Jeparit Flood Study

Report No. J403/R02 Final 2

June 2008

Michael Cawood and Associates Pty Ltd

Planning and Environmental Design

Price Merrett Consulting

Jeparit Flood Study

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WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

15 Business Park Drive, Notting Hill Victoria Australia 3168

tel : 61 (03) 9558 9366 fax : 61 (03) 9558 9365

web : www.watech.com.au

ACN No. 093 377 283

ABN No. 60 093 377 283

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Front cover photo: Flood 1996 Wimmera River adjacent to the Museum. Provided by David Livingston

EXECUTIVE SUMMARY

This report details the input data, approach and outcomes for the Jeparit Flood Study.

The study has been initiated by the Wimmera Catchment Management Authority (Wimmera CMA) and Hindmarsh Shire Council (HSC) with funding provided under the Natural Disaster Risk Management Studies Programme by the Australian and Victorian Governments, and from HSC.

The study provides information on flood levels and flood risks within the township for riverine and stormwater flooding.

The study team was lead by Water Technology with sub-consultants, Michael Cawood and Associates, Price Merrett Consulting, MPMedia Solutions, and Planning and Environmental Design.

Community consultation was undertaken with three community information sessions held, and an information brochure and questionnaire distributed. A number of residents provided photos and recollections of past flood events. The flood information provided by the residents was invaluable in the development of the study outcomes.

A hydrologic analysis of the Wimmera River determined design flood hydrographs for the 10, 20, 50, 100 and 200 year flood events at Jeparit. Considerable uncertainty surrounds the design flood estimates developed by this study. Rigorous calibration and/or validation of the approach was restricted by the absence of a lengthy streamflow record. The absolute reliability of design estimates is unknown, however, the relativity of design estimates is considered reasonable. The continued collection of streamflow data at three gauges in the lower catchment will provide reduced uncertainty surrounding design flood estimates. Table 1 displays the design peak flows at Jeparit.

Table - 1 Design peak flows at Jeparit

Location	Design peak flow											
	1 in 5 year		1 in 10 year		1 in 20 year		1 in 50 year		1 in 100 year		1 in 200 year	
	m^3/s	ML/d	m^3/s	ML/d	m^3/s	ML/d	m^3/s	ML/d	m^3/s	ML/d	m^3/s	ML/d
Wimmera River at Jeparit	118	10,200	172	14,860	232	20,045	308	26,620	386	33,350	429	37,065

To place the design peak flows in a historical context, the approximate average recurrence interval (ARI) of significant historical flood events are provided in Table 2 Estimation of ARIs for historical flood events requires a long term streamflow record. Given the lack of long term streamflow information for the lower Wimmera River, the approximate ARIs have been determined by comparison of observed peak flows at Horsham (Walmer gauge). As such, the approximate ARIs for the historical event should be treated with caution.

Table - 2 Wimmera River – Approximate ARIs for significant historical flood events

Historical event	Approximate ARI (based at Horsham) (years)
1909	Greater than 190 years
1956	Greater than 70 years
1974	Greater than 40 years
1981	Greater than 25 years

A digital terrain model (DTM) was developed from a field and aerial survey. Using the DTM, a hydraulic model was established to simulate flood behaviour within the study area. Flood behaviour was assessed for flooding originating from the Wimmera River and local stormwater runoff. For Wimmera River floods, the flood extents are generally limited to the river corridor. The hydraulic models revealed that the Museum levee was overtopped in approximately 1 in 70 year ARI with the football ground levee overtopped in 1 in 50 year ARI flood event. The breakaway from the Wimmera River over the Museum levee results in extensive inundation to the north of the Rainbow – Dimboola Road. Limited Wimmera River flooding occurs in the township for the 1 in 100 year ARI event. Table 3 outlines the flood behaviour over a range of flood magnitude under the existing conditions.

Table - 3 Flood behaviour existing conditions

Design flood event (ARI)	Behaviour
10 year (equivalent to 1996 event)	Flooding contained within the Wimmera River corridor. Limited impact on surrounding properties and infrastructure
20 year (less than 1981 event)	Flooding contained within the Wimmera River corridor. Limited impact on surrounding properties and infrastructure
50 year (greater than 1974 and less than 1956)	Breakout across Football ground levee Flood level close to the crest of the Museum levee
100 year (less than 1909 event)	Breakout across Football ground levee Breakout across Museum levee. Number of buildings with the Museum affected.

Previous available flood mapping was based on the 1909 flood event. This flood mapping shows extensive flooding in the township extending through to Lower Roy Street. As discussed above, the 1909 flood event has an estimated ARI greater than 190 years. Also the additional inundation in the 1909 event is due to absence of the Museum levee along the Dimboola – Rainbow Road

Stormwater flooding in Jeparit is considered as "nuisance flooding" and does not present any immediate threat to property owners. Some deeper pooling is experienced in more defined low points surrounding the township which correlate with areas flooded during levee overtopping. A large pool is also experienced at the intersection of Broadway and Lower Roy Street. The local stormwater drainage network may be able to remove much of this flooding.

A key factor influencing the model sensitivity is the water level of Lake Hindmarsh. Several model conditions were trialled to find the most probable lake level based on historical events. For this study it was assumed that the water level in Lake Hindmarsh was full. In times of lower lake levels, such as the present, much lower flood levels would be experienced in Jeparit.

It should be noted that the model cannot predict the condition of the levees and therefore during an actual event localised washout of structurally inadequate areas may cause unpredicted affects. This possibility became particularly clear during field visits to the levee structures. Both of the levee's structural integrity may have been affected by the growth of several trees with their roots weakening the levee embankment, and numerous rabbit burrows

Formal calibration of the hydraulic model for Jeparit was limited by the absence of systematic concurrent streamflow and flood level information. The study team undertook a broad validation of the modelled design flood extents through community consultation and a comparison to flood photos. General community agreement with the modelled design flood extents was achieved.

The study team acknowledges considerable uncertainty surrounding the reliability of the flood extents for Jeparit. This uncertainty arises from the lack of streamflow data for model calibration/verification. Flood extents may be reviewed following future flood events.

The average annual damages (AAD) were calculated to be approximately **$13,370** per year with the current levee configuration. It is worth noting no residential properties experience above floor flooding for events up to the 1 in 100 year ARI. The four properties experiencing above floor flooding are public buildings including two sheds at the football grounds and two buildings at the Museum. Five residential properties experience below floor flooding during the 1 in 100 year event. These residential properties are located on Rainbow Dimboola Road (Charles Street) and Tullyvea Street. The remaining eight properties flooded below floor level in the 1 in 100 year event were public buildings.

Because there has been no maintenance on the Jeparit levees since construction in 1974, there are several sections of the levees that have eroded and weakened by rabbits and tree growth. As the stability of these levees is uncertain a flood extent was developed in case the levees failed. Flood damages were estimated for the 1 in 100 year event without the Museum and football ground levees at approximately $1,020,000. This damage estimate represents an increase of about 300% from the existing condition damages. Without the levee, above floor flooding would occur for 16 buildings.

Given the overtopping of the Museum levee, refurbishment and raising to provide protection from the 1 in 100 year flood event plus freeboard was investigated as a mitigation option. The refurbishment of the Museum levee was considered by the study team to warrant further investigation, which was undertaken in the Jeparit Floodplain Management Plan.

Draft flood related planning overlays (FO and LSIO) have been prepared to reflect the study outcomes. To enable the incorporation of the study outcomes in the Hindmarsh Planning

Scheme, draft Planning Scheme Amendment documentation has been prepared as part of the Floodplain Management Plan.

Wimmera CMA, in conjunction with local authorities in the Wimmera River catchment, including HSC, is undertaking a project to enhance the total flood warning system for the Wimmera River catchment. Stream and rainfall gauges are being upgraded with radio telemetry to enhance real-time access to data which will enable more accurate prediction of flood behaviour and extended warning lead times. More warning for the community will translate to reduced flood damages and trauma for residents. The study team recommends that HSC and Wimmera CMA continue to actively pursue the completion of the current flood warning related project.

ACKNOWLEDGEMENTS

Numerous organisations and individuals have contributed both time and valuable information to the Jeparit Flood Study. The study team acknowledges the contributions made by these groups and individuals, in particular, The Reference Group for the study, consisting of:

Clare Wilson (Wimmera CMA & Project Manager)

Elyse Riethmuller (Wimmera CMA)

Eric Altmann (Wimmera CMA Regional Waters Committee)

Lyle Tune (Hindmarsh Shire Council)

Mick Gawith (Hindmarsh Shire Council)

Darryl Argall (Hindmarsh Shire Council)

The study team also wishes to thank all those stakeholders and members of the public that attended the information sessions, contributed flooding information, returned questionnaires and discussed their experiences with the study team.

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1 INTRODUCTION

The Jeparit Flood Study has been initiated by the Wimmera Catchment Management Authority (Wimmera CMA) and Hindmarsh Shire Council (HSC). The study provided information on flood levels and flood risks within the township of Jeparit due to riverine and stormwater flooding.

The study was funded under the Natural Disaster Risk Management Studies Programme by the Australian and Victorian Governments with a contribution from the HSC.

The study team was lead by Water Technology with sub-consultants Michael Cawood and Associates, Price Merrett Consulting, MPMedia Solutions and, Planning and Environmental Design providing specialist input.

