Jerilderie Shire Council

Jerilderie Flood Study

Final Report

August 2014

Cover photograph: Jerilderie Weir, view looking northwards across the Billabong Creek.

Executive Summary

The Jerilderie Flood Study was commissioned by the Jerilderie Shire Council. The study has assessed Billabong Creek and Wangamong Creek flooding conditions at the township of Jerilderie.

The study has been carried out in accordance with the NSW Government's Floodplain Development Manual (2005). The primary objective of the NSW Government's Flood Prone Land Policy is to reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone property, and to reduce private and public losses resulting from floods.

In urban areas, the management of flood-prone land remains the responsibility of local government. The NSW State Government provides funding to assist local councils with the development of floodplain risk management plans and their implementation.

The study has been overseen by Council's Floodplain Risk Management Committee. The Committee met regularly during the study to review progress and provide direction for future activities. The investigations carried out as part of this Flood Study may form the foundations for a future Floodplain Risk Management Study.

Data Review and Community Consultation

Data review and community consultation activities are documented in Sections 3 and 4 of this report. The data review focused on the available records for the Billabong Creek gauging station at Jerilderie.

A newsletter was distributed to all residents of Jerilderie in September 2013 shortly after the commencement of the project providing an overview of the project, identifying the local community representatives on the Committee and requesting residents to contact Council if they are aware of any data or issues of relevance to the study.

Hydrology

The hydrology analysis activities are documented in Section 5 of this report. Hydrology analysis was limited to flood frequency analysis of the gauging station records for Billabong Creek at Jerilderie and a review of previous study flow estimates for Wangamong Creek.

The adopted 100 year ARI peak design flood level at the Billabong Creek gauging station is 108.57 m AHD. This is marginally higher than a previous estimate derived from a study undertaken in 2002.

The flood frequency analysis results place the recent March 2012 Billabong Creek event as equivalent to a 5 year ARI design event. The 2012 event was much smaller than the largest Jerilderie floods on record which occurred in 1931, 1956 and 1974.

Hydraulic Modelling - Calibration

The hydraulic modelling activities are documented in Sections 6 and 7 of the report.

Hydraulic modelling was carried out using the TUFLOW model. All of the study area floodplain was represented using two dimensional modelling techniques based on a 5 metres grid. The terrain data source used was a 2013 LIDAR aerial survey obtained specifically for the study.

The TUFLOW model was calibrated using recorded flood height data from the March 2012 flood. The model was calibrated to achieve the optimum level of agreement between the available recorded flood heights and the modelled flood heights. The level of agreement achieved is considered satisfactory after taking into account the accuracy limitations of recorded flood height marks.

The 100 year ARI inflow into the TUFLOW model was then adjusted until the modelled flood level at the gauging station matched the adopted 100 year ARI flood level derived from the flood frequency analysis. The subsequent resultant 100 year ARI design flow identified was 15,500 ML/day.

The absence of recorded flows and flood heights for Wangamong Creek did not allow for calibration of the hydraulic conditions for that creek.

Hydraulic Modelling – Design Flood Events

The modelling results for the 5, 10, 20, 50, 100, 200 and extreme event are described in Section 7 of the report. Flood map outputs associated with the design event modelling are included in Appendix B (design flood extents and heights), Appendix C (provisional flood hazard maps), Appendix D (hydraulic category maps) and Appendix E (flood profile plans).

Notable features of flooding conditions as derived from the modelling results are:

- The Newell Highway is not overtopped by the 200 year ARI flood at either Billabong Creek or Wangamong Creek.
- The disused Railway line at Billabong Creek is not overtopped in a 100 year ARI flood. The railway line at Wangamong Creek is marginally overtopped in a 100 year ARI flood.
- 100 year ARI flooding from Billabong Creek affects some properties at Ashton Street, Bolton Street, McDougall Street and Powell Street.
- Floodwaters from Billabong Creek will spill into Lake Jerilderie in events more severe than an 80 year ARI event.
- The airport is subject to shallow inundation from Wangamong Creek flooding in a 100 year ARI event.

It is important that flood height data is collected following future flood events to assist in verifying model predicted conditions, particularly for Wangamong Creek where little or no data has been recorded in the past.

Flood Damages

Flood damages at Jerilderie were estimated using the outputs from the hydraulic modelling (i.e. design flood levels for full range of events modelled). The damages are estimated based on a comparison of the flood levels with building floor levels and flood damage data which accounts for direct property damages (e.g. contents damages, external damages and structural damages) and indirect damages (e.g. clean-up costs, loss of business).

The principle outputs from the flood damage analysis are summarised as follows:

- Negligible flood damage for events up to and including the 20 year ARI flood.
- Total flood damage in a 100 year ARI event is $733,000.
- There are seven properties subject to above floor flooding in a 100 year ARI event (five houses, one block of flats and one school building). The maximum depth of 100 year ARI above floor flooding for these properties is 0.31 metres. Four of the properties are located in Bolton Street with one each in Powell Street, Ashton Street and the Old Showground Road.
- The average annual flood damage at Jerilderie is $31,000 per annum.

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1. Introduction

The primary objective of the NSW Government's Flood Prone Land Policy is to reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone property, and to reduce private and public losses resulting from floods.

The Jerilderie Flood Study has been undertaken to provide the Jerilderie Shire Council and other stakeholders with an up to date understanding of riverine flooding conditions at Jerilderie (flooding due to Billabong Creek and Wangamong Creek). This will assist Council and other government agencies to make appropriate decisions in relation to future land use planning and also provide the basis from which to proceed with a floodplain management study to mitigate flood risks.

Past floods are understood to have caused limited damage at Jerilderie. This includes the most recent large flood in 1974.

This Flood Study represents the first step in the floodplain management process as set out by the NSW Floodplain Development Manual (2005). The four steps are:

- Flood Study – technical assessment to define the nature and extent of flooding under existing conditions;
- Floodplain Risk Management Study - evaluates management options for the floodplain giving consideration to hydraulic, environmental, social and economic issues;
- Floodplain Risk Management Plan – formal plan prepared which outlines the adopted strategies to manage flood risk and flood management issues; and
- Plan Implementation – measures nominated by the plan are put in place.

The study was undertaken in the following stages:

- Stage 1 – Data collection / assessment, community consultation and hydrology. This stage encompassed the identification, acquisition and review of data available for the project, confirmation of any additional survey data to be obtained, a summary of initial community consultation activities and the hydrologic investigations undertaken.
- Stage 2 – Hydraulic modelling compilation and calibration. This stage encompassed the establishment and calibration of the study area hydraulic model and preliminary 100 year ARI flood height and extent mapping.
- Stage 3 - Final hydraulic modelling and related tasks. This stage consisted of hydraulic modelling of the range of required design flood events, the preparation of flood mapping, assessment of climate change potential impacts and location specific flood output data at point of interest.
- Stage 4 – Draft Flood Study Report. Draft final report prepared detailing all of the investigations. Flood map outputs form an important part of the report.
- Stage 5 – Final Flood Study report. The draft report will be updated as appropriate to take into account any comments received from the Committee.
- Stage 6 – Completion of contract. All data and deliverables will be handed over to Council at the completion of the project.

The Flood Study was overseen by Council's Floodplain Risk Management Committee. The Committee met on four occasions during the project. Progress reports were submitted to the Committee at the completion of the respective stages.

Two terms are typically used to define the severity of flood events in Australia. The term Average Recurrence Interval (ARI) refers to the long term average number of years between the occurrence of a flood as big as or larger than the selected event. A flood with a discharge as great or greater than the 20-year ARI flood event for example will occur on average once every 20 years. The term ARI is used in this report to describe the size of flood events as it is generally well understood by most.

The alternative term is Annual Exceedance Probability (AEP). This term expresses the chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage. A 5% AEP event has a 5% chance (i.e. one in twenty) of being equaled or exceeded in any one year.

Page size A4

0 5 10 20 30 40

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

LEGEND

- State border
- Populated place
- Highway or principal road
- Lake
- Perennial watercourse
- Forestry Reserve
- Nature Conservation Reserve

Jerilderie Shire Council
Jerilderie Flood Study

Job Number | 23-14980
Revision | A
Date | 28 Apr 2014

Locality Plan - Jerilderie

Figure 1

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Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

Data Source: Geoscience Australia: 250k Data - Jan 2011. Created by: sdwoodger

2. Description of Flooding Conditions

2.1 Billabong Creek Catchment Description

The Billabong Creek catchment headwaters are located at the Carabost State Forest, to the east of the Hume Freeway, approximately 180 km east of Jerilderie (refer to Figure 2).

The Billabong Creek route is aligned through Garryowen (Hume Freeway 15 km north east of Holbrook), Culcairn, Walbundrie and Rand on route to Jerilderie.

Catchment areas are as follows:

- At Garryowen – 714 km^2
- At Walbundrie – 3,065 km^2
- At Jerilderie – 7,000 km^2 (approximately only)

Typical flood travel times based on a review of past floods are as follows:

- Garryowen to Walbundrie – 2 days
- Walbundrie to Innes bridge – 9 to 14 days
- Innes Bridge to Jerilderie – 4 to 5 days

The catchment at Walbundrie is relatively self-contained (i.e. no inflows or outflows from or to outside catchments). Between Lake Urana and Jerilderie, there is an exchange of floodwaters between the Billabong Creek and the Murrumbidgee River system. Outflows also occur into the adjoining Wangamong Creek system. This has a significant influence on flooding conditions at Jerilderie.

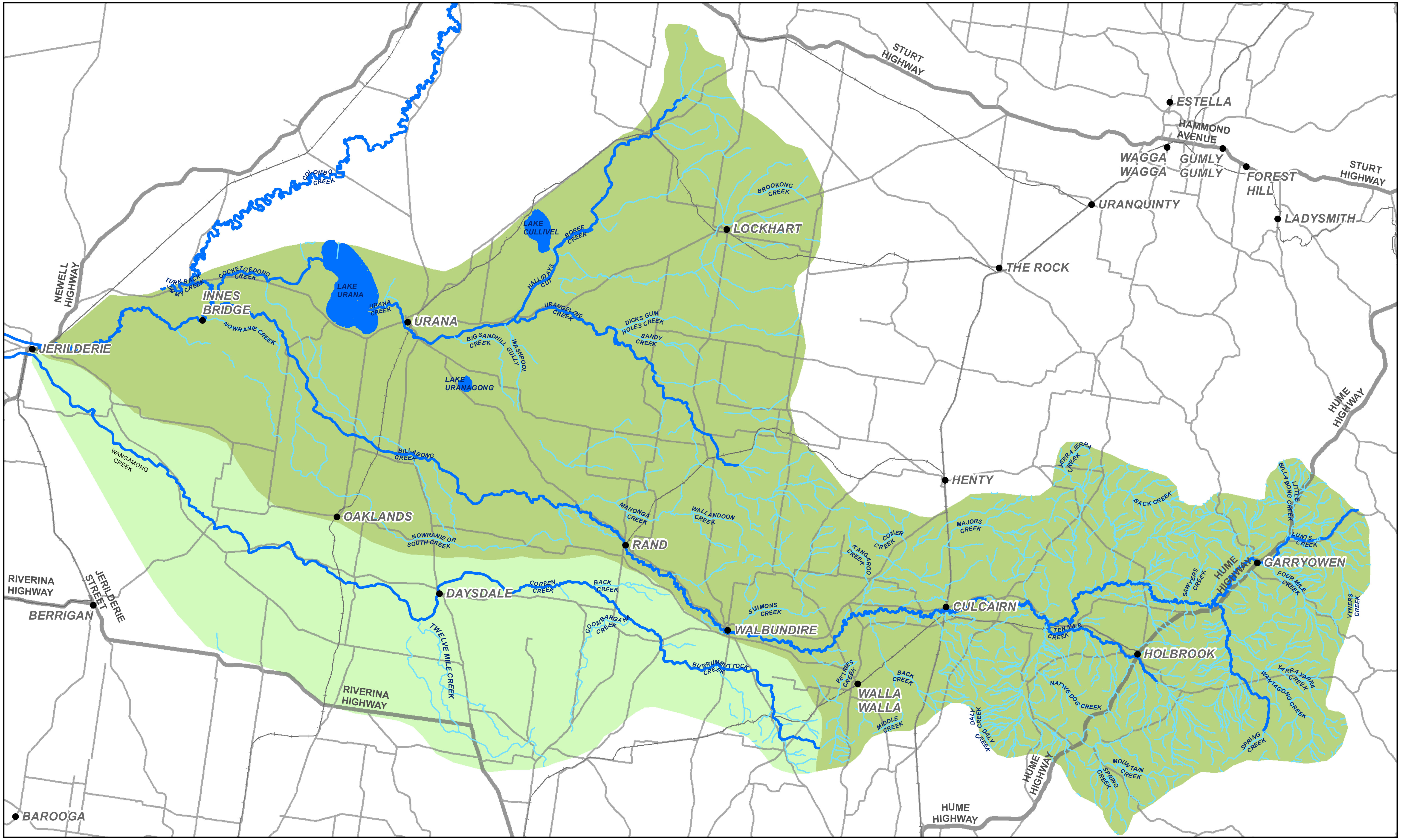
Past reports (Bewsher, 2002) indicate that peak Billabong Creek flows at Jerilderie are significantly lower than the peak flows at Walbundrie for the following reasons:

- Natural floodplain storage attenuation of peak flows along the floodplain between Walbundrie and Jerilderie.
- Permanent storage of floodwaters within water bodies.
- Diversion of floodwater into the south side Wangamong Creek system.

'Every flood is different' is a time honoured phrase and is very much applicable to the Billabong Creek system. Shorter duration floods are typically most affected by floodplain storage attenuation affects. Longer duration floods (e.g. 1956) are less affected by floodplain storage attenuation.

There are two large storages which affect flooding conditions at Jerilderie. They are:

- Lake Urana. This is the largest natural storage on the Billabong Creek floodplain. The lake absorbs a substantial portion of Billabong Creek flows in large flood events, assuming that the lake is not full prior to the event. The storage volume in the lake below the peak 1974 flood level is 278,000 ML.
- Lake Uranagong. This is a much smaller storage lake, with an estimated 5% of the volume of Lake Urana. It is the second largest storage on the floodplain between Walbundrie and Jerilderie.



Page size A3

0 2,2004,400 8,800 13,200 17,600
Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

N

LEGEND

- Major Creek
- Minor Creek
- Billabong Creek Catchment
- Wangamong Creek Catchment
- Lakes
- Populated place
- Highways
- Major roads
- Railways

GHD

Jerilderie Shire Council
Jerilderie Flood Study

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Date	17 Jul 2014

Catchment plan
- Billabong Creek and Wangamong Creek

Figure 2

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Data Source: NSW Department of Lands: DTDB and DCDB - 2012. Created by: AFoddy

Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

The Colombo Creek is an effluent stream which discharges flood flows from the Murrumbidgee River system into the Billabong Creek system. Colombo Creek flows enter the Billabong Creek system between Lake Urana and Jerilderie. The Yanco Creek bypasses Jerilderie to the north, before flowing into the Billabong Creek upstream of Conargo.

2.2 Wangamong Creek Catchment Description

The headwaters of the Wangamong Creek catchment are located at Burrumbuttock, 115 km south east of Jerilderie (refer to Figure 2). Burrumbuttock Creek flows into the Coreen Creek which in turn flows into Wangamong Creek downstream of Daysdale. Wangamong Creek itself originates east of Lowesdale.

Indicative catchment areas are as follows:

- At Daysdale – 760 km^2 (i.e. Coreen Creek catchment)
- At Wangamong – 1,440 km^2 (i.e. Coreen Creek catchment plus Twelve Mile Creek catchment).
- At Jerilderie – 2,100 km^2

Almost the entire catchment is extremely flat. The amount of natural floodplain storage along the waterway routes leading to Jerilderie is vast.

Wangamong Creek does not discharge into Billabong Creek until 10 km west (downstream) of Jerilderie. The creek route skirts around the southern fringe of the Jerilderie township.

The 2002 Bewsher report identified the following sources of inflow to Wangamong Creek:

- Inflows from the Coreen Creek system upstream of Daysdale. The Coreen Creek becomes known as the Wangamong Creek downstream of Daysdale.
- Inflows from the Twelve Mile Creek. This creek joins the Wangamong Creek immediately downstream of Daysdale.
- Overflows from Billabong Creek between Walbundrie and Rand into the Coreen Creek.

The flow in Wangamong Creek downstream of the Twelve Mile Creek junction was gauged in the 1970 flood. The gauged flow was 1,600 ML/day.

2.3 Past Floods – Overview

The peak annual recorded flood heights and associated estimated flows at the Jerilderie Billabong Creek gauging station are discussed in Section 3.2.

A previous report (Bewsher, 2002) indicated that the five highest ranked floods to have occurred at Jerilderie since records commenced in 1912 are as follows:

- 1931
- 1974
- 1956
- 1939
- 1960

An overview of both recent floods and the largest floods on record is provided as follows. Further details on historical floods are provided in Section 4.2.

2.3.1 March 2012, February 2011 and November 2010

Three recent floods have occurred at Jerilderie. All three of these floods peaked within a few cm of 1.74 m (107.14 m AHD) at the Jerilderie gauge, ranking outside the 15 highest recorded flood events at Jerilderie (i.e. for the period since the Jerilderie gauge commenced operation in 1912). This was despite the 2010 and 2012 peak recorded flood levels at the Walbundrie gauge ranking only below the 1931 flood level.

Impacts at Jerilderie are understood to have been very minor in each of the recent floods. The very high peaks at Walbundrie in 2010, 2011 and 2012 are understood to have caused considerable concern, however floodplain storage effects between Walbundrie and Jerilderie substantially reduced the Billabong Creek peak flow by the time it reached Jerilderie.

2.3.2 September 1990

The ninth highest ranked flood at Jerilderie occurred in September 1990, peaking at 2.10 metres. This followed an earlier almost identical peak in early August of the same year.

Floodwaters remained above 1.6 metres at the Jerilderie gauge for a two month period from mid-July through to mid-September of 1990. This event is the largest flood at Jerilderie since 1981.

2.3.3 July 1981 and September 1983

The floods of 1981 and 1983 peaked at 2.19 and 1.98 metres respectively at the Jerilderie gauge. This places the 1981 flood as the 7th highest flood at Jerilderie, with the 1983 flood ranked 10th highest. The 2002 Bewsher report quotes flood volumes for the 1981 event as 304,000 ML and for the 1983 event as 142,000 ML.

2.3.4 October 1974

The 2002 Bewsher report indicate this event is the second highest flood on record at Jerilderie, peaking at 2.73 metres in July. The 2002 report quotes a flood volume of 491,000 ML at Jerilderie for the 1974 flood.

Impacts at Jerilderie are reported to have been relatively minor. Reports indicate a number of buildings were close to being subject to above floor flooding. No confirmed accounts of above floor flooding have been identified.

2.3.5 July 1956

The 2002 Bewsher report indicates that the 1956 event is the third highest flood on record at Jerilderie, peaking at 2.61 metres in July. Flooding occurred over a number of months, notably between May and September. A further rise then occurred in October / November.

The 2002 report quotes a flood volume of 1,220,000 ML for the 1956 flood, considerably more than all other floods on record.

2.3.6 July 1931

The 2002 Bewsher report indicates that the July 1931 flood is the highest flood on record at Jerilderie. The current study has not been able to confirm this, given the absence of a reliable recorded height at the gauging station (refer to Section 4.2 for further details). The 1931 event is confirmed however as the highest flood experienced at Walbundrie since at least the early 1900s.

The 2002 Bewsher report indicates that significant flooding at Jerilderie in 1931 would have extended over a period of at least four weeks. The estimated 1931 flood volume at Jerilderie is quoted as 688,000 ML.

3. Community Consultation

3.1 Floodplain Risk Management Committee

Council established a Floodplain Risk Management Committee to oversee the Jerilderie Flood Study. The eight person Committee consists of the following members:

- Three Council staff representatives.
- Two Councillors.
- One local community representatives.
- One OEH representative.

The initial Committee meeting took place on the 29 August 2013. At this meeting, the Committee agreed that a Flood Study Community Newsletter would be distributed to all residents of Jerilderie. The Newsletter provided an overview of the project, identified the local community representatives on the Committee and requested those residents who have reliably recorded past flood height marks to contact Council or GHD.

The Committee subsequently met in October 2013, March 2014, May 2014 and July 2014 to discuss progress on the study. Progress reports were submitted to Council prior to these meetings.

3.2 Community Newsletter

The Flood Study Community Newsletter was prepared following the inception Committee meeting. The Newsletter was distributed to all residents of Jerilderie in late September 2013 (i.e. to approximately 580 households and businesses). A copy of the Community Newsletter is included in Appendix F.

The Newsletter provided residents with project information concerning:

- The reasons why the Flood Study is being undertaken.
- A brief overview of the most significant past floods at Jerilderie.
- The role of the Committee and the local community members on the Committee.
- The names of the Councillors and the community representative on the Committee.
- A request that residents contact GHD or Council if they have previously recorded the peak flood height in previous large flood events.
- Contact details for both Council and GHD.

The only direct contact following the distribution of the Newsletter was from a landholder on the Columbo Creek, well outside the township hydraulic modelling area.

3.3 Public Meeting and Public Exhibition of Draft Report

A draft version of the Jerilderie Flood Study report was placed on public exhibition by Council in June/July 2014. No written public submissions were subsequently received by Council.

A public meeting was held during the public exhibition period on the 24 June 2014. An overview of the draft report was presented to those present. An open question and answer session followed during which various aspects of the study were discussed.

4. Data Review

4.1 Previous Reports

4.1.1 Conargo Studies

Flood Data Assessment Study Report (Lyall & Associates, December 2008)

This report documents the preliminary investigations undertaken in advance of the Conargo Flood Study and the Conargo Floodplain Risk Management Study (FRMS). Conargo is located on the Billabong Creek approximately 50 km west (downstream) of Jerilderie and has a population of about 30.

The report describes the flood history at Conargo based largely on the Puckawidge gauging station (410017). This station is located 3 km upstream of Conargo and has operated since 1912.

Notable historic flood events on record that are referred to are the 1956 flood and the 1974 flood.

Conargo FRMS and Plan Report (Lyell & Associates, July 2010)

The results of hydrologic flood frequency analysis and hydraulic modelling investigations are documented in this 2010 report.

The hydrologic flood frequency analysis is applied to the Puckawidge gauging station data. The resulting adopted 100 year ARI peak design flow at the Puckawidge site is 19,500 ML/day. This compares to the following five highest peak flow events recorded since 1912:

- July 1956 – 22,000 ML/day (equivalent to greater than a 100 year ARI event).
- August 1952 – 18,000 ML/day (between a 50 and 100 year ARI event)
- September 1974 – 16,800 ML/day (between a 50 and 100 year ARI event)
- May 1950 – 12,700 ML/day (between a 20 and 50 year ARI event)
- August 1931 – 12,400 ML/day (between a 20 and 50 year ARI event)

The major inflows into the Billabong Creek downstream of Jerilderie, prior to Conargo, occur from Yanco Creek. Yanco Creek is an effluent creek of the Murrumbidgee River. The report notes that in past major floods, the peak at Puckawidge often occurs in advance of the peak at Jerilderie indicating that the peak flow in Yanco Creek is a major influence. The peak 1956 flow in Yanco Creek recorded at the Morundah gauging station is given as 19,600 ML/day (i.e. close to 90% of the peak gauged flow at Puckawidgee).

Given the above, flooding conditions at Conargo are not reflective of flooding conditions upstream at Jerilderie.

4.1.2 Billabong Creek Rural Floodplain Studies

Data Review and Flood Behaviour Report (Bewsher Consulting, June 2002)

This was the first stage in the process leading to the preparation of a floodplain management plan for the rural Billabong Creek floodplain between Walbundrie and Jerilderie.

This 2002 report documents the data review and flooding behaviour investigation activities. The report includes:

- Flood data summary including gauged streamflow data and rainfall data.
- Overview of past flood events and influences.

- Flood frequency analysis of the available gauged records at Walbundrie, Cocketgedong, Jerilderie and Morundah.
- Flood extent mapping based on interpretation of the available data (e.g. oblique aerial photography, field inspections, advice from landholders, previous mapped extents).
- MIKE11 hydraulic modelling results for the study area floodplain. The model was used to simulate flooding conditions in a number of past flood events (1970, 1974, 1981, 1983 and 1995). The model was assembled from cross section survey data (203 cross sections) obtained in 1978 and 1999. The report indicates a lack of survey cross sections for the Billabong Creek channel in the vicinity of Jerilderie.
- The only peak recorded flood levels identified in the report in the immediate vicinity of Jerilderie are at the streamflow gauging station site.

Modelled flows are given in the 2002 report for Billabong Creek and Wangamong Creek on the upstream side of Jerilderie. The 2002 report modelled flows are repeated in Table 1 below. The recorded (estimated) flows at the Jerilderie gauge are listed for comparison purposes. There are no gauged flow records for Wangamong Creek.

