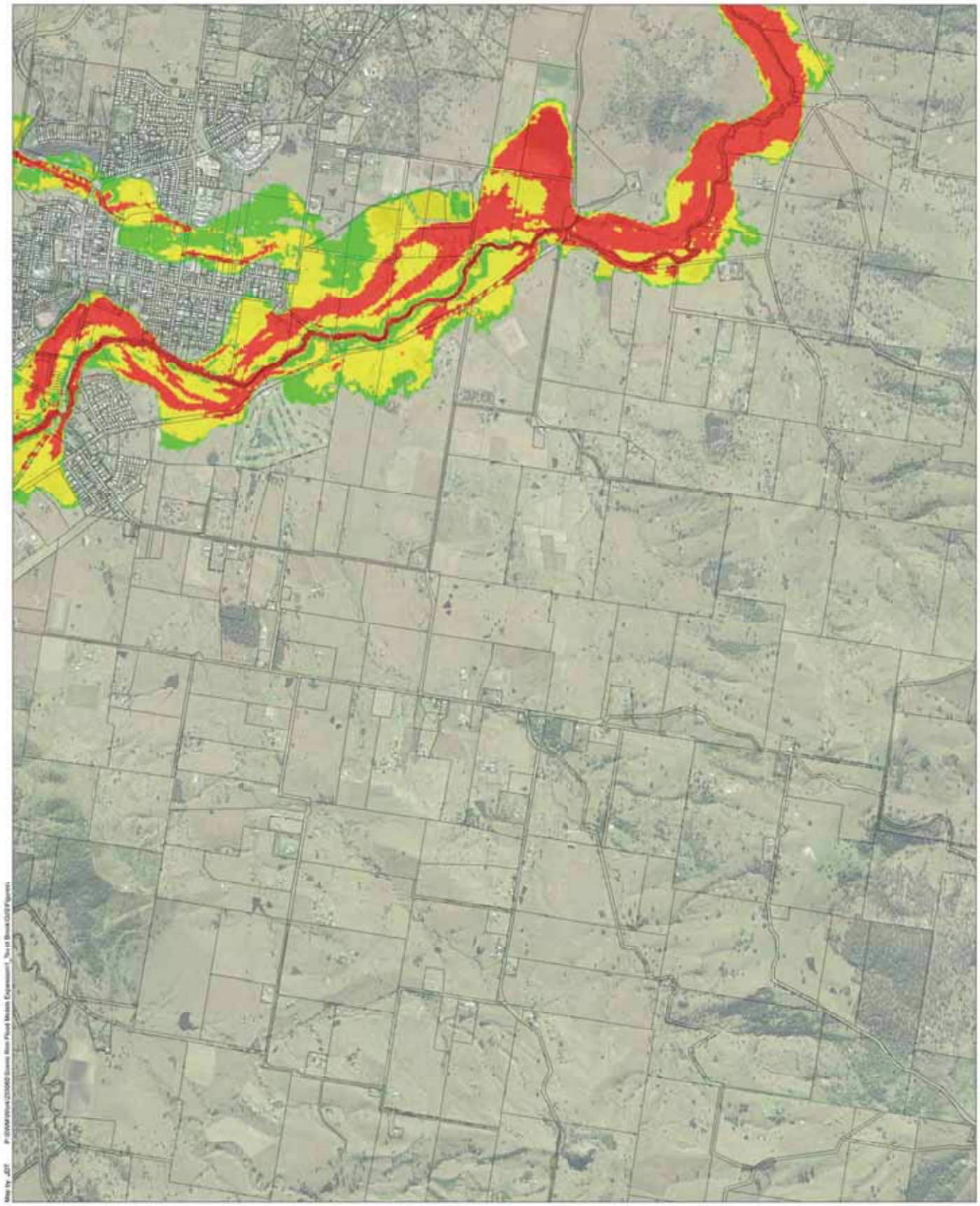


1:25,000
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060
Projection: MGA Zone 56

Teviot Brook Flood Study Figure D4-e

5% AEP Event - Peak Hazard Map



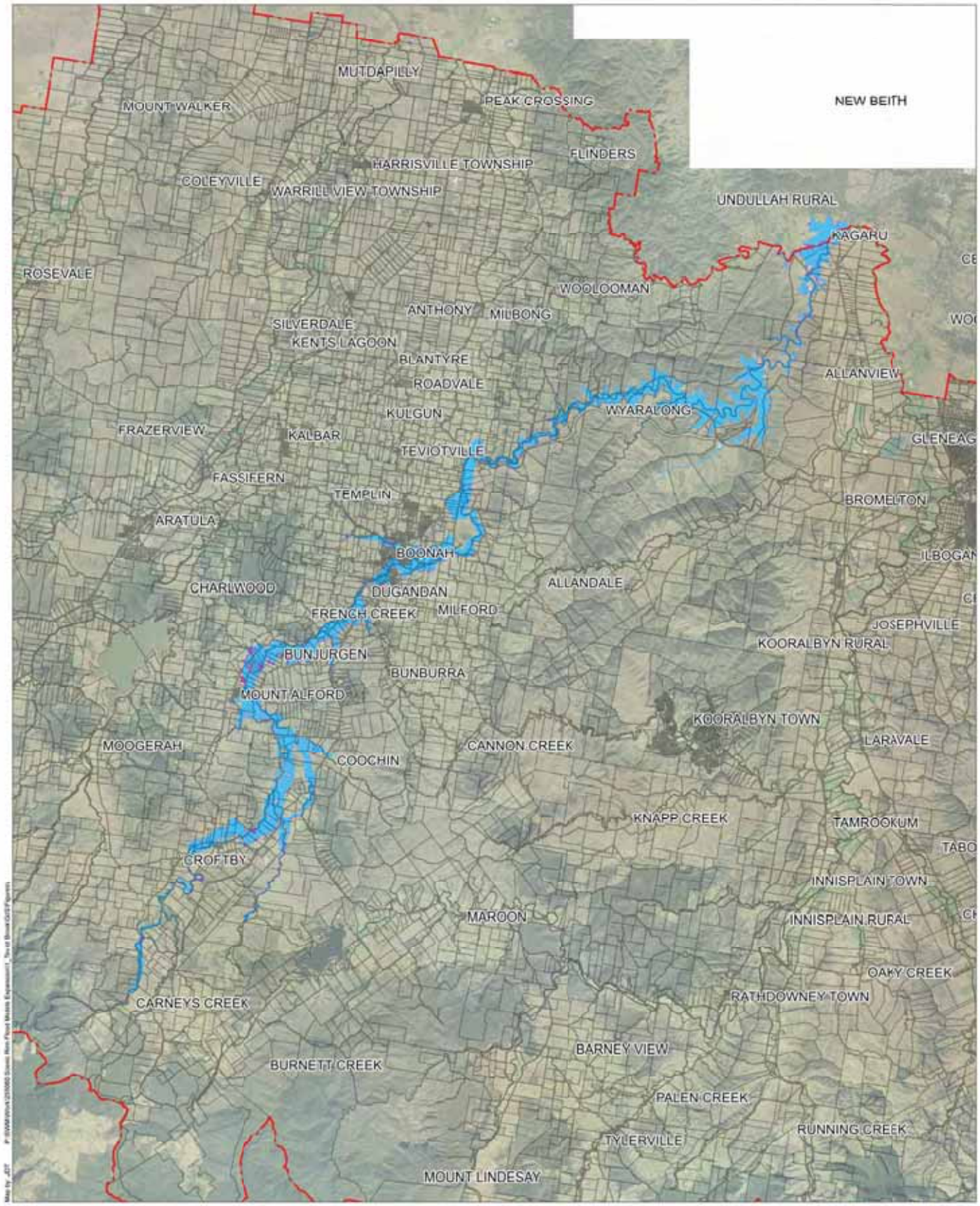
1:25,000
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060
Projection: MGA Zone 56

Teviot Brook Flood Study Figure D4-f

5% AEP Event - Peak Hazard Map

aurecon



Legend

SRRC Boundary

Cadastral Boundary

Inundation Extent

Climate Change Inundation Extent

Notes:

1:100,000

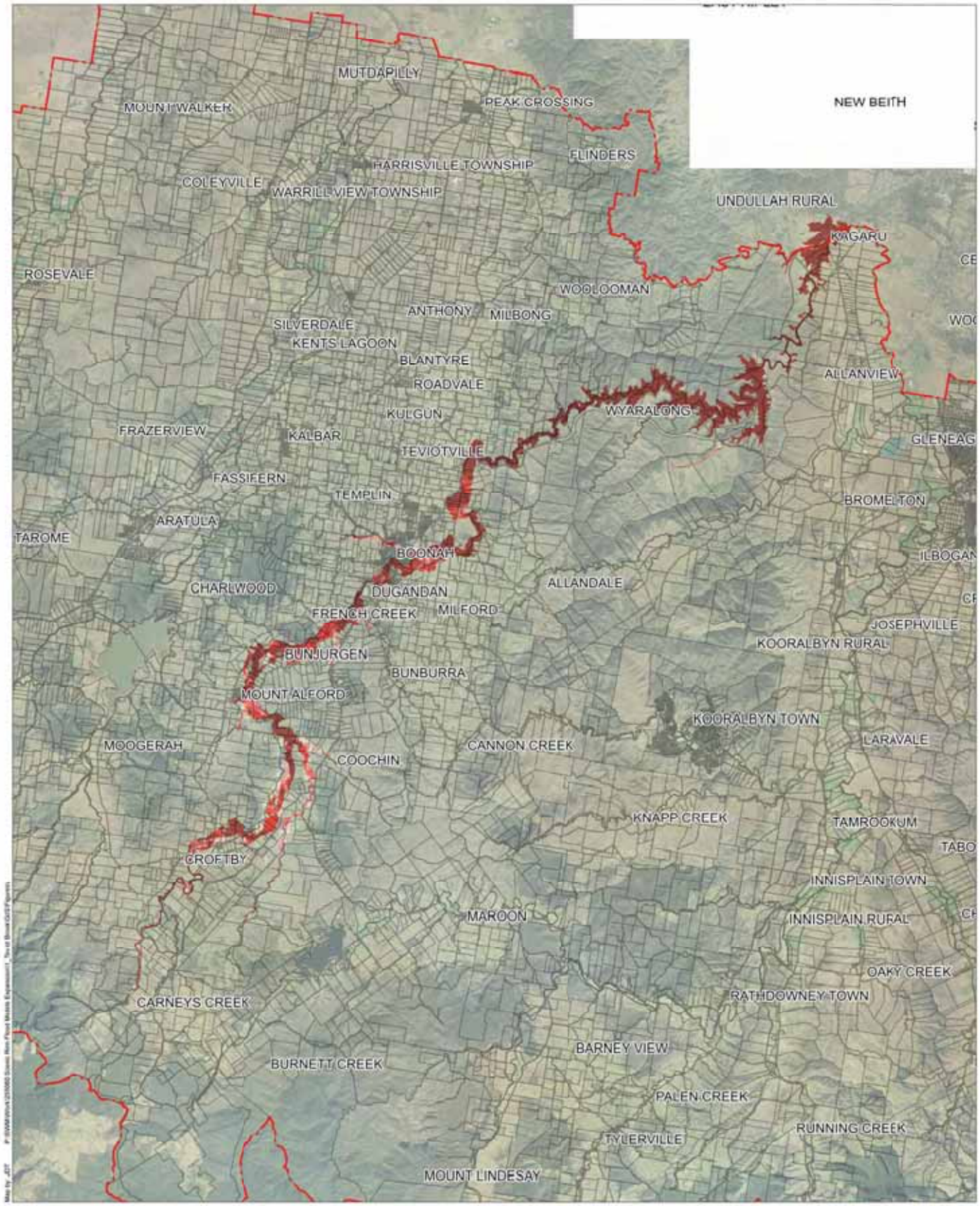
0 2,500 m 5,000 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

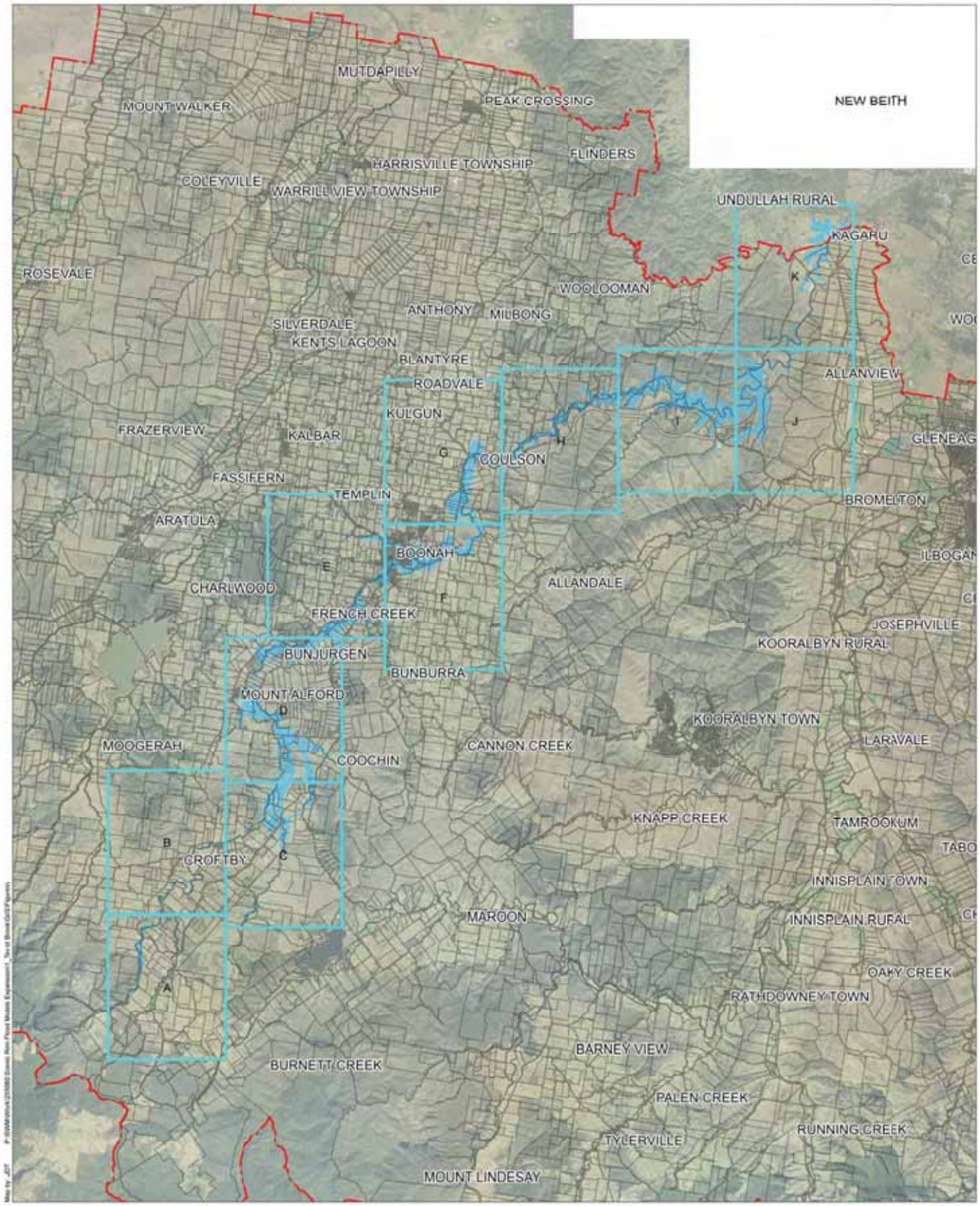
Teviot Brook Flood Study Figure D5 - a

5% AEP Event - Climate Change Inundation Extent



Teviot Brook Flood Study **Figure D5 - b**

Climate Change Scenario 4.5 - 5% AEP Event Afflux Map



Legend

SRRC Boundary

Cadastral Boundary

Inundation Extent

Peak Water level Contour (mAHD)