The township lies on the Wimmera River adjacent to Lake Hindmarsh, a terminal lake of the Wimmera River. Jeparit and surrounds have been subject to flooding on a number of occasions including 1894, 1909, 1915, 1923, 1955, 1956, 1960, 1964, 1974, 1975, 1981, 1983, 1992, 1993 and 1996. Of these, the 1909 event was the worst with most of the township being inundated.

Figure 1-1 displays the contributing catchment and Figure 1-2 shows the study area.

The flood study involved a hydrologic analysis of the Wimmera River, and a hydraulic assessment of flood behaviour in the town and surrounding floodplain areas. The flood levels and inundation extents were mapped for a range of design events up to the 200 year flood event. Assessment of flood related damages and potential mitigation measures were also undertaken.

A floodplain management study and plan has been conducted in parallel with this flood study. The Floodplain Management Plan has also been completed (Water Technology 2008).

The structure of this report is as follows:

- Section 2 – provide a brief study background
- Section 3 – outlines the input data gathered for use in the study
- Section 4 – details the community consultation process
- Section 5 – outlines approach and outcomes from the hydrologic analysis
- Section 6 – discuss the hydraulic analysis for the existing conditions
- Section 7 – summarises the flood damage assessment
- Section 8 – outlines preliminary assessment of structural mitigation measures
- Section 9 – discusses preliminary assessment of non-structural mitigation measures
- Section 10- provides a summary of the study key conclusions

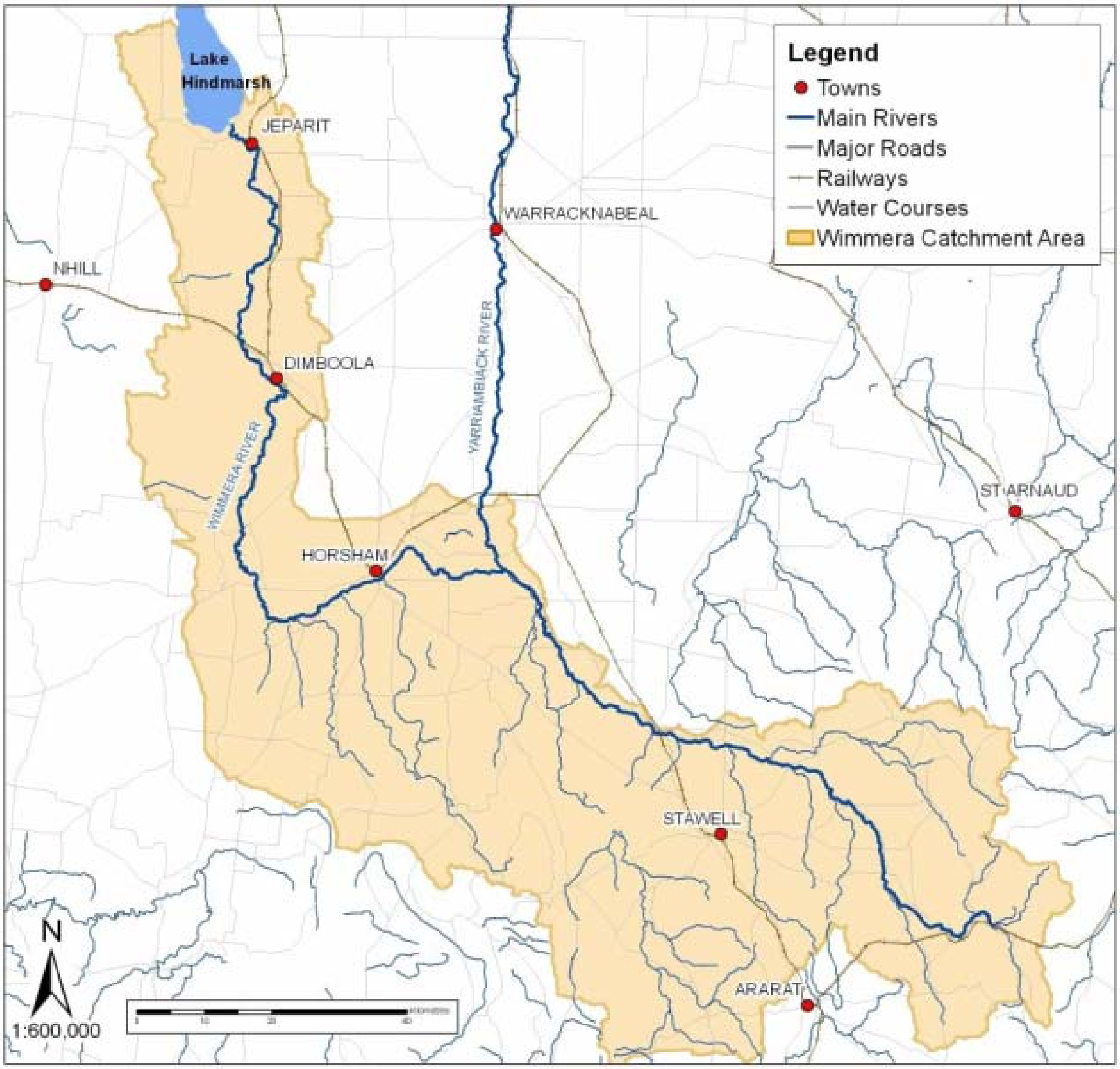

Figure 1-1 Contributing catchments

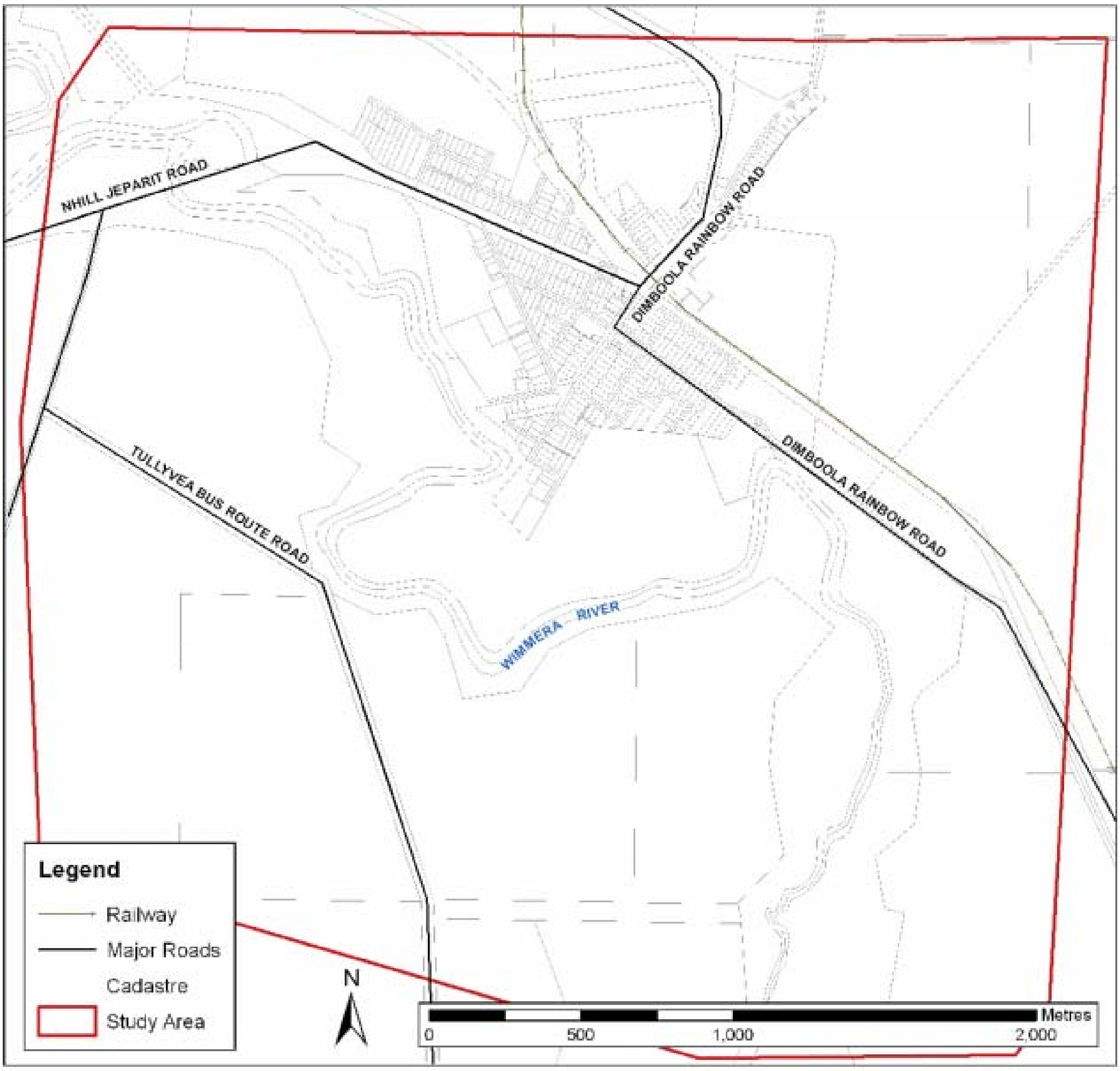

Figure 1-2 Study area

2 STUDY BACKGROUND

Jeparit is located in the north west of the Wimmera River catchment, adjacent to one of the Wimmera's River terminal lakes, Lake Hindmarsh. The Wimmera River is the longest terminal river in Victoria. The river rises on the north west slopes of Mount Buangor. Major tributaries include Mount William Creek, Burnt Creek and the Mackenzie River. These tributaries generally flow in a northerly direction and drain the wetter southern part of the catchment around the Grampians. The Wimmera River flows northwest to Horsham, and continues north through Dimboola and Jeparit to Lake Hindmarsh. During prolonged wet periods, Lake Hindmarsh overflows to the north via Outlet Creek to Lake Albacutya.