Table 1 2002 Bewsher Report Documented Flows

Year	Peak Flow (ML/day)		
	Billabong Creek (modelled)	Billabong Creek (gauged)	Wangamong Creek (modelled)
1970	6,900	5,580	2,200
1974	9,500	9,200	1,800
1981	5,000	5,770	1,300
1983	5,000	4,830	2,000
1995	5,200	3,450	1,300

Note:

1. The above flows are documented in the Phase A Data Review and Flood Behaviour Main Report (Bewsher, 2002).

Floodplain Management Study Report (Bewsher Consulting, July 2004)

This report documents activities as part of the floodplain management study phase leading to the preparation of a floodplain management plan for the Billabong Creek system rural floodplain between Walbundrie and Jerilderie.

The report documents activities to assess issues associated with the management of floodplain wetlands, the distribution of floodwater, existing levees and infrastructure located on the floodplain.

The study adopted a ‘design flood’ basis for the floodway system coinciding with a combination of the 1974 and 1983 floods. This coincides with a design ARI of 25 to 32 years and is intended for application to rural land use activities only.

Outcomes from the study include the proposed floodway network, modifications to flood control works, environmental improvement measures, development assessment criteria and ongoing monitoring measures.

Floodplain Management Plan Report (NSW Department of Natural Resources, May 2006)

This report is the adopted Floodplain Management Plan document. It presents the proposed management plan measures. Key aspects of the Plan are the:

- Floodway network.
- Design flood flow distributions.
- Recommended hydraulic measures and environmental measures generally requiring modifications to flood control works.
- Implementation and monitoring details.

The adopted design flows immediately upstream of Jerilderie are 9,500 ML/day for Billabong Creek (1974 modelled flow) and 2,000 ML/day for Wangamong Creek (1983 modelled flow). These design flows are described within the Plan as being equivalent to 25 to 32 year ARI event. The broader area design flows are shown on Figure 3. Notable flows are the 4,100 ML/day inflow from the Columbo Creek to the Billabong Creek system upstream of Jerilderie and the 2,200 ML/day outflow from Lake Urana. Flow exchange between the Billabong Creek and Wangamong Creek systems is shown downstream of Walbundrie.

None of the recommended modifications to flood control works specified in the 2006 FMP are in the immediate vicinity of Jerilderie.

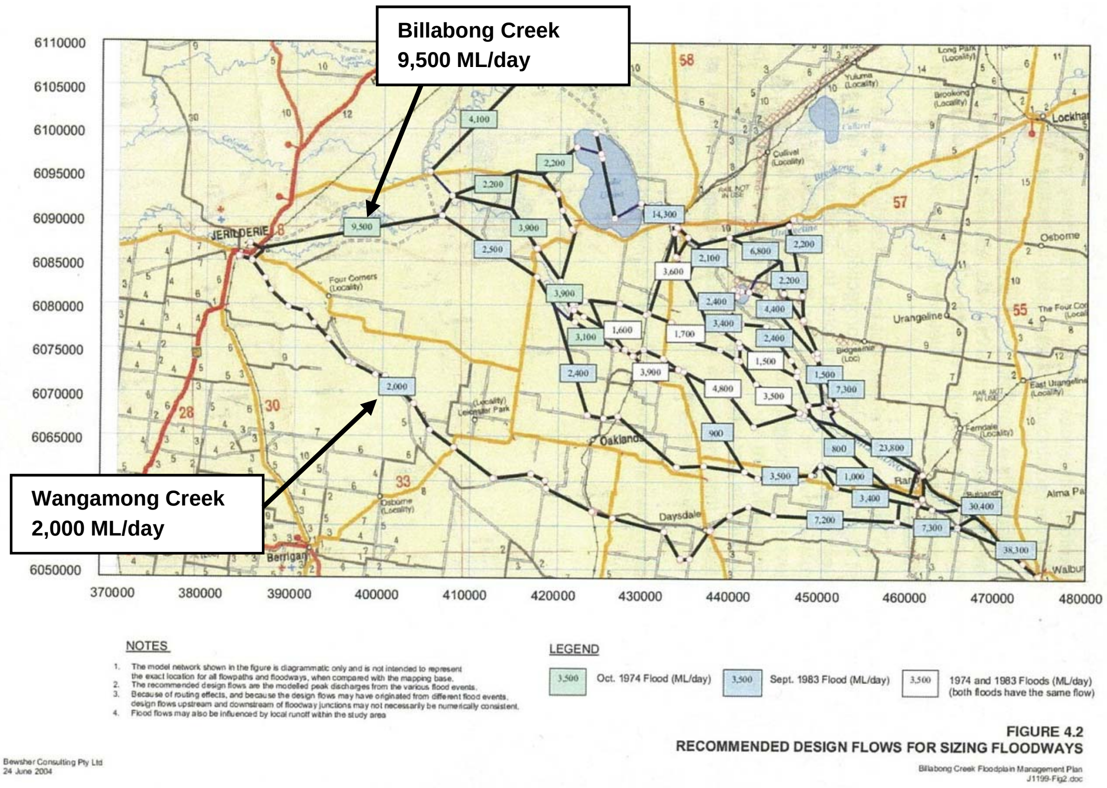

Figure 3 2006 Billabong Creek Floodplain Management Plan Adopted Design Flows

4.2 Streamflow Data

The Billabong Creek streamflow gauging station at Jerilderie (station number 410016) commenced operation in 1912. Semi-continuous records are available since 1912 to the current day.

The Water Monitoring Unit of the NSW Office of Water was able to provide the following information for the Jerilderie station:

- Station for the period 1912 to 1930 was located at the Town Bridge site. This is likely to coincide with the location of the Bolton Street bridge site prior to 1968 (i.e. approximately 50 metres upstream of the existing Bolton Street bridge). The gauge zero elevation was 103.542 m AHD (342.00 feet WCD).
- Station for a brief period around 1930 was moved to the Jerilderie Weir, however reverted back to the Town Bridge site during 1931 as a result of the weir washing out and being damaged by the 1931 flood.
- The current Pump Station site located 600 metres upstream of the weir as shown on Figure 4 has been used since the start of 1950.

The gauge zero datum is the vertical elevation of 0.00 on the gauge relative to a recognised datum (e.g. Australian Height Datum (AHD)). The Water Monitoring Unit of the NSW Office of Water has provided information in regards to the various changes in the gauge zero datum for the Billabong Creek gauge at Jerilderie. The history account is however somewhat confusing and potentially unreliable due to the poor quality of records documenting the changes in zero datums and the apparent numerous changes.

Gauge zero datum information for the Town Bridge site (1912 to 1949) is as follows:

- Initial gauge zero datum following the station commencement in 1912 appears to have been 103.542 m AHD (342 feet WCD). This is approximately 2 metres lower than the gauge zero datum at the Pump Station site.
- Gauge zero datum for the period 1912 to 1949 may have been 103.542 m AHD.

Gauge zero datum information for the Pump Station site (1949 to 2013) is as follows:

- Gauge zero datum for the period 1949 to 1963 appears to be 105.705 m AHD, although this is not completely certain.
- Gauge zero datum for the period 1964 to end of 1974 appears to be 105.571 m AHD. Again there is some doubt attached.
- Gauge zero datum for the period 1974 to 1985 appears to be 105.402 m AHD. Again there is some doubt attached.
- Gauge zero datum for the period 1985 to 2013 is 105.402 m AHD. This appears to be certain.

Recorded flood heights at the Jerilderie gauging station are given in Table 2. Heights are listed as per those documented within the 2002 Bewsher report and also those based on recent advice provided by the Water Monitoring Unit of NSW Office of Water.

The adopted peak flood heights at the Jerilderie gauging station will be used for the flood frequency analysis. Generally recorded heights at NSW government gauging stations are known (i.e. the actual peak heights have been reliably recorded and documented, any changes in the gauge zero datum heights have also been reliably recorded and documented). In this instance, the quality of records would appear to be somewhat dubious, particularly prior to 1950.

Table 2 Peak Recorded Billabong Creek Flood Heights at Jerilderie

Year	Bewsher 2002 Report			NSW Office of Water 2013		
	Peak Stage (m)	Gauge Zero Datum	Peak Stage (m AHD)	Peak Stage (m)	Guage Zero Datum	Peak Stage (m AHD)
1913	0.68	105.40	106.08			
1914	0.40	105.40	105.80			
1915	1.06	105.40	106.46			
1916		105.40	105.40			
1917	1.77	105.40	107.17			
1918		105.40	105.40			
1919		105.40	105.40			
1920	1.75	105.40	107.15			
1921	0.35	105.40	105.75			
1922		105.40	105.40			
1923		105.40	105.40			
1924	1.35	105.40	106.75			
1925		105.40	105.40			
1926		105.40	105.40			
1927	0.37	105.40	105.77			
1928	0.74	105.40	106.14			
1929	0.53	105.40	105.93			
1930	0.91	105.40	106.31			
1931	2.93	105.40	108.33			
1932	1.78	105.40	107.18			
1933	1.23	105.40	106.63			
1934	1.82	105.40	107.22			
1935	1.72	105.40	107.12			
1936	1.85	105.40	107.25			
1937	0.58	105.40	105.98			
1938	0.45	105.40	105.85			
1939	2.37	105.40	107.77			
1940	0.36	105.40	105.76			
1941	0.45	105.40	105.85			
1942	1.55	105.40	106.95			
1943	0.89	105.40	106.29			
1944	0.36	105.40	105.76			
1945	0.48	105.40	105.88			
1946	0.67	105.40	106.07			
1947	0.99	105.40	106.39			
1948	0.73	105.40	106.13			
1949	0.87	105.40	106.27			
1950	1.10	105.40	106.50	0.98	105.70	106.68
1951	1.30	105.40	106.70	1.12	105.70	106.82
1952	2.23	105.40	107.63	2.06	105.70	107.76
1953	0.94	105.40	106.34	0.86	105.70	106.56
1954	1.26	105.40	106.66	1.09	105.70	106.79
1955	1.69	105.40	107.09	1.45	105.70	107.15
1956	2.61	105.40	108.01	2.72	105.70	108.42
1957	0.53	105.40	105.93	0.53	105.70	106.23
1958	1.36	105.40	106.76	1.16	105.70	106.86
1959	0.60	105.40	106.00	0.6	105.70	106.30
1960	2.30	105.40	107.70	2.17	105.70	107.87
1961	0.84	105.40	106.24	0.84	105.70	106.54
1962	0.68	105.40	106.08	0.68	105.70	106.38
1963	0.83	105.40	106.23	0.83	105.70	106.53
1964	1.85	105.40	107.25	1.68	105.57	107.25
1965	0.46	105.40	105.86	0.46	105.57	106.03
1966	0.84	105.40	106.24	0.84	105.57	106.41
1967	0.49	105.40	105.89	0.49	105.57	106.06
1968	1.13	105.40	106.53	0.98	105.57	106.55
1969	1.44	105.40	106.84	1.44	105.57	107.01
1970	2.15	105.40	107.55	2.15	105.57	107.72

Year	Bewsher 2002 Report			NSW Office of Water 2013		
	Peak Stage (m)	Gauge Zero Datum	Peak Stage (m AHD)	Peak Stage (m)	Guage Zero Datum	Peak Stage (m AHD)
1971	0.64	105.40	106.04	0.64	105.57	106.21
1972	0.52	105.40	105.92	0.52	105.57	106.09
1973	1.75	105.40	107.15	1.78	105.57	107.35
1974	2.73	105.40	108.13	2.73	105.57	108.30
1975	1.51	105.40	106.91	1.39	105.40	106.79
1976	0.86	105.40	106.26	0.83	105.40	106.23
1977	0.59	105.40	105.99	0.59	105.40	105.99
1978	1.69	105.40	107.09	1.59	105.40	106.99
1979	0.36	105.40	105.76	0.36	105.40	105.76
1980	0.64	105.40	106.04	0.64	105.40	106.04
1981	2.19	105.40	107.59	2.19	105.40	107.59
1982	0.38	105.40	105.78	0.38	105.40	105.78
1983	1.98	105.40	107.38	1.98	105.40	107.38
1984	1.51	105.40	106.91	0.75	105.40	106.15
1985	0.97	105.40	106.37	0.95	105.40	106.35
1986	1.57	105.40	106.97	1.57	105.40	106.97
1987	1.28	105.40	106.68	1.28	105.40	106.68
1988	1.49	105.40	106.89	1.49	105.40	106.89
1989	1.74	105.40	107.14	1.74	105.40	107.14
1990	2.10	105.40	107.50	2.10	105.40	107.50
1991	1.41	105.40	106.81	1.41	105.40	106.81
1992	1.79	105.40	107.19	1.79	105.40	107.19
1993	1.34	105.40	106.74	1.34	105.40	106.74
1994	0.85	105.40	106.25	0.85	105.40	106.25
1995	1.59	105.40	106.99	1.59	105.40	106.99
1996	1.29	105.40	106.69	1.29	105.40	106.69
1997	0.54	105.40	105.94	0.54	105.40	105.94
1998	0.76	105.40	106.16	0.76	105.40	106.16
1999	0.72	105.40	106.12	0.72	105.40	106.12
2000	1.08	105.40	106.48	1.08	105.40	106.48
2001	0.48	105.40	105.88	0.48	105.40	105.88
2002	0.44	105.40	105.84	0.44	105.40	105.84
2003	0.76	105.40	106.16	0.76	105.40	106.16
2004	0.53	105.40	105.93	0.53	105.40	105.93
2005	0.81	105.40	106.21	0.81	105.40	106.21
2006	0.37	105.40	105.77	0.37	105.40	105.77
2007	0.30	105.40	105.70	0.30	105.40	105.70
2008	0.32	105.40	105.72	0.32	105.40	105.72
2009	0.37	105.40	105.77	0.37	105.40	105.77
2010	1.74	105.40	107.14	1.74	105.40	107.14
2011	1.70	105.40	107.10	1.70	105.40	107.10
2012	1.735	105.40	107.14	1.74	105.40	107.14

Notes:

1. The above recorded heights are at the Billabong Creek gauging station (410016) at Jerilderie. Details in regards to this station are discussed in Section 4.2.

2. The station has been located at the current site, 600 metres upstream of the Jerilderie Weir, since 1949 (refer to Figure 4).

3. Prior to 1949, the Station was located just upstream of the existing Bolton Street bridge site with the exception of a brief period prior to the 1931 flood when the station was moved to the Jerilderie Weir.

4.3 Waterway Structures

The following waterway structures are located within the study area:

- Three rail bridges.
- Two road bridges
- Three footbridges
- Four road culverts
- One weir (Billabong Creek).

The location of the waterway structures is shown on Figure 4. Structures details are summarised in Table 3.

4.3.1 Railway Bridges

Plan data was not available for the railway bridges as advised by the Australian Rail Track Corporation and the private firm John Holland. The three rail bridges were subsequently measured up during field inspections. Rail surface levels were also able to be identified using the 1 m grid LiDAR DEM data.

A soffit level for the main Billabong Creek railway bridge was specified on the Newell Highway bridge plan.

4.3.2 Road Bridges and Culverts

Plans for the two Billabong Creek road bridges were provided by Roads and Maritime Services (Newell Highway bridge) and Council (Bolton Street).

The Newell Highway culvert structure details were obtained from plans supplied by Roads and Maritime Services (Billabong Creek overbank culvert and the Wangamong Creek culvert). The Rifle Range Road culvert structure was measured up in the field.

Road and deck surface levels were able to be identified using the 1 m grid LiDAR DEM data.

4.3.3 Footbridges

Council supplied design plan information for the three foot bridges (Golf course, Ashton Street and Powells Bridge).

Deck levels were able to be identified using the 1 m gird LiDAR DEM data.

Table 3 Waterway Structures Details

ID No.	Crossing (year constructed if known)	Structure Details	Waterway area (m^2)	Levels (m AHD)	Road / Rail Surface (m AHD)	Source data
R1	Railway – main bridge at Billabong Creek	Bridge – total span 62 m	140	Soffit 108.53	110.0	Soffit from plan, rail surface from LIDAR
R2	Railway – north side overbank bridge at Billabong Creek	Bridge – total span 11 m	15	Soffit 109.1	110.0	LIDAR track surface, field measurements soffit
R3	Railway – bridge at Wangamong Creek	Bridge – total span 17 m	19	Soffit 107.9	108.45	LIDAR track surface, field measurements soffit
B1	Newell Highway – Billabong Creek bridge (1984)	Bridge – total span 58 m	230	Soffit 109.4	110.55	DMR plan – bridge completed in 1984.
B2	Bolton Street – Billabong Creek bridge (1968)	Bridge – total span 57 m	240	Soffit 108.5	109.2	Council surveyed level, soffit from 1963 design plan
F1	Golf course footbridge – Billabong Creek	Bridge – total span 36 m	90	107.4 approx.	107.7	Deck from LIDAR, soffit 0.3 m lower from plan
F2	Ashton Street footbridge – Billabong Creek	Bridge – total span 27 m	53	105.9 approx.	106.2 approx.	Council supplied plans – imperial dated 1959
F3	Powells footbridge – Billabong Creek (1997)	Bridge total span 34 m	95	Soffit 108.0 approx.	109.0	Deck approx. only from LIDAR. Soffit 0.3 m lower
C1	Newell Highway – north side overbank culvert – Billabong Creek (1984)	Culvert – five 2.1m (W) x 1.2 m (H) cells	12.6	IL 107.7	110.55	DMR plans and LIDAR
C2	Newell Highway – culvert at Wangamong Creek (1980)	Culvert – seven 2.4 m (w) x 1.2 m (H) cells	20.6	IL 106.7	108.73	DMR plans – dated 1979.
C3	Rifle Range Rd - culvert at Wangamong Creek	Culvert – three 0.9 m diameter culverts.	1.9	IL 106.4	107.7	Road surface LIDAR, IL field measurement.
W1	Billabong Creek Weir	30 metres fixed overflow crest	na	Crest approx. 105.5	na	No plan data available – LIDAR WL upstream 105.75 m AHD

Note: The location of the above structures is shown on Figure 4.

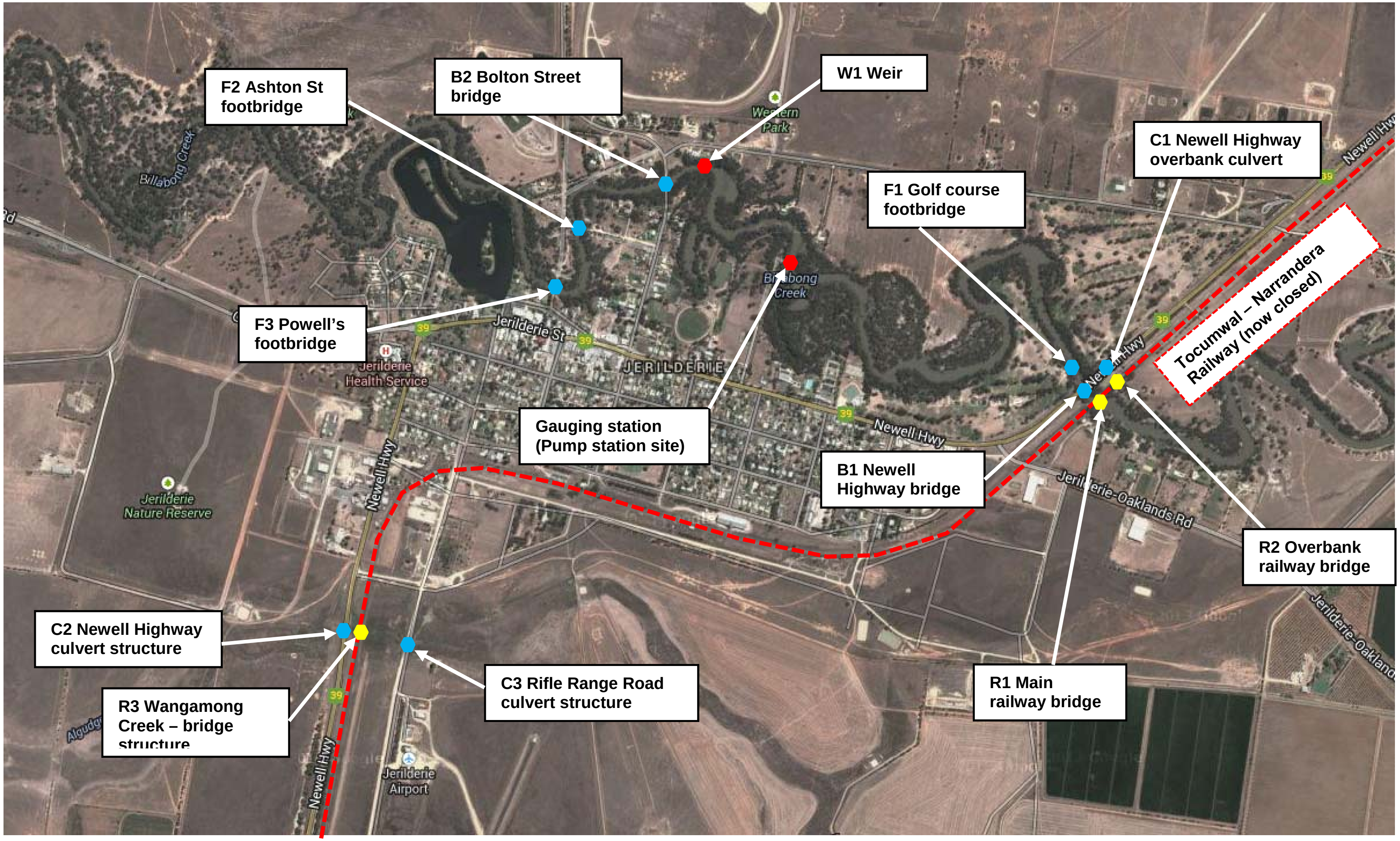

Figure 4 Waterway Structures Plan

Photograph 1 Looking downstream towards the Billabong Creek rail bridge (R1)

Photograph 2 Looking upstream toward the Billabong Creek Newell Highway Bridge (B1)

Photograph 3 Wangamong Creek railway bridge (R3)

Photograph 4 Wangamong Creek Newell Highway culvert (C2)

4.3.4 Weir

There was no plan information available for the Billabong Creek weir. Past reports indicate the following:

- Weir was originally constructed in 1894 and last modified in 1943.
- Weir crest is 30 metres long and approximately 2 metres in height.
- Weir becomes drowned out at a flow of approximately 800 ML/day.

The LiDAR DEM data shows a pool level of 105.75 m AHD on the upstream side of the weir. This would suggest a weir crest level of approximately 105.5 m AHD. This concurs well with the existing rating table at the upstream gauging station, where zero flow is assigned up to 105.53 m AHD.

4.4 Terrain Elevation Data

An aerial survey of the study area was undertaken to produce a digital elevation model of the study area ground surface. The LiDAR survey details are as follows:

- Acquisition date 9 and 10th July 2013
- Accuracy vertical +/- 0.3 metres at two sigma (i.e. 95% of points are within +/- 0.3 metres).

The main limitation of the aerial survey approach is that it does not provide elevation data below the water line at the time of the aerial survey. Billabong Creek waterway cross sections are known at the Billabong Creek streamflow gauging station, the Bolton Street bridge and the Newell Highway bridge. Based on the normal low flow water depth in the creek (i.e. 0.35 metres at the gauging station), the waterway area below the low flow water level is as follows:

- Gauging station 13 m^2. This is estimated to be equivalent to 4% of the high flow (1931) water level waterway area.
- Bolton Street 22 m^2. This is estimated to be equivalent to 10% of the high flow (1931) water level waterway area.
- Newell Highway 40 m^2. This is estimated to be equivalent to 21% of the high flow (1931) water level waterway area.

Of the three above locations, the waterway area details at the gauging station are considered to be by far the most reliable. Given therefore that the low flow channel area represents a small proportion of the active floodplain waterway area in large floods, it was concluded that the acquisition of surveyed in-channel creek cross sections to better define the creek bed geometry was not necessary.

The hydraulic model will however not be capable of simulating low flow conditions within the creek. This would require additional cross sections of the creek bed to be obtained. Modelling of low flow conditions is not necessary for the flood study.

4.5 Recorded Flood Heights

Recorded spot flood heights (flood height marks) are the primary source of data used to calibrate the hydraulic model. The hydraulic model predicted flood height is compared with the available recorded flood heights. Hydraulic model parameters (e.g. Mannings roughness values) are varied until an adequate match is achieved between the model predicted and recorded levels.

Recorded flood heights available for the hydraulic model calibration are currently limited to:

- Recorded heights at the Billabong Creek streamflow gauging station site.
- March 2012 recorded heights at three locations downstream of the gauging station (refer to Figure A1). The three sites are located at:
  - 'The Willows' on the upstream side of Powells Bridge (106.89 m AHD)
  - 'The Estate' opposite Bundoora Avenue (106.69 m AHD).
  - 'South Coree Road' opposite the Conargo Road / South Coree Road intersection (106.44 m AHD).

The Community Newsletter distributed to all Jerilderie residents in late September 2013 requested those residents who have previously recorded reliable peak flood heights to contact Council or GHD. No contact from residents within the study area advising of recorded heights was subsequently received.

5. Hydrology

5.1 Billabong Creek

5.1.1 Approach

The estimation of Billabong Creek design flows for the study area was undertaken using flood frequency analysis techniques. This approach was suited given the availability of long term streamflow records at the Jerilderie station (409016).