1:100,000

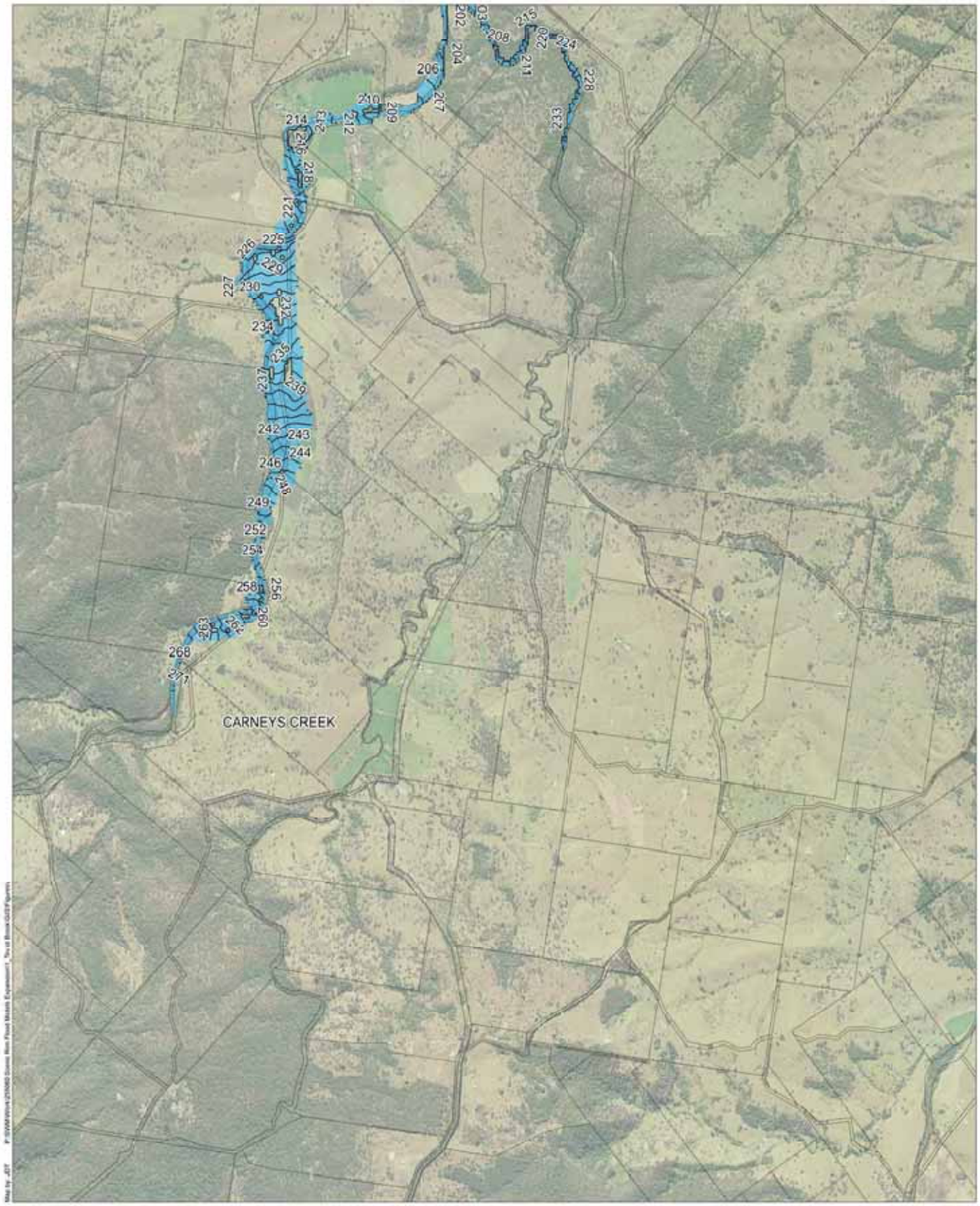
0 2,500 m 5,000 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Teviot Brook Flood Study **Figure E1**

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

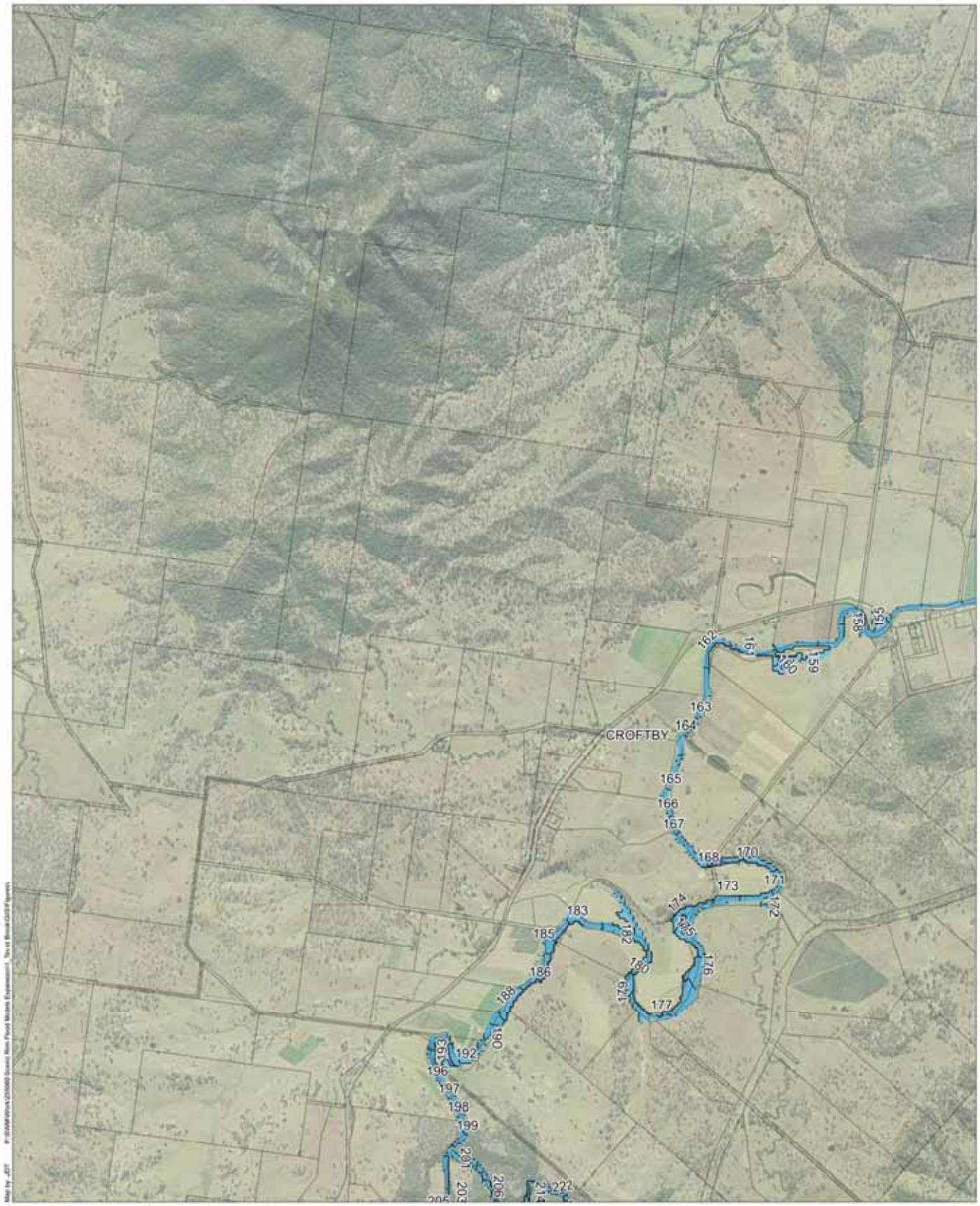
Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Teviot Brook Flood Study Figure E1-a

10% AEP Event - Inundation Extent

aurecon



Legend

SRRC Boundary

Cadastral Boundary

Inundation Extent

Peak Water level Contour (mAHD)

1:25,000

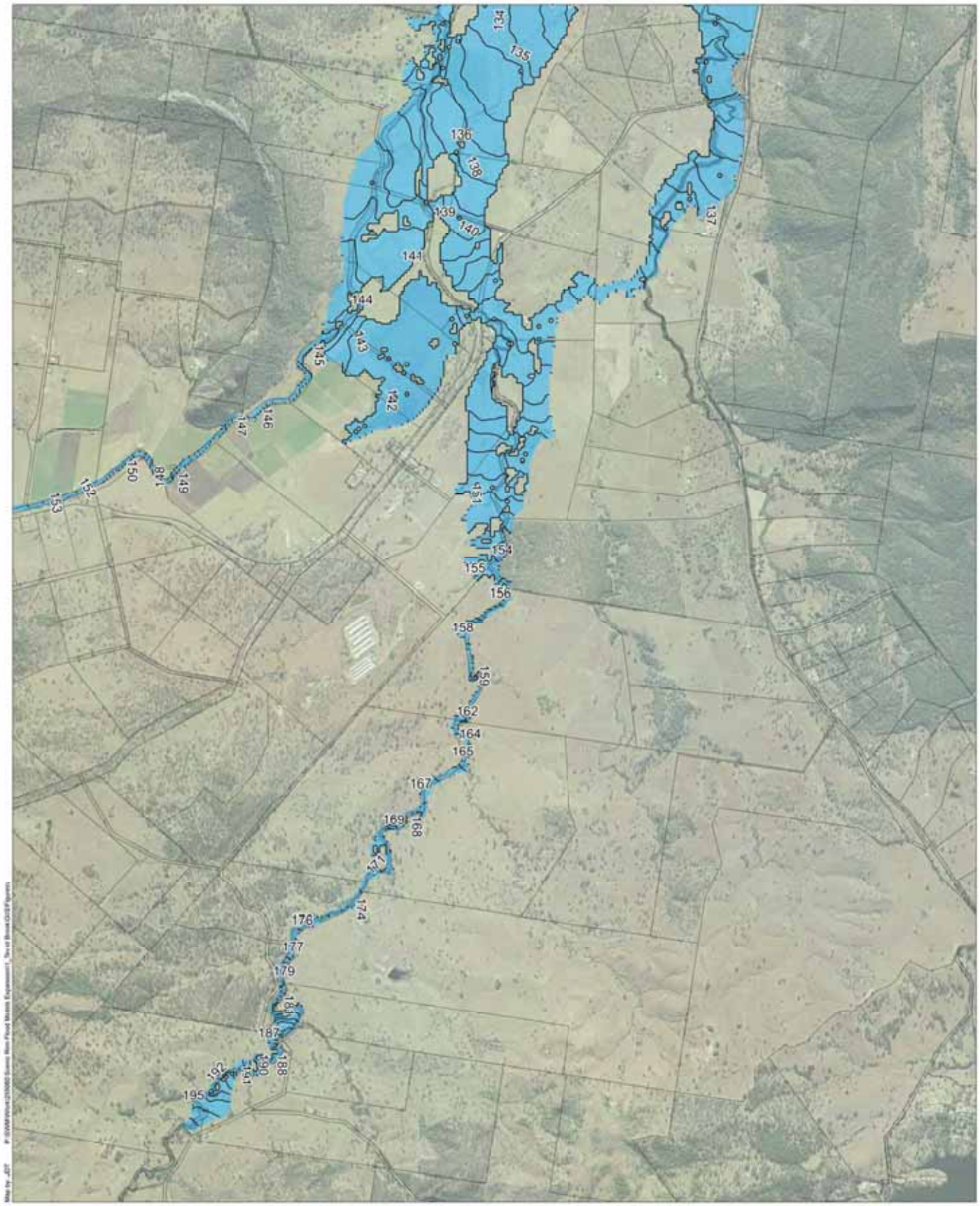
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Teviot Brook 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

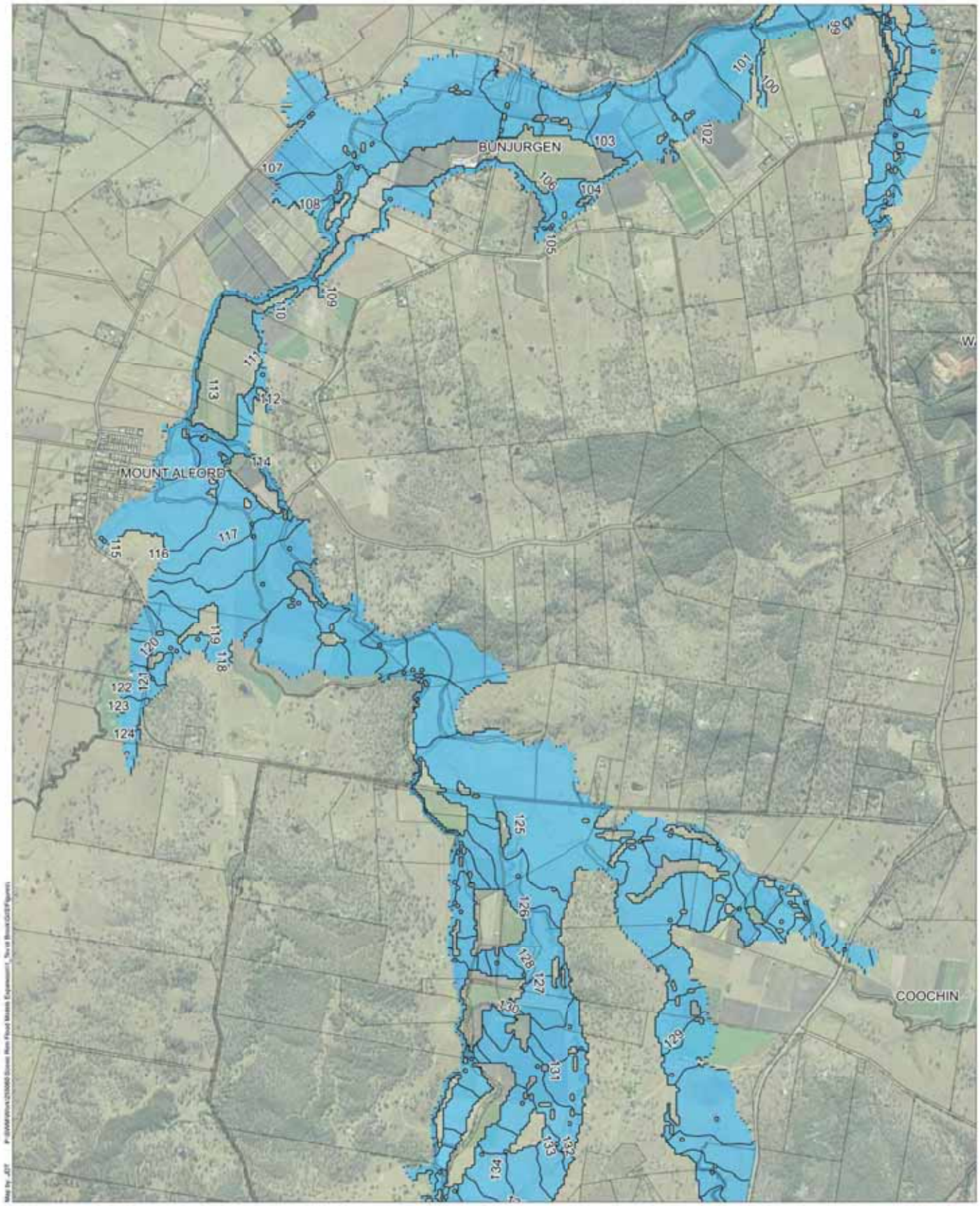
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Teviot Brook Flood Study **Figure E1-c**

10% AEP Event - Inundation Extent



Legend

SRRC Boundary

Cadastral Boundary

Inundation Extent

Peak Water level Contour (mAHD)