Significant rainfall gradient exists from the south to north. The annual rainfall in the catchment varies from up to 1000 mm in the Grampians down to 300 mm in the northern plains.

Streamflows in the lower Wimmera (downstream of Dimboola) are highly variable (SKM 2001). Significant losses occur due to evaporation and seepage, and minor flow events may fail to reach Lake Hindmarsh. Lake Hindmarsh is a wetland of national significance and, Lake Albacutya is recognised internationally under the Ramsar Convention, and as such is a wetland of national environmental significance under the Commonwealth Environment Protection and Biodiversity Conservation Act (Ecological Associates 2004).

The Wimmera River is regulated by the Wimmera Mallee Stock and Domestic Supply System (WMSDSS) which is operated by Grampians Wimmera Mallee Water (GWMWater). Figure 2-1 displays the major elements in the WMSDSS. The WMSDSS captures, detains and distributes water in the Wimmera and Glenelg catchments primarily for stock and domestic supply. The GWMWater storages have a total capacity of about 770,000 ML. Water is captured in winter and spring and released to consumers in summer, autumn, winter or spring (SKM 2004).

Flood behaviour in Jeparit is heavily influenced by the storage in Lake Hindmarsh prior to a significant flood event. Water diversion to storages has significantly reduced flooding of the terminal lakes (SKM 2003). Prolonged periods of high rainfall, occurring over at least two years, are required to fill spare capacity in the system and efficiently transmit significant flows downstream of Lake Hindmarsh (Bren and Acenolaza 2000). Storages in the WMSDSS have the capacity to capture a significant proportion of high flows over a long period, effectively reducing the frequency and magnitude of flow events reaching the terminal lakes.

The WMSDSS is comprised of 18, 000 km of open earthen channels and 12 storages. The system is highly inefficient and suffers distribution losses of 80-95% due to evaporation, distance and seepage. In response to the poor distribution efficiency of the WMSDSS, open channels in the Northern Mallee section of the system were recently replaced by pipework. Water savings generated by the Northern-Mallee Pipeline have provided an environmental allocation of 34, 690 ML to the Wimmera and Glenelg catchments (SKM 2004).

The Wimmera Mallee Pipeline Project, managed by GWMWater, is an initiative aimed at replacing the remaining open channels of the WMSDSS with a new pipeline system throughout the region. This could generate water savings in the order of 83 GL per year on average, which would be available to the environment. Together with the Northern Mallee Pipeline project, the total water savings available for the environment, will be nearly 120 GL annually (Ecological Associates 2004).

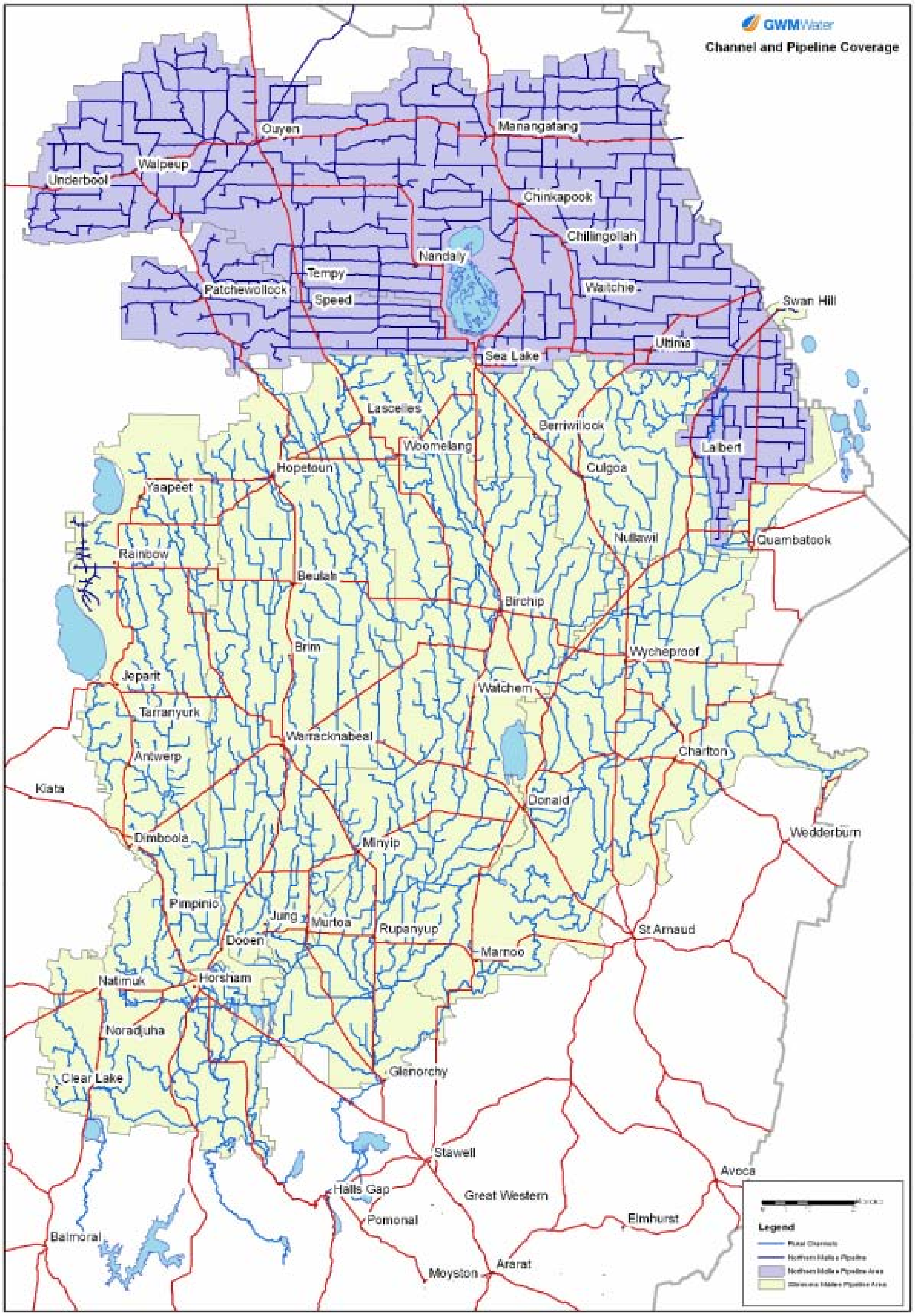

Figure 2-1 Wimmera Mallee Stock and Domestic Supply System (Source GWM Water)

3 AVAILABLE INFORMATION

This section outlines the range of information utilised in this study including previous reports and documents as well as data, both previously available and collected specifically for this study.

3.1 Previous studies

Previous key hydrologic and/or hydraulic studies relevant to the present project and region include:

- **Bureau of Meteorology (BoM)** - Wimmera River Basin URBS Model (2004)
- **Sinclair Knight Merz (SKM)** – River Basin Report. Wimmera River. Lower Sub Catchment. DNRE Flood Data Transfer Project (2000)
- **Water Technology -** Dimboola Flood Study (2003) and Floodplain Management Plan (2006)
- **Binnie and Partners** – Study of Flood events within Wyperfeld National Park (1991)
- **Ecological Associates -** The Environmental Water Needs of the Wimmera Terminal Lakes -Final Report November 2004 Report BF001-A (2004)

These resources have been reviewed and drawn upon as necessary to provide background, context and verification of the current study approach and outcomes. A brief summary of the above material follows.

3.1.1 Wimmera River Basin URBS Model (BoM 2004)

The BoM developed a URBS rainfall-runoff model for the Wimmera River basin to Dimboola. The purpose of the URBS model was flood forecasting. Calibration of the URBS model was undertaken with a range of model parameters developed such that the model can be used in a predictive manner with some confidence.

Of interest to this study is the URBS model ability to provide estimates of flood hydrographs for the Wimmera River at Jeparit.

3.1.2 River Basin Report - Wimmera River - DNRE Flood Data Transfer Project (SKM 2000)

Flood Data Transfer Project for the Wimmera-Mallee Catchment (SKM 2000) collated flood related information.

Due to poor quality data, low topographic relief, and the absence of detailed ground survey information the delineated 100 year average recurrence interval (ARI) flood extent could not be achieved with any degree of confidence (SKM 2000). This highlights the lack of reliable data and complexity of the flooding regime in the Wimmera River.

It is understood, that the current flood extent mapping used for planning purposes is based on the 1909 event. As discussed in Section 5.5, the 1909 flood is considered to have a magnitude well in excess of the 1 in 100 year flood event.