Flood frequency analysis is the statistical analysis of recorded flood heights or the corresponding flow rates. The resultant statistically derived design flood levels / flows are therefore a reflection of the past recorded flood levels / flows for the period of available record. As more and more years of records are accumulated, it is possible that the estimated design flows can be revised upwards or downwards depending on the magnitude of future floods.

The alternative to flood frequency analysis is rainfall / runoff (hydrologic) modelling. Rainfall / runoff modelling is the favoured approach in the absence of lengthy streamflow records. This was not the case at Jerilderie. Rainfall / runoff modelling of the catchment above Jerilderie will also have been complicated by the influx of flows from the adjoining Murrumbidgee River catchment (i.e. Columbo Creek) and the significant influence of large storages, particularly Lake Urana, upstream of Jerilderie.

The Billabong Creek streamflow gauge at Jerilderie takes into account all of these upstream influences. It does not require any assumptions to be made in terms of storage starting water levels, antecedent moisture conditions etc.

5.1.2 Billabong Creek Gauging Station Data (409016)

The peak annual recorded flood heights at the Jerilderie gauging station are given in Table 2. There are serious problems in regards to the reliability of the station records as discussed in Section 4.2.

There have been some changes since 1912 which will have had some impact on stage discharge characteristics at the gauging station. Notable changes have included:

- Replacement bridge at Bolton Street completed in 1968. This is expected to have had limited effect on the rating curve at the Pump Station gauge site, given the large waterway opening provided, and the likely elevation of the bridge superstructure above the 100 year ARI flood level.
- Current weir structure which is through to be unchanged since 1943. Previous reports indicate that the weir drowns out at a flow of about 800 ML/day. Given this, the Weir is only likely to influence the lower end of the rating curve at the Pump Station gauge site.
- Jerilderie Lake construction completed in the late 1970s. The Lake is off-line from Billabong Creek.

The rating (stage versus discharge) curve for the gauging station, aside from low flows under the influence of the weir, is unlikely to have been greatly impacted by any of the above changes.

5.1.3 Flood Frequency Analysis Results

The flood frequency analysis was undertaken using the computer program FLIKE. FLIKE is a program which uses the Bayesian approach and up to five probability models which are commonly used in flood frequency analysis.

The current study flood frequency analysis was limited to the period 1950 to 2012. The gauging station has been located at the current Pump Station site since 1949. The data records prior to 1950 are considered not sufficiently reliable to include within the analysis period (i.e. due to uncertainties in regards to gauge zero datums). The gauging station prior to 1950 was located at the Town Bridge site (i.e. the pre 1968 Bolton Street Bridge site) except for an apparent brief period when the station was located at the Weir. Further discussion of these matters is provided in Section 4.2.

The flood frequency analysis results are given in Table 4 and Figure 5. The 2002 Bewsher study design flood level estimates are also included in Table 4 for comparison.

Table 4 Billabong Creek at Jerilderie – Flood Frequency Analaysis Results

ARI (years)	Peak Design Flood Level (m AHD)		
	2002 Bewsher Study – analysis period 1913 to 1998 (m AHD)	2014 Study – analysis period 1950 to 2012	
		(m AHD)	5- 95% confidence limits (m AHD)
2	-	106.54	106.37 – 106.72
5	107.17	107.14	106.92 – 107.38
10	107.60	107.52	107.22 – 107.84
20	107.93	107.85	107.46 – 108.29
50	108.31	108.27	107.74 – 108.87
100	**108.55**	**108.57**	**107.93 – 109.31**
200	-	108.85	108.10 – 109.74

Note:

1. Current gauge zero datum at the Jerilderie gauging station site (Station 409016) is 105.402 m AHD. The gauging station is located as shown on Figure 4, 600 metres upstream of the weir.

The current study flood frequency analysis results in Table 4 are very similar to the 2002 Bewsher study results. The derived 100 year ARI flood level of 108.57 m AHD is 0.02 metres higher than the 2002 study estimate of 108.55 m AHD. Similarly the other recurrence interval results are all very similar. This is somewhat surprising given the changes to the recorded AHD flood levels in response to the gauge height zero datum adjustments. The recorded AHD flood heights since 1974 used for both the 2002 study and the current study flood frequency analysis are the same. The AHD heights prior to 1974 are different however as per Table 2.

Given the results, the following equivalent ARI's are applicable to the post 1950 flood events listed below:

- 1956 flood (peak recorded height 108.42 m AHD) – equivalent to 80 year ARI event
- 1974 flood (108.30 m AHD) – 60 year ARI event
- 1960 event (107.87 m AHD) – 20 year ARI event
- 2012 flood (107.14 m AHD) – 5 year ARI event.

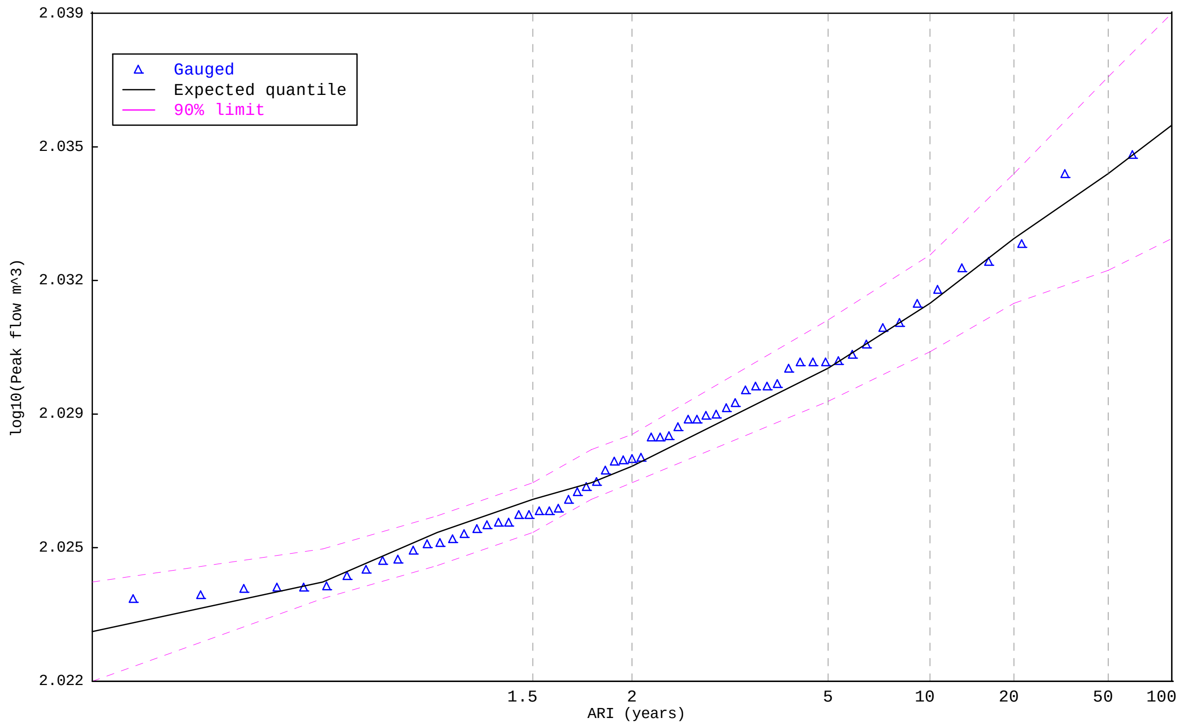

Figure 5 Flood Frequency Analysis Curve (period 1950-1912)

5.1.4 1931 Event

The status of the 1931 flood event is uncertain given the issues associated with the gauged records prior to 1950 (refer to Section 4.2).

The 1931 event remains the highest recorded Billabong Creek peak flood depth (9.65m) at Walbundrie (streamflow gauge 410091). The second highest recorded peak flood level on record at Walbundrie is the October 2010 flood which peaked at 9.10 metres. The 2010 flood peak at Jerilderie was only equivalent to around a 5 year ARI event. This reinforces that the flood peak at Walbundrie is not an accurate indicator for the peak at Jerilderie. Other factors including the runoff volume, the starting water levels in Lake Urana, and the size and timing of flooding in the Murrumbidgee River system all influence the severity of Billabong Creek flooding at Jerilderie.

At Narrandera (streamflow gauge 410005), the Murrumbidgee River 1931 flood peaked at a depth of 8.7 metres, below both the 1974 and 2012 recorded peak levels (9.0 metres in both).

Given the above, it is not possible to definitively state the equivalent ARI of the 1931 flood event at Jerilderie. Nor is it possible to definitively state that the 1931 flood is the most severe at Jerilderie since at least 1900.

5.1.5 Design Flows

The current rating table for Jerilderie station is quite different to the rating curve used previously (e.g. 2002 Bewsher study). The reasons for this are not readily apparent.

NSW Office of Water has advised that there has not been any high flow event gauging undertaken since 1974. The recent run of minor floods including the March 2012 event all peaked at around 1.7 metres. The two rating tables are closely matched at this height.

Given the above, the following approach was adopted in relation to the assignment of flows to the flood frequency analysis derived design flood levels:

- Hydraulic model was initially calibrated against the available recorded flood heights for the March 2012 event. A steady state Billabong Creek inflow of 4,100 ML/day was used (coincides with 2002 study utilised rating table, flow is slightly lower at 4,000 ML/day under current rating table).
- Hydraulic model will was tested with a Billabong Creek inflow of 12,700 ML/day as per the adopted 100 year ARI flow given in the 2002 Bewsher report. The modelled flood level at the Pump Station site was then compared to the flood frequency analysis derived 100 year ARI flood level of 108.57 m AHD. At this point a decision was made as to whether to adopt the flow of 12,700 ML/day or alternatively adjust the flow until the hydraulic model predicted water level matches the flood frequency analysis derived flood level of 108.57 m AHD at the gauge (refer to Section 6.4.1).

5.2 Wangamong Creek

5.2.1 Approach

Unlike Billabong Creek, there is no streamflow gauging station at Jerilderie or for that matter at any point on the Wangamong Creek system upstream or downstream of Jerilderie. Flood frequency analysis is therefore not possible for determining design flow estimates.

The upstream flooding conditions within the Wangamong Creek system are extremely complex. It is known that there are overflows from the Billabong Creek catchment into the Wangamong Creek catchment downstream of Walbundrie (2002 Bewsher study). Hydrologic and hydraulic modelling of these overflows was not a viable option given the limitations associated with the Jerilderie project.

Given the above, the approach to determining Wangamong Creek design flows at Jerilderie was based on a simplified approach involving a review of previous modelled event flows from the 2002 Bewsher study and also taking into account flow ratios for the different design event recurrence intervals consistent with the Billabong Creek design flow estimates.

5.2.2 Adopted Peak Design Flows

The preparation of the 2006 Billabong Creek Floodplain Management Plan involved coarse hydraulic modelling of the Billabong Creek and the Wangamong Creek systems. Flows were adjusted during the calibration process particularly in the absence of streamflow data as was the case for Wangamong Creek.

The 2002 Bewsher study included hydraulic modelling undertaken for flood events in 1970, 1974, 1981, 1983 and 1995. The modelled 2002 study flows adopted for Wangamong Creek at Jerilderie are as follows:

- 1970 event – 2,200 ML/day
- 1974 event – 1,800 ML/day
- 1981 event – 1,300 ML/day
- 1983 event – 2,000 ML/day
- 1995 event – 1,300 ML/day

After consideration of the above flows and the respective equivalent ARI's at the Walbundrie and Jerilderie Billabong Creek gauges, design flows for the 5, 10 and 20 year ARI events were adopted as per those given in Table 5.

The 50 and 100 year ARI design flows are based on similar ratios to the 2002 Bewsher study adopted design flows for Billabong Creek at Jerilderie. The relative closeness of the modelled event peak flows would suggest that if anything the 3,800 ML/day figure for the 100 year ARI event represents a high end estimate.

The above approach represents quite a simplistic method, however in the absence of any other practical options, was considered the most reasonable basis.

Table 5 Wangamong Creek at Jerilderie – Adopted Design Flows

Design Event ARI (years)	Peak Design Flow (ML/day)	% of adopted 100 year ARI flow
5	1,300	34
10	1,800	47
20	2,200	58
50	3,200	84
100	3,800	100
200	4,900	-

6. Hydraulic Modelling – Calibration

6.1 Approach

6.1.1 Overview

Hydraulic modelling was carried out consistent with the approach outlined in the NSW Floodplain Development Manual. This approach involves the following steps:

- Assembly of the hydraulic model using the available terrain and waterway structure data.
- Calibration of the model using the available historical flood gauged flow data and recorded flood height data.
- Modelling of a range of design floods using the adopted design flow rates derived from the preceding hydrologic assessment and the calibrated hydraulic model.

The availability of digital elevation model (DEM) data for the study area floodplains allowed the use of a two dimensional hydraulic model, TUFLOW, for the hydraulic modelling. TUFLOW is a computational engine that provides two-dimensional (2D) and one-dimensional (1D) solutions of the free-surface flow equations to simulate flood propagation.

Aspects of the hydraulic model compilation are described as follows:

- A 5 metres grid spacing was adopted. Run time durations with a 5 metres grid size were typically longer than 24 hours. The 5 metres grid spacing was also sufficient to adequately represent the floodplain features within the hydraulic model.
- A time step of 1 second was used for the modelling based on the Courant stability criterion and the recommendations of the TUFLOW manual.

6.1.2 Model Limitations

The TUFLOW hydraulic model has been developed to primarily simulate flooding conditions in 5, 10, 20, 50, 100 and 200 year ARI design events.

The hydraulic model is not able to reliably simulate low flow or minor flood flow conditions. The base of the Billabong Creek was covered by the low flow and weir pool water surface level at the time of the LiDAR aerial survey acquisition. The resulting DEM produced does not provide detailed creek bed geometry definition below the water surface level at the time of the LiDAR acquisition. A review of other terrain data sources concludes that the low flow creek channel area represents a relatively small proportion of the active floodplain waterway area in large flood events (refer to Section 4.4). Given this, it was concluded that the hydraulic model would be capable of adequately simulating the design floods required to be assessed, without the need for obtaining additional creek bed detailed survey data.

The hydraulic model will be used to approximate flooding conditions in an extreme event. Flooding conditions within the Billabong Creek catchment and the adjoining Murrumbidgee River catchment are extremely complex. This is partly due to the relatively flat terrain conditions. In an extreme flood event, the inundation extent will cover a huge expanse and involve complex flow exchanges between the Murrumbidgee River floodplain, the Billabong Creek floodplain and the Wangamong Creek floodplain. The extreme event modelling approach adopted is a simplistic one involving the adoption of a flow rate equal to four times the 100 year ARI design flow, with flows confined to the limits of the hydraulic model area.

6.1.3 Inflow Approach

The rate of rise and fall of Billabong Creek floodwaters at Jerilderie is a relatively slow process as highlighted by the following historic event durations:

- In March 2012, the Billabong Creek flood level at Jerilderie rose steadily from 0.7 metres at the start of March 2012, before peaking at 1.74 metres on the 19 March 2012. The flow remained above 1.70 metres for four days.
- In 1990, the Billabong Creek flood level at Jerilderie remained above 1.6 metres for two months. The flood level peaked at 2.10 metres, remaining above 2.0 metres for 13 days.

The rise and fall of Wangamong Creek floodwaters at Jerilderie is expected to be similarly slow occurring over days and weeks.

Given the above, the approach to the hydraulic modelling was to input flows to the hydraulic model as steady state flows. The hydraulic model was then run until steady state hydraulic conditions were achieved.

6.1.4 Downstream Boundary Conditions

Downstream boundary conditions were defined by a fixed water level coinciding with the estimated flood level for each particular design event modelled at the downstream boundary of the TUFLOW model.

The downstream boundary flood levels were estimated using a coarse HEC-RAS model of the downstream floodplains assembled using floodplain cross sections extracted from the DEM data.

The HEC-RAS model for Billabong Creek was extended 3.5 km downstream of the TUFLOW model downstream boundary. A total of five cross sections were extracted within this reach (i.e. fifth cross section at the TUFLOW downstream boundary).

The HEC-RAS model for Wangamong Creek was extended 2.5 km downstream of the TUFLOW model downstream boundary. A total of six cross sections were extracted within this reach (i.e. sixth cross section at the TUFLOW downstream boundary).

The respective peak design flows for the two creeks were input into the two HEC-RAS models. The resultant HEC-RAS modelled flood levels at the downstream boundary of the TUFLOW model were subsequently identified using this approach.

6.1.5 Waterway Structures

A total of ten waterway structures are defined within the TUFLOW model. The structures modelled are as follows:

- Billabong Creek
  - Railway line main bridge
  - Railway line overbank bridge
  - Newell Highway main bridge
  - Newell Highway overbank culvert
  - Golf course footbridge
  - Bolton Street bridge
  - Powells footbridge

- Wangamong Creek
  - Kennedy Street culvert
  - Railway line bridge
  - Newell Highway culvert

The footbridge across Billabong Creek near Ashton Street was not modelled as it is a low level bridge and will be drowned out in large flood events.

Bridge and culvert structure details (e.g. opening dimensions, soffit / deck elevations) were obtained from either available plan information and / or from field measurements (refer to Section 4.3).

6.2 TUFLOW Model Calibration Approach

6.2.1 Billabong Creek

There is very limited recorded flood height data with which to calibrate the TUFLOW hydraulic model. The available recorded heights are limited to the following:

- Recorded heights at the Pump Station gauging site since 1950.
- March 2012 recorded flood heights at three locations in addition to the gauging station site.

The March 2012 event is approximately equivalent to a 5 year ARI event based on the flood frequency analysis results. Ideally there would also be recorded flood levels available for a larger flood, however this is not the case at Jerilderie.

The stage discharge rating curve for the Billabong Creek gauging station at Jerilderie is also of extremely low reliability. There has been very limited high flow gauging undertaken.

Given the available calibration data limitations, the approach adopted for the calibration of the TUFLOW hydraulic model was as follows:

- **March 2012 calibration.** Model calibrated to match the four recorded March 2012 flood levels (refer to Figure A1). The peak flow used for the March 2012 event is consistent with the gauging station stage discharge rating curve (i.e. 4,100 ML/day). Model calibration involved adjusting the Mannings roughness values until a reasonable match with the four recorded spot heights was achieved. A downstream boundary Billabong Creek water level of 106.3 m AHD was used based on the HEC-RAS model results.
- **Preliminary 100 year ARI event.** With the calibrated Mannings roughness parameter values left unchanged, a flow consistent with the old stage discharge rating curve (i.e. 12,700 ML/day) at the flood frequency analysis derived 100 year ARI flood level of 108.57 m AHD was initially input into the model.
- **Adjusted 100 year ARI event**. Given the suspect nature of the rating table, the Billabong Creek 100 year ARI peak design flow was adjusted to produce a modelled flood level of 108.57 m AHD at the Pump Station gauging site.

6.2.2 Wangamong Creek

There is no gauged streamflow data or recorded flood level data with which to calibrate the modelled flooding conditions within Wangamong Creek.

The approach adopted was to:

- Input steady state design flows consistent with those identified during the hydrological assessment. The 5 year ARI design flow of 1,300 ML/day will be used for the purpose of the March 2012 calibration exercise, given that the peak flow in Billabong Creek was of this magnitude. A downstream boundary Wangamon Creek water level of 106.9 m AHD was used based on the HEC-RAS model results.
- Assign Mannings roughness values consisted with the floodplain conditions (i.e. essentially a broad treeless grassed depression).

6.3 March 2012 Event Calibration

Details for the March 2012 event calibration are as follows:

- Inflow (peak):
  - Billabong Creek – 4,100 ML/day
  - Wangamong Creek – 1,300 ML/day
- Downstream boundary water level:
  - Billabong Creek – 106.3 m AHD
  - Wangamong Creek – 106.9 m AHD

The March 2012 calibration process involved the following:

- Main channel Mannings roughness value for Billabong Creek was reduced down to 0.04 in order to achieve good agreement with the four available recorded flood level marks.
- Similarly the Manning roughness value for the adjoining riparian woodland zone fringing the Billabong Creek was reduced down to 0.06.
- Subsequent to the above adjustments, good agreement (i.e. modelled water level within 0.10 metres of the recorded level) was achieved with the three recorded flood heights downstream of the Jerilderie Weir. The modelled flood level at the Pump Station gauging site however remained more than 0.2 metres above the recorded level.
- The terrain creek bed elevations upstream of the Jerilderie Weir were subsequently lowered to represent the likely indicative creek bed elevations. Prior to this adjustment, the LIDAR creek bed elevations upstream of the Weir represented the water pool surface elevations.
- Subsequent to the creek bed lowering upstream of the Weir, the modelled flood level at the gauge was lowered to within 0.1 metres of the recorded flood level.

The final adopted modelled flood levels for the March 20012 event are given in Table 6. The modelled levels are in good agreement with the recorded levels.

The March 2012 event is equivalent to a 5 year ARI event based on the flood frequency analysis results. The modelled flood extent associated with the March 2012 event is shown on Figure A1.

Table 6 March 2012 Calibration Results

Location	Recorded Flood Level (m AHD)	Modelled Flood Level (m AHD)	Difference (m)
Conargo Rd / South Coree Road	106.44	106.49	+0.05
Bundoora Avenue	106.69	106.65	-0.04
Upstream side Powells Bridge	106.89	106.90	+0.01
Pump Station gauge	107.14	107.23	+0.09

Note:

1. Recorded flood level locations are shown on Figure A1.

Billabong Creek flooding characteristics for the March 2012 event are described as follows:

- Extent of flooding is relatively confined as shown on Figure A1.
- Modelled flood level on the downstream side of the Newell Highway is 107.58 m AHD. The flood level on the upstream side of the Railway bridge is 107.64 m AHD, confirming minimal combined afflux through the Railway and Newell Highway bridges in an event of this size.
- The Golf Course footbridge deck is marginally above the modelled 2012 flood level. The deck of the Powells footbridge is well above the 2012 flood level.
- There is minimal afflux through the Bolton Street footbridge, which is elevated well above the 2012 flood level.

Wangamong Creek flooding characteristics for this event are described as follows:

- Extent of flooding is relatively confined as shown on Figure A1.
- The flood level downstream of the Newell Highway is 107.28 m AHD.
- The flood level immediately upstream of the Newell Highway is 107.55 m AHD, approximately 1.1 metres below the road surface level.
- The flood level upstream of the Railway line is 107.64 m AHD, approximately 0.8 metres below the rail surface level.
- Rifle Range Road is overtopped. The flood level on the upstream side of the road is 108.13 m AHD, approximately 0.5 metres above the road low point.
- Backwater flooding from Wangamong Creek up the depression leading to Billabong Creek occurs for a limited distance as shown on Figure A1. The flood level within this depression is 108.17 m AHD.

6.4 Preliminary 100 Year ARI Event

The Mannings roughness parameter values derived from the March 2012 calibration modelling were adopted for the purpose of the preliminary 100 year ARI design event modelling.

Initially a Billabong Creek inflow of 12,700 ML/day was input into the model consistent with the rating curve derived flow, and the flood frequency analysis derived 100 year ARI flood level at the gauging station of 108.57 m AHD.

The adopted fixed downstream boundary water levels for the 100 year ARI event were derived from the HEC-RAS model. Details for the 100 year ARI event are as follows:

- Inflow (peak):
  - Billabong Creek – 12,700 ML/day (preliminary flow only)
  - Wangamong Creek – 3,800 ML/day
- Downstream boundary water level:
  - Billabong Creek – 107.5 m AHD
  - Wangamong Creek – 107.3 m AHD

6.4.1 Billabong Creek

The Billabong Creek flow of 12,700 ML/day resulted in a modelled flood level of 108.32 m AHD at the Pump Station gauging site, 0.25 metres below the flood frequency analysis derived 100 year ARI flood level.

There are two approaches which could have been used to achieve a modelled flood level of 108.57 m AHD at the Pump Station gauging site. These are:

- Increasing the Mannings roughness parameter values until the modelled flood level reaches 108.57 m AHD. This approach was not used as it invalidates the March 2012 calibration modelling outcomes.
- Increasing the Billabong Creek flow until the modelled flood level reaches 108.57 m AHD. This required an increase in the flow from 12,700 ML/day to 15,500 ML/day. This approach was adopted.

The upper end of the Pump Station rating curve is considered to be of low reliability. There has not been any high flow event gauging undertaken since 1974. The maximum gauged flow height is thought to have been undertaken in 1974 coinciding with a flow rate of 7,400 ML/day. This is equivalent to around a 20 year ARI event.

There is also a flow split at the gauging station site as shown on Figures 6, B1 and B2. The modelled flows coinciding with a modelled flood level of 108.57 m AHD at the Pump Station site are:

- 12,600 ML/day – flow past the gauge site.
- 2,900 ML/day – bypass flow to the north.

The modelled flow past the gauge site agrees with the old rating curve for the Pump Station site. This would suggest that the bypass flow to the north is excluded from the rating curve, or alternatively the rating curve may simply be inaccurate.

Given the above, a peak design 100 year ARI flow of 15,500 ML/day was adopted for Billabong Creek at Jerilderie.