1:25,000

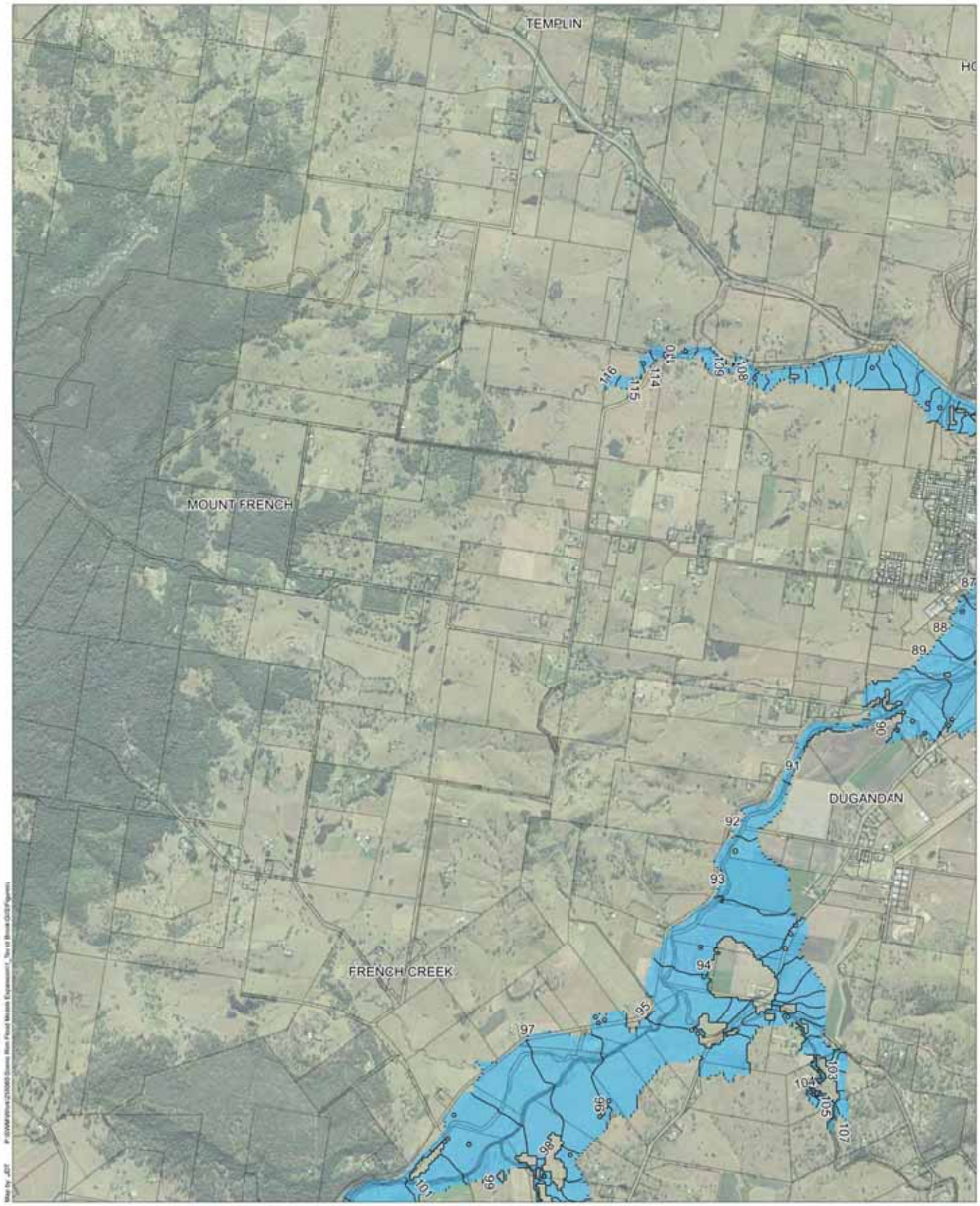
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Teviot Brook Flood Study Figure E1-d

10% AEP Event - Inundation Extent

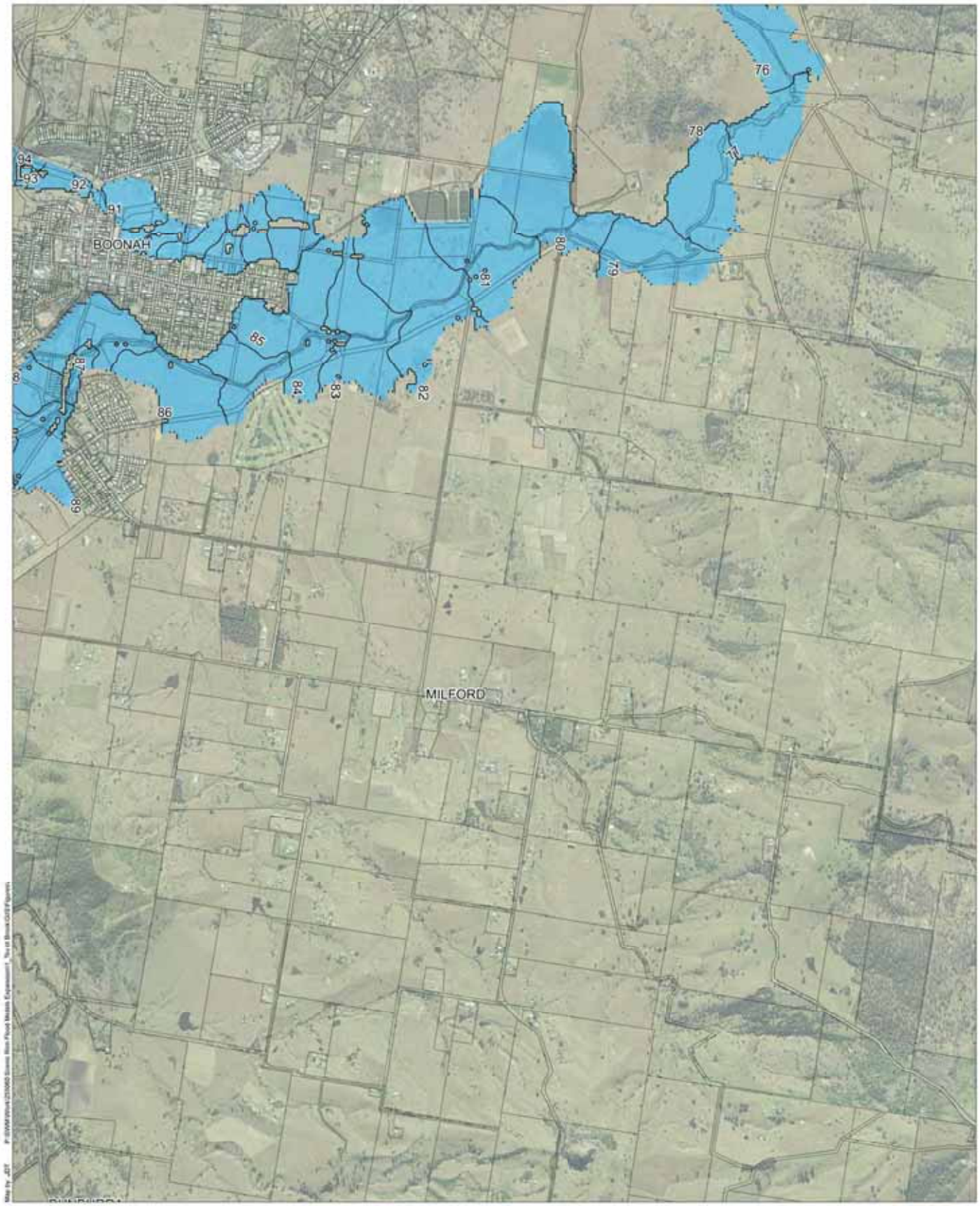


1:25,000
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060
Projection: MGA Zone 56

Teviot Brook Flood Study **Figure E1-e**

10% AEP Event - Inundation Extent

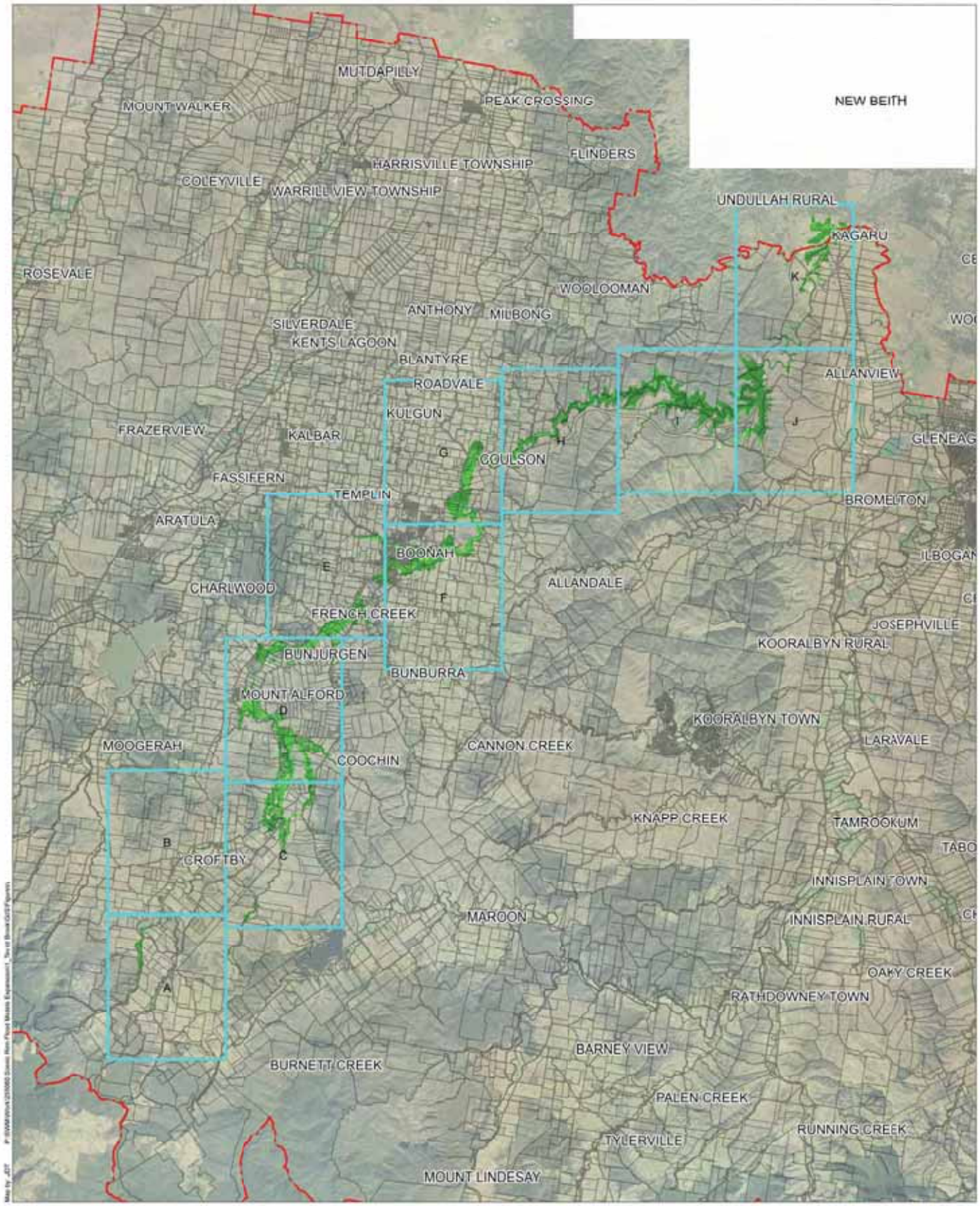


1:25,000
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060
Projection: MGA Zone 56

Teviot Brook Flood Study **Figure E1-f**

10% AEP Event - Inundation Extent



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:

1:100,000

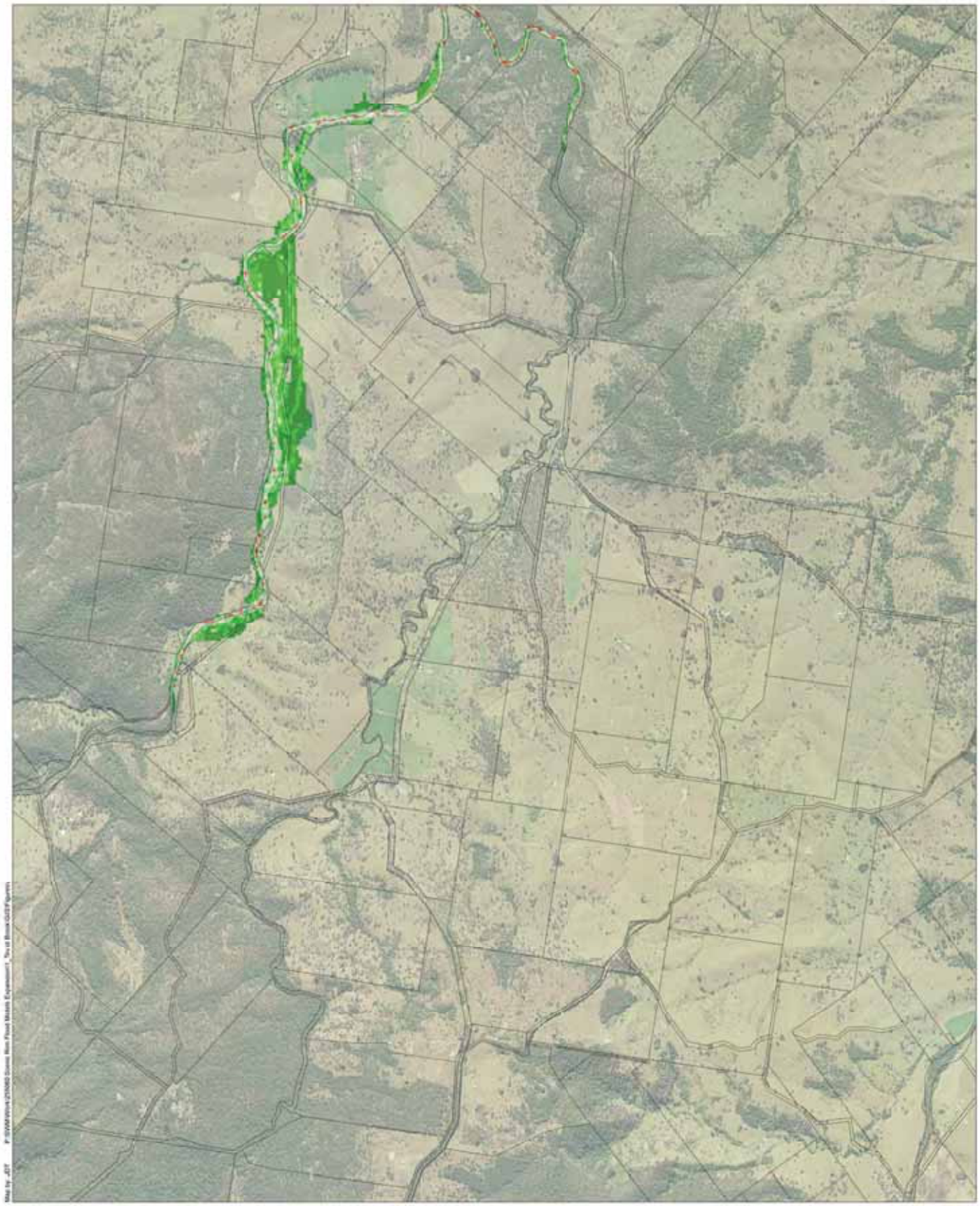
0 2,500 m 5,000 m

Date: 24/10/2017 Version: 0 Job No: 235080

Projection: MGA Zone 56

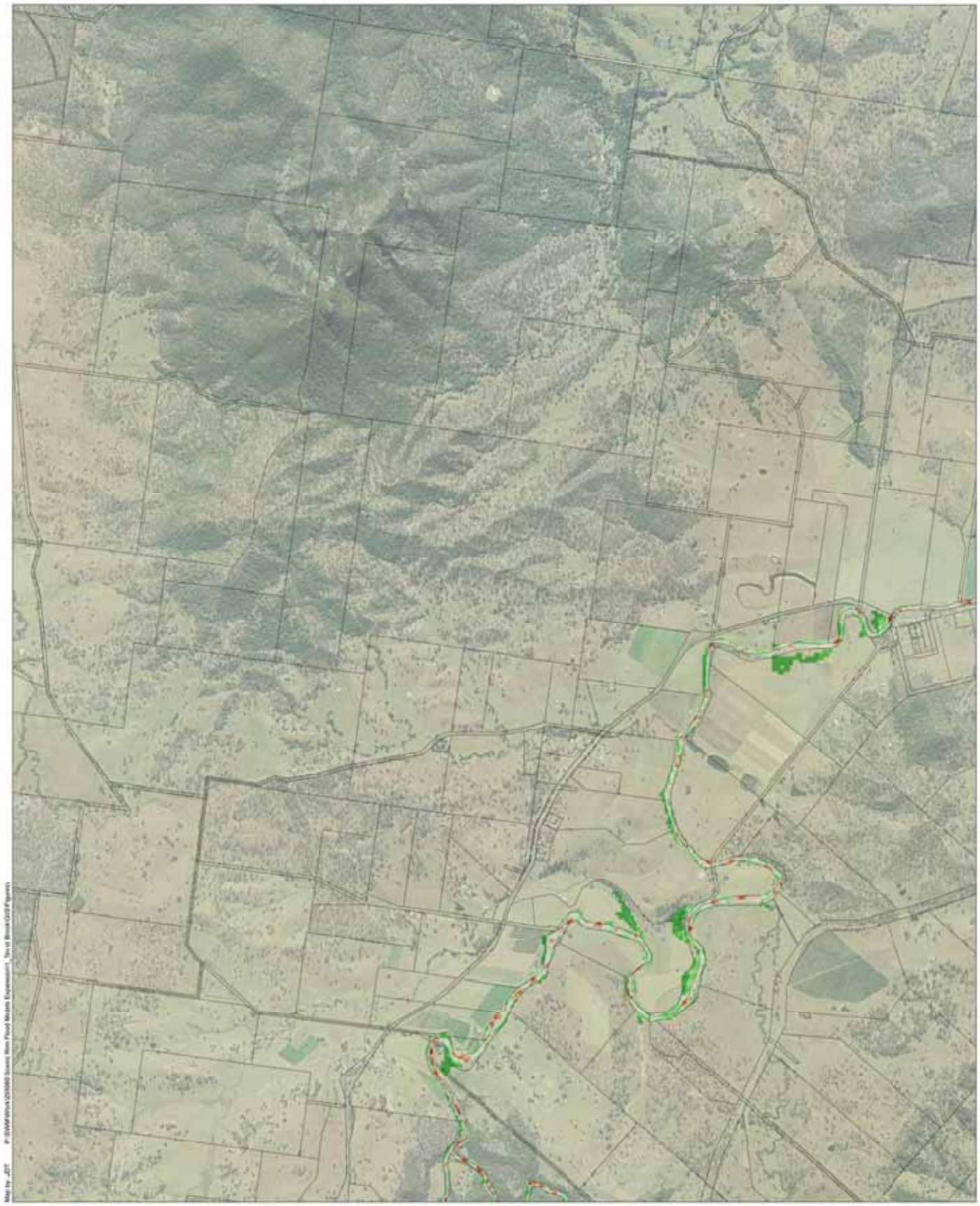
Teviot Brook Flood Study Figure E2

10% AEP Event - Peak Velocities



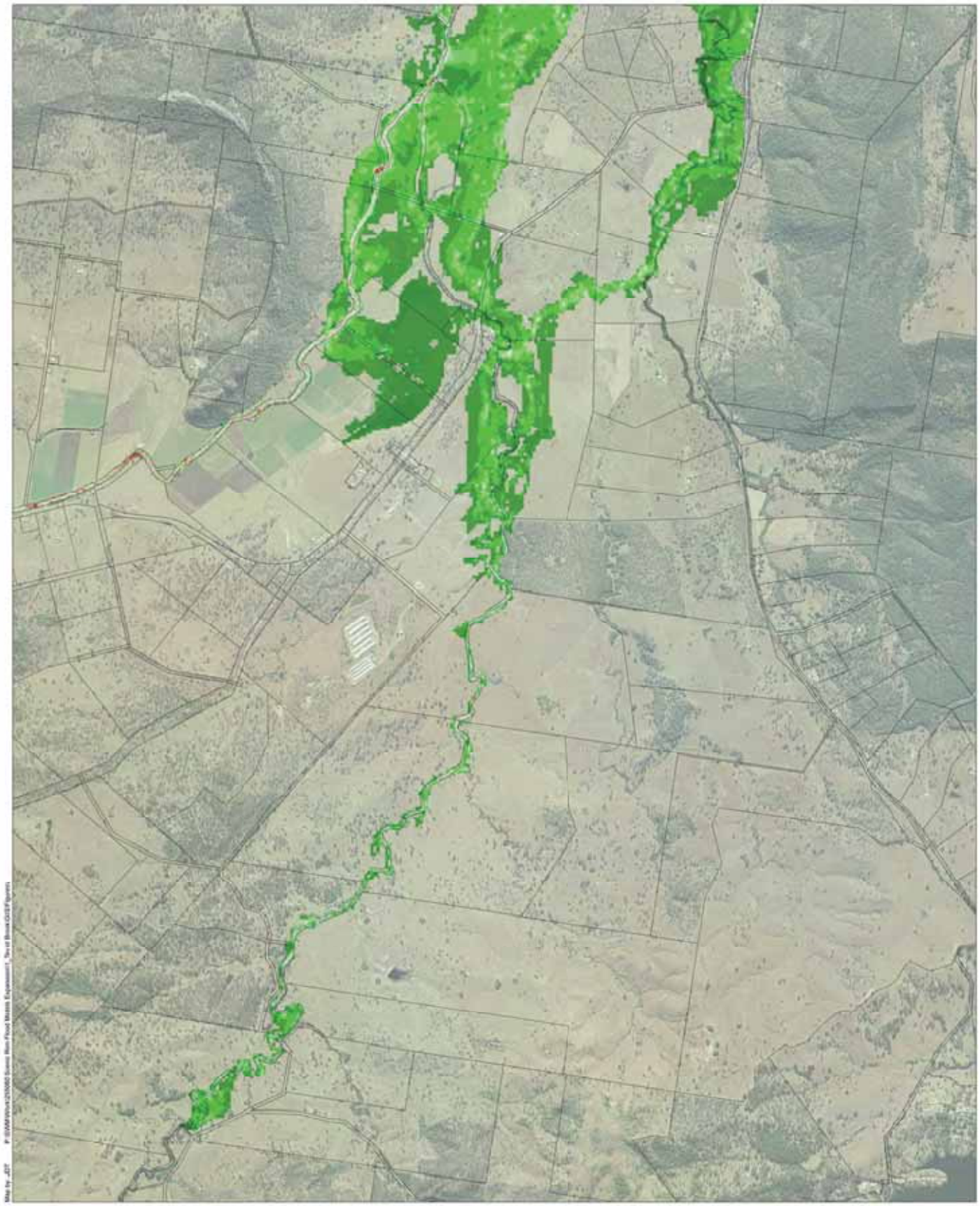
Teviot Brook Flood Study **Figure E2-a**

10% AEP Event - Peak Velocities



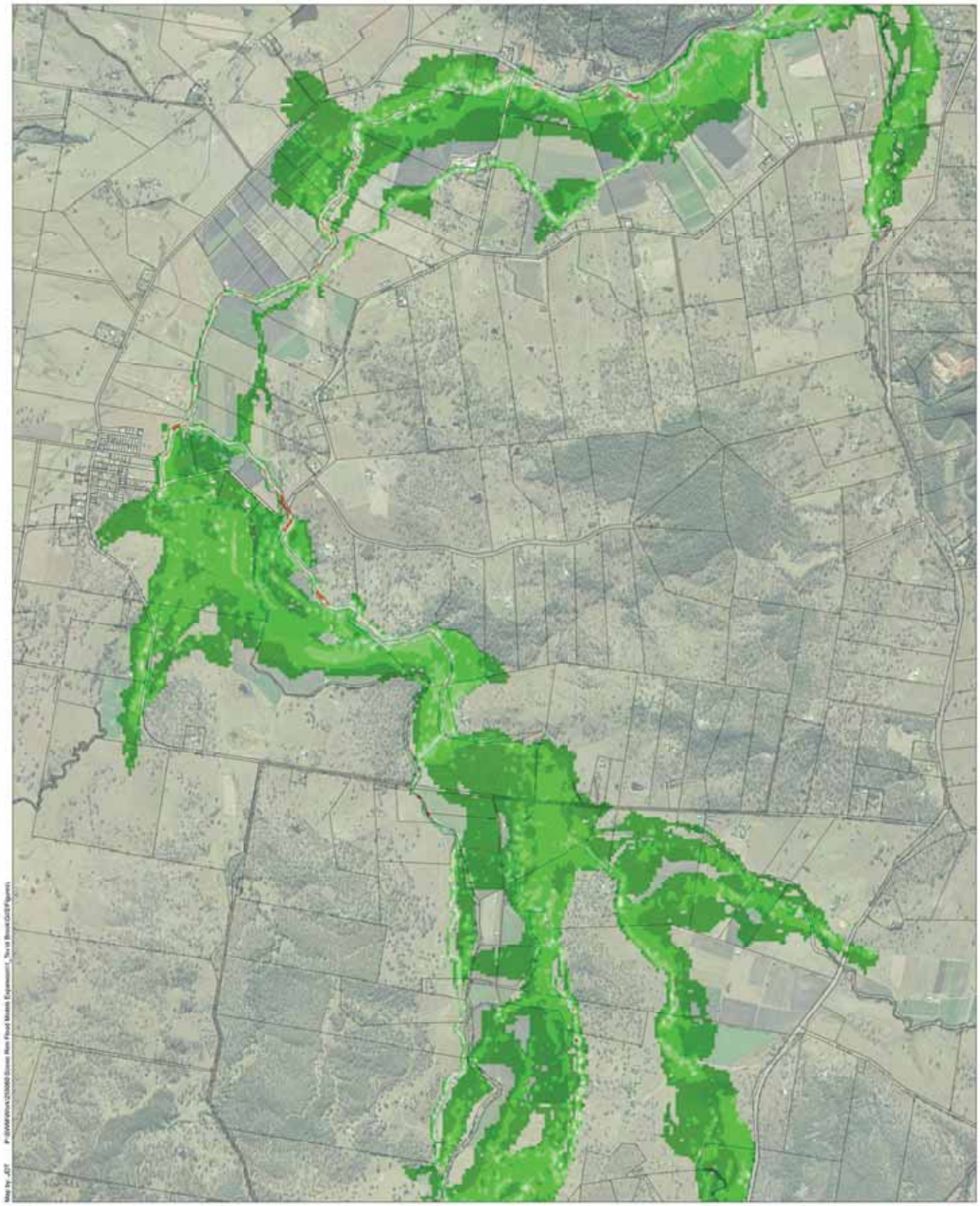
Teviot Brook Flood Study **Figure E2-b**

10% AEP Event - Peak Velocities



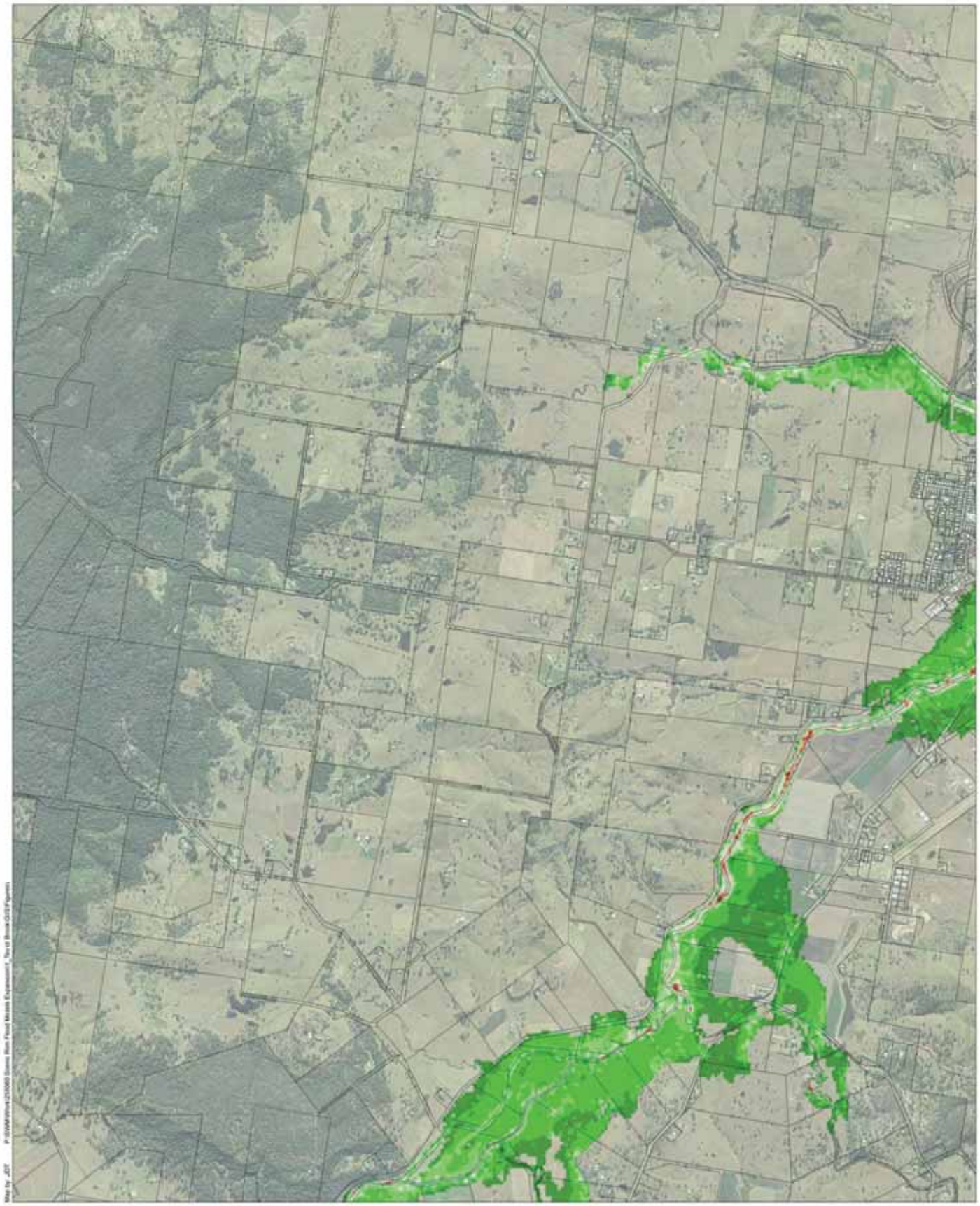
Teviot Brook Flood Study **Figure E2-c**

10% AEP Event - Peak Velocities



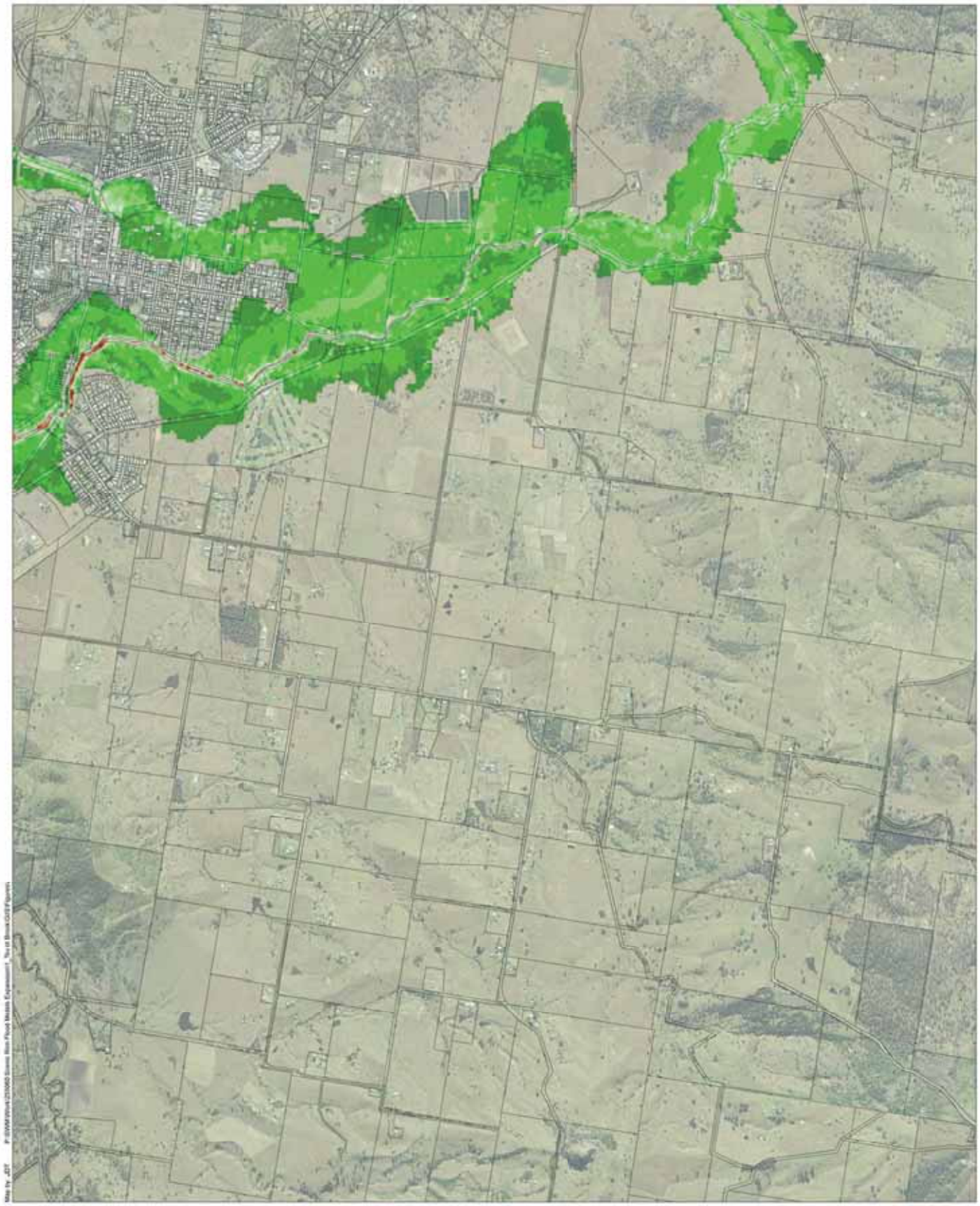
Teviot Brook Flood Study **Figure E2-d**