3.1.3 Dimboola Flood Study and Floodplain Management Plan – Water Technology (2003 and 2006)

Hydrologic and hydraulic analysis was undertaken at Dimboola to assess flooding risks and various mitigation measures. Design peak flows at Dimboola were translated from a flood frequency analysis at Horsham.

These design peak flows at Dimboola were employed as validation data for the hydrologic analysis undertaken in this study. Further details provided in Section 5.

3.1.4 Binnie and Partners – Study of Flood events within Wyperfeld National Park (1991)

This study determined the flooding frequency within the Wyperfeld National Park, north of Lake Albacutya. The study concluded that the frequency of flood events at the south park have reduced from 1 in 18 year event for the natural conditions, to 1 in 23 year event due to diversions from the WMSDSS. For Lake Hindmarsh, the frequency of filling was reduced from 1 in 11 year (natural conditions) to 1 in 17 year (current conditions) event.

3.1.5 Ecological Associates - The Environmental Water Needs of the Wimmera Terminal Lakes -Final Report November 2004 Report BF001-A (2004)

As part of the study, the flooding characteristics of Lake Hindmarsh were investigated under various catchment scenarios. This study investigated the current and natural flow regimes within the terminal lakes using Wimmera REALM, a monthly time-step flow allocation model for the Wimmera River provided by the Department of Sustainability and Environment. This investigation showed that under current catchment water management, the frequency and duration of flow to the terminal lakes has declined significantly compared with natural conditions. Hydrological change threatens the ecological values of the lakes, particularly in terms of their capacity to maintain their unique ecological character, to support threatened species and to support large populations of dependent fauna.

3.2 Hydrologic data

3.2.1 Streamflow data

Numerous streamflow gauges are located within the Wimmera River catchment. A subset of the available streamflow gauges were utilised in this hydrologic analysis. Table 3-1 outlines their details and Figure 3-1 displays their location.

The streamflow gauges utilised for this study have a limited period of available data, less than 20 years. This limited period of streamflow data contributes to the uncertainty surrounding design flood estimates. This uncertainty will reduce with additional streamflow data collected over time. The study team supports strong lobbying of the Department of Sustainability and Environment by Wimmera CMA and HSC for the ongoing operation of the streamflow gauges, shown in Table 3-1. Figure 3-1 shows the location of these gauges.

Daily streamflow data, with significant flood events shown, is displayed in Figure 3-2. Only significant events within the available streamflow record (1987 to date) are shown in Figure 3-2. Other flood events include August 1909, May 1974, August 1981 and August 1983. Figure 3-3 displays flooding at the Jeparit Weir in August 1981.

Table 3-1 Details of Streamflow Gauge

Station Number	Station name	Period of record
415256	Wimmera River at Upstream Dimboola	1989 to date
415246	Wimmera River at Lochiel Railway Bridge	1987 to date
415247	Wimmera River at Tarranyurk	1993 to date

3.2.2 Rainfall data

A number of daily and pluviographic rainfall stations are located within or to adjacent to the Wimmera River catchment. Figure 3-1 shows the location of both the pluviographic and daily rainfall stations.

Figure 3-4 and Figure 3-5 show a time-series of significant daily rainfall events, greater than 50 mm, at selected rainfall stations throughout the Wimmera catchment.

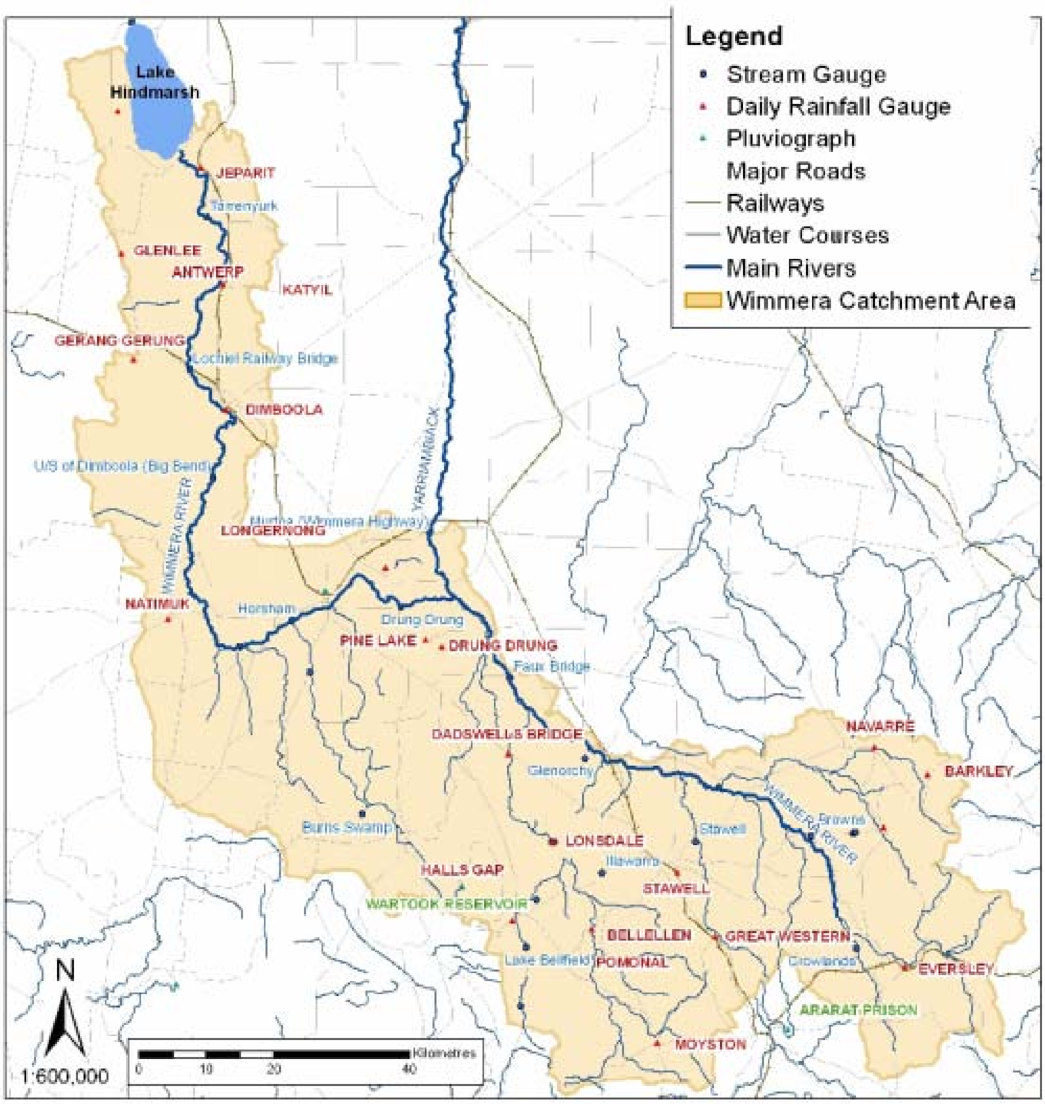

Figure 3-1 Streamflow and rainfall gauges

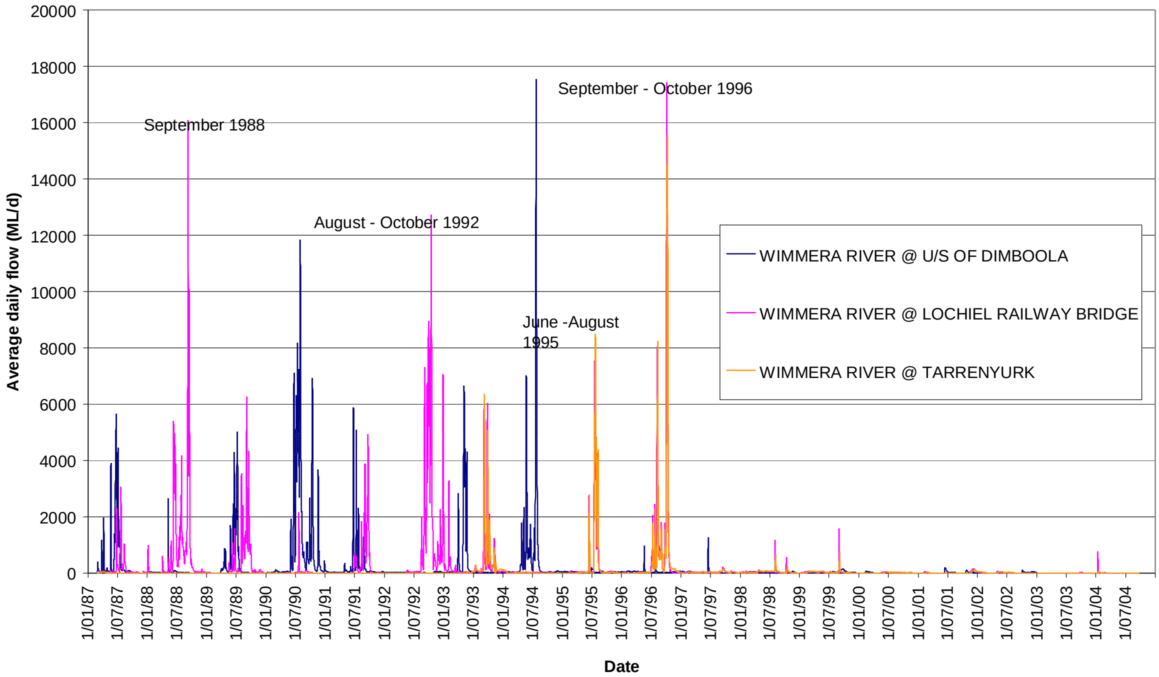

Figure 3-2 Daily streamflow data (Major events marked)