The Billabong Creek 100 year ARI flood extent and flood height contours are shown on Figures B1 and B2 in Appendix B. The floor level of any buildings located within the mapped inundation area is not necessarily below flood level. Building floor level elevations should be compared with the flood height to determine whether their floors are above or below the 100 year ARI flood height.

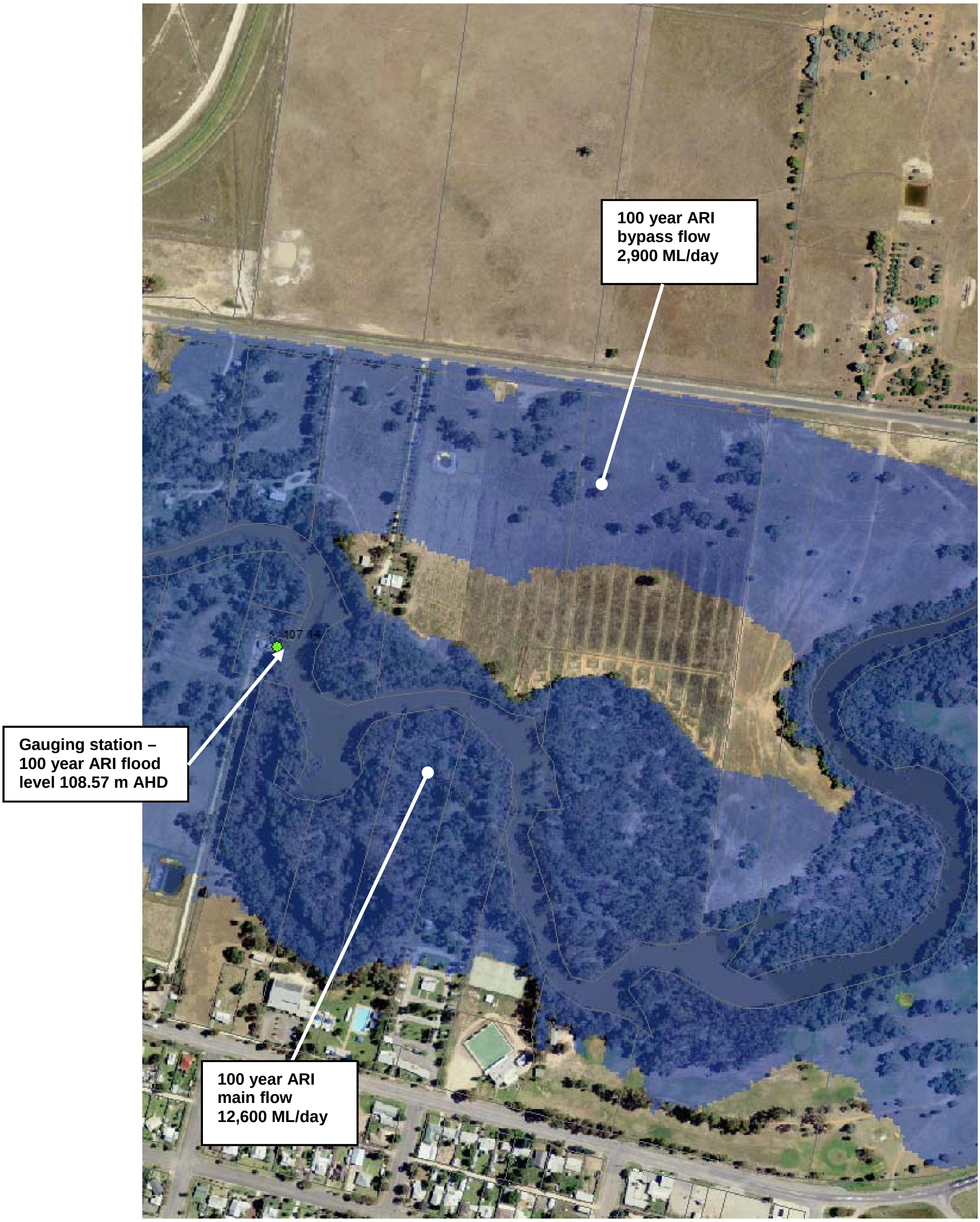

Figure 6 Billabong Creek Flow Split at Gauging Station

Billabong Creek 100 year ARI flooding characteristics are described as follows:

- Jerilderie-Oaklands Road – Billabong Creek modelled 100 year ARI flood level at the road low point is approximately 109.0 m AHD, 0.6 metres below the road overflow level of 109.6 m AHD. The only flow discharging from Billabong Creek across the Jerilderie-Oaklands Road towards the Wangamong Creek will therefore be limited to that discharged via a 375 mm diameter low flow culvert under the road.
- Afflux through the Newell Highway and Railway bridges remains relatively low. The average velocities through the bridge openings is 1.2 m/s for the Railway bridge and 1.1 m/s for the Newell Highway bridge. The modelled 100 year ARI flood levels are as follows:
  - Downstream side of the Newell Highway 108.71 m AHD
  - Between Newell Highway and Railway line 108.80 m AHD (0.3 metres below the Highway bridge soffit, 1.7 metres below the Highway road surface overflow level).
  - Upstream side of Railway line 108.85 m AHD (0.3 metres below the Railway bridge soffit, 1.2 metres below the Railway overflow level).
- The modelled flood level on the upstream side of the Bolton Street bridge is 108.44 m AHD, marginally below the soffit level. The average velocity through the bridge opening is 0.9 m/s.
- Bolton Street is overtopped on the south side approach to the bridge. The modelled 100 year ARI flood level overtopping the road is 108.45 m AHD. The maximum depth of overtopping is 0.3 metres.
- Flows spill into Jerilderie Lake at its Powell Street end. The peak 100 year ARI flood level in the lake is 108.32 m AHD. There are no outflows from the lake. The embankment crest level is generally close to 108.9 m AHD around the lake perimeter. The threshold at which flood flows spill into the lake is 108.2 m AHD. This will be in the vicinity of an 80 year ARI Billabong Creek flood event. The active lake storage volume used in a 100 year ARI event is approximately 110 ML. This is small compared to the peak design flow of 15,500 ML/day.
- Powells Bridge is not overtopped. The approaches to the foot bridge will however be inundated.
- The Ashton Street footbridge is overtopped to a depth of 2.2 metres in a 100 year ARI event.
- The Golf Course footbridge is overtopped to a depth of 1.0 metre in a 100 year ARI event.
- The 100 year ARI flood level is 107.90 m AHD at Bundoora Avenue. The 100 year ARI flood extents are confined to the creek side of Bundoora Avenue. Approximately 200 metres downstream of Bundoora Avenue, backwater flooding of a floodplain depression and woodland area occurs on the south side of Billabong Creek. This depression is located on the west side of an area which is currently being developed.
- Existing developed areas which are within the preliminary 100 year ARI extent are:
  - Some Bolton Street properties on the south side of Billabong Creek.
  - Properties on the north side of Powell Street adjacent to Lake Jerilderie.
  - McDougall Street properties between Bolton Street and Wilson Road.

It is noted that the flood extent mapping produced for Billabong Creek and Wangamong Creek (refer to Appendices B, C and D) does not take into account small road culverts present on the depression link between the Billabong Creek and Wangamong Creek adjoining the south-east side of the town. Specifically the model excludes the Jerilderie-Oaklands Road culvert (single cell 375 mm diameter pipe), James Street culvert (twin cell 450 mm diameter pipes) and an unnamed local road culvert 500 metres west of James Street (single cell 525 mm diameter pipe). The absence of these culverts results in all floodwater flows being excluded from the depression on the south side of the Jerilderie-Oaklands Road up until the roadway is overtopped. This requires in excess of a 200 year ARI event. A small amount of floodwater will however be free to discharge via the 375 mm diameter road culvert unless it is closed off (e.g. sandbagged).

The hydraulic model also excludes small waterway structures under the Railway and the Newell Highway on the north side of Billabong Creek. The major overbank Railway and Newell Highway waterway structures have been modelled (refer to the Railway overbank bridge - B2 and the Newell Highway overbank culvert – C1 shown on Figure 4). The smaller secondary overbank structures consist of a Railway opening structure (estimated waterway area 4 m^2) and a Newell Highway culvert (four cell box culvert - 1.5 m (W) x 0.45 m (H)).

6.4.2 Wangamong Creek

The Wangamong Creek 100 year ARI flood extent and flood height contours are shown on Figure B1 in Appendix B. The floor level of any buildings located within the mapped inundation area is not necessarily below flood level. Building floor level elevations should be compared with the flood height to determine whether their floors are above or below the flood height.

Flooding characteristics are described as follows:

- The 100 year ARI flood level immediately downstream of the Newell Highway is 107.54 m AHD.
- The flood level immediately upstream of the Newell Highway is 108.22 m AHD, 0.5 metres below the road surface level of 108.7 m AHD. The afflux at the Newell Highway is approximately 0.7 metres.
- The flood level upstream of the Railway line is 108.47 m AHD, 0.02 metres above the rail surface level. The Railway line is only marginally overtopped in the immediate vicinity of the Railway bridge.
- Rifle Range Road is overtopped. The flood level on the upstream side of Rifle Range Road is 108.49 m AHD, 0.9 metres above the road low point of 107.6 m AHD.
- Floodwater extends to the south of Wangamong Creek between the Railway line and Rifle Range Road. Some minor local backwater overtopping occurs across Rifle Range Road close to the entrance of Jerilderie Airport.
- Backwater flooding from Wangamong Creek up the depression leading to Billabong Creek occurs until James Street. The flood level of 108.53 m AHD is marginally lower than the road low point of 108.6 m AHD.
- Inundation of the depression between James Street and the Jerilderie-Oaklands Road will occur via low flow culverts at James Street (twin 450 mm diameter pipes) and the low flow pipe at the Jerilderie-Oaklands Road (375 mm diameter pipe).
- There is shallow 100 year ARI inundation of the Jerilderie Airport and surrounding area on the south side of Wangamong Creek. Local roads are only marginally overtopped leading to the shallow inundation. Although the 100 year ARI flood extent on the south side of the Airport abuts the TUFLOW model boundary, this has very little influence on the results.

6.5 Sensitivity Assessment

Sensitivity of the 100 year ARI hydraulic modelling results to the following influences was undertaken:

- Flow rate (e.g. due to climate change influences)
- Manning roughness
- Waterway structure blockage
- Downstream boundary water level

6.5.1 Flow Rate (Climate Change)

The Floodplain Risk Management Guideline (FRMG) '*Practical Considerations of Climate Change*' (DECC, 2007) provides details on the possible implication of climate change as they relate to flood studies in NSW. This includes the following predicted rainfall intensities for the 40 year ARI, 24 hour duration design rainfall intensity for the Murray catchment:

- Indicative range of -3% to + 25% by the year 2030.
- Indicative range of -7% to + 29% by the year 2070.

A 25% increase in design intensity would reduce the equivalent ARI of the existing 100 year ARI 24 hour duration design intensity to approximately 25 years ARI. Similarly the equivalent ARI of the existing 500 year ARI design intensity would reduce to approximately 125 years ARI.

The 25% increase is however at the upper end of the nominated range. The lower end of the nominated range results in a small reduction in the future rainfall intensities. Also Jerilderie is located at the extremities of the Murray catchment. The upper end predicted change in rainfall intensities for the Murrumbidgee catchment is much less (i.e. less than 15%).

The Climate Change FRMG recommends the following sensitivity analyses be undertaken as part of flood studies:

- 10% increase in the design storm peak rainfall intensity and volume;
- 20% increase in the design storm peak rainfall intensity and volume; and
- 30% increase in the design storm peak rainfall intensity and volume.

For the purposes of this study, in the absence of a rainfall runoff model with which to directly assess the impacts on flood flows resulting from a 10%, 20% and 30% increase in design rainfall intensities, the following approach was used for assessing the sensitivity of hydraulic model outputs to potential climate change impacts:

- 10% scenario – assume 15% increase in peak 100 year ARI flow (i.e. 207 m^3/s Billabong Creek, 51 m^3/s Wangamong Creek).
- 20% scenario – assume 30% increase in peak 100 year ARI flow (i.e. 234 m^3/s Billabong Creek, 57 m^3/s Wangamong Creek).
- 30% scenario – assume 45% increase in peak flow in peak 100 year ARI flow (i.e. 261 m^3/s Billabong Creek, 64 m^3/s Wangamong Creek).

Modelling results based on the above are summarised in Table 7.

Assuming a 10% increase in rainfall intensity and further assuming that this translates to a 15% increase in the peak 100 year ARI flow at Jerilderie, the resultant increase in the 100 year ARI flood level within the study area is expected to vary from 0.13 to 0.18 metres for Billabong Creek and 0.09 to 0.24 metres for Wangamong Creek.

Table 7 Sensitivity of 100 Year ARI Flood Levels to Flow Rate

Location	Predicted Increase in 100 Year ARI Flood Level (m)		
	10% increase in rainfall intensity	20% increase in rainfall intensity	30% increase in rainfall intensity
Billabong Creek at Conargo Rd / South Coree Rd	0.15	0.26	0.36
Billabong Creek Bundoora Avenue	0.13	0.25	0.35
Billabong Creek on upstream side Powells Bridge	0.18	0.32	0.42
Billabong Creek at Pump Station gauge	0.16	0.28	0.39
Billabong Creek upstream of Newell Highway	0.16	0.31	0.38
Billabong Creek upstream of Railway	0.16	0.32	0.44
Billabong Creek at upstream limit of model	0.14	0.28	0.40
Wangamong Creek downstream of Newell Highway	0.07	0.11	0.13
Wangamong Creek upstream of Newell Highway	0.24	0.41	0.53
Wangamong Creek upstream of Railway	0.17	0.29	0.30
Wangamong Creek upstream of Kennedy Street	0.17	0.24	0.30
Wangamong Creek at upstream limit of model	0.09	0.14	0.19

6.5.2 Floodplain Roughness

The sensitivity of the modelled 100 year ARI flood levels to the adopted Mannings roughness values was assessed using the TUFLOW hydraulic model. The adopted calibrated Mannings roughness values are given below:

- Billabong Creek – in- channel – 0.04
- Billabong Creek riparian / woodland zone – 0.06
- Wangamong Creek depression base – 0.04
- Rural residential floodplain – 0.05
- Normal density township – 0.15
- Cleared rural land – 0.035

The hydraulic model was used to predict the revised 100 year ARI flood levels based on the adopted Mannings roughness values reduced by 25% and increased by 25%. Results are summarised in Table 8.

In relation to Billabong Creek, with 25% higher Mannings roughness values, the modelled 100 year ARI flood levels are approximately 0.15 metres higher. The increases are smaller towards the downstream end of the model due to the downstream boundary fixed water level influence. With 25% lower Mannings roughness values, the modelled flood levels are approximately 0.15 metres lower.

In relation to Wangamong Creek, the changes in the 100 year ARI flood levels are less due to the significant influence of the waterway structures (i.e. Newell Highway culvert and Railway bridge) on upstream flood levels.

Table 8 Sensitivity of 100 Year ARI Flood Levels to Mannings Roughness

Location	Model Predicted Change in Flood Level (m)	
	25% decrease in Mannings roughness	25% increase in Mannings roughness
Billabong Creek at Conargo Rd / South Coree Rd	-0.07	+0.06
Billabong Creek Bundoora Avenue	-0.09	+0.09
Billabong Creek on upstream side Powells Bridge	-0.18	+0.16
Billabong Creek at Pump Station gauge	-0.17	+0.15
Billabong Creek upstream of Newell Highway	-0.16	+0.17
Billabong Creek upstream of Railway	-0.19	+0.15
Billabong Creek at upstream limit of model	-0.15	+0.15
Wangamong Creek downstream of Newell Highway	-0.09	+0.05
Wangamong Creek upstream of Newell Highway	-0.01	+0.01
Wangamong Creek upstream of Railway	-0.03	+0.03
Wangamong Creek upstream of Kennedy Street	-0.03	+0.02
Wangamong Creek at upstream limit of model	-0.05	+0.05

6.5.3 Bridge and Culvert Blockage

The sensitivity of the of the 100 year ARI modelled flood levels to blockage within the bridge and culvert openings was assessed based on the following assumptions:

- Bridge openings of the larger bridge structures were assumed to be 20% blocked (i.e. large openings and therefore a low probability of debris accumulating within the opening). This was applied to the Powells Footbridge, Bolton Street, Newell Highway and Railway Billabong Creek bridges.
- The other smaller waterway structures were assumed to be 33% blocked (i.e. smaller openings, therefore a higher probability of increased blockage occurring compared to the larger bridges). This was applied to the remaining Billabong Creek waterway structures and all of the Wangamong Creek structures.

The TUFLOW modelling results are summarised in Table 9. The Billabong Creek bridges are large enough such that the 20% blockage assumed only increases the upstream 100 year ARI flood level by a relatively small amount.

There is however potential for a significant increase in the 100 year ARI flood level if the Wangamong Creek culvert structure under the Newell Highway becomes partly blocked. With two of the seven 2.4 m (W) x 1.8 m (H) box culvert cells assumed to be fully blocked, the 100 year ARI flood level on the upstream side of the Highway increases from approximately 108.2 m AHD to 108.7 m AHD. There is only limited potential for further increases to occur if the blockage becomes more severe, given that the Highway road surface level is 108.7 m AHD.

The increase in the Wangamong Creek flood level upstream of the Railway line diminishes to 0.1 metres. Without any blockage at the Newell Highway or the Railway line, the 100 year ARI flood level marginally overtops the Railway line. This reduces the size of the increase under the blockage scenario assessed as further rises in flood level above the surface of the Railway line require large increases in flow.

Table 9 Sensitivity of 100 Year ARI Flood Levels to Bridge and Culvert Blockage

Location	Predicted change in 100 year ARI flood level (m)
Billabong Creek upstream of Powells Bridge	0.00
Billabong Creek upstream of Bolton Street	+0.01
Billabong Creek upstream of Newell Highway	+0.02
Billabong Creek upstream of Railway	+0.03
Wangamong Creek upstream of Newell Highway	+0.50
Wangamong Creek upstream of Railway	+0.10
Wangamong Creek upstream of Kennedy Street	+0.05

6.5.4 Downstream Boundary Water Level

The downstream boundary water levels adopted for the TUFLOW 100 year ARI modelling were based on flood levels identified using a coarse HEC-RAS hydraulic model extending well downstream of the TUFLOW model downstream boundary (3.5 km downstream in the case of Billabong Creek and 2.5 km downstream in the case of Wangamong Creek). The adopted downstream boundary water levels are consequently considered quite reliable.

To test the sensitivity of the upstream 100 year ARI flood levels to the adopted downstream boundary water levels (107.5 m AHD for Billabong Creek and 107.3 m AHD for Wangamong Creek) the downstream boundary water level was raised by 0.3 metres to 107.8 m AHD for Billabong Creek and 107.6 m AHD for Wangamong Creek.

The resultant modelled upstream 100 year ARI flood levels with the altered downstream boundary water levels are as follows:

- Billabong Creek:
  - Increase in flood height reduces to 0.19 metres opposite the South Coree Road / Conargo Road intersection.
  - Increase in flood height reduces to 0.15 metres opposite Bundoora Avenue.
  - Increase in flood level reduces to 0.04 metres at the Pump Station site.
- Wangamong Creek:
  - Increase in flood height reduces to 0.14 metres on the downstream side of the Newell Highway.
  - Increase in flood height reduces to 0.02 metres on the upstream side of the Newell Highway.
  - No increase in flood height on the upstream side of the Railway line.

Ideally the downstream boundary of the TUFLOW model would be located sufficiently downstream to eliminate potential downstream boundary assumption influences within the flood study focus area. In the case of Jerilderie, the flat hydraulic gradient present (average floodplain water surface gradient is 1 in 3,500) would require the TUFLOW model downstream boundaries to be located a considerable distance further downstream compared to that shown on Figure A1. The approach adopted, taking into account the means by which the downstream boundary water levels were assigned (refer to Section 6.1.4), is considered to represent a reasonable approach and most unlikely to have produced any marked influence on the results within and adjoining the town area.

7. Final Design Flood Modelling

7.1 Approach

Following the completion of Stage 3, a progress report including preliminary 100 year ARI flood height and extent mapping was submitted to Council. The results of the Stage 3 work were presented and discussed at a Committee meeting in early March 2014. Council and the Committee subsequently agreed to adopt the preliminary 100 year ARI modelling outputs and to proceed with the remaining design event modelling.

The adopted design event peak flows and flood heights are summarised in Table 10 below.

The design event peak flood heights for Billabong Creek are based on the results of flood frequency analysis as documented in Section 5.2. The peak design flows are based on a combination of the rating curve for the Billabong Creek gauging station at Jerilderie and the hydraulic modelling results obtained for this study.

The design event peak flood flows for Wangamong Creek are based on a hydrological assessment documented in Section 5.3 of this report.

The design event inflow approach and the downstream boundary condition approach are as described in Section 6.1.

Table 10 Adopted Design Event Flows

Design Event (years)	Billabong Creek at Jerilderie			Wangamong Creek at Jerilderie
	Flood Level (m)	Flood Level (m AHD)	Peak Flow (ML/day)	Peak Flow (ML/day)
5	1.74	107.14	4,100	1,300
10	2.12	107.52	5,400	1,800
20	2.45	107.85	7,400	2,200
50	2.87	108.27	11,600	3,200
100	3.17	108.57	15,500	3,800
200	3.45	108.85	20,200	4,900
Extreme	3.95	109.35	62,000	15,200

Notes:

1. The flood levels in Table 10 coincide with the Billabong Creek gauging station site (410016) located 600 metres upstream of the Jerilderie Weir (refer to Figure 4).

2. Current gauge zero datum at the gauging station site is 105.402 m AHD.

3. Extreme event is based on a flow rate equal to four times the adopted 100 year ARI event flow.

7.2 Flood Map Outputs

A description of flood map outputs produced is provided in the following sections. The map outputs are included in Appendices B to F of this report.

7.2.1 Design Flood Extents and Flood Height Contour Map Series

Design flood extent and flood height contour mapping for the full range of design floods modelled is included in Appendix B. The flood height contours have been defined at 0.2 metres intervals. Mapping included in Appendix B consists of:

- Figure B1 – 100 year ARI covering the whole study area reach (scale 1:20,000 at A3)
- Figure B2 – 100 year ARI for the immediate township area (scale 1:10,000 at A3)
- Figure B3 – 5 year ARI
- Figure B4 – 10 year ARI
- Figure B5 – 20 year ARI
- Figure B6 – 50 year ARI
- Figure B7 – 200 year ARI
- Figure B8 – Extreme event

The following comments are made in relation to the design event flood maps in Appendix B:

- The extreme flood heights and extents shown on Figure C8 are an approximation of what could be expected to occur in a very rare flood. The limited coverage of the hydraulic model will have tended to artificially confine the floodwaters in such an event, leading to flood heights and extents which are higher than what would be expected to occur in reality.
- Although the TUFLOW model boundary on the south side of the Airport confines the 100 year ARI flood extent, this has only very marginally affected the modelled 100 year ARI flood height for this area.
- Although there may be buildings located within the mapped inundation areas, it should not be assumed that the floor level of any individual building is below the flood level. Building floor level elevations should be compared with the design event flood heights to determine whether their floors are above or below the design flood height.

7.2.2 Hazard Category Map Series

The 2005 FDM provides the following definitions for the two floodplain hazard categories:

- High Hazard
  - '*Possible danger to personal safety, evacuation by trucks difficult, able-bodied adults would have difficulty in wading to safety, potential for significant structural damage to buildings*.'
- Low Hazard
  - '*Should it be necessary, truck could evacuate people and their possessions, able-bodied adults would have little difficulty in wading to safety*.'

The hazard maps are included in Appendix C. The provisional hazard categories have been identified based solely on hydraulic conditions coinciding with the 100 year ARI flood (Figure C1) and the 20 year ARI flood (Figure C2). This has been determined in accordance with Figure L2 of the 2005 FDM as reproduced below in Figure 7.

The provisional hazard categories could be reviewed at the time of a Floodplain Risk Management Study taking into account other factors aside from the depth and velocity of floodwaters (e.g. effective warning time, flood readiness, rate of rise of floodwaters, duration of flooding, evacuation problems and flood access considerations).