10% AEP Event - Peak Velocities



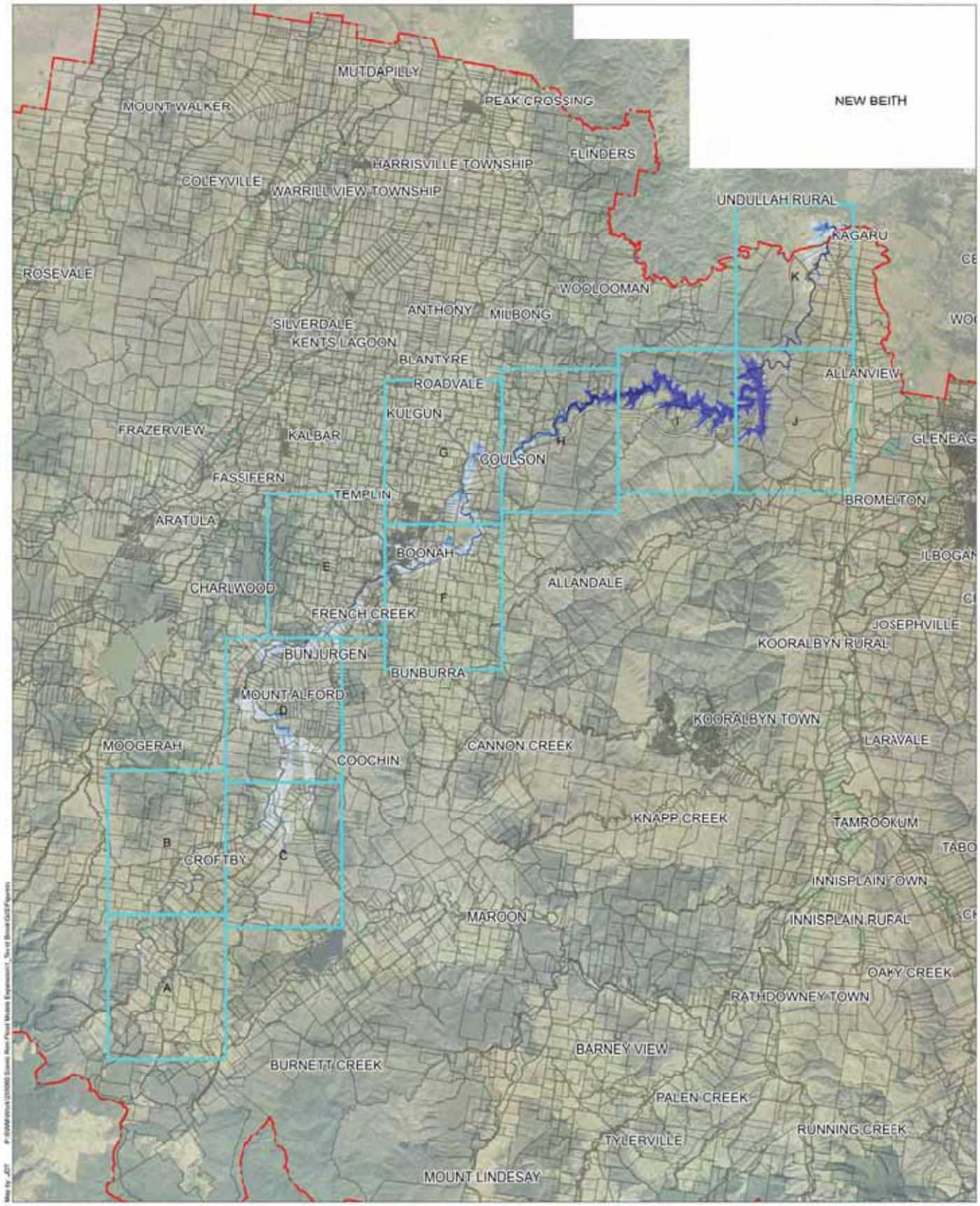
Teviot Brook Flood Study **Figure E2-e**

10% AEP Event - Peak Velocities



Teviot Brook Flood Study **Figure E2-f**

10% AEP Event - Peak Velocities



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:

1:100,000

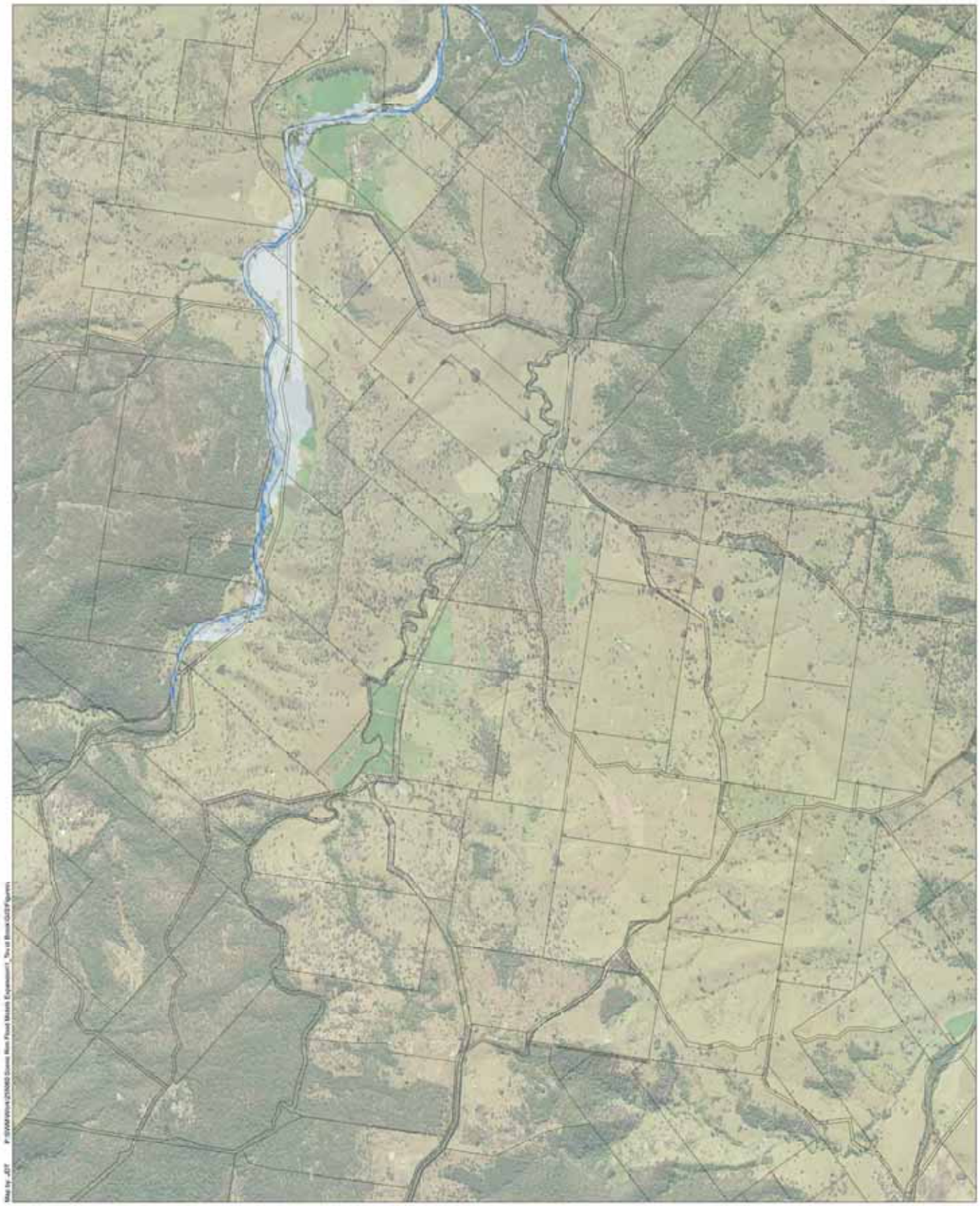
0 2,500 m 5,000 m

Date: 24/10/2017 Version: 0 Job No: 235060

Projection: MGA Zone 56

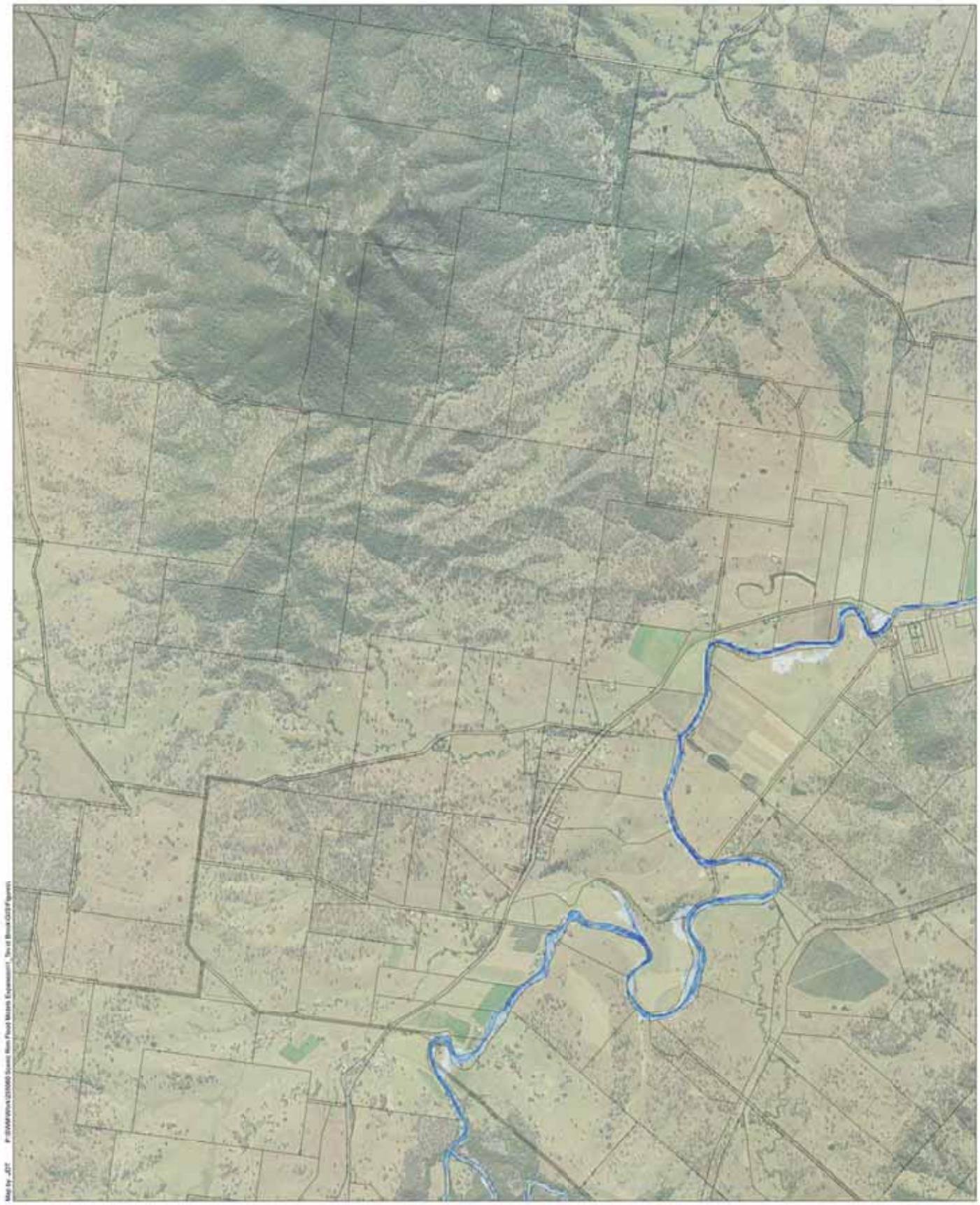
Teviot Brook Flood Study Figure E3

10% AEP Event - Peak Depth Map



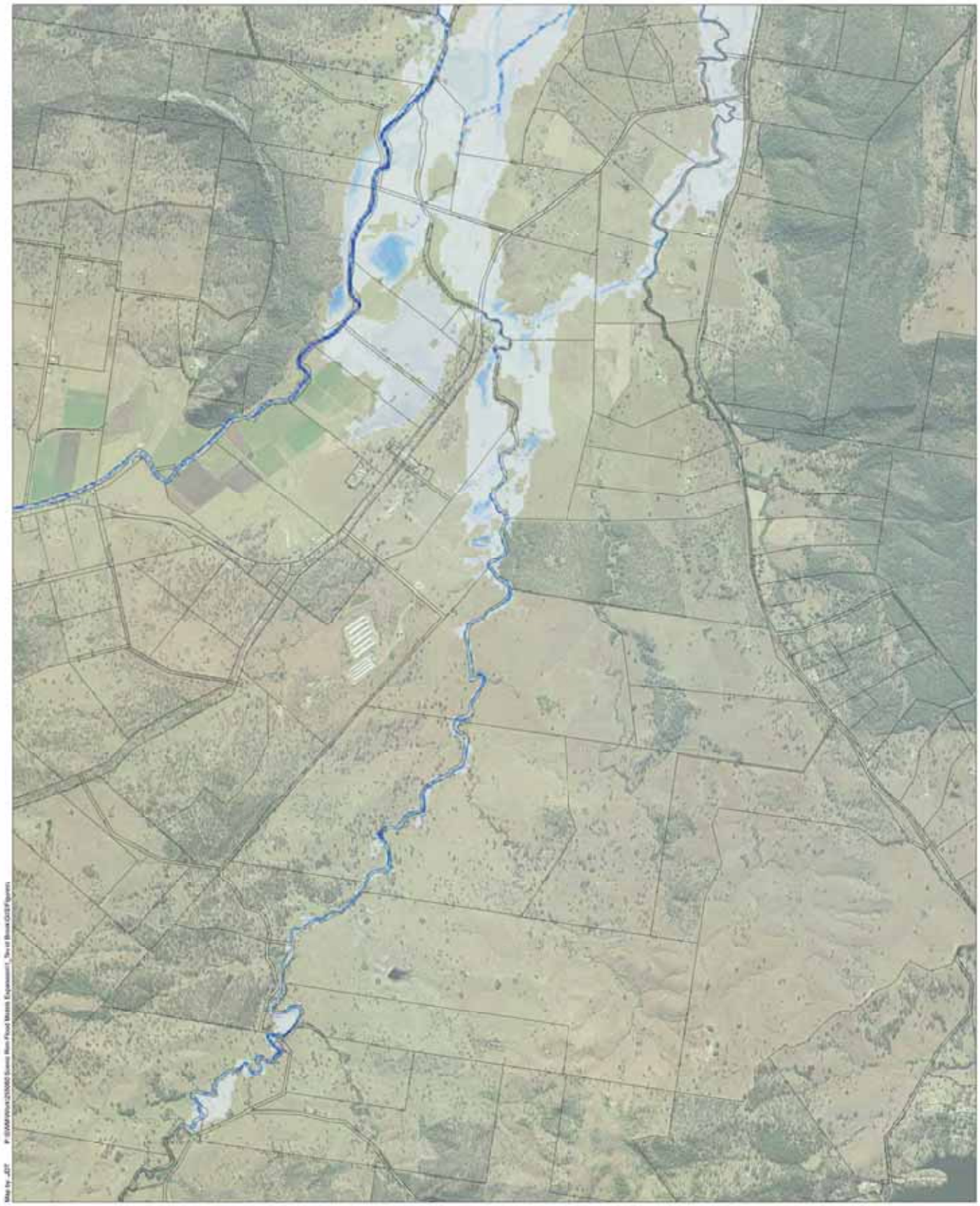
Teviot Brook Flood Study **Figure E3-a**