Figure 3-3 Jeparit Weir during 1981 flood (Source David Livingston)

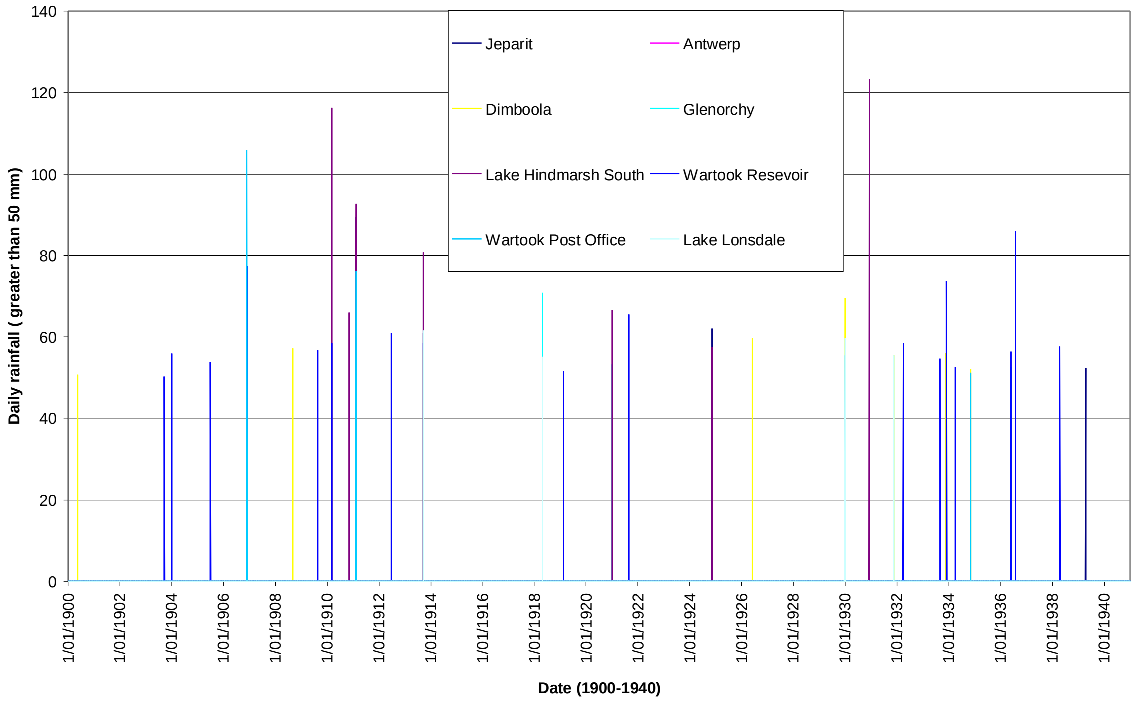

Figure 3-4 Daily rainfall time series – significant daily rainfall events (greater than 50 mm) for selected rainfall stations in the Wimmera River : 1900-1940

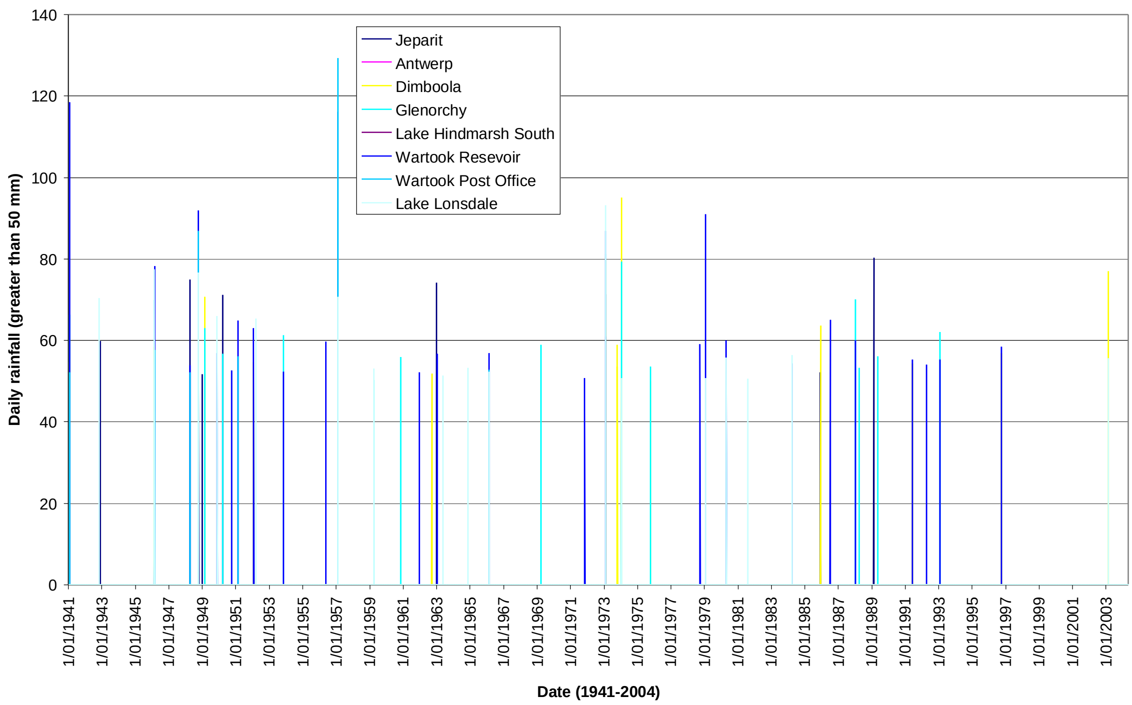

Figure 3-5 Daily rainfall time series – significant daily rainfall events (greater than 50 mm) for selected rainfall stations in the Wimmera River : 1941-2004

3.3 Topographic data

3.3.1 Overview

There have been two major sources of topographic information gathered during the course of the investigation, these being:

- Aerial Laser Survey (ALS)
- Field Survey

Following the collection and processing of the topographic information, a detailed digital terrain model (DTM) was developed as the basis for the establishment of a hydraulic model of the study areas. The sources of the topographic information are discussed in more detail below.

3.3.2 Aerial survey

Aerial Laser Survey (ALS)

Wimmera CMA undertook extensive ALS for the authority's entire catchment in October 2004. At the time of the ALS capture, the Jeparit Flood Study was earmarked for commencement in 2006. In response, high resolution data capture was undertaken for Jeparit study area. The ALS data employed for the Jeparit study area has a nominated accuracy (standard error) of 0.15 m in the vertical plane. Figure 3-6 displays the ALS data for the study area.