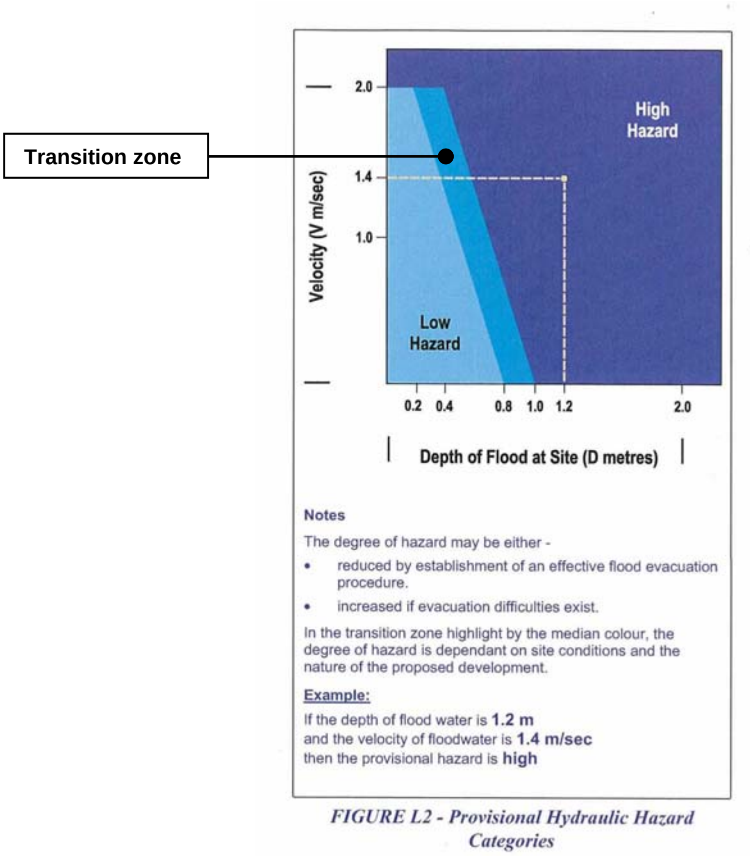

Figure 7 2005 FDM Hazard Categories

(extract from 2005 FDM)

In relation to the Billabong Creek floodplain, high hazard flooding conditions within the study area are generally restricted to the creek channel and the adjoining overbank areas. There are some adjoining billabong depressions along the route which are classified as high hazard due to the high depth of flooding. The breakaway flow path on the north side of the Billabong Creek downstream of the golf course is categorised as high hazard and transition zone.

In relation to the Wangamong Creek floodplain, high hazard flooding conditions are confined to the broad flatbed area of the creek. This is more pronounced on the upstream side of the Newell Highway and railway line due to the elevated flood levels in this reach caused by the afflux generated by the highway and the railway. The broad shallow overbank flooding covering much of the airport area is categorised as low hazard.

7.2.3 Hydraulic Category Map Series

The 2005 FDM defines three hydraulic categories as follows:

- Floodways
  - '*Those areas where a significant volume of water flows during floods and are often aligned with obvious natural channels. They are areas that, even if only partially blocked, would cause a significant increase in flood levels and / or a significant redistribution of flood flow, which may in turn adversely affect other areas. They are often, but not necessarily, areas with deeper flow or areas where higher velocity occurs*.'
- Flood Storage
  - '*Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. If the capacity of a flood storage area is substantially reduced by, for example, the construction of levees or by landfill, flood levels in nearby areas may rise and the peak discharge downstream may be increased. Substantial reduction of the capacity of a flood storage area can also cause a significant redistribution of flood flows*.'
- Flood Fringe
  - '*The remaining area of land affected by flooding, after floodway and flood storage areas have been defined. Development in flood fringe areas would not have any significant effect on the pattern of flood flows and / or flood levels*.'

Explicit quantitative criteria for defining the above three hydraulic categories are not provided by the 2005 Manual or the 2007 DECC Guideline for Floodway Definition. The 2005 Manual nominates a guideline which defines flood storage areas as those areas which, if completely filled with solid material, would cause peak flood levels to increase anywhere more than 0.1 m and / or would cause the peak discharge anywhere downstream to increase by more than 10%. The 2007 DECC Guideline nominates that the obstruction of a floodway would lead to either the significant diversion of water away from its existing flow path and / or lead to a significant increase in flood levels.

Recent studies have made use of criteria identified within a technical paper (Howells et al, 2004) as the basis for the hydraulic categorisation. This criteria has been used to produce the hydraulic category mapping at Jerilderie presented in Appendix D. The approach uses the following criteria for the delineation of the floodway:

- Velocity depth product must be greater than 0.25 m^2/s and the velocity must be greater than 0.25 m/s, or
- Velocity is greater than 1.0 m/s

As an exception to the above, those areas where the depth of flooding is 1.0 metre or more but do not meet either of the above two criteria were defined as floodway.

Outside the above defined floodway area, flood storage was defined as those areas where the depth exceeds 0.5 metres. The remaining inundated area was defined as flood fringe.

The hydraulic categorisation mapping is provided in Appendix D for the 100 year ARI event (Figure D1) and the 20 year ARI event (Figure D2).

7.2.4 Flood Planning Area

The flood planning area is the area of land below the flood planning level (FPL) which is consequently subject to flood related development controls (e.g. minimum floor level requirements). The FPLs are the combination of flood levels and freeboards selected for floodplain risk management purposes. This typically amounts to the 100 year ARI flood levels plus a freeboard provision. The FPLs are generally adopted during a floodplain risk management study.

7.2.5 Design Event Profile Map Series

The flood height contours represent the flood height surface gradient. Flood profiles present the same information plotted on a longitudinal section.

Design flood profiles for Billabong Creek (Figure E1) and Wangamong Creek (Figure E2) are presented in Appendix E.

7.3 Other Features of Interest

Detailed hydraulic model output is provided in Table 11 at particular points of interest within the study area floodplain. This data is provided to assist with flood response plans. The data is generally based on modelled predictions as distinct from actual recorded observations in past flood events. There may therefore be some differences between actual flood conditions encountered in future floods and the modelled data given in Table 11.

7.3.1 Newell Highway

The Newell Highway at Billabong Creek does not overtop in any of the events modelled, including the extreme event. In an extreme event, Billabong Creek floodwater overtops the Jerilderie-Oaklands Road spilling into the Wangamong Creek floodplain. This prevents the Newell Highway from overtopping.

The Newell Highway at Wangamong Creek is also not expected to overtop in a 200 year ARI event. In the extreme event modelled, the highway will be overtopped. The flat highway profile will limit overtopping depths in the event of an extreme event.

7.3.2 Bolton Street

Bolton Street is overtopped on the south side approach to Billabong Creek. The road low point is located close to Ashton Street. In a 100 year ARI event, a 250 metres section of the road overtops to a maximum depth of 0.3 metres.

Bolton Street rises sufficiently to be clear of the 100 year ARI flood at the bridge itself. The bridge deck and the north side road approach is not overtopped by the 100 year ARI flood.

7.3.3 Jerilderie-Oaklands Road

A high level flood runner depression links the Billabong Creek floodplain to the Wangamong Creek floodplain on the upstream side of Jerilderie. This depression crosses the Jerilderie-Oaklands Road 0.9 km east of the Newell Highway.

The road is raised at the depression crossing. Billabong Creek flood levels need to exceed 109.6 m AHD for overtopping to occur. Of the floods modelled, overtopping only occurs in the extreme event.

7.3.4 Rifle Range Road

Rifle Range Road is subject to flooding at the Wangamong Creek crossing. Rifle Range Road is an unsealed road which provides access to Jerilderie Airport.

Alternative access to the Airport is available via the south side Rifle Range Road approach. The south side approach connects to the Newell Highway 3 km south of the Airport.

7.3.5 Other Features

The footbridges across Billabong Creek opposite Ashton Street and within the golf course will overtop in small floods.

The Powells Bridge footbridge is elevated higher. The pathway approaches to Powells Bridge will however become inundated preventing access to the footbridge in large flood events.

The Tocumwal-Narrandera Railway track has been closed since 1988. The track and structures remain in place. The Railway is not overtopped at Billabong Creek. At Wangamong Creek, a 100 year ARI flood will marginally overtop the Railway.

There are some local unsealed access roads on the south side of Jerilderie which are affected by Wangamong Creek flooding.

Table 11 Flood Data – Points of Interest

Location	Overtopping Threshold			100 Year ARI Depth Overtopping (m)	Indicative Duration Overtopping (hours)
	Flow (ML/day)	ARI (years)	Pump Station gauge height (m)		
Newell Highway at Billabong Creek	> 60,000	>1000	> 4.0	0.0	-
Bolton Street on south side approach	10,000	40	2.7	0.3	1 to 7 days
Jerilderie-Oaklands Road at Jerilderie	> 20,000	> 500	> 3.5	0.0	-
Conargo Road at Jerilderie	> 20,000	> 500	> 3.5	0.0	-
Newell Highway at Wangamong Creek	> 5,000	> 200	na	0.0	-
Rifle Range Road at Wangamong Creek	400	< 2	na	0.9	1 to 14 days

Note:

1. Current gauge zero datum at the Pump Station gauging station site is 105.402 m AHD.

7.4 Flood Damages

7.4.1 Floor Level Survey

The floor levels of 50 buildings located either within or in close proximity to the area inundated by the 100 year ARI flood were surveyed to allow for the risk of above floor flooding to be assessed at each building, and to allow for the computation of flood damages.

Buildings surveyed were located in the following areas:

- Bolton Street south of Billabong Creek. A total of 22 building floor levels were obtained (17 houses, two blocks of flats and three school buildings).
- Ashton Street. One floor level was obtained (house).
- Argoon Avenue. One floor level was obtained (house).
- North side of Powell Street. A total of five building floor levels were obtained (three houses, one block of flats and the Museum building).
- McDougall Street. A total of four building floor levels were obtained (all houses).
- Old Showgrounds Road. A total of five building floor levels were obtained (all houses).
- Jerilderie-Oaklands Road. A total of eight building floor levels were obtained (all houses).
- Upstream of the Newell Highway on the north side of Billabong Creek. A total of three building floor levels were obtained (all houses).
- Cape Road. One floor level was obtained (house).

In addition to the above surveyed floor levels, indicative floor levels for a further 60 buildings located outside the 100 year ARI flood extent but within the extreme flood extent (refer to Figure B8) were estimated. The estimated floor levels for these additional buildings are based on adding 300 mm to the average ground surface elevation at each building site. The ground surface levels were obtained from the LiDAR 1 m grid terrain data.

7.4.2 Flood Risk Status

The design flood levels at each of the above building locations were compared with the surveyed floor level elevations.

The results are documented in Table 12. Of the seven buildings which are subject to above floor 100 year ARI flooding:

- Five are houses
- One is a block of flats
- One is a school building

Of the above seven buildings, only one is subject to above floor flooding in a 50 year ARI event. There are no buildings subject to 20 year ARI above floor flooding (this excludes minor / secondary buildings such as sheds).

In more severe events than the 100 year ARI event, 21 buildings are subject to above floor flooding in a 200 year ARI event and up to 56 buildings are estimated to be subject to above floor flooding in the extreme event modelled (i.e. flow equal to four times the 100 year ARI design flow).

7.4.3 Flood Damages

Flood damages are categorised as follows:

- Tangible damages. These are financial in nature and can be measured in monetary terms. Tangible damages are further subcategorised into:
  - Direct damages. These are caused by floodwaters wetting goods and possessions, thereby reducing their value.
  - Indirect damages. These are the additional financial losses caused by a flood and include accommodation and food costs for evacuees, loss of wages due to disruption to employment, loss of business sales.
- Intangible damages. These include the stress and illness caused to those during and after a flood. By definition, they cannot be quantified in monetary terms.

In relation to the Jerilderie study, the flood damages were estimated as follows:

- Site inspections and aerial photography were used order to confirm property types.
- Flood behaviour and Australian Bureau of Statistics data for Jerilderie was used to configure the OEH Residential Damages Spreadsheet input parameters and to produce direct residential flood damages specifically for this study. Indirect damages were assumed to equate to 40% of direct damages.
- Commercial damages were specified based on approaches adopted for other flood studies within the region for small towns (e.g. current study being undertaken at Lockhart and The Rock).
- TUFLOW modelled design flood water surfaces were exported to WaterRide for analysis. Flood levels and underlying terrain levels were used to calculate the flood depth over the surveyed floor level at each premise, and to determine the corresponding flood damages for each premise.

Table 12 Above Floor Flooding Assessment Results

Area	Number of buildings subject to above floor flooding (metres) excludes secondary buildings (e.g. sheds, carports, garages etc)							
	50 year ARI event		100 year ARI event		200 year ARI event		Extreme event	
	Residential	Commercial & industrial	Residential	Commercial & industrial	Residential	Commercial & industrial	Residential	Commercial & industrial
Ashton Street	0	0	1	0	1	0	1	0
Bolton Street	0	0	3	1	8	2	21	3
Bundoora Avenue estate	0	0	0	0	0	0	0	0
Cape Road	0	0	0	0	0	0	1	0
Jerilderie-Oaklands Road	0	0	0	0	2	0	7	2
Jerilderie Street / Newell Highway	0	0	0	0	1	0	1	2
Kennedy St / Coonong St	0	0	0	0	0	0	0	0
McDougall Street	0	0	0	0	3	0	4	0
Old Showgrounds Road	1	0	1	0	1	0	5	0
Powell Street	0	0	1	0	2	1	4	1
Racecourse property	0	0	0	0	0	0	0	3
Rifle Range Rd (airport buildings)	0	0	0	0	0	0	0	1
Total	1	0	6	1	18	3	44	12

Note:

1. Above is for the main building on each property.

The resulting flood damages are summarised in Table 13.

The average annual damage for Jerilderie is a relatively low $31,000 per annum. The low damage figure is a reflection of the high threshold at which damages commence. There is no significant damage for flood events up to the 20 year ARI event.

Table 13 Flood Damage Assessment Results

ARI	Estimated Flood Damage ($)		
	Residential	Commercial	Total
20	0	0	
50	56,000	62,000	118,000
100	599,000	134,000	733,000
200	1,523,000	455,000	1,978,000
Extreme	4,562,000	1,079,000	5,641,000
Average Annual Damage (AAD)	$31,000/annum		
Net present value over 20 years at a discount rate of 4 %	$420,000		

8. Acknowledgements

GHD has completed the Jerilderie Flood Study project with the assistance of the Jerilderie Shire Council's Floodplain Risk Management Committee, Council's staff, Office of Environment of Heritage's staff and the other government agency and local residents who have had involvement in the project. The assistance which has been provided is very much appreciated by both GHD and the Jerilderie Shire Council.

The Jerilderie Shire Council has prepared this document with financial assistance from the NSW and Commonwealth Governments through the Natural Disaster Resilience Program. This document does not necessarily represent the opinions of the NSW or Commonwealth Governments.

9. Abbreviations and Glossary

9.1 Abbreviations

AAD	Average annual damage
AEP	Annual exceedance probability
AHD	Australian Height Datum
ARI	Average Recurrence Interval
CMA	Catchment Management Authority
DEM	Digital elevation model
LEP	Local Environmental Plan
FDM	Floodplain Development Manual (2005)
FPA	Flood planning area
FPL	Flood planning level
FRMS	Floodplain Risk Management Study
FRMP	Floodplain Risk Management Plan
LiDAR	Light Detection and Ranging (also known as ALS)
ML/day	Megalitres per day (1 megalitre is equal to 1,000 cubic metres)
OEH	Office of Environment and Heritage
PMF	Probable Maximum Flood
SES	State Emergency Service

9.2 Glossary

Annual Exceedance Probability (AEP) - AEP (measured as a percentage) is a term used to describe flood size. AEP is the long-term probability between floods of a certain magnitude. For example, a 1% AEP flood is a flood that occurs on average once every 100 years. It is also referred to as the '100 year flood' or 1 in 100 year flood'.

0.5% AEP sometimes referred to as the 1 in 200 year ARI event

1% AEP sometimes referred to as the 1 in 100 year ARI event

2% AEP sometimes referred to as the 1 in 50 year ARI event

5% AEP sometimes referred to as the 1 in 20 year ARI event

10% AEP sometimes referred to as the 1 in 10 year ARI event

20% AEP sometimes referred to as the 1 in 5 year ARI event

Afflux - The increase in flood level upstream of a constriction of flood flows. A road culvert, a pipe or a narrowing of the stream channel could cause the constriction.

Australian Height Datum (AHD) - A common national plane of level approximately equivalent to the height above sea level. All flood levels; floor levels and ground levels in this study have been provided in meters AHD.

Average annual damage (AAD) - Average annual damage is the average flood damage per year that would occur in a nominated development situation over a long period of time.

Average recurrence interval (ARI) - ARI (measured in years) is a term used to describe flood size. It is a means of describing how likely a flood is to occur in a given year. For example, a 100-year ARI flood is a flood that occurs or is exceeded on average once every 100 years.

Catchment - The land draining through the main stream, as well as tributary streams.

Critical Duration – The storm duration at which the peak flood flow and/or flood level occurs

Development Control Plan (DCP) - A DCP is a plan prepared in accordance with Section 72 of the *Environmental Planning and Assessment Act, 1979* that provides detailed guidelines for the assessment of development applications.

Design flood level - A flood with a nominated probability or average recurrence interval, for example the 100 year ARI flood is commonly use throughout NSW.

OEH (formerly DECCW, DECC, DNR, DLWC, DIPNR) - Office of Environment and Heritage. Covers a range of conservation and natural resources science and programs, including native vegetation, biodiversity and environmental water recovery to provide an integrated approach to natural resource management. The NSW State Government Office provides funding and support for flood studies.

Discharge - The rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second (m3/s) or megalitres per day (ML/day). Discharge is different from the speed or velocity of flow, which is a measure of how fast the water is moving.

Effective warning time - The time available after receiving advice of an impending flood and before the floodwaters prevent appropriate flood response actions being undertaken. The effective warning time is typically used to move farm equipment, move stock, raise furniture, evacuate people and transport their possessions.

Extreme flood - An estimate of the probable maximum flood (PMF), which is the largest flood likely to occur.

Flood - A relatively high stream flow that overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami.

Flood awareness - An appreciation of the likely effects of flooding and knowledge of the relevant flood warning, response and evacuation procedures.

Flood Fringe - The remaining area of land affected by flooding, after floodway and flood storage areas have been defined. Development in flood fringe areas would not have any significant effect on the pattern of flood flows and / or flood levels.'

Flood hazard - The potential for damage to property or risk to persons during a flood. Flood hazard is a key tool used to determine flood severity and is used for assessing the suitability of future types of land use.

Flood level - The height of the flood described either as a depth of water above a particular location (e.g. 1m above a floor, yard or road) or as a depth of water related to a standard level such as Australian Height Datum (e.g. the flood level was 77.5 m AHD). Terms also used include flood stage and water level.

Flood liable land - Land susceptible to flooding up to the Probable Maximum Flood (PMF). Also called flood prone land. Note that the term flood liable land now covers the whole of the floodplain, not just that part below the flood planning level, as indicated in the superseded Floodplain Development Manual (NSW Government, 2005).

Flood Planning Levels (FPLs) - The combination of flood levels and freeboards selected for planning purposes, as determined in floodplain management studies and incorporated in floodplain management plans. The concept of flood planning levels supersedes the designated flood or the flood standard used in earlier studies.

Flood Prone Land - Land susceptible to flooding up to the Probable Maximum Flood (PMF). Also called flood liable land.

Flood stage - see flood level.

Flood Storage - Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. If the capacity of a flood storage area is substantially reduced by, for example, the construction of levees or by landfill, flood levels in nearby areas may rise and the peak discharge downstream may be increased. Substantial reduction of the capacity of a flood storage area can also cause a significant redistribution of flood flows.

Flood Study - A study that investigates flood behaviour, including identification of flood extents, flood levels and flood velocities for a range of flood sizes.

Floodplain - The area of land that is subject to inundation by floods up to and including the Probable Maximum Flood event, that is, flood prone land or flood liable land.

Floodplain Risk Management Study – Studies carried out in accordance with the Floodplain Development Manual and assess options for minimising the danger to life and property during floods.

Floodplain Risk Management Plan - The outcome of a Floodplain Management Risk Study.

Floodway - Those areas of the floodplain where a significant discharge of water occurs during floods. Floodways are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood levels.

Freeboard - A factor of safety expressed as the height above the design flood level. Freeboard provides a factor of safety to compensate for uncertainties in the estimation of flood levels across the floodplain, such as wave action, localised hydraulic behaviour and impacts that are specific event related, such as levee and embankment settlement, and other effects such as "greenhouse" and climate change.

High Flood Hazard - For a particular size flood, there would be a possible danger to personal safety, able-bodied adults would have difficulty wading to safety, evacuation by trucks would be difficult and there would be a potential for significant structural damage to buildings.

Hydraulics Term - given to the study of water flow in waterways, in particular, the evaluation of flow parameters such as water level and velocity.

Hydrology Term - given to the study of the rainfall and runoff process; in particular, the evaluation of peak discharges, flow volumes and the derivation of hydrographs (graphs that show how the discharge or stage/flood level at any particular location varies with time during a flood).

Local catchments - Local catchments are river sub-catchments that feed river tributaries, creeks, and watercourses and channelised or piped drainage systems.

Local Environmental Plan (LEP) – A Local Environmental Plan is a plan prepared in accordance with the *Environmental Planning and Assessment Act*, 1979, that defines zones, permissible uses within those zones and specifies development standards and other special matters for consideration with regard to the use or development of land.

Local overland flooding - Local overland flooding is inundation by local runoff within the local catchment.

Local runoff - local runoff from the local catchment is categorised as either major drainage or local drainage in the NSW Floodplain Development Manual, 2005.

Low flood hazard - For a particular size flood, able-bodied adults would generally have little difficulty wading and trucks could be used to evacuate people and their possessions should it be necessary.

Flows or discharges - It is the rate of flow of water measured in terms of volume per unit time.

Overland flow path - The path that floodwaters can follow if they leave the confines of the main flow channel. Overland flow paths can occur through private property or along roads. Floodwaters travelling along overland flow paths, often referred to as 'overland flows', may or may not re-enter the main channel from which they left — they may be diverted to another watercourse.

Peak discharge - The maximum flow or discharge during a flood.

Probable Maximum Flood (PMF) - The largest flood likely to ever occur. The PMF defines the extent of flood prone land or flood liable land, that is, the floodplain.

Risk - Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of this study, it is the likelihood of consequences arising from the interaction of floods, communities and the environment.

Runoff - the amount of rainfall that ends up as flow in a stream, also known as rainfall excess.

SES - State Emergency Service of New South Wales

Stage–damage curve - A relationship between different water depths and the predicted flood damage at that depth.

Velocity - the term used to describe the speed of floodwaters, usually in m/s (metres per second). 10km/h = 2.7m/s.

Water surface profile - A graph showing the height of the flood (flood stage, water level or flood level) at any given location along a watercourse at a particular time.

10. References

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Lyall & Associates Consulting Water Engineers (December 2008). Conargo Floodplain Risk Management Study and Plan – Flood Data Assessment Study. Prepared for Conargo Shire Council.

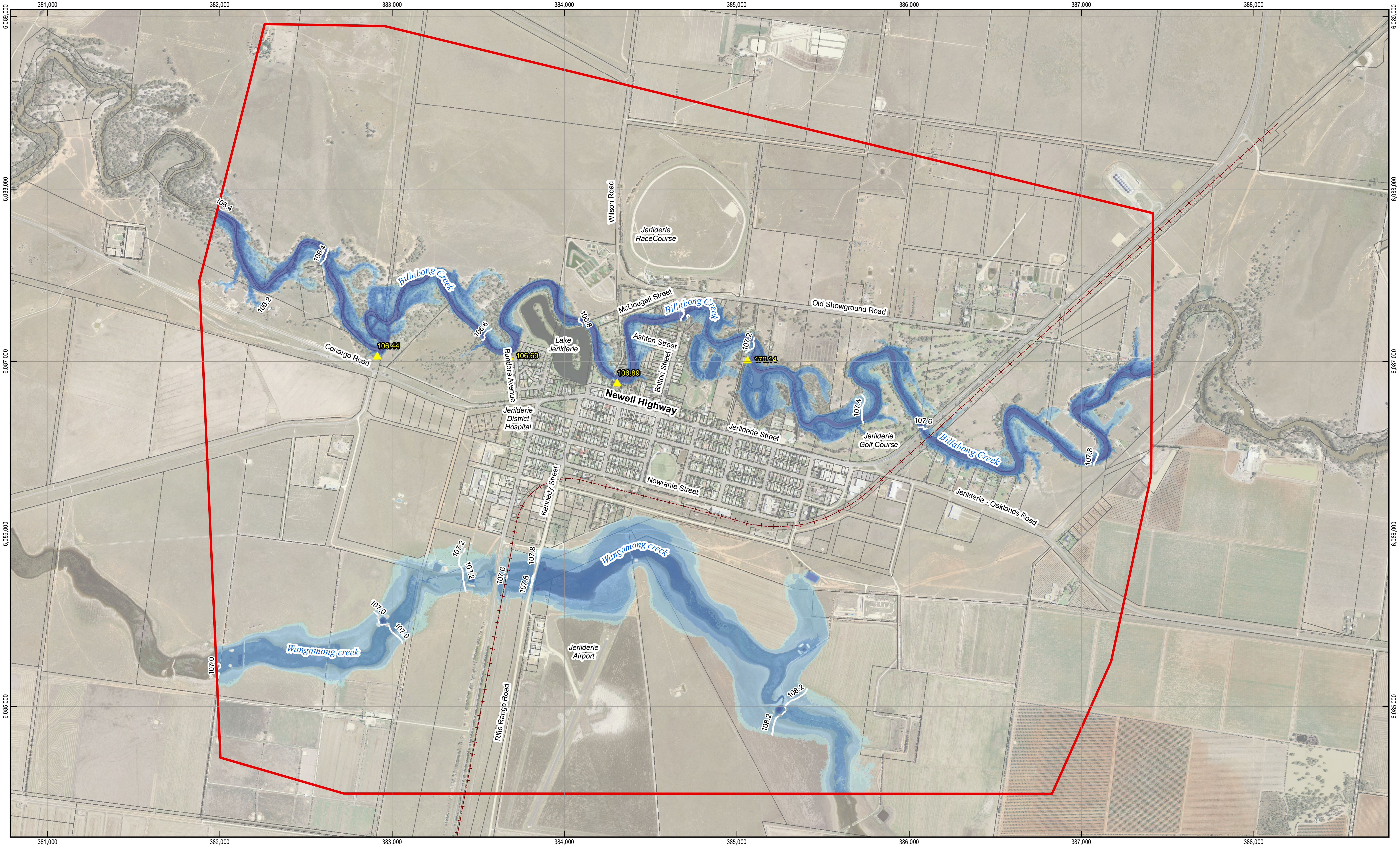
Lyall & Associates Consulting Water Engineers (July 2010). Conargo Floodplain Risk Management Study and Plan – Final Report. Prepared for Conargo Shire Council.