10% AEP Event - Peak Depth Map



Teviot Brook Flood Study **Figure E3-b**

10% AEP Event - Peak Depth Map



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

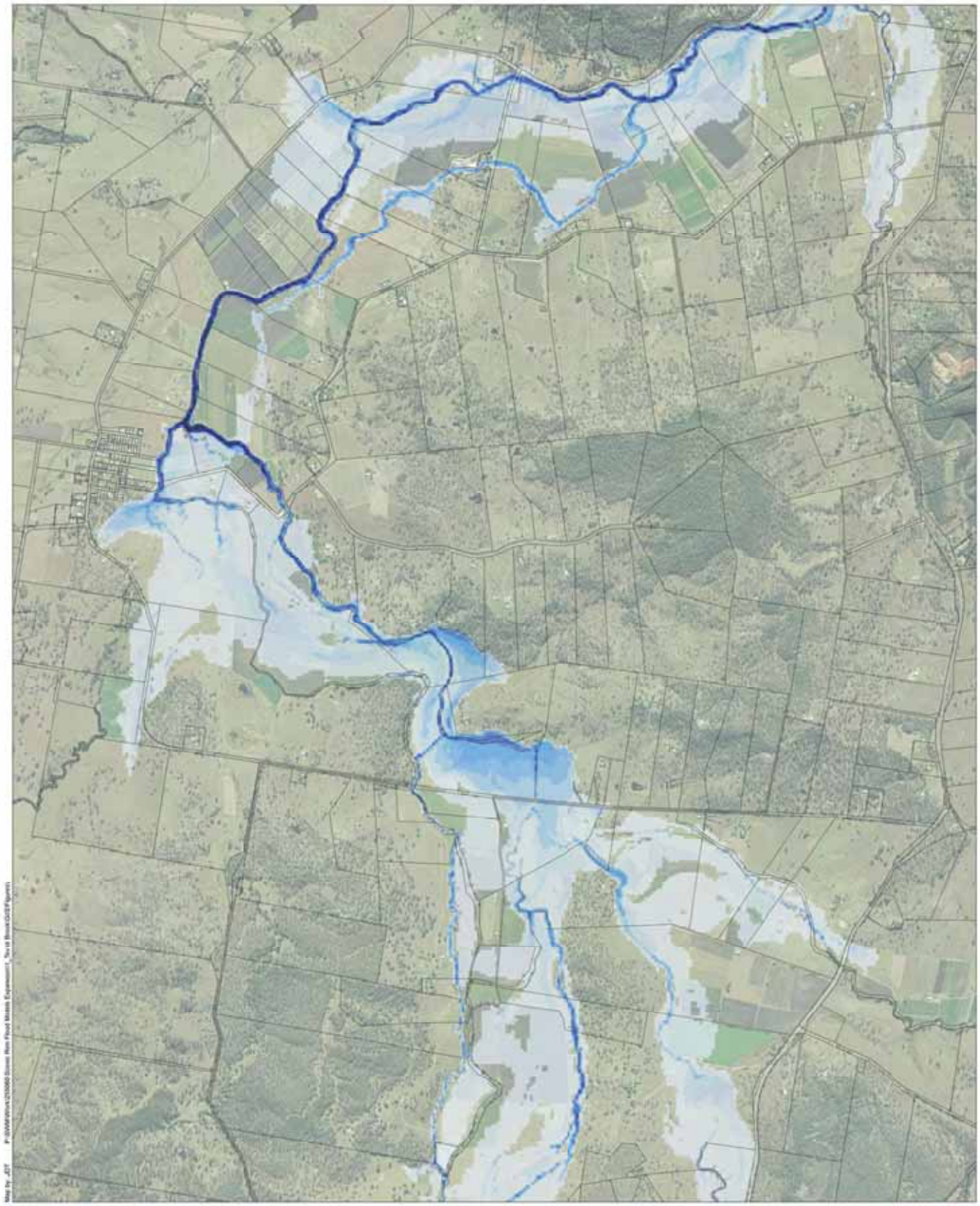
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 235080

Projection: MGA Zone 56

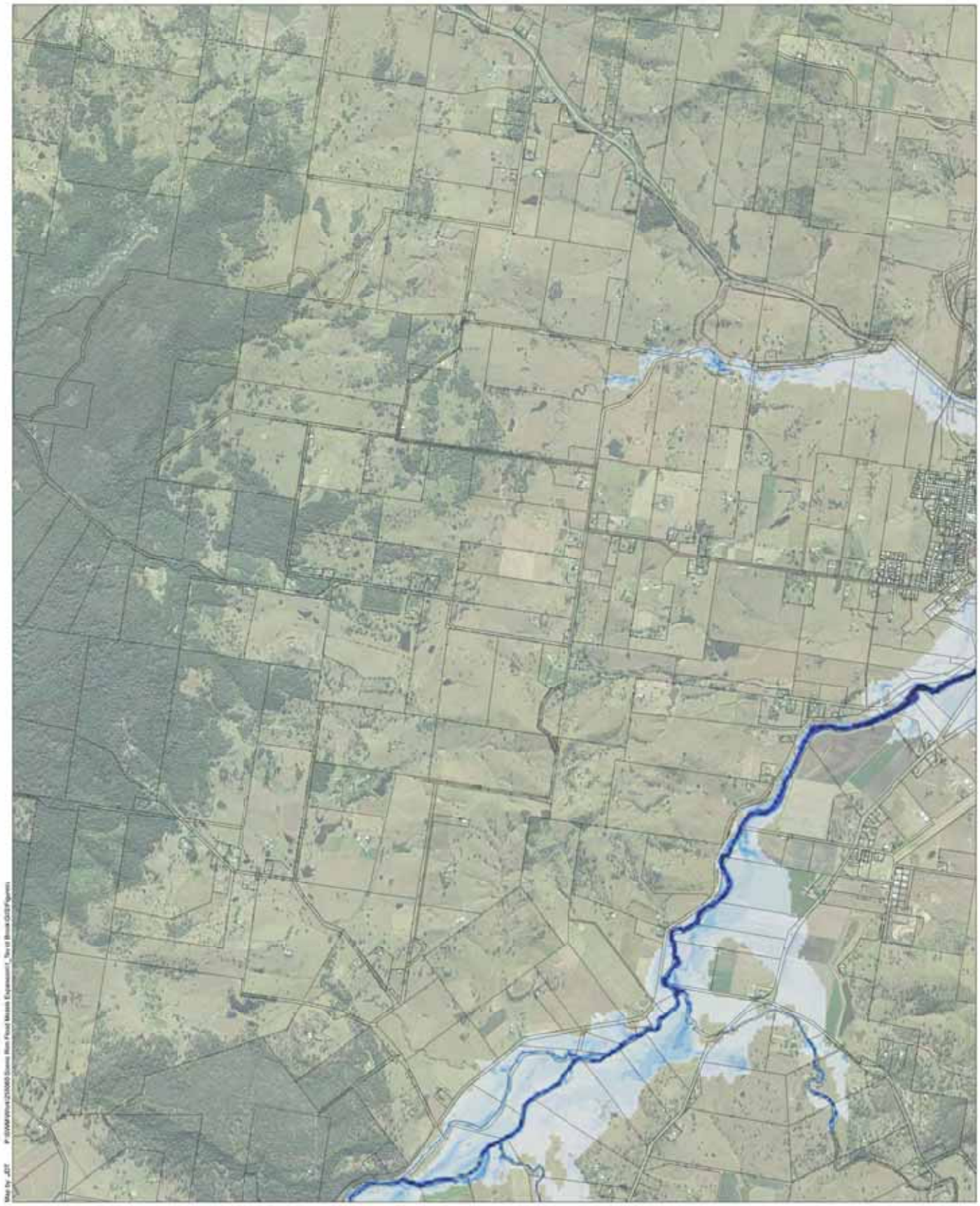
Teviot Brook Flood Study **Figure E3-c**

10% AEP Event - Peak Depth Map



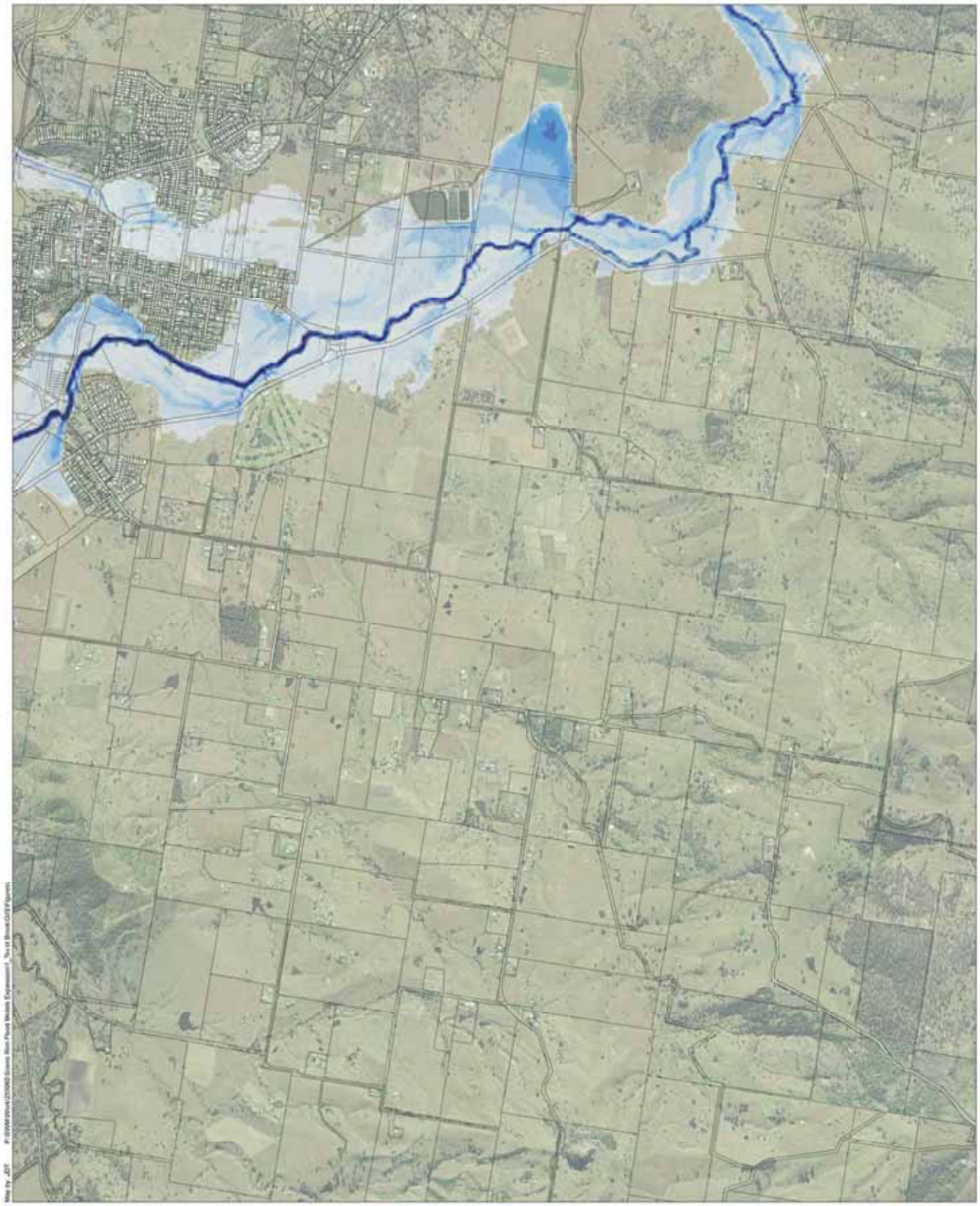
Teviot Brook Flood Study **Figure E3-d**

10% AEP Event - Peak Depth Map



Teviot Brook Flood Study **Figure E3-e**

10% AEP Event - Peak Depth Map



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

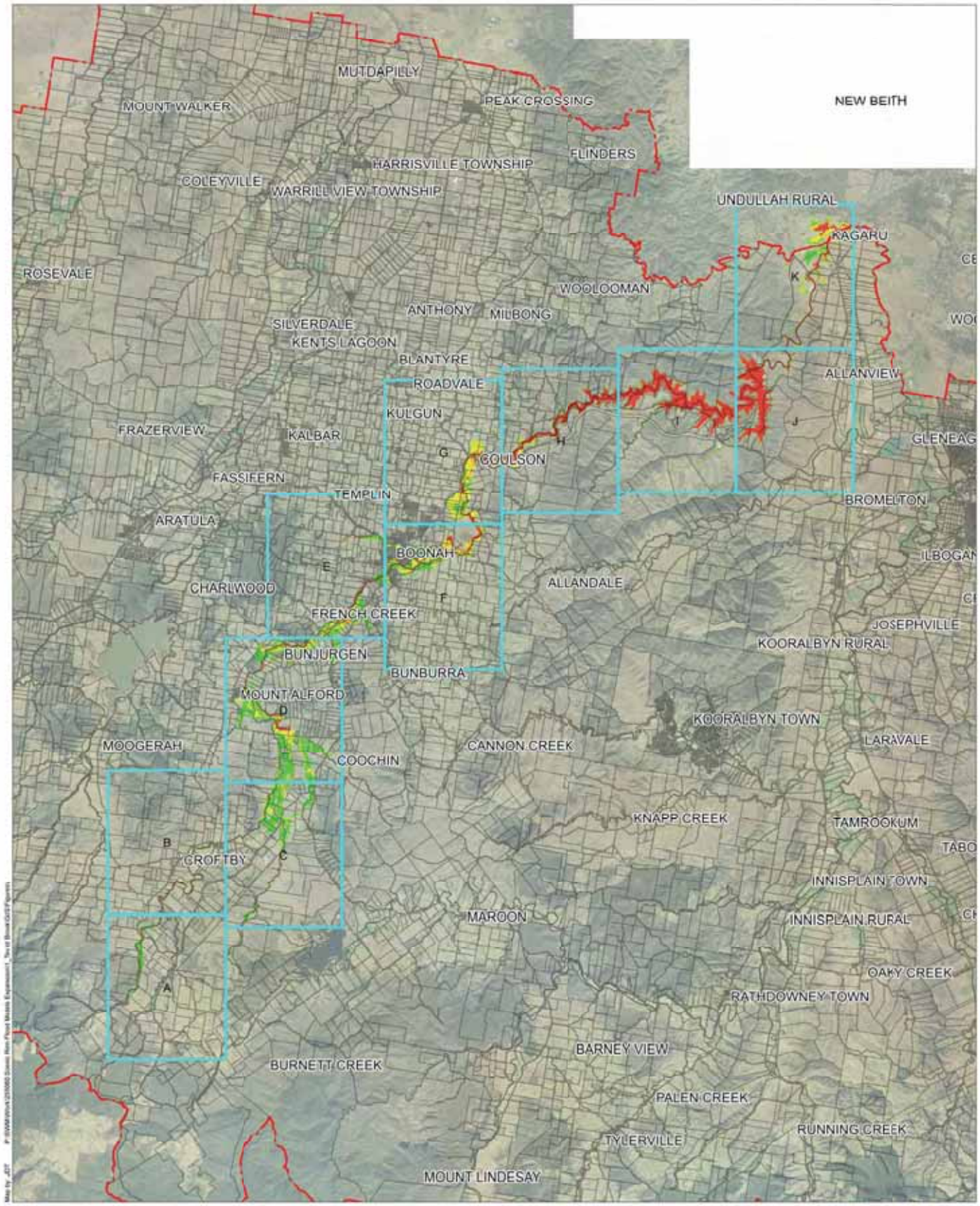
Date: 24/10/2017 Version: 0 Job No: 235060