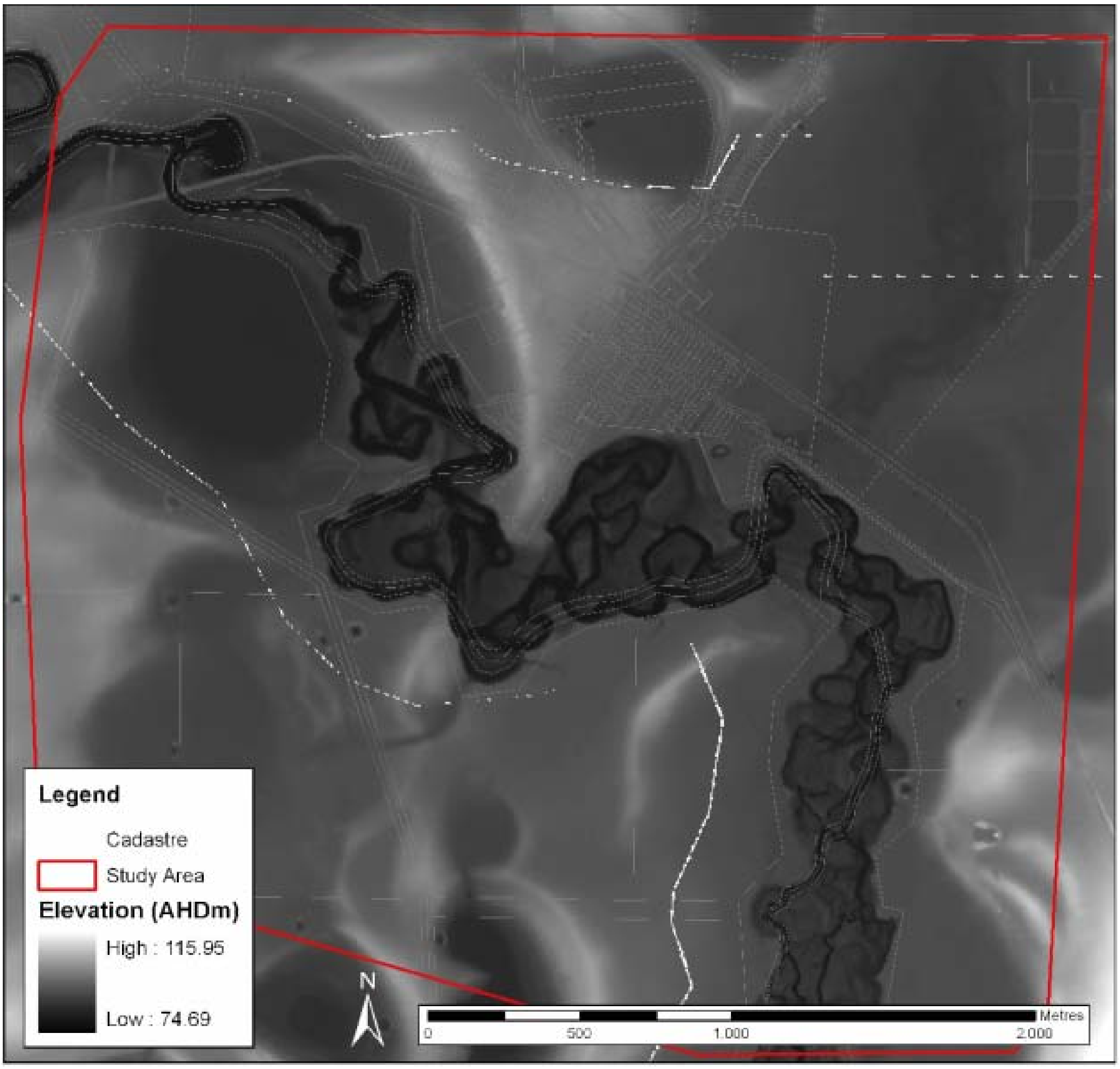

Figure 3-6 Jeparit study area: ALS survey

3.3.3 Field Survey

Field survey was conducted by Price Merrett Consulting to provide waterway cross sections, levees and bridge structure details. The absence of the available cross sections, required the survey of 5 cross sections for the Wimmera River at Jeparit. For Jeparit, the structure survey included the following:

- Levee from Football ground to the Museum Levee
- Weir structure
- Nhill-Jeparit Road bridge (Old and new structures)

The extent location and extent of the field survey is illustrated in Figure 3-7.

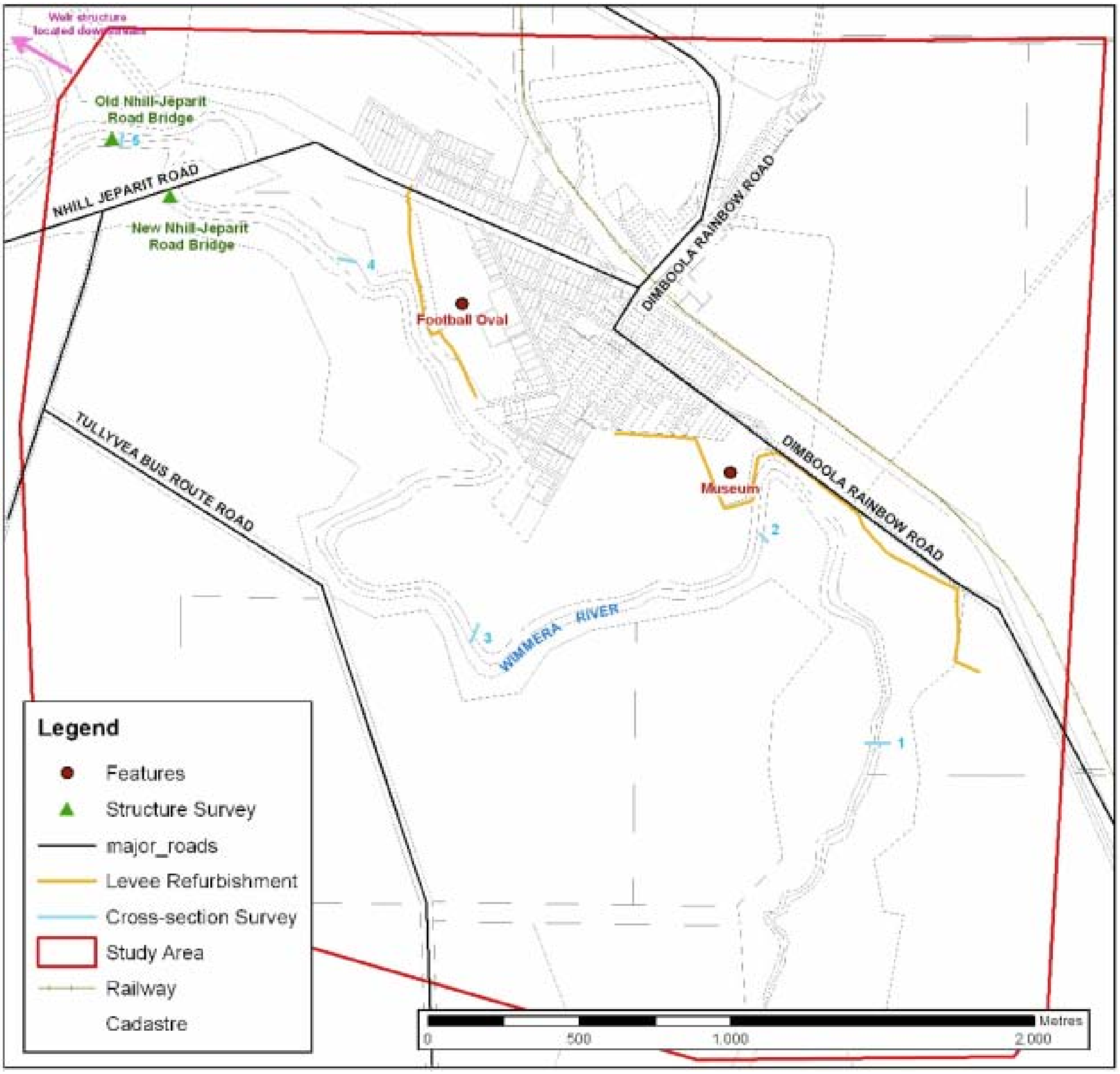

Figure 3-7 Jeparit study area: Topographic survey elements

Appendix A shows the long section of the levee crest obtained from the field survey component.

3.3.4 Digital elevation model

Using the topographic survey discussed in Section 3.3.2, a digital elevation model of the Jeparit study area was constructed. A grid size of 5m was employed in Jeparit. Figure 3-8 displays the digital elevation model for Jeparit.

Further details on the use of the digital elevation model in the hydraulic analysis are provided in Section 6.

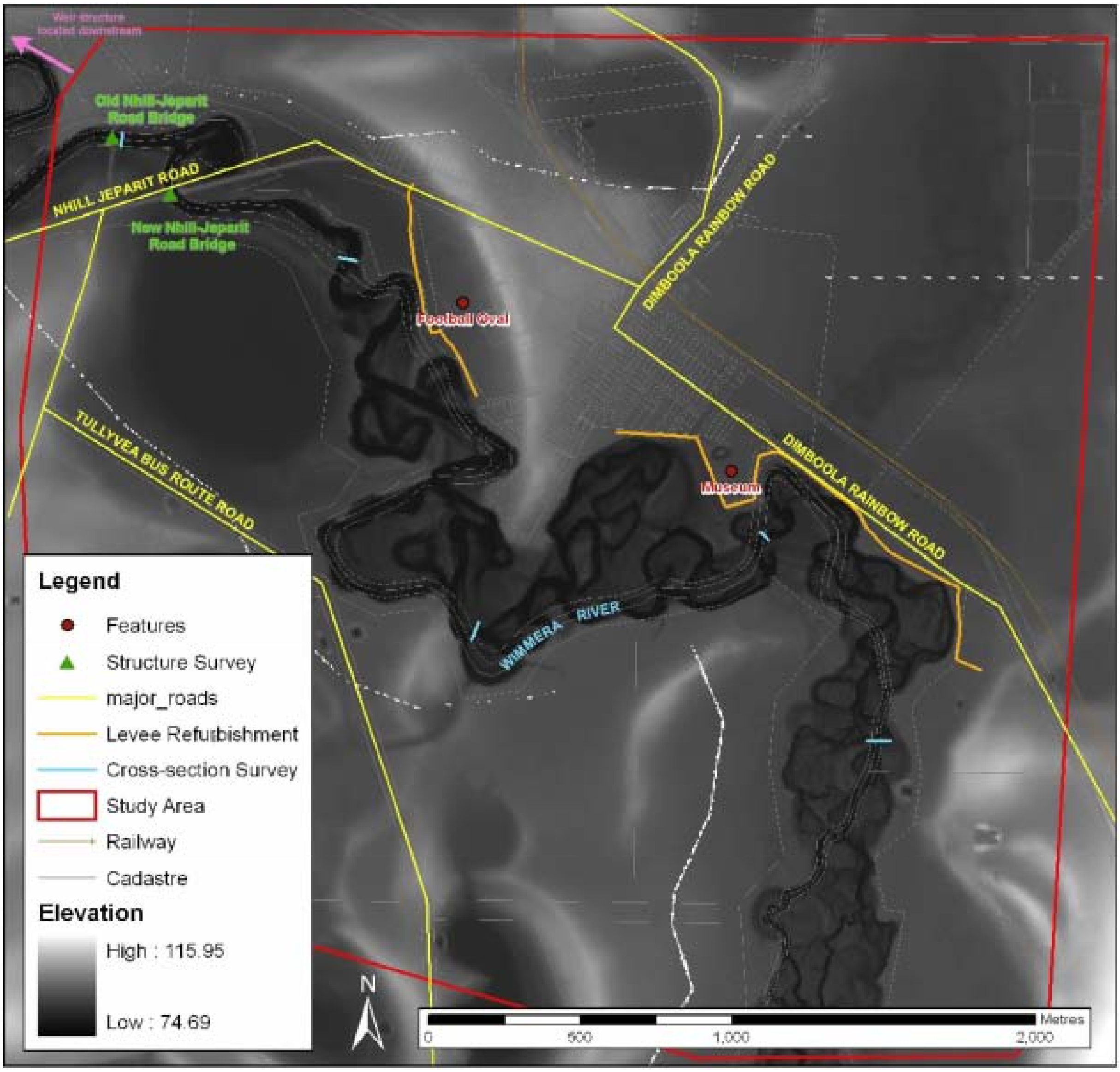

Figure 3-8 Digital elevation model- Jeparit ALS topographic data

4 COMMUNITY CONSULTATION

4.1 Overview

A key ingredient in the development of a widely accepted study outcomes was the active engagement of the community in the study. The communications strategy adopted by this study was aimed at the community developing a "sense of ownership" of the final study outcomes.