NSW Government Department of Natural Resources (May 2006). Billabong Creek Floodplain Management Plan.

Appendices

Appendix A – Calibration Event Flood Map

Figure A1 March 2012 Calibration Event – Flood Extent and Depth



1:20,000 (at A3)

0 100 200 400 600 800

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

Flood Extent and Depth (m)

- < 0.10
- 0.10 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- 2.00 - 4.00
- > 4.00
- Recorded Flood levels (March 2012)
- TUFLOW Model Extents
- Cadastre
- Flood Level Contours (mAHD)
- Railway

Jerilderie Shire Council
Jerilderie Flood Study

Job Number	23-14980
Revision	0
Date	25 Jul 2014

March 2012 Calibration Event Flood Extent and Depth

Figure A1

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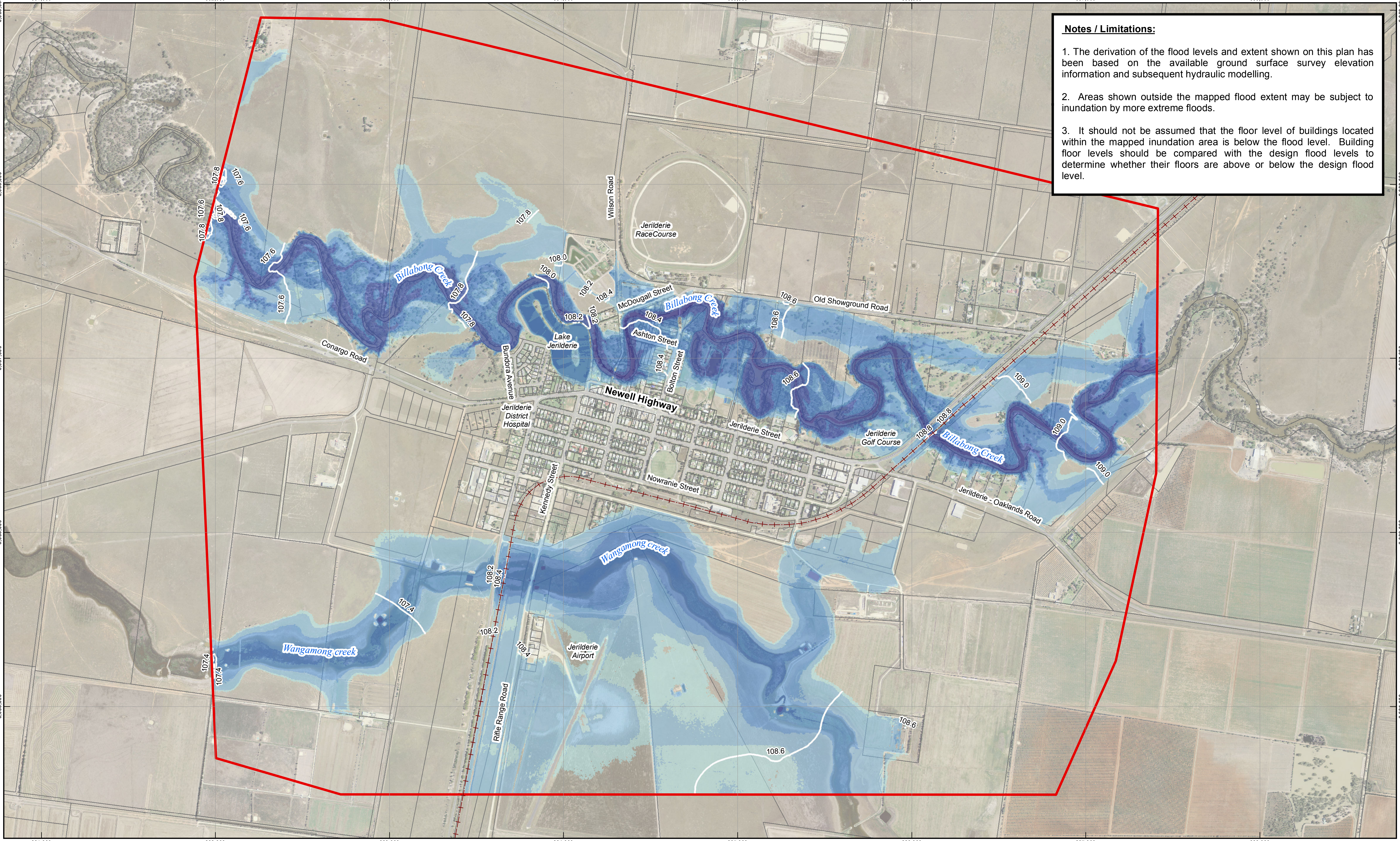
230 Harbour Drive Coffs Harbour NSW 2450 Australia T 61 2 6650 5600 F 61 2 6650 5601 E cfsmail@ghd.com W www.ghd.com

Data source: DEPI, VicMap, 2014; Jerliderie Shire Council, aerial, LiDAR, 2013; GHD, flood extents & contours, 2014. Created by:sldouglas

Appendix B – Design Flood Maps



1:20,000 (at A3)

0 100 200 400 600 800

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

Flood Extent and Depth (m)

- < 0.10
- 0.10 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- 2.00 - 4.00
- > 4.00
- TUFLOW Model Extents
- Cadastre
- Flood Level Contours (mAHD)
- Railway

Jerilderie Shire Council
Jerilderie Flood Study

Job Number	23-14980
Revision	0
Date	25 Jul 2014

100 Year ARI Flood Event
Flood Extent and Depth

Figure B1

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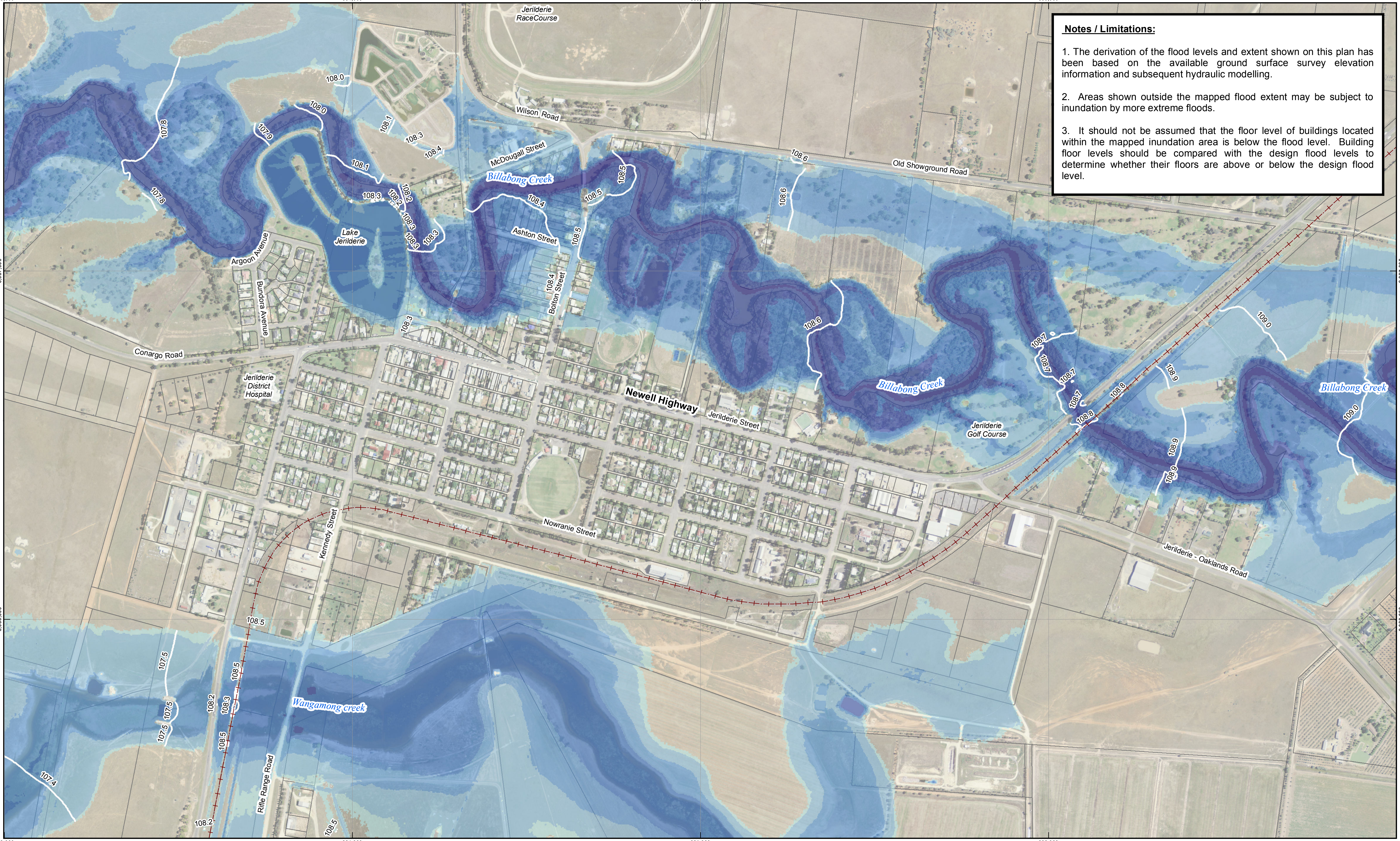
230 Harbour Drive Coffs Harbour NSW 2450 Australia T 61 2 6650 5600 F 61 2 6650 5601 E cfsmail@ghd.com W www.ghd.com

Data source: DEPI, VicMap, 2014; Jerilderie Shire Council, aerial, LiDAR, 2013; GHD, flood extents & contours, 2014. Created by:sldouglas



1:10,000 (at A3)

0 50 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

Flood Extent and Depth (m)

- < 0.10
- 0.10 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- 2.00 - 4.00
- > 4.00
- TUFLOW Model Extents
- Cadastre
- Flood Level Contours (mAHD)
- Railway

Jerilderie Shire Council
Jerilderie Flood Study

Job Number	23-14980
Revision	0
Date	25 Jul 2014

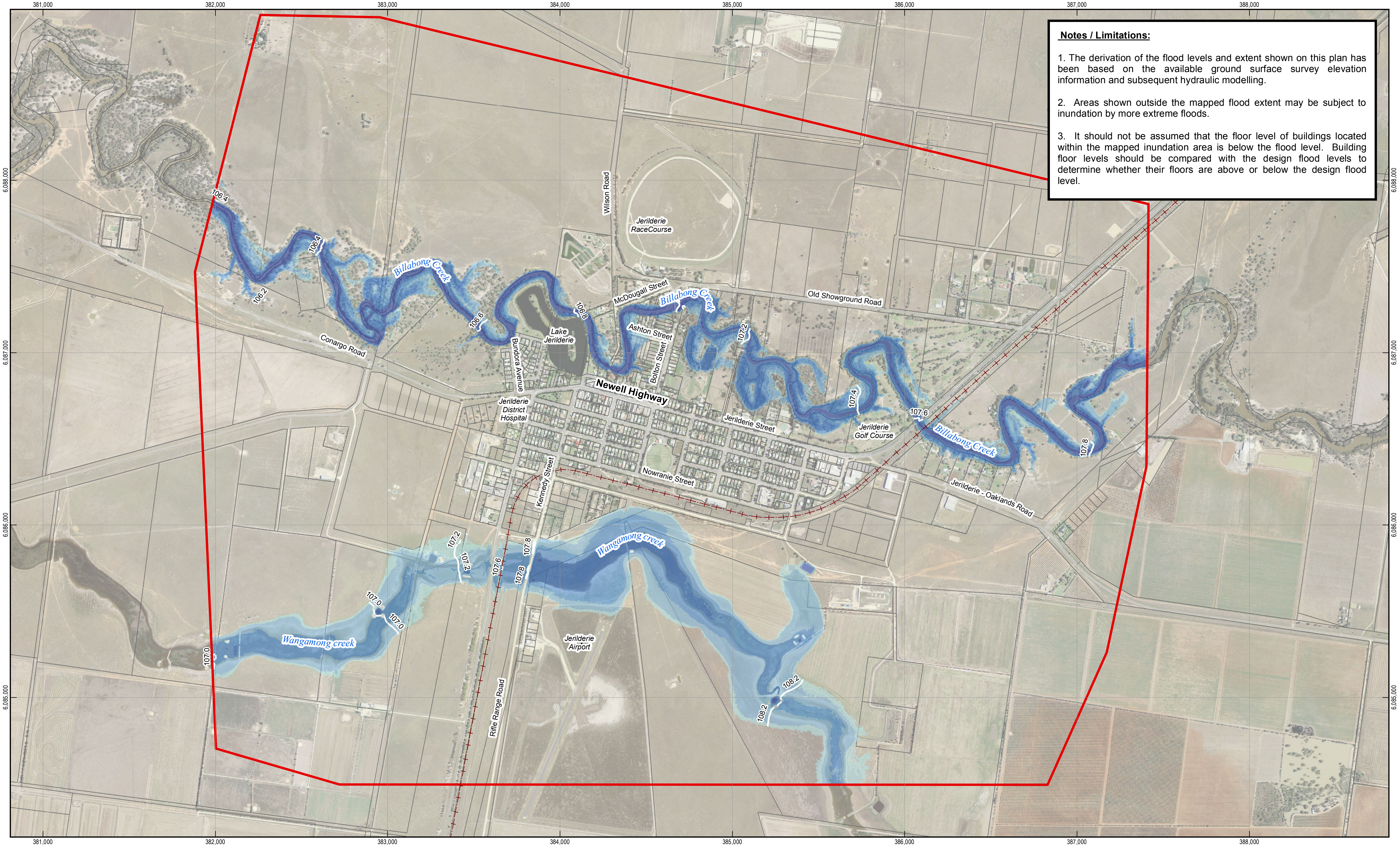
100 Year ARI Flood Event
Flood Extent and Depth

Figure B2

G:\23\14980\GIS\Maps\Deliverables\23_14980_Jerilderie_FS_Figure_B2_Rev_0.mxd

Data source: DEPI, VicMap, 2014; Jerliderie Shire Council, aerial, LiDAR, 2013; GHD, flood extents & contours, 2014. Created by:sldouglas

230 Harbour Drive Coffs Harbour NSW 2450 Australia T 61 2 6650 5600 F 61 2 6650 5601 E cfsmail@ghd.com W www.ghd.com



Notes / Limitations:

1. The derivation of the flood levels and extent shown on this plan has been based on the available ground surface survey elevation information and subsequent hydraulic modelling.

2. Areas shown outside the mapped flood extent may be subject to inundation by more extreme floods.

3. It should not be assumed that the floor level of buildings located within the mapped inundation area is below the flood level. Building floor levels should be compared with the design flood levels to determine whether their floors are above or below the design flood level.

1:20,000 (at A3)

0 100 200 400 600 800

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

Flood Extent and Depth (m)

- < 0.10
- 0.10 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- 2.00 - 4.00
- > 4.00
- TUFLOW Model Extents
- Cadastre
- Flood Level Contours (mAHD)
- Railway

GHD

Jerilderie Shire Council
Jerilderie Flood Study

Job Number	23-14980
Revision	0
Date	25 Jul 2014

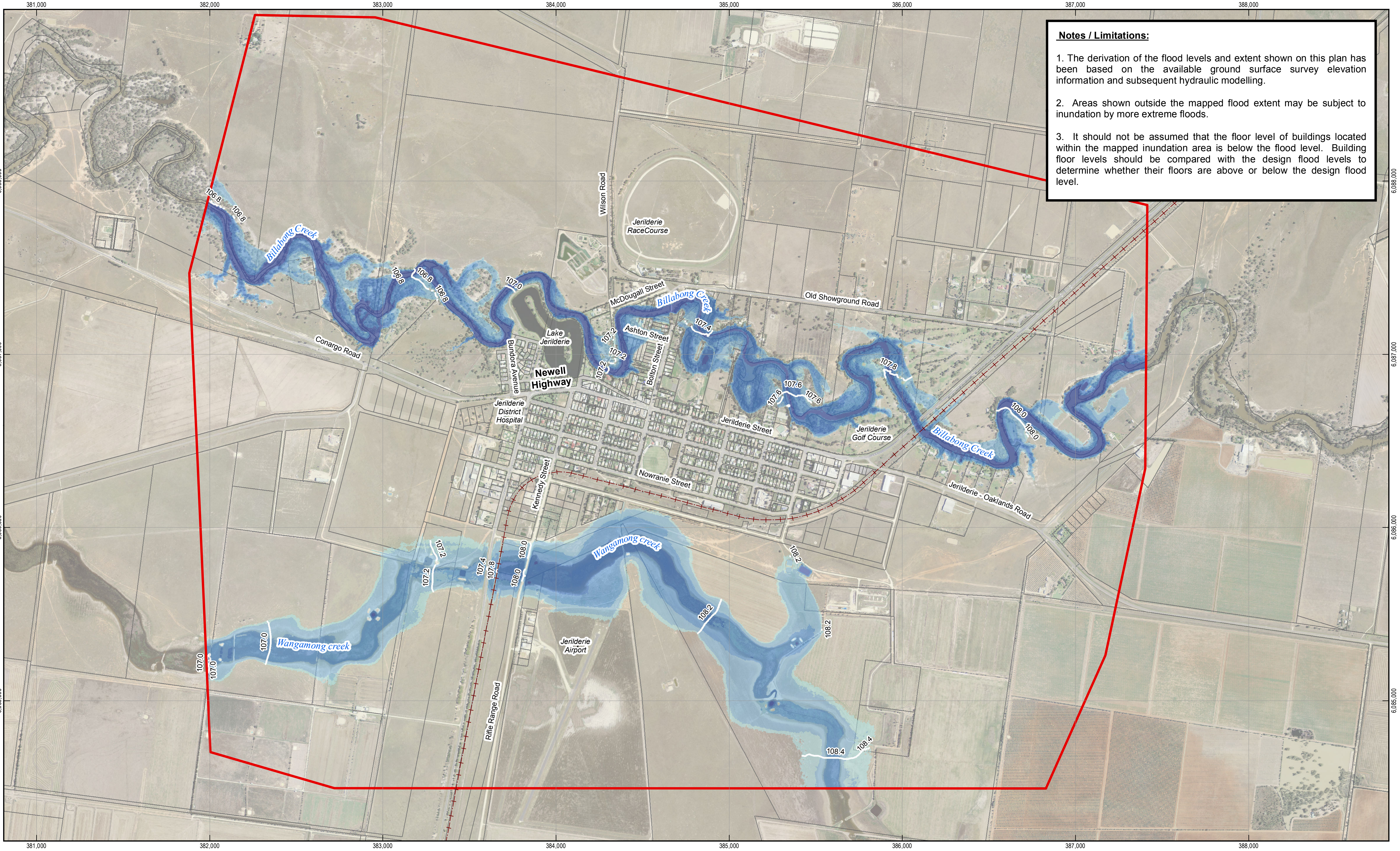
5 Year ARI Flood Event
Flood Extent and Depth

Figure B3

G:\23\14980\GIS\Maps\Deliverables\23_14980_Jerilderie_FS_Figure_B3_Rev_0.mxd

230 Harbour Drive Coffs Harbour NSW 2450 Australia T 61 2 6650 5600 F 61 2 6650 5601 E cfsmail@ghd.com W www.ghd.com

Data source: DEPI, VicMap, 2014; Jerilderie Shire Council, aerial, LiDAR, 2013; GHD, flood extents & contours, 2014. Created by:sldouglas



Notes / Limitations:

1. The derivation of the flood levels and extent shown on this plan has been based on the available ground surface survey elevation information and subsequent hydraulic modelling.

2. Areas shown outside the mapped flood extent may be subject to inundation by more extreme floods.

3. It should not be assumed that the floor level of buildings located within the mapped inundation area is below the flood level. Building floor levels should be compared with the design flood levels to determine whether their floors are above or below the design flood level.

1:20,000 (at A3)

0 100 200 400 600 800

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

Flood Extent and Depth (m)

- < 0.10
- 0.10 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- 2.00 - 4.00
- > 4.00
- TUFLOW Model Extents
- Cadastre
- Flood Level Contours (mAHD)
- Railway

Jerilderie Shire Council
Jerilderie Flood Study

Job Number	23-14980
Revision	0
Date	25 Jul 2014

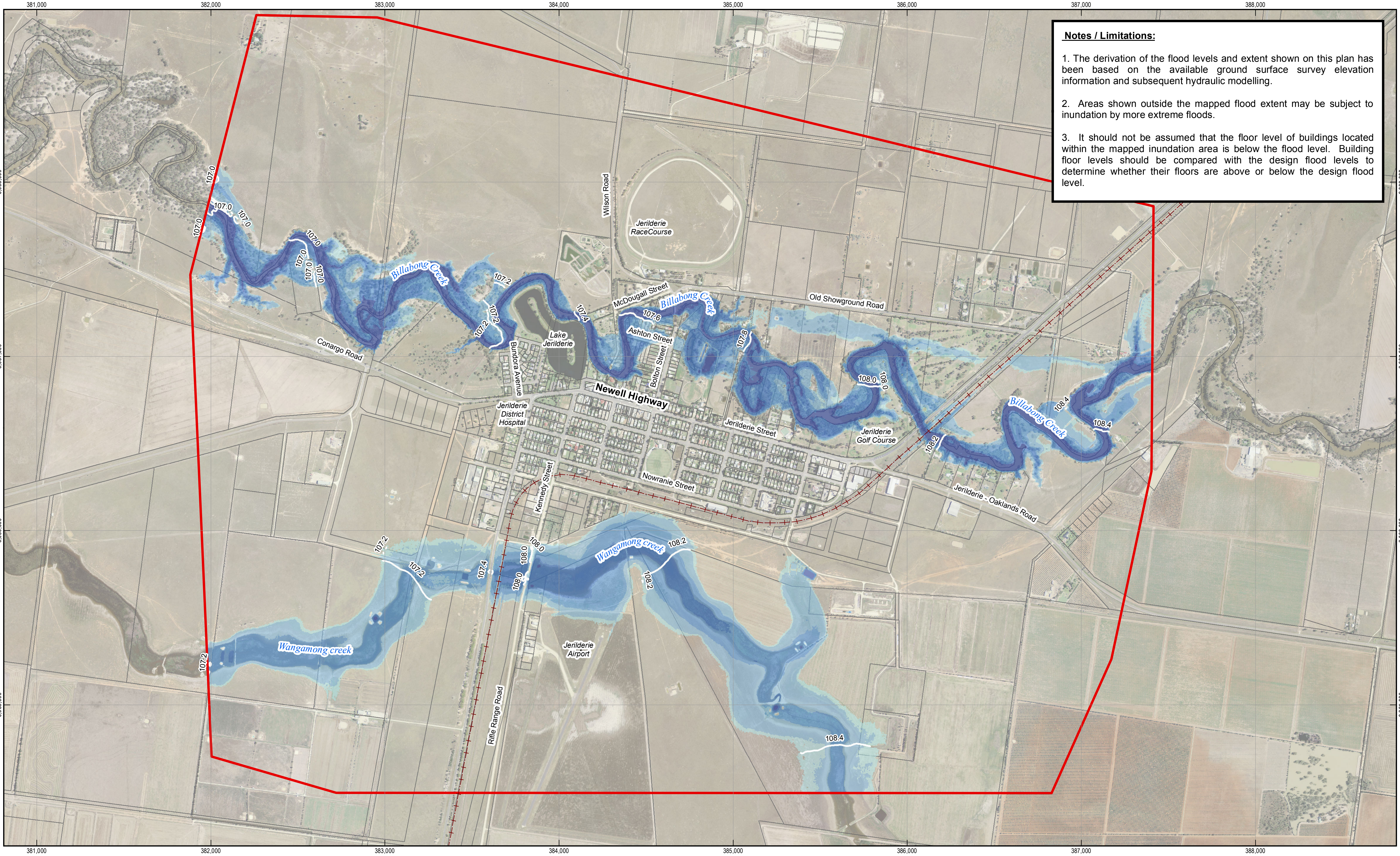
10 Year ARI Flood Event
Flood Extent and Depth

Figure B4

G:\23\14980\GIS\Maps\Deliverables\23_14980_Jerilderie_FS_Figure_B4_Rev_0.mxd

230 Harbour Drive Coffs Harbour NSW 2450 Australia T 61 2 6650 5600 F 61 2 6650 5601 E cfsmail@ghd.com W www.ghd.com

Data source: DEPI, VicMap, 2014; Jerliderie Shire Council, aerial, LiDAR, 2013; GHD, flood extents & contours, 2014. Created by:sldouglas



Notes / Limitations:

1. The derivation of the flood levels and extent shown on this plan has been based on the available ground surface survey elevation information and subsequent hydraulic modelling.