Projection: MGA Zone 56

Teviot Brook Flood Study **Figure E3-f**

10% AEP Event - Peak Depth Map

aurecon



Legend

SRRC Boundary

Cadastral Boundary

Low Hazard

Medium Hazard

High Hazard

1:100,000

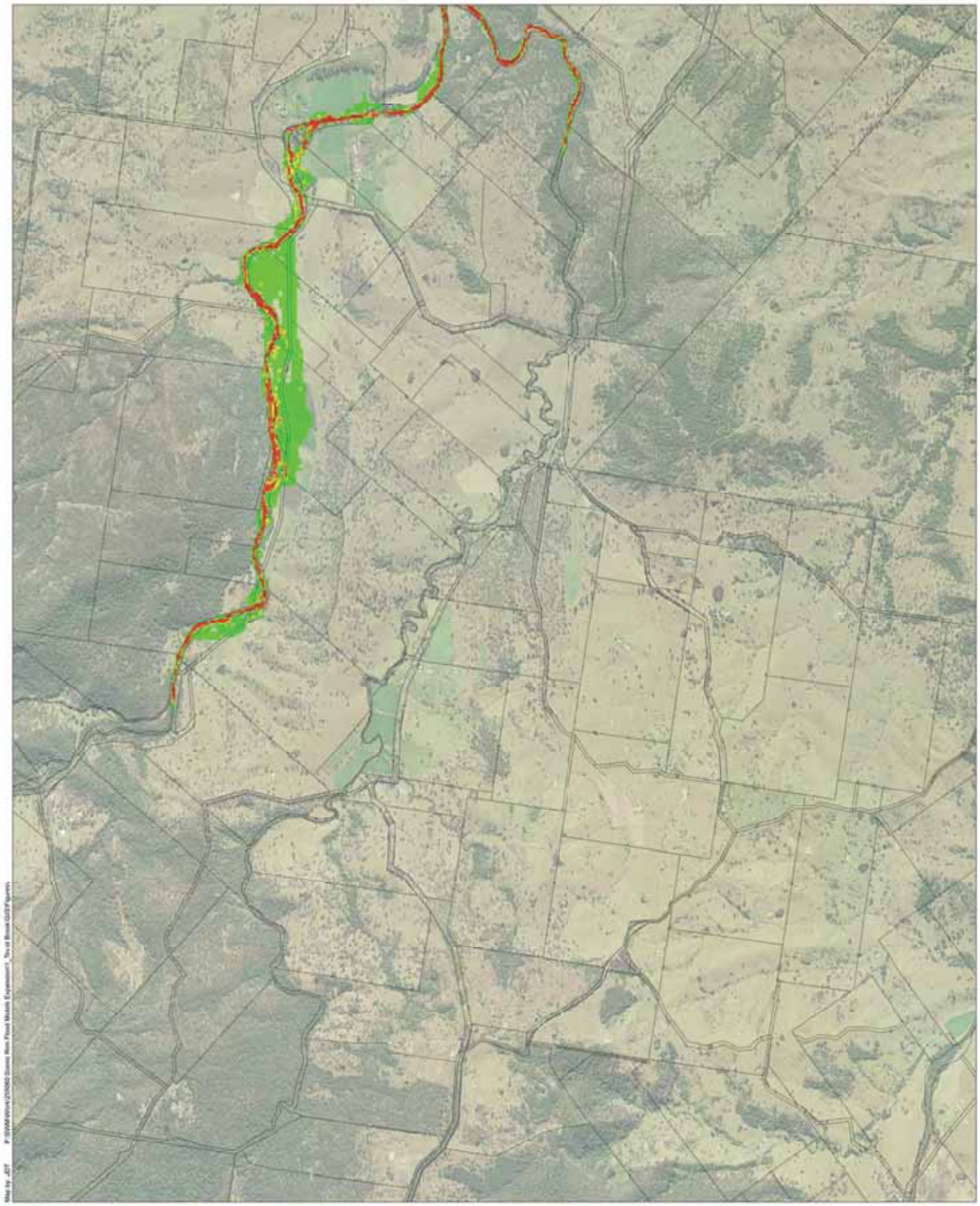
0 2,500 m 5,000 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Teviot Brook Flood Study Figure E4

10% 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

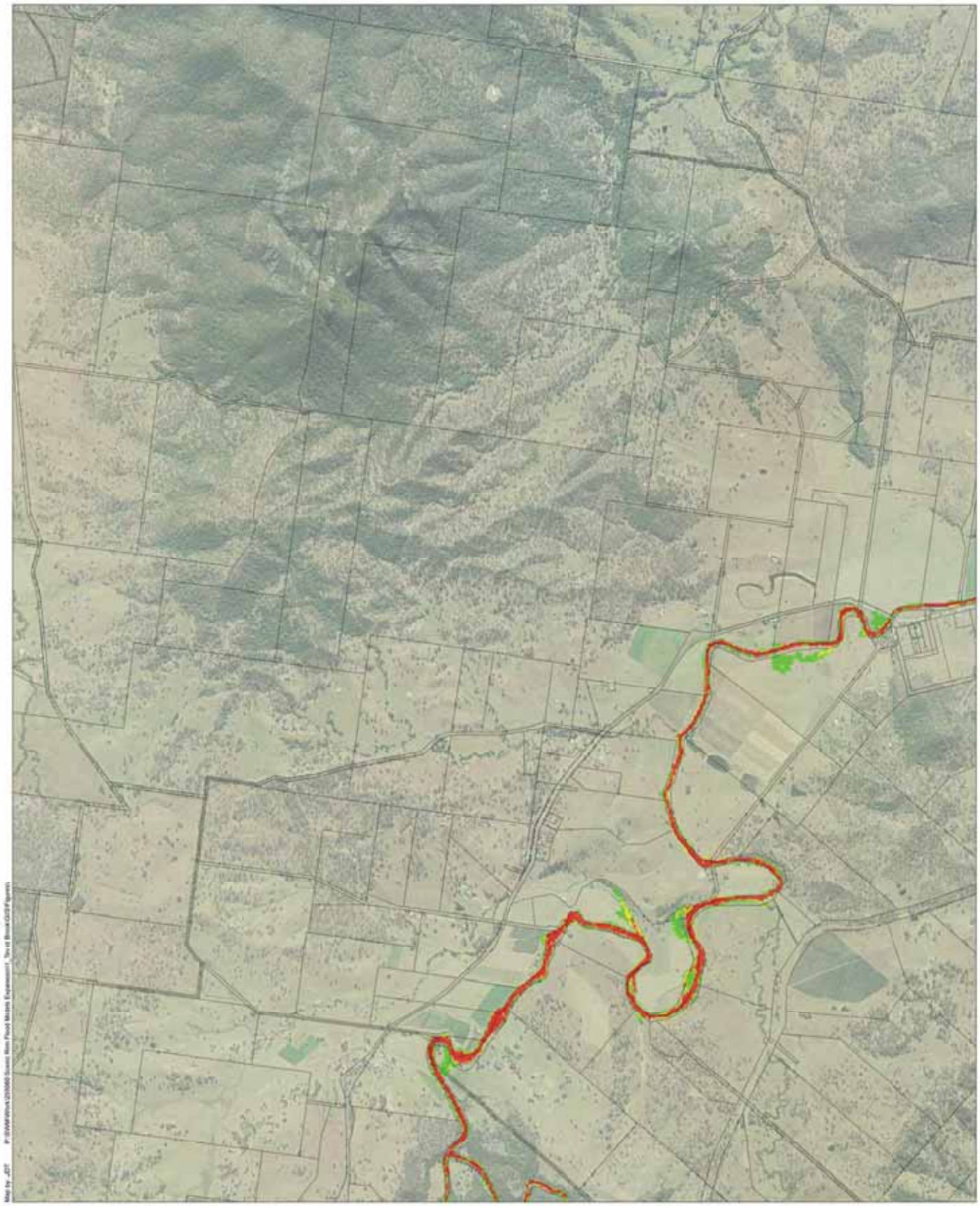
Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Teviot Brook 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

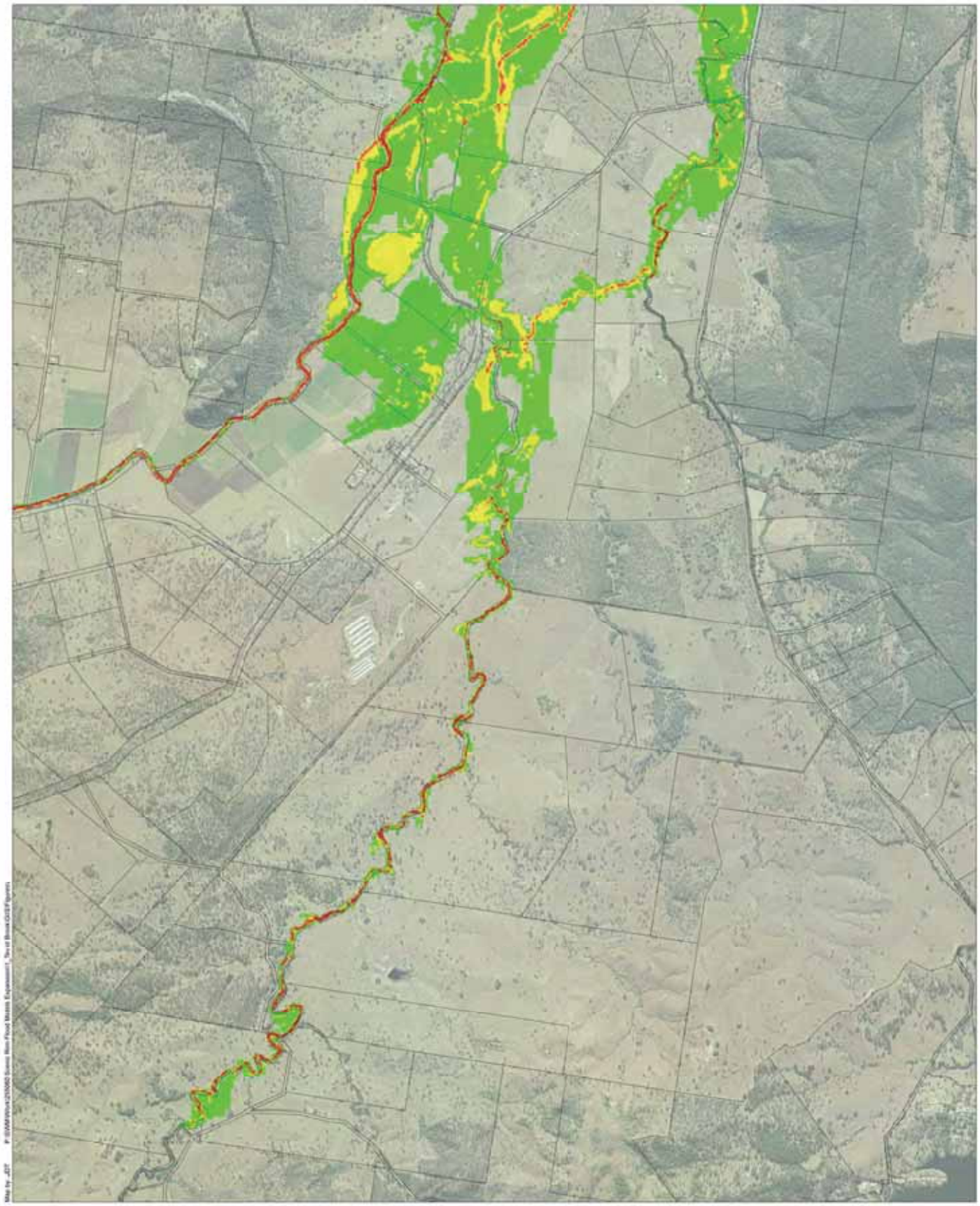
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Teviot Brook Flood Study **Figure E4-b**

10% AEP Event - Peak Hazard Map



Legend

SRRC Boundary

Cadastral Boundary

Low Hazard

Medium Hazard

High Hazard

Notes:

1:25,000

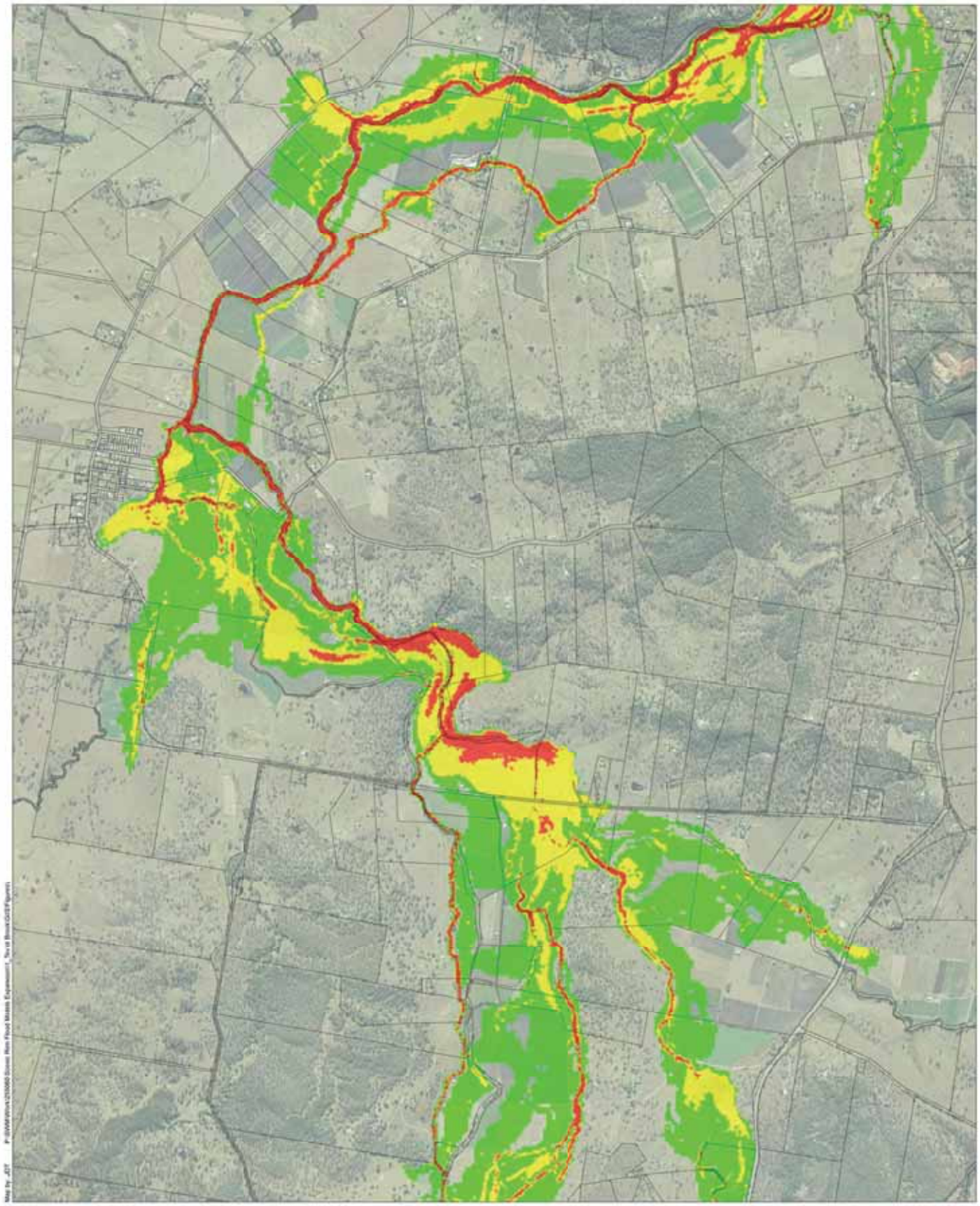
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Teviot Brook Flood Study Figure E4-c