In an effort to engender this "sense of ownership" the consultation process proposed was based on relationships with landholders within the study area. These relationships were developed over the course of the study through community information sessions and on-going communication of study progress.

To provide regular input to the study from the community, a three stage community process has been undertaken. The aims of the three stages are as follows:

- First stage community consultation:- to establish the linkages with the community, raise awareness of the study and identify community concerns.
- Second stage community consultation:- to seek community feedback/input regarding draft flood study report and potential mitigation options.
- Third stage community consultation:- to seek community feedback/input regarding draft Floodplain Management Plan, flood warning and response options.

4.2 Stage 1 community consultation

Prior to the first community information session being held, an information brochure and questionnaire was developed by the study team in consultation with Wimmera CMA. The purpose of the information brochure and questionnaire was to:

- Raise awareness of the study's objectives and scope within the community
- Provide opportunity for the community to express their knowledge of past flooding and present flood related concerns.

The questionnaire contained 10 questions aimed at seeking local community flood knowledge and their flood related concerns.

The information brochure and questionnaire were delivered to approximately 350 residences located within the study area. Only 4 questionnaire responses were received.

The first community information session was held at the Jeparit Football Club Rooms: Monday 19th June 2006 from 2.30-4.30pm.

The session was conducted in an informal manner with a short introduction presented by Clare Wilson (Wimmera CMA) and a study overview presented by Steve Muncaster (Water Technology).

The participation in the community information session and subsequent meetings showed "passion" in the community about the Wimmera River. This passion highlights the place the Wimmera River holds in the community. The residents provided a wealth of flood information, including numerous flood photos and recollections of past flood events. This information was of significant benefit to assisting the study team's understanding of Jeparit's flood behaviour.

In particular, a number of photos were provided by David Livingston showing the construction of the levee during the 1956 flood event, refer to Figure 4-1, Figure 4-2 and Figure 4-3. The levee was reportedly "pushed up" with available machinery. During the 1974 flood event, flood levels "lapped" at the top of the levee and several rows of sand bags were required to prevent any overtopping.

Figure 4-1 Sandbagging behind the Jeparit football shed during the 1956 flood (source David Livingston)

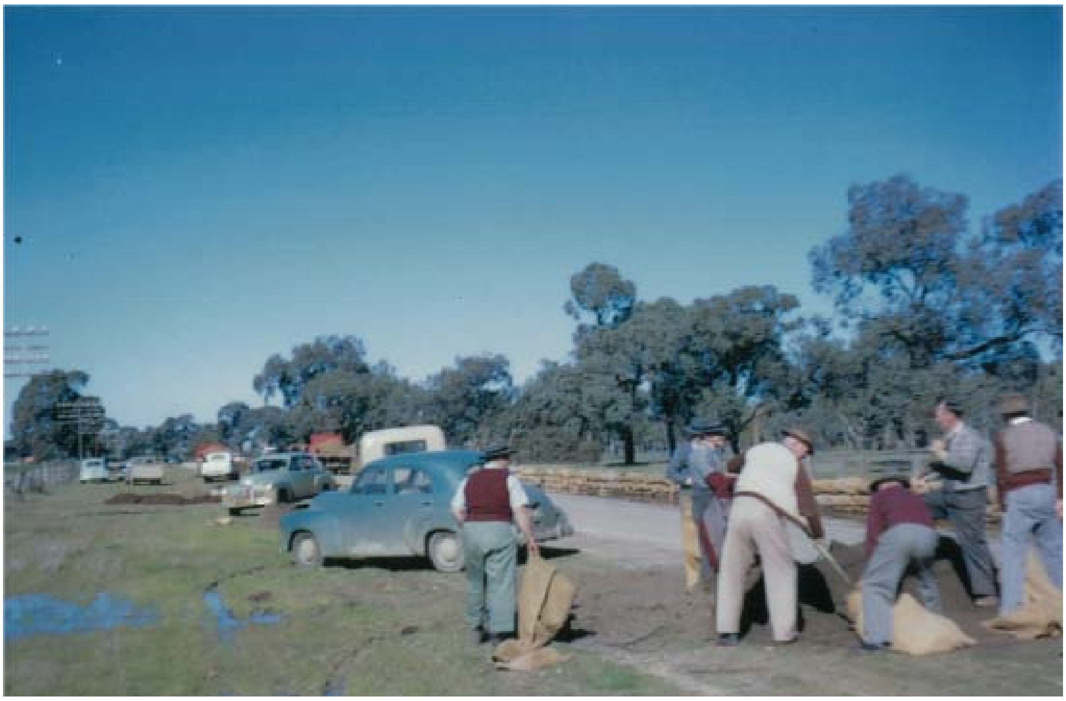

Figure 4-2 Sandbagging along Dimboola Road during the 1956 flood (source David Livingston)

Figure 4-3 Sandbagging near the Museum during the 1956 flood (source David Livingston)

There were general comments regarding the maintenance and operation of the weir. The issue of debris being caught in the weir during a flood event was a concern to residents. The residents were also concerned that if a flood event occurred today, the elderly population of the town would struggle to do the sandbagging work needed.

4.3 Stage 2 community consultation

The second community information session was held at the Hindmarsh Hotel Jeparit: Wednesday 15th November 2006 from 7 pm – 9pm

The session was conducted in an informal manner with a short introduction presented by Clare Wilson (Wimmera CMA) and study progress presented by Steve Muncaster (Water Technology).

Draft flood maps were provided for community comment. Several residents commented that the 1909 flood event reached Roy Street. Some residents were confused as to why the draft maps did not show flood water in Roy Street, as community photos showed flood water had inundated houses in the 1909 flood event. The study team explained that the 100 year flood extent was shown not to reach Roy Street as the Jeparit Flood Study showed that the 1909 flood was considerably larger than the 100 year flood event.

4.4 Stage 3 community consultation

The community information session was held at the Jeparit Town Hall on Monday 16th April 2007 at 7pm, approximately 17 residents attended.

The session was conducted in an informal manner with a short introduction presented by Clare Wilson (Wimmera CMA) and study progress presented by Steve Muncaster (Water Technology).

The discussion focused on the proposed mitigation measures, in particular refurbishment of the levees adjacent to the football clubrooms and the museum. Section 8 provides further details on the proposed mitigation measures. Strong community support was shown for the refurbishment of the levees due to the protection of the Museum and the football clubrooms. Significant investment has been made in the Museum and efforts to safeguard against potential flooding were supported by the community. The community requested an investigation into the cost and possible design of a levee upgrade. It was agreed that the project team would undertake this investigation as part of the Jeparit Floodplain Management Plan.

5 HYDROLOGIC ANALYSIS

5.1 Overview

Design flood hydrographs were required for the 5, 10, 20, 50, 100 and 200 year floods and the probable maximum flood for the Wimmera River at Jeparit.

The catchment hydrologic model, URBS, was the principal tool employed for the Wimmera River design flood hydrograph estimation. The URBS model is an event based conceptual runoff routing model in which rainfall is routed through a network of lumped storages to the catchment outlet. The URBS model parameters were determined through calibration of the modelled flood hydrographs to recorded flood hydrographs at available streamflow gauges. Once calibrated, the URBS model was applied to estimate design flood hydrographs using design rainfall events as an input.

The following sections detail the input data, methodology and outputs for the hydrologic analysis of the Jeparit Flood Study.

5.2 URBS model construction

5.2.1 Description of URBS Runoff Routing Model

URBS is a networked conceptual runoff and streamflow routing program that calculates flood hydrographs from rainfall and other channel inputs. The model is based on catchment geometry and topographic data. It is an areally distributed, non-linear model that is applicable to both urban and rural catchments. The model can account for both temporal and spatial distribution of rainfall and losses.

The rainfall excess (runoff) is determined by the application of rainfall loss model. URBS offers two rainfall loss models including the initial loss/continuing loss model and the initial loss/volumetric runoff coefficient model.

Two runoff routing approaches are available within URBS to describe catchment and channel storage routing behaviour. These are the URBS *Basic* and *Split* routing models.

The *Basic* model considers catchment and channel storage as a function of stream length (or derivative).