2. Areas shown outside the mapped flood extent may be subject to inundation by more extreme floods.

3. It should not be assumed that the floor level of buildings located within the mapped inundation area is below the flood level. Building floor levels should be compared with the design flood levels to determine whether their floors are above or below the design flood level.

1:20,000 (at A3)

0 100 200 400 600 800

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

Flood Extent and Depth (m)

- < 0.10
- 0.10 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- 2.00 - 4.00
- > 4.00
- TUFLOW Model Extents
- Cadastre
- Flood Level Contours (mAHD)
- Railway

Jerilderie Shire Council
Jerilderie Flood Study

Job Number	23-14980
Revision	0
Date	25 Jul 2014

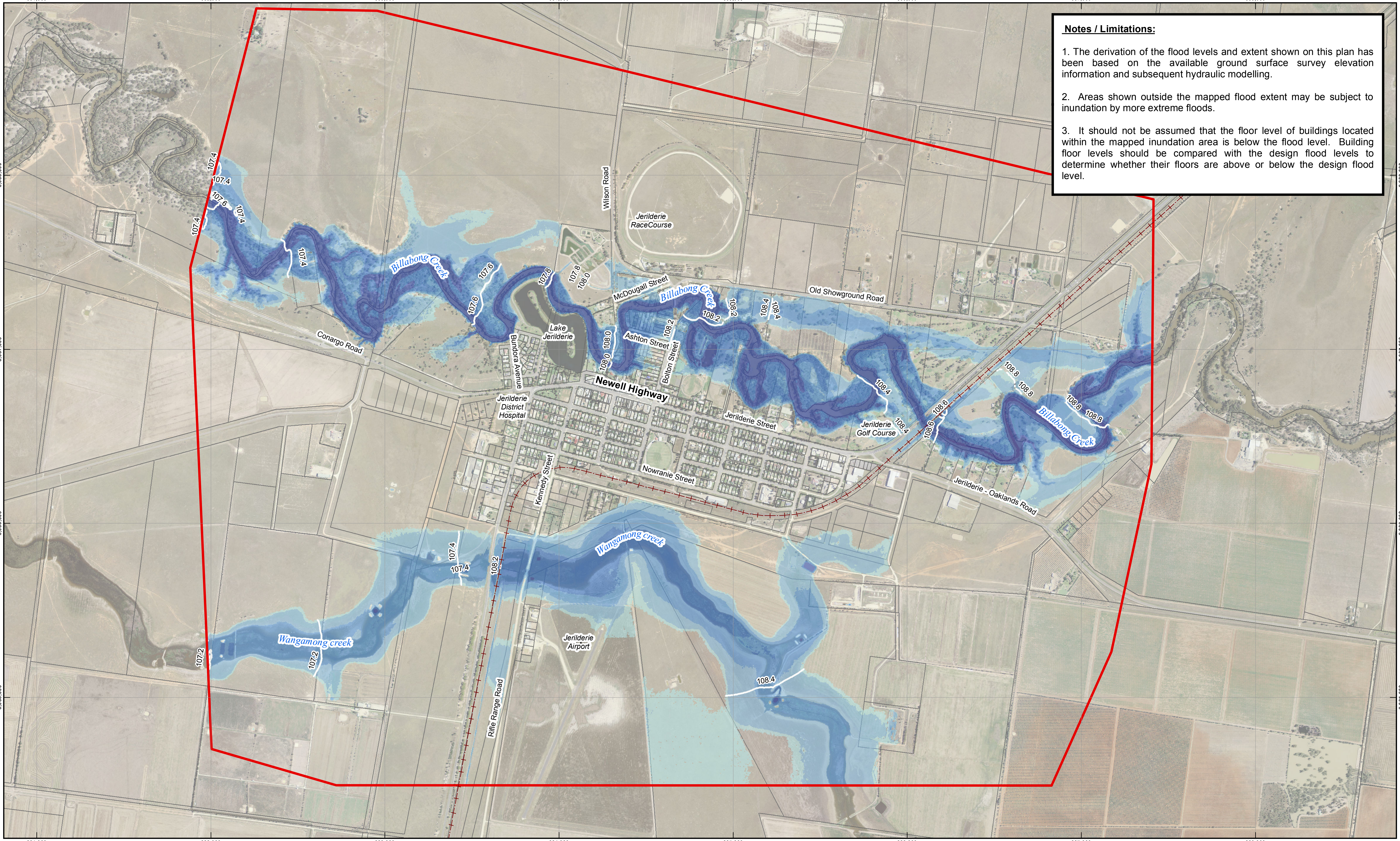
20 Year ARI Flood Event
Flood Extent and Depth

Figure B5

G:\23\14980\GIS\Maps\Deliverables\23_14980_Jerilderie_FS_Figure_B5_Rev_0.mxd

230 Harbour Drive Coffs Harbour NSW 2450 Australia T 61 2 6650 5600 F 61 2 6650 5601 E cfsmail@ghd.com W www.ghd.com

Data source: DEPI, VicMap, 2014; Jerilderie Shire Council, aerial, LiDAR, 2013; GHD, flood extents & contours, 2014. Created by:sldouglas



Notes / Limitations:

1. The derivation of the flood levels and extent shown on this plan has been based on the available ground surface survey elevation information and subsequent hydraulic modelling.

2. Areas shown outside the mapped flood extent may be subject to inundation by more extreme floods.

3. It should not be assumed that the floor level of buildings located within the mapped inundation area is below the flood level. Building floor levels should be compared with the design flood levels to determine whether their floors are above or below the design flood level.

1:20,000 (at A3)

0 100 200 400 600 800

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

Flood Extent and Depth (m)

- < 0.10
- 0.10 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- 2.00 - 4.00
- > 4.00
- TUFLOW Model Extents
- Cadastre
- Flood Level Contours (mAHD)
- Railway

Jerilderie Shire Council
Jerilderie Flood Study

Job Number	23-14980
Revision	0
Date	25 Jul 2014

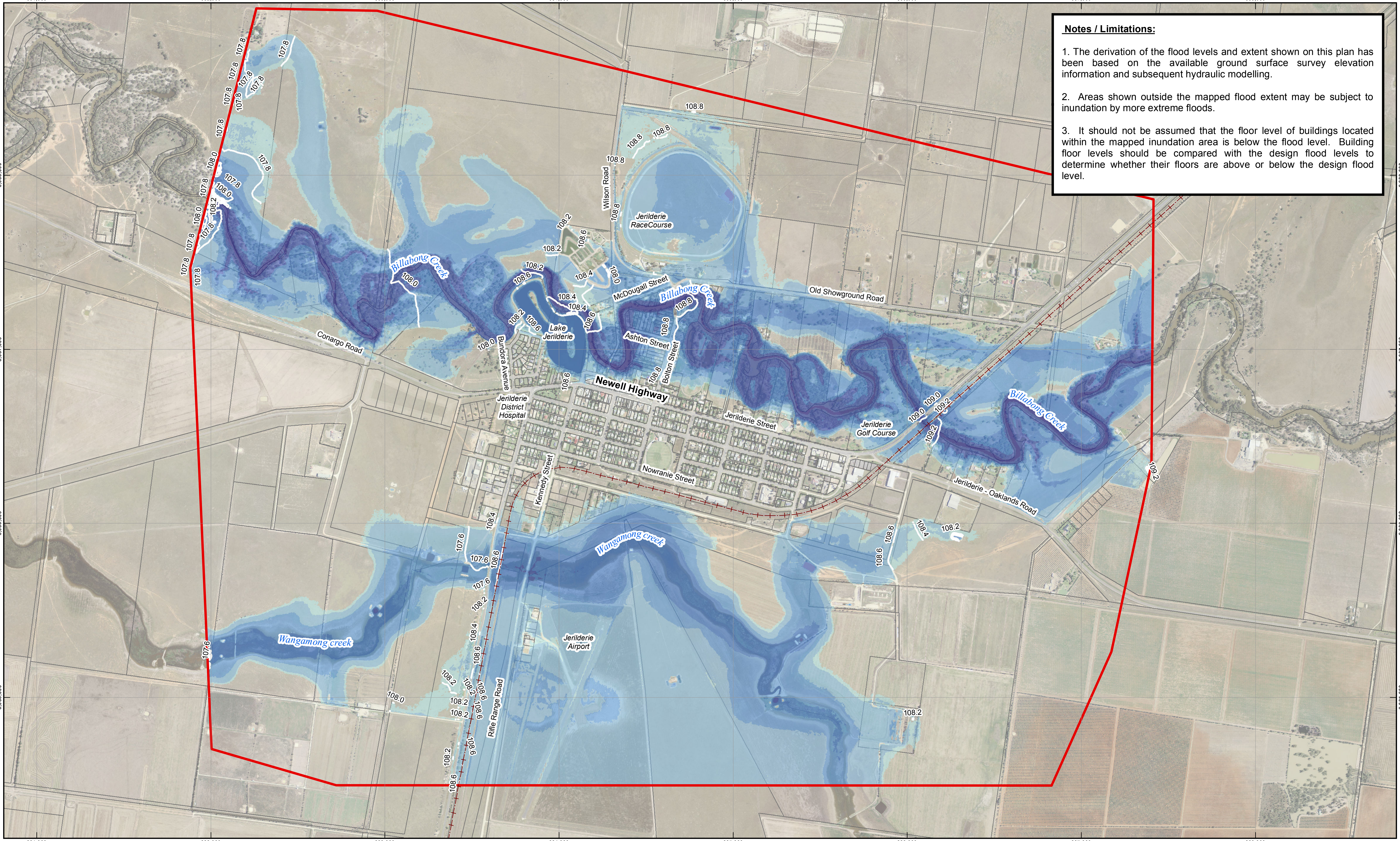
50 Year ARI Flood Event
Flood Extent and Depth

Figure B6

G:\23\14980\GIS\Maps\Deliverables\23_14980_Jerilderie_FS_Figure_B6_Rev_0.mxd

230 Harbour Drive Coffs Harbour NSW 2450 Australia T 61 2 6650 5600 F 61 2 6650 5601 E cfsmail@ghd.com W www.ghd.com

Data source: DEPI, VicMap, 2014; Jerilderie Shire Council, aerial, LiDAR, 2013; GHD, flood extents & contours, 2014. Created by:sldouglas



Notes / Limitations:

1. The derivation of the flood levels and extent shown on this plan has been based on the available ground surface survey elevation information and subsequent hydraulic modelling.

2. Areas shown outside the mapped flood extent may be subject to inundation by more extreme floods.

3. It should not be assumed that the floor level of buildings located within the mapped inundation area is below the flood level. Building floor levels should be compared with the design flood levels to determine whether their floors are above or below the design flood level.

1:20,000 (at A3)

0 100 200 400 600 800

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

Flood Extent and Depth (m)

- < 0.10
- 0.10 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- 2.00 - 4.00
- > 4.00
- TUFLOW Model Extents
- Cadastre
- Flood Level Contours (mAHD)
- Railway

Jerilderie Shire Council
Jerilderie Flood Study

Job Number	23-14980
Revision	0
Date	25 Jul 2014

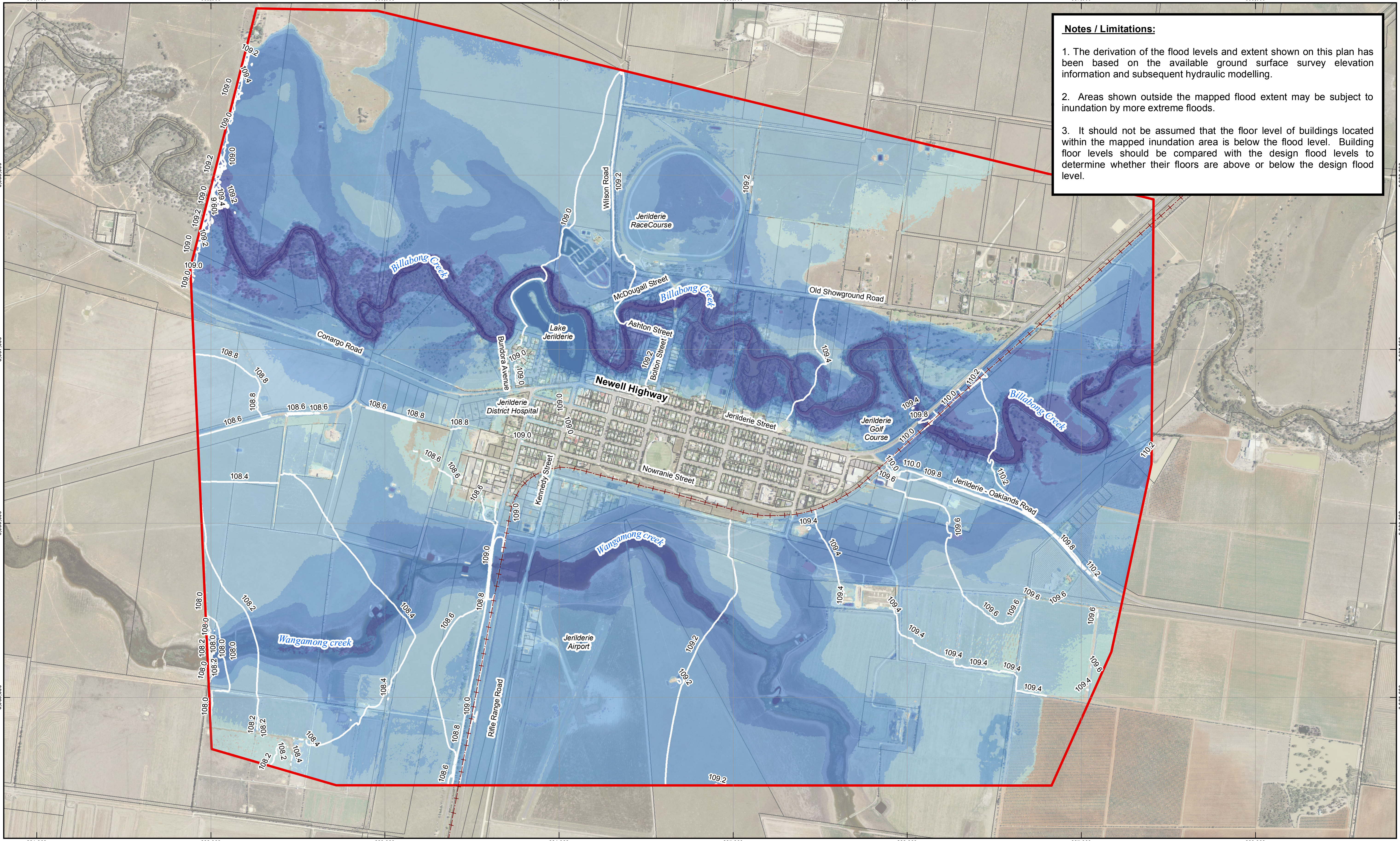
200 Year ARI Flood Event
Flood Extent and Depth

Figure B7

G:\23\14980\GIS\Maps\Deliverables\23_14980_Jerilderie_FS_Figure_B7_Rev_0.mxd

230 Harbour Drive Coffs Harbour NSW 2450 Australia T 61 2 6650 5600 F 61 2 6650 5601 E cfsmail@ghd.com W www.ghd.com

Data source: DEPI, VicMap, 2014; Jerilderie Shire Council, aerial, LiDAR, 2013; GHD, flood extents & contours, 2014. Created by:sldouglas



Notes / Limitations:

1. The derivation of the flood levels and extent shown on this plan has been based on the available ground surface survey elevation information and subsequent hydraulic modelling.

2. Areas shown outside the mapped flood extent may be subject to inundation by more extreme floods.

3. It should not be assumed that the floor level of buildings located within the mapped inundation area is below the flood level. Building floor levels should be compared with the design flood levels to determine whether their floors are above or below the design flood level.

1:20,000 (at A3)

0 100 200 400 600 800

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

Flood Extent and Depth (m)

- < 0.10
- 0.10 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- 2.00 - 4.00
- > 4.00

- TUFLOW Model Extents
- Cadastre
- Flood Level Contours (mAHD)
- Railway

GHD

Jerilderie Shire Council
Jerilderie Flood Study

Job Number	23-14980
Revision	0
Date	25 Jul 2014

Extreme Flood Event
Flood Extent and Depth

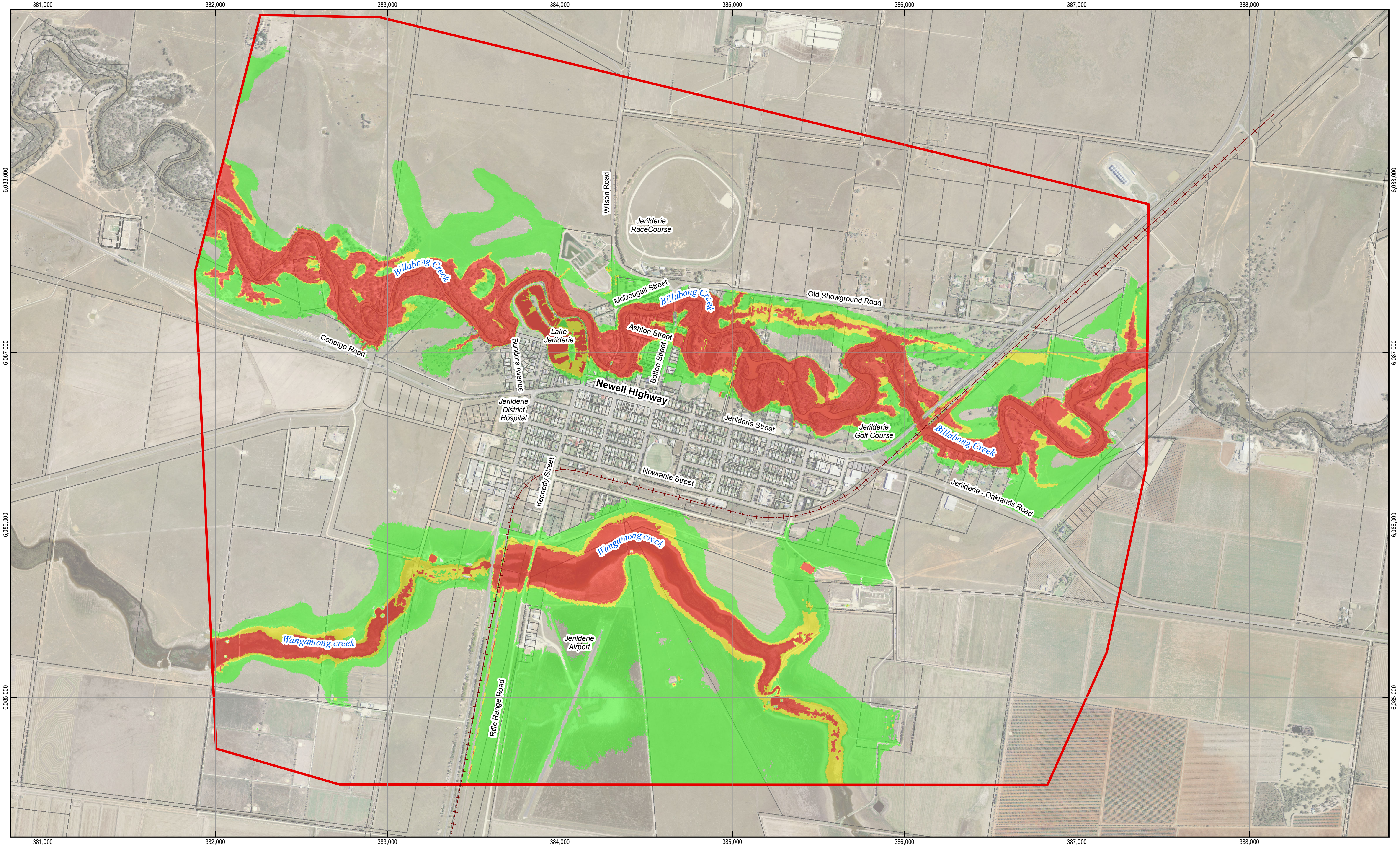
Figure B8

G:\23\14980\GIS\Maps\Deliverables\23_14980_Jerilderie_FS_Figure_B8_Rev_0.mxd

230 Harbour Drive Coffs Harbour NSW 2450 Australia T 61 2 6650 5600 F 61 2 6650 5601 E cfsmail@ghd.com W www.ghd.com

Data source: DEPI, VicMap, 2014; Jerilderie Shire Council, aerial, LiDAR, 2013; GHD, flood extents & contours, 2014. Created by:sldouglas

Appendix C – Provisional Hazard Category Maps



1:20,000 (at A3)

0 100 200 400 600 800

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

- TUFLOW Model Extents
- Cadastre
- Railway
- 1 - Low Hazard
- 2 - Intermediate Hazard
- 3 - High Hazard

Jerilderie Shire Council
Jerilderie Flood Study

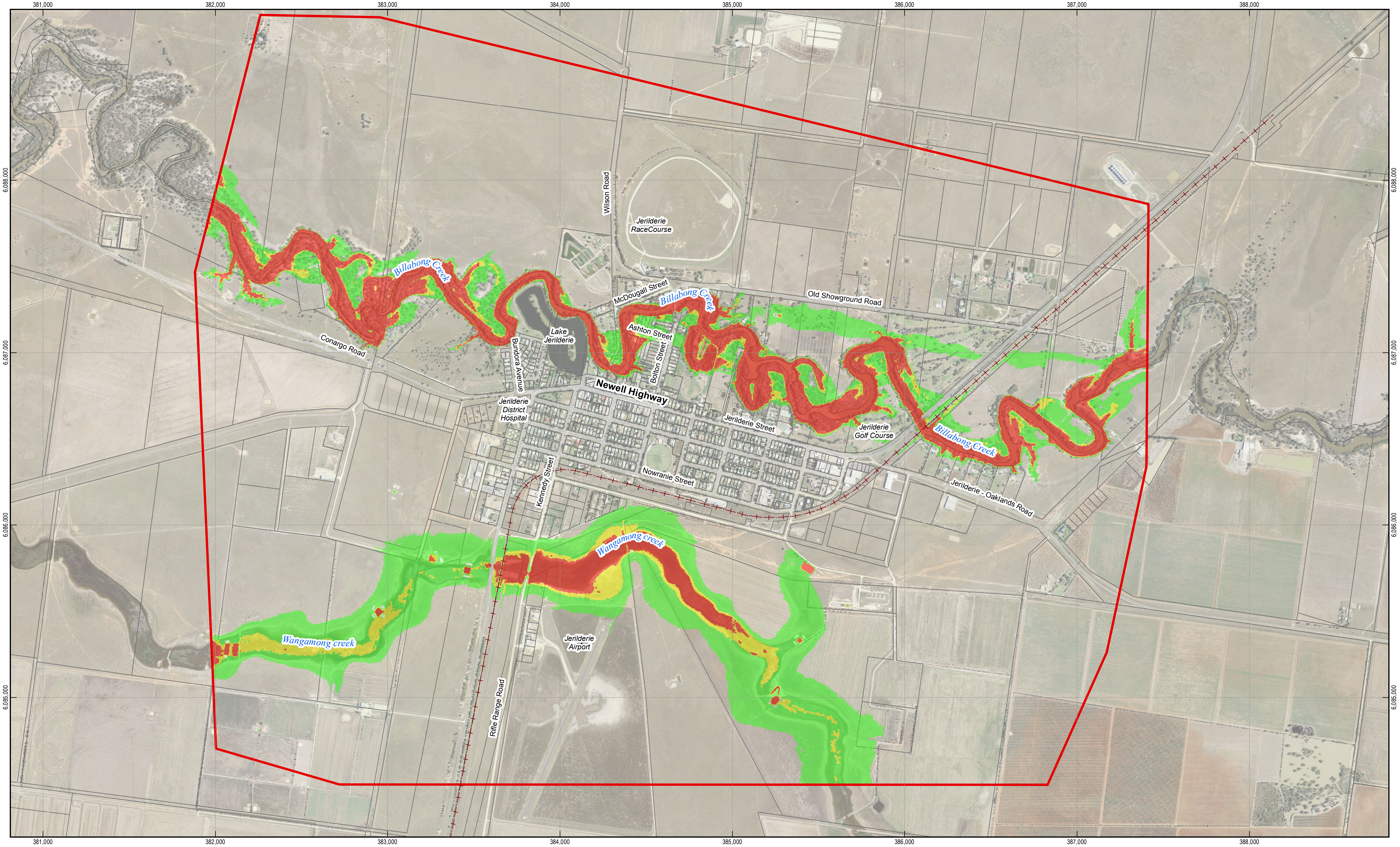
Job Number	23-14980
Revision	0
Date	25 Jul 2014