10% AEP Event - Peak Hazard Map

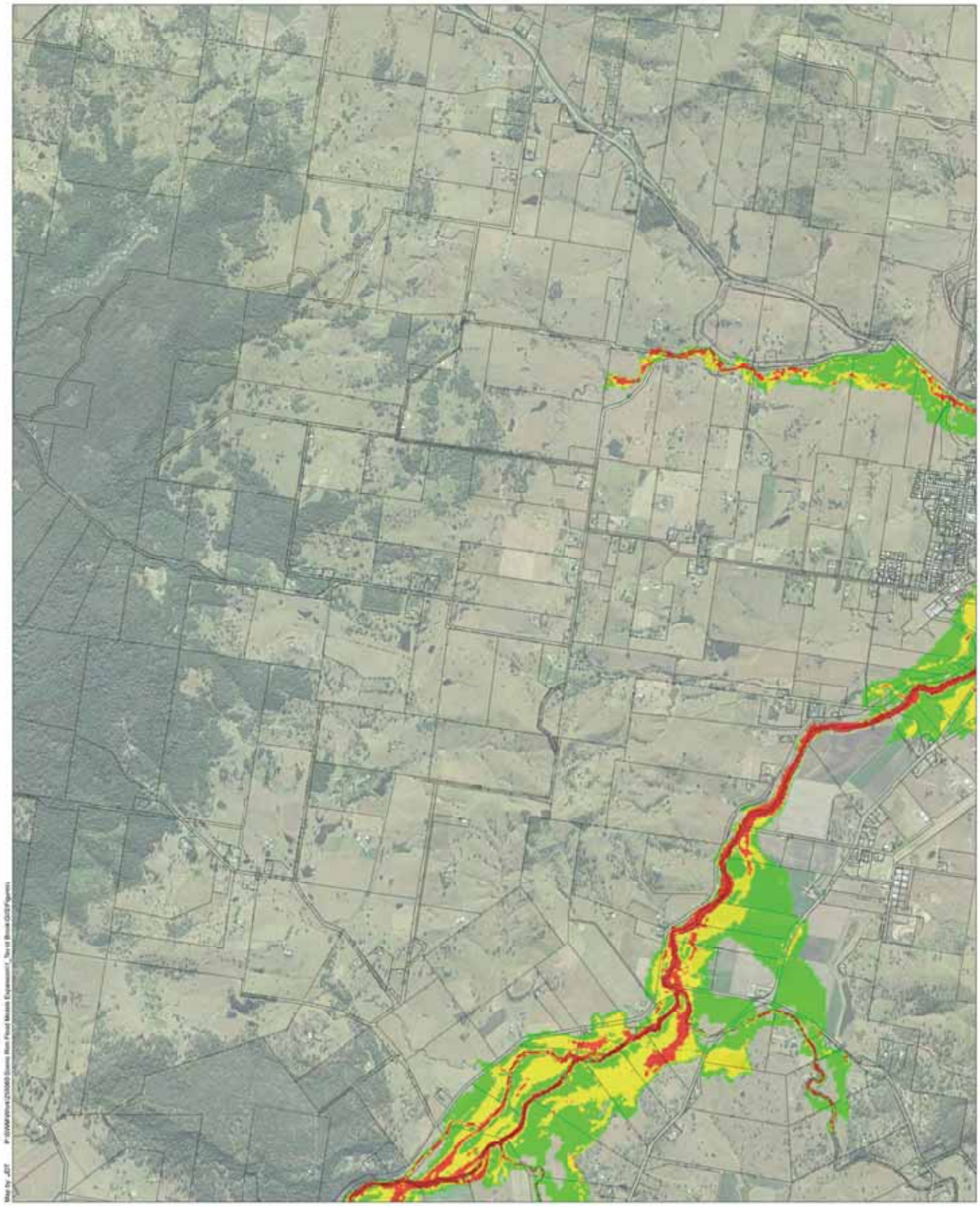


1:25,000
0 625 m 1,250 m

Date: 24/10/2017 Version: 0 Job No: 255060
Projection: MGA Zone 56

Teviot Brook Flood Study Figure E4-d

10% 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

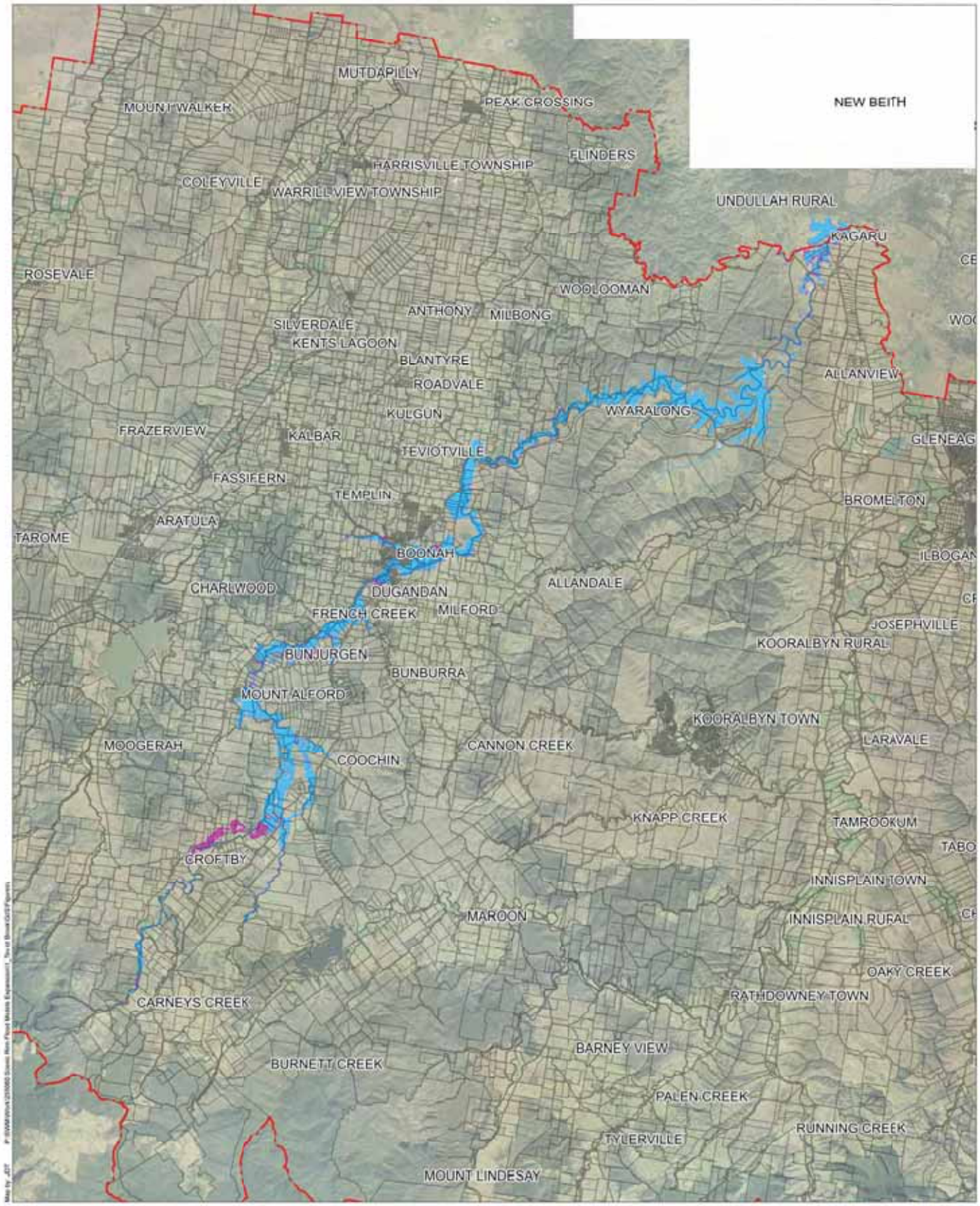
Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Teviot Brook Flood Study Figure E4-e

10% AEP Event - Peak Hazard Map

aurecon



Legend

SRRC Boundary

Cadastral Boundary

Notes:

1:100,000

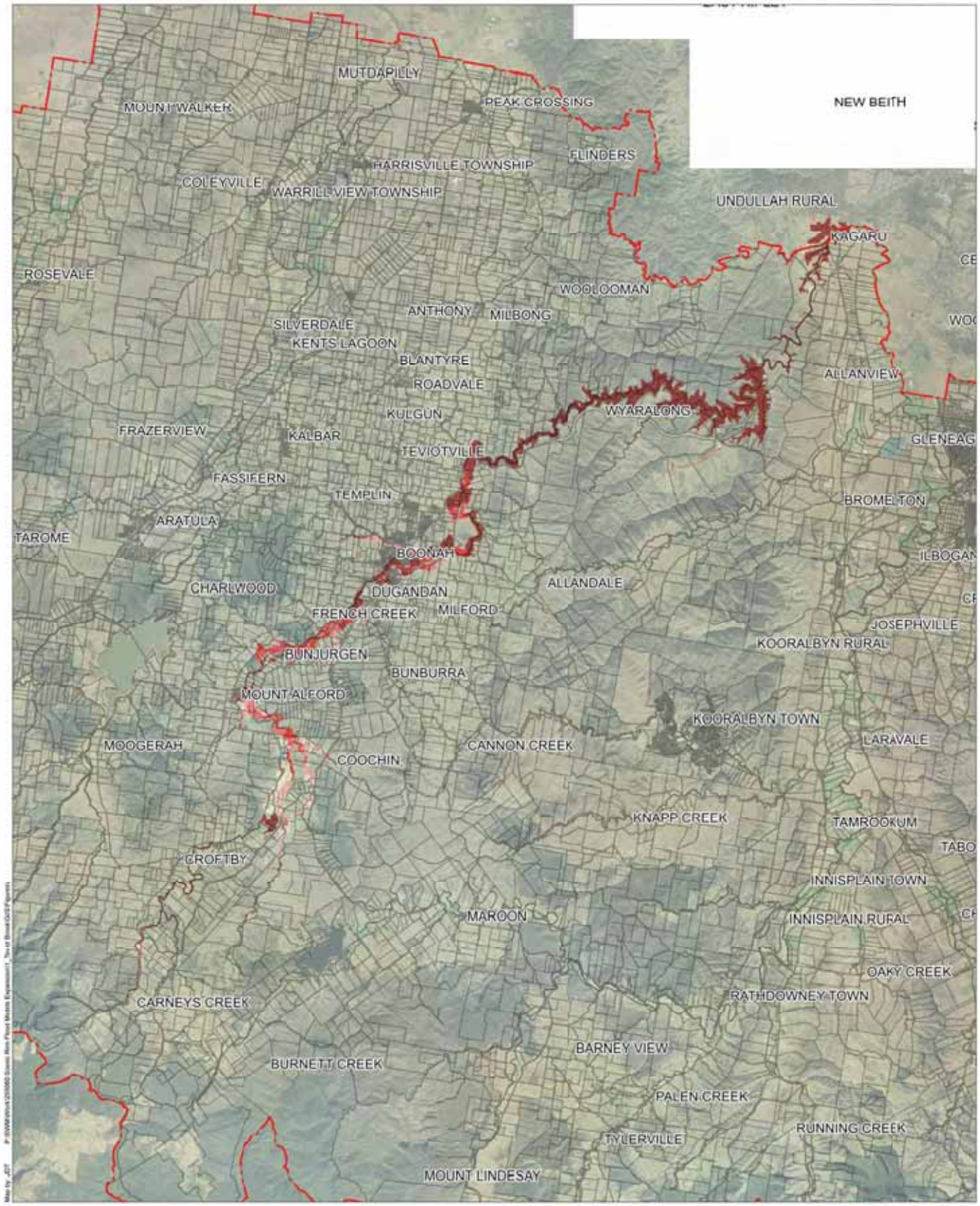
0 2,500 m 5,000 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Teviot Brook Flood Study Figure E5 - a

10% AEP Event - Climate Change Inundation Extent



Legend

SRRC Boundary

Cadastral Boundary

Afflux (m)

< -1.20	0.03 to 0.30
-1.20 to -0.90	0.30 to 0.60
-0.90 to -0.60	0.60 to 0.90
-0.60 to -0.30	0.90 to 1.20
-0.30 to -0.03	> 1.20
-0.03 to 0.03	

Was Dry Now Wet

Was Wet Now Dry

Notes:

1:100,000

0 2,500 m 5,000 m

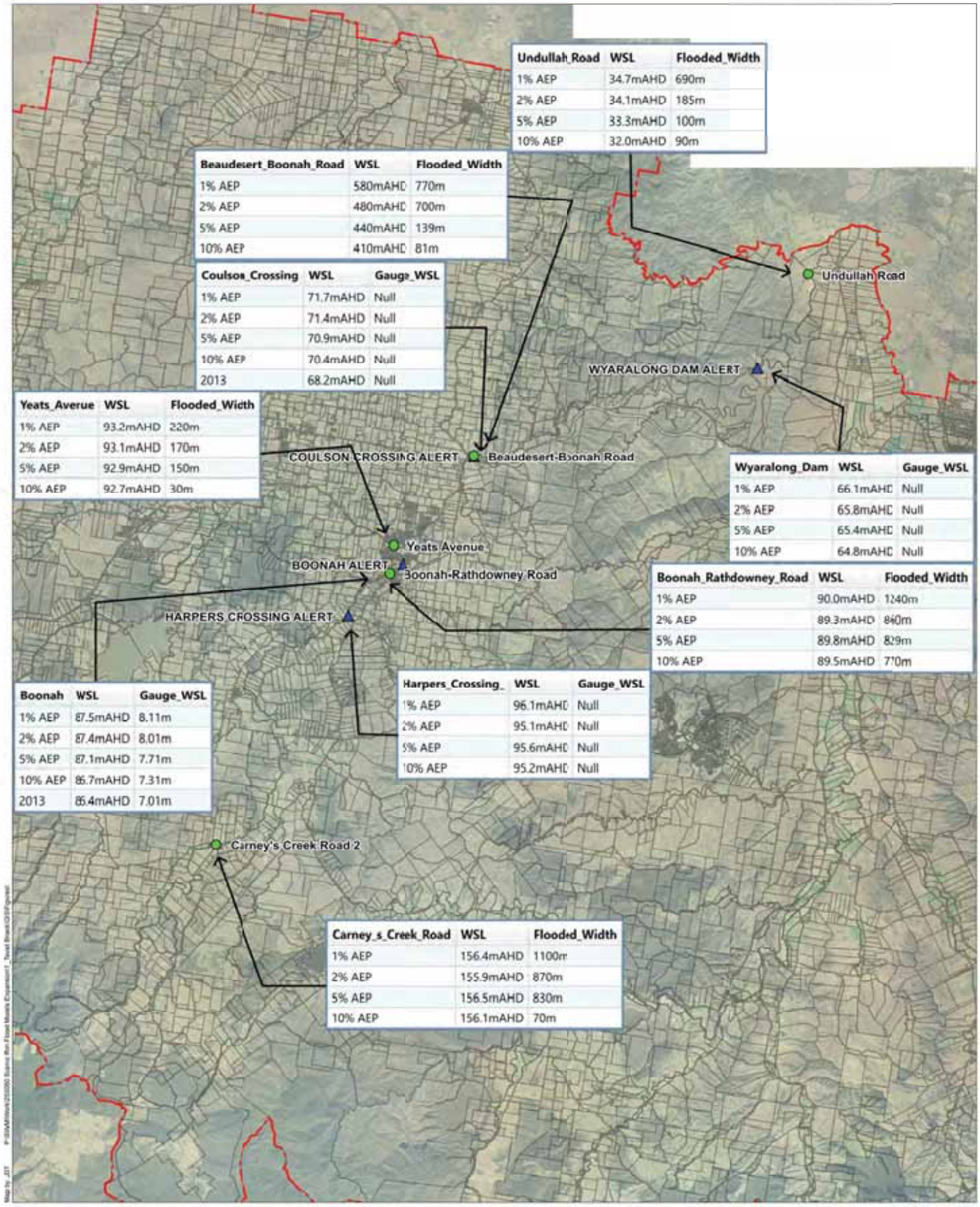
Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Teviot Brook Flood Study **Figure E5 - b**

Climate Change Scenario 4.5 - 10% AEP Event Afflux Map

aurecon



Undullah_Road	WSL	Flooded_Width
1% AEP	34.7mAHD	690m
2% AEP	34.1mAHD	185m
5% AEP	33.3mAHD	100m
10% AEP	32.0mAHD	90m

Beaudesert_Boonah_Road	WSL	Flooded_Width
1% AEP	580mAHD	770m
2% AEP	480mAHD	700m
5% AEP	440mAHD	139m
10% AEP	410mAHD	81m

Coulson_Crossing	WSL	Gauge_WSL
1% AEP	71.7mAHD	Null
2% AEP	71.4mAHD	Null
5% AEP	70.9mAHD	Null
10% AEP	70.4mAHD	Null
2013	68.2mAHD	Null

Yeats_Averue	WSL	Flooded_Width
1% AEP	93.2mAHD	220m
2% AEP	93.1mAHD	170m
5% AEP	92.9mAHD	150m
10% AEP	92.7mAHD	30m

Wyaralong_Dam	WSL	Gauge_WSL
1% AEP	66.1mAHD	Null
2% AEP	65.8mAHD	Null
5% AEP	65.4mAHD	Null
10% AEP	64.8mAHD	Null

Boonah_Rathdowney_Road	WSL	Flooded_Width
1% AEP	90.0mAHD	1240m
2% AEP	89.3mAHD	840m
5% AEP	89.8mAHD	829m
10% AEP	89.5mAHD	710m

Harpers_Crossing_	WSL	Gauge_WSL
1% AEP	96.1mAHD	Null
2% AEP	95.1mAHD	Null
5% AEP	95.6mAHD	Null
10% AEP	95.2mAHD	Null

Boonah	WSL	Gauge_WSL
1% AEP	87.5mAHD	8.11m
2% AEP	87.4mAHD	8.01m
5% AEP	87.1mAHD	7.71m
10% AEP	86.7mAHD	7.31m
2013	86.4mAHD	7.01m

Carney_s_Creek_Road	WSL	Flooded_Width
1% AEP	156.4mAHD	1100m
2% AEP	155.9mAHD	870m
5% AEP	156.5mAHD	830m
10% AEP	156.1mAHD	70m

Legend

Notes:

1:100,000

0 2,500 m 5,000 m

Date: 24/10/2017 Version: 0 Job No: 255060

Projection: MGA Zone 56

Teviot Brook Flood Study Figure F1

Emergency Response Map

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