The *Split* model separates the channel and catchment storage components of each sub-catchment. The *split* model applies the rainfall to a sub-catchment, routes the rainfall excess runoff routed overland to the sub-catchment centroid, then routes along the stream to the sub-catchment outlet. The sub-catchment storage is assumed to be proportional to the square root of the sub-catchment area. Once at the sub-catchment outlet, the runoff is then routed along the channel network to the catchment outlet with downstream sub-catchment runoff entering at sub-catchment outlets. The channel storage is assumed to be proportional to the length of the channel. There are three principal model parameters in the split model, α (channel storage parameter), β (catchment storage parameter) and m (degree of non-linearity of flood response).

The storage characteristics for the sub-catchment and channel can be modified by the channel slope, catchment slope, fraction urbanised (various degrees), proportion forested and channel roughness. These other variables are included optionally in the modelling process at the discretion of the modeller (Carroll (2002)). Further details of URBS can be obtained from Carroll (2002).

5.2.2 URBS model structure

The URBS *Split* model was adopted in this study due to the availability of a recently developed URBS *Split* model developed by BoM (Baker pers comm. 2006, BoM 2004). This model was developed as part of the flood warning system for the Wimmera River to Dimboola.

The available model was developed for the entire Wimmera River catchment excluding the Yarriambiack Creek distributary. Several minor modifications were made to the model structure to enable output of flood hydrographs required for this study. The modifications included extending the model to Jeparit from Dimboola. This was done by including the reach lengths from Dimboola to Jeparit without adding in the additional catchment area. The study team believes this is an acceptable approach given the contribution of the Wimmera River catchment downstream of Dimboola is likely to be limited.

Within the Wimmera River catchment, model sub-catchments were then defined to coincide with watershed boundaries, stream junctions, and the location of gauging stations. In total the Wimmera River catchment to Dimboola was sub-divided into 97 sub-catchments. Figure 5-1 shows the URBS model catchment sub-division.

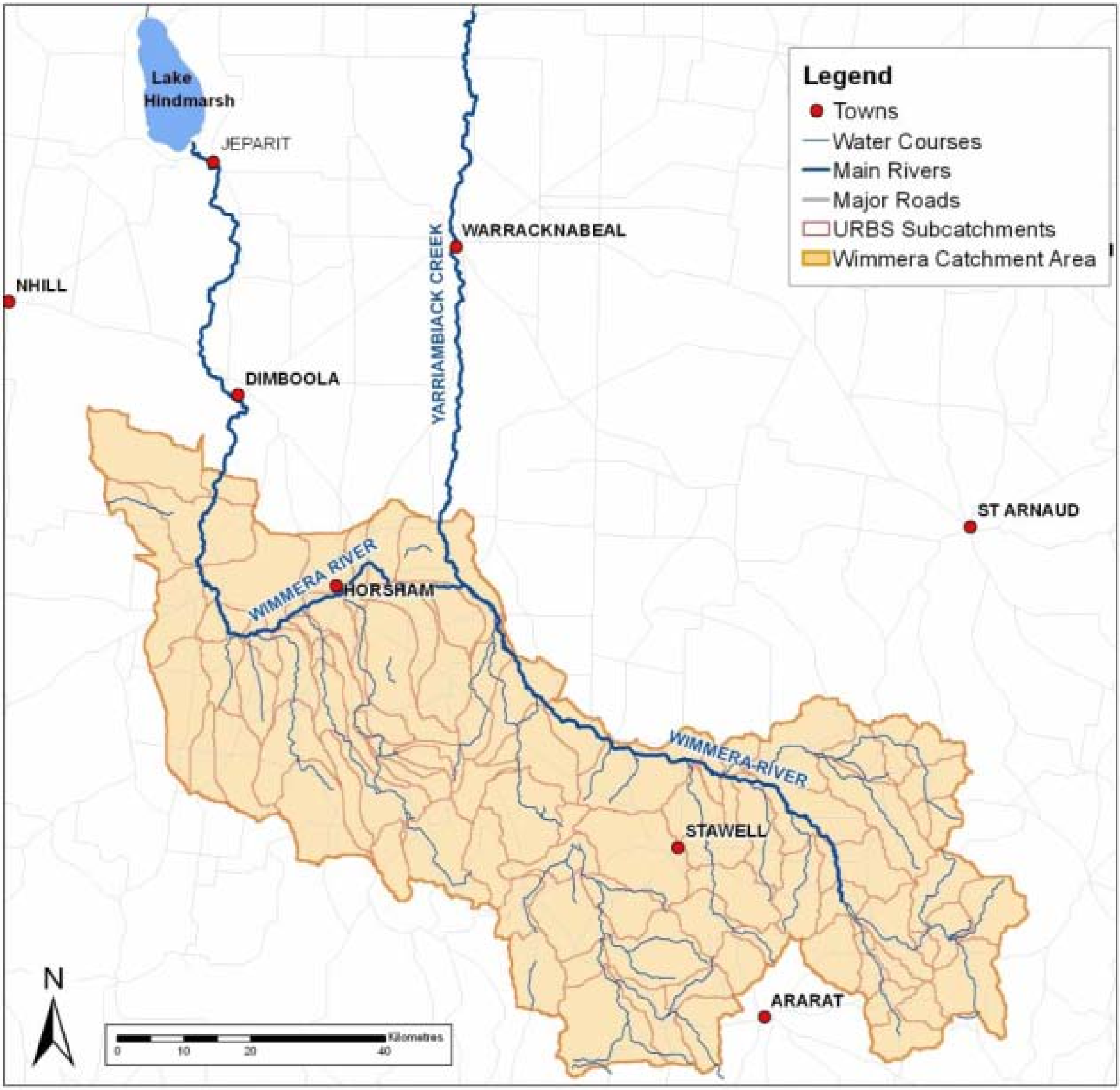

Figure 5-1 URBS Model Structure – Catchment Subdivision

5.3 URBS model calibration

5.3.1 Background

As discussed previously, the URBS split model routes excess runoff through the sub-catchment to the sub-catchment outlet and then routes the excess runoff along the channel network to the catchment outlet. The three model parameters α (channel storage parameter), β (catchment storage parameter) and m (degree of non-linearity of flood response) require determination during the model calibration.

Model parameters (α, β & m) were determined by BoM as part of the Wimmera River flood warning investigations (Baker pers comm. 2006, Leahy 2006). For this previous investigation, the main focus of the model was on estimation of flood heights at major population centres adjacent to the Wimmera River. In turn, the calibration undertaken as part of the flood warning investigations focused on the reliable estimation of observed flood heights at these major centres (e.g. Dimboola).

This hydrologic analysis is focused on the estimation of design flood events at Jeparit. As no streamflow data is available at Jeparit, the model calibration utilised available stream flow at Lochiel and Tarranyurk (refer to figure 3-1). Tarranyurk is approximately 7 km downstream of Jeparit. Design flood estimates at Dimboola provide validation for the model parameters employed for Jeparit.

5.3.2 Selection of model calibration events

The selection of suitable flood events for model calibration was dependent on the availability of concurrent streamflow and pluviographic records. Three flood events selected for calibration were: August 1992, June 1995 and September 1996. The details of the selected calibration flood events are given in Table 5-1. Two of the three calibration events, August 1992 and June 1995, were considered relatively minor flood events. The September 1996 event was considered a major flood event. Given the relatively large size of the September 1996 flood, additional weight in the model calibration process was placed on this event.

Table 5-1 URBS Model Calibration Events

Event	Event Start & Finish Date	Wimmera River upstream Dimboola			Wimmera River at Lochiel Railway			Wimmera River at Tarranyurk		
		Recorded Peak flow (m³/s)	Date and Time of Peak	Qualitative Estimate of flood magnitude	Recorded Peak flow (m³/s)	Date and Time of Peak	Qualitative Estimate of flood magnitude	Recorded Peak flow (m³/s)	Date and Time of Peak	Qualitative Estimate of flood magnitude
August 1992	28/08/1992 17/09/1992	98.9	4/09/1992 22:00	Moderate	96.2	7/09/1992 4:00	Moderate	--	--	--
June 1995	05/06/1995 25/06/1995	34.4	15/06/1992 0:00	Minor	32.3	15/06/1995 17:00	Minor	32.7	16/06/1995 17:00	Minor
September 1996	27/09/1996 20/10/1996	207.9	6/10/1996 18:00	Major	204.3	7/10/1996 9:00	Major	188.5	8/10/1996 9:00	Major

The observed peak flows at the above three gauges show a downstream reduction due to limited catchment contribution in the lower Wimmera River catchment, and attenuation of the peak flows from channel and floodplain storage.

The limited streamflow data at the above three streamflow gauges constrained the selection of calibration events. Figure 3-2 shows the significant flood events within the available streamflow record.

5.3.3 URBS model parameter calibration

As outlined, there are three model parameters (α, β & m) requiring calibration. The calibration approach adopted by this study was as follows:

- Set m = 0.8. This value is acceptable for the degree of non-linearity of catchment response (IEAust, 1987)
- For each calibration event, the initial loss was determined to result in a reasonable match between the modelled and observed rising limb of the flood hydrograph, where available. The continuing loss/runoff co-efficient was determined to match the modelled and observed runoff volume.
- For each calibration event, a combination of α and β were trialled