100 Year ARI Flood Event
Provisional Hazard Category **Figure C1**

G:\23\14980\GIS\Maps\Deliverables\23_14980_Jerilderie_FS_Figure_C1_Rev_0.mxd

Data source: DEPI, VicMap, 2014; Jerilderie Shire Council, aerial, LiDAR, 2013; GHD, flood extents & contours, 2014. Created by:sldouglas

230 Harbour Drive Coffs Harbour NSW 2450 Australia T 61 2 6650 5600 F 61 2 6650 5601 E cfsmail@ghd.com W www.ghd.com



1:20,000 (at A3)

0 100 200 400 600 800

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

- TUFLOW Model Extents
- Cadastre
- Railway
- 1 - Low Hazard
- 2 - Intermediate Hazard
- 3 - High Hazard

GHD

Jerilderie Shire Council
Jerilderie Flood Study

Job Number	23-14980
Revision	0
Date	25 Jul 2014

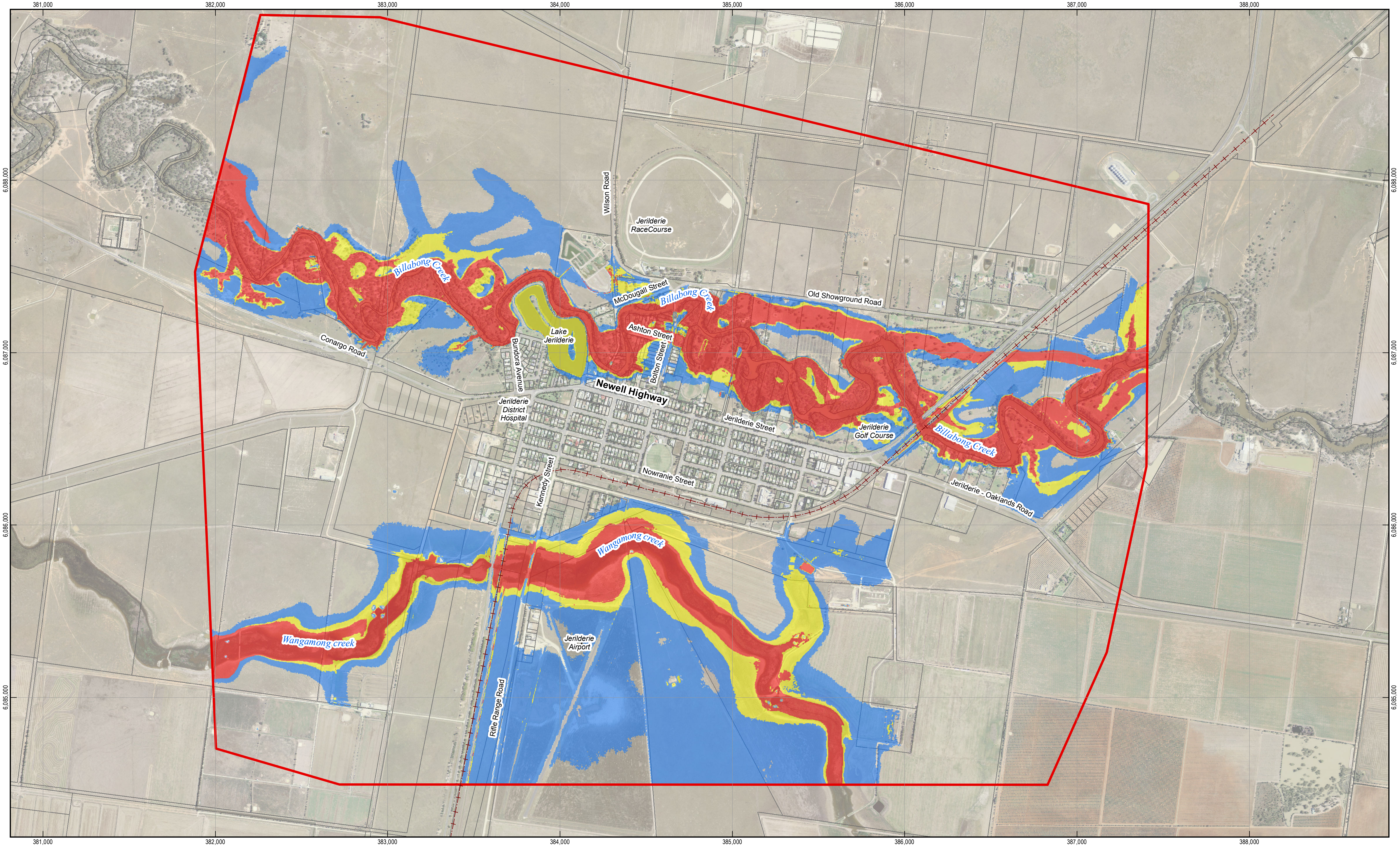
20 Year ARI Flood Event
Provisional Hazard Category Figure C2

G:\23\14980\GIS\Maps\Deliverables\23_14980_Jerilderie_FS_Figure_C2_Rev_0.mxd

230 Harbour Drive Coffs Harbour NSW 2450 Australia T 61 2 6650 5600 F 61 2 6650 5601 E cfsmail@ghd.com W www.ghd.com

Data source: DEPI, VicMap, 2014; Jerliderie Shire Council, aerial, LiDAR, 2013; GHD, flood extents & contours, 2014. Created by:sldouglas

Appendix D – Hydraulic Category Maps



1:20,000 (at A3)

0 100 200 400 600 800

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

- TUFLOW Model Extents
- Cadastre
- Railway
- Flood Fringe
- Flood Storage
- Flood Way

GHD

Jerilderie Shire Council
Jerilderie Flood Study

Job Number	23-14980
Revision	0
Date	25 Jul 2014

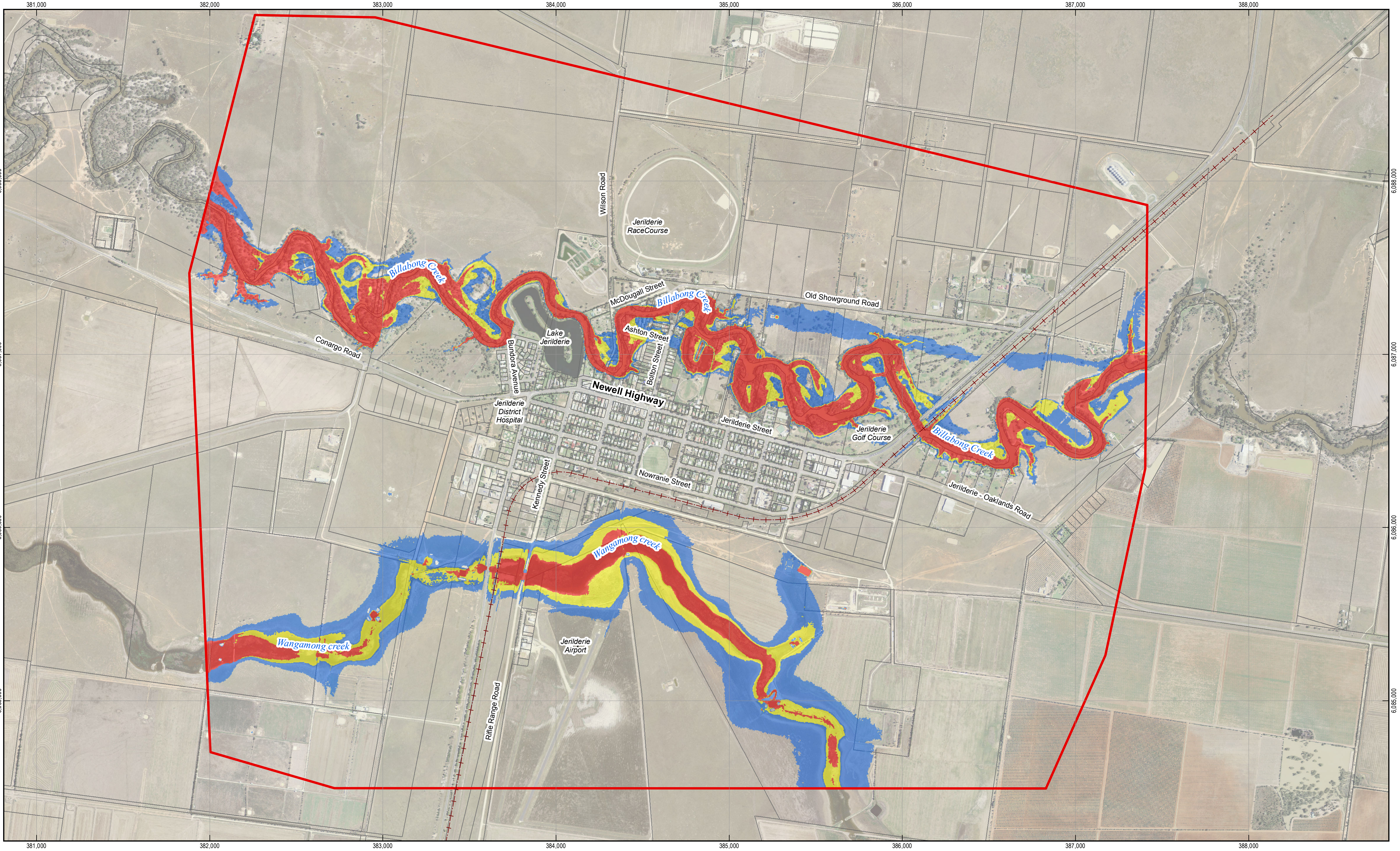
100 Year ARI Flood Event
Hydraulic Category

Figure D1

G:\23\14980\GIS\Maps\Deliverables\23_14980_Jerilderie_FS_Figure_D1_Rev_0.mxd

230 Harbour Drive Coffs Harbour NSW 2450 Australia T 61 2 6650 5600 F 61 2 6650 5601 E cfsmail@ghd.com W www.ghd.com

Data source: DEPI, VicMap, 2014; Jerliderie Shire Council, aerial, LiDAR, 2013; GHD, flood extents & contours, 2014. Created by:sldouglas



1:20,000 (at A3)

0 100 200 400 600 800

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

- TUFLOW Model Extents
- Cadastre
- Railway
- Flood Fringe
- Flood Storage
- Flood Way

Jerilderie Shire Council
Jerilderie Flood Study

Job Number	23-14980
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Date	25 Jul 2014

20 Year ARI Flood Event Hydraulic Category

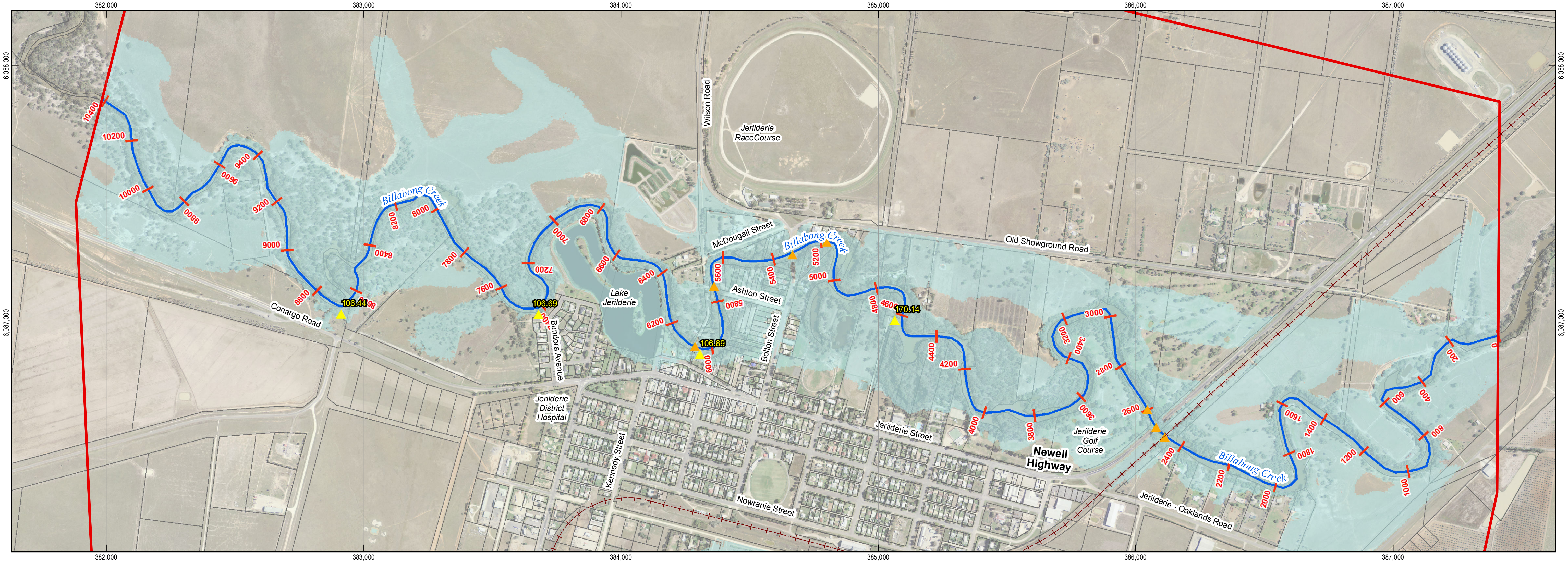
Figure D2

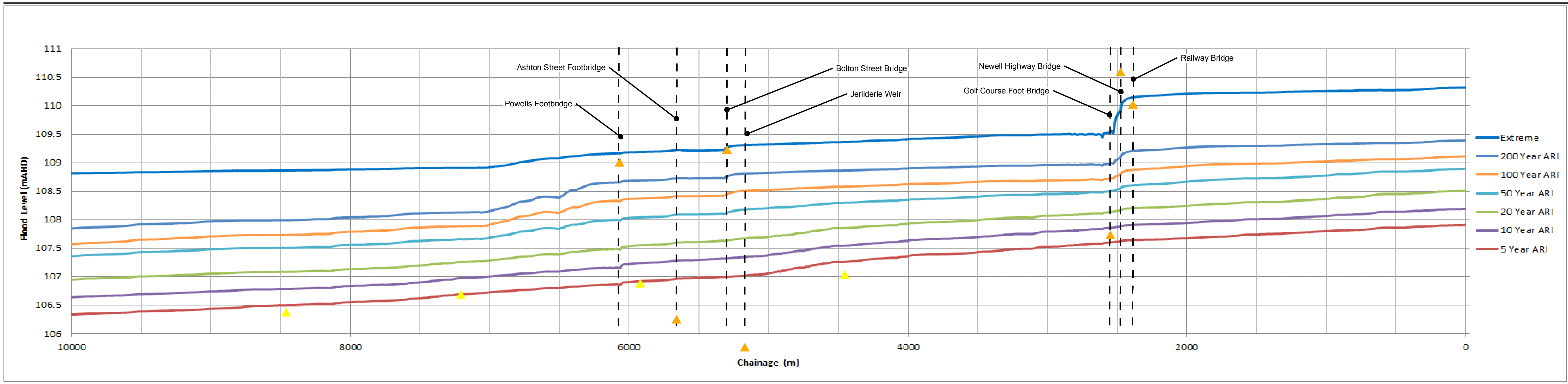
G:\23\14980\GIS\Maps\Deliverables\23_14980_Jerilderie_FS_Figure_D2_Rev_0.mxd

230 Harbour Drive Coffs Harbour NSW 2450 Australia **T** 61 2 6650 5600 **F** 61 2 6650 5601 **E** cfsmail@ghd.com **W** www.ghd.com

Data source: DEPI, VicMap, 2014; Jerilderie Shire Council, aerial, LiDAR, 2013; GHD, flood extents & contours, 2014. Created by:sldouglas

Appendix E – Flood Profile Plans





1:15,000 (at A3)

0 100 200 400 600

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

- TUFLOW Model Extents
- Recorded Flood levels (March 2012)
- Cadastre
- Railway
- Road/ Rail Structure Location and Overflow Elevation
- Creek Line
- 100 Year ARI Flood Extent

Jerilderie Shire Council
Jerilderie Flood Study

Job Number	23-14980
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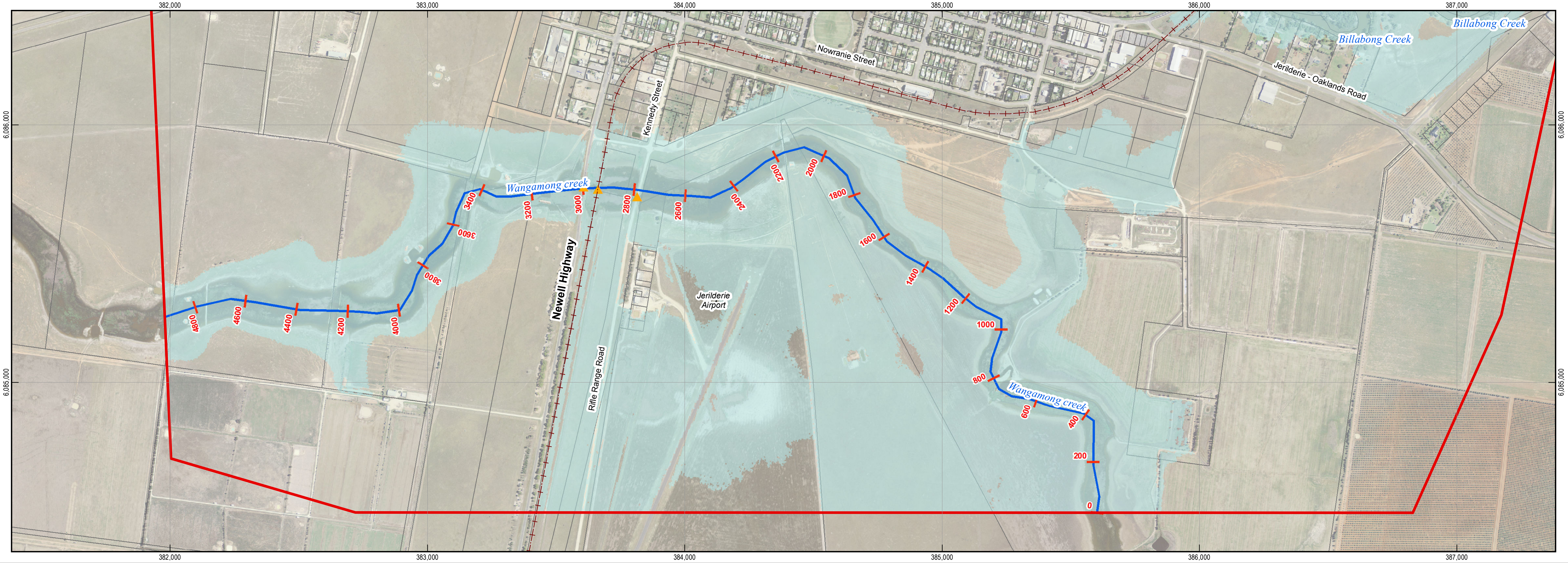
Billabong Creek Flood Profile

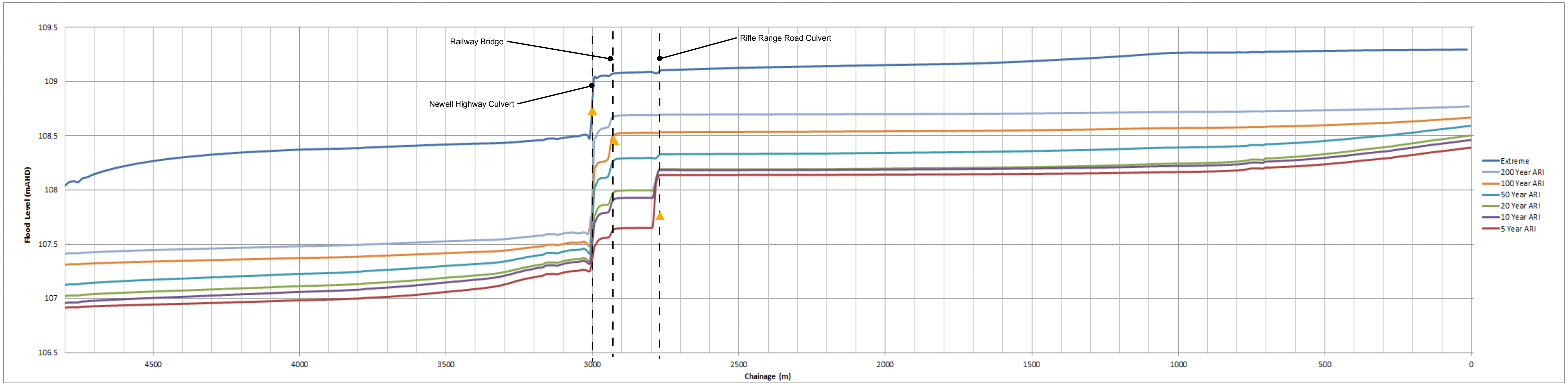
Figure E1

G:\23\14980\GIS\Maps\Deliverables\23_14980_Jerilderie_FS_Figure_E1_Rev_0.mxd

230 Harbour Drive Coffs Harbour NSW 2450 Australia T 61 2 6650 5600 F 61 2 6650 5601 E cfsmail@ghd.com W www.ghd.com

Data source: DEPI, VicMap, 2014; Jerilderie Shire Council, aerial, LiDAR, 2013; GHD, flood extents & contours, 2014. Created by:sldouglas





1:15,000 (at A3)

0 100 200 400 600 800

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

- TUFLOW Model Extents
- Cadastre
- Railway
- Road/ Rail Structure Location and Overflow Elevation
- Creek Line
- 100 Year ARI Flood Extent

GHD

Jerilderie Shire Council
Jerilderie Flood Study

Job Number	23-14980
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Wangamong Creek Flood Profile

Figure E2

G:\23\14980\GIS\Maps\Deliverables\23_14980_Jerilderie_FS_Figure_E2_Rev_0.mxd

230 Harbour Drive Coffs Harbour NSW 2450 Australia **T** 61 2 6650 5600 **F** 61 2 6650 5601 **E** cfsmail@ghd.com **W** www.ghd.com

Data source: DEPI, VicMap, 2014; Jerilderie Shire Council, aerial, LiDAR, 2013; GHD, flood extents & contours, 2014. Created by:sldouglas

Appendix F – Community Newsletter

JERILDERIE FLOOD STUDY

COMMUNITY NEWSLETTER NO.1

September 2013

About the Project

Jerilderie is located on the Billabong Creek. The Wangamong Creek is also aligned close to the southern fringe of the township area. Recent minor floods occurred in March 2012 and November 2010.

The recent floods were considerably lower than the largest recorded floods. Detailed records of Billabong Creek flood heights at Jerilderie date back to 1912. The largest recorded floods for the 101 year period of record occurred in July 1931 (highest), November 1974 (second highest) and July 1956 (third highest).

Past flooding impacts have generally been of a relatively minor nature at Jerilderie, particularly in recent decades. Notwithstanding this, Jerilderie Shire Council has commissioned a Flood Study to better understand flooding conditions and risks. The study will provide detailed flood mapping which will assist in confirming areas suitable for future development and for the setting of minimum floor level heights.

Council has engaged consultants GHD to undertake the Flood Study. Both Council and GHD are committed to listening to the concerns and issues of the community and stakeholders in relation to any flood related matters.

Floodplain Risk Management Committee

Council has formed a Floodplain Risk Management Committee (FRMC) to oversee the Flood Study. Members of this Committee include Councillors Tim Sheed and Gaila Smith, and local community representative Ian Sneddon

The FRMC will provide a link between the Flood Study team and the community during the project. The FRMC will meet throughout the course of the project.

Data Collection

The project team is keen to learn from local residents when and where past flooding has occurred at Jerilderie and what impact, if any, it has had. We are interested in how you and your property have been affected, particularly if your house or workplace has been subject to above floor flooding.

There is a gauging station on the Billabong Creek located downstream of the golf course which provides an accurate record of flood heights at this location. Of particular interest to the project team are any other reasonably accurate records of the height that past floods have reached within or just outside the township area.

You may for example have noted the peak flood height as a mark on a tree, fence post, shed wall, house wall or some other object. If you have yourself recorded such flood height marks or are aware of others recording marks, it would be appreciated if you could contact the Flood Study project team.

Of particular interest are any marks associated with flood events which occurred in 2012, 2010, 1990, 1981, 1974, 1956 or 1931.

Project Team Contact Details

Contact details are provided below if you have any questions in regards to the project in general, or if you have any particular matters you would like to discuss or simply make Council aware of, or if you have any recorded flood height marks on your property or are aware of flood height marks elsewhere.

Please do not hesitate to contact:

GHD Project Manager - Trevor Clark
PO Box 992, Wodonga, Vic, 3689
Phone – 02 6043 8735
Email – trevor.clark@ghd.com

Council Project Supervisor – David Tamlyn
PO Box 96, Jerilderie, NSW, 2716
Phone – 03 5886 1200
Email – mail@jerilderie.nsw.gov.au

GHD

Suite 3, Level 1, 161-169 Baylis Street
Wagga Wagga NSW 2650
T: 61 2 6923 7400 F: 61 2 6971 9565 E: wgamail@ghd.com.au

Document Status

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0	T Clark	R Berg		R Berg		24/7/2014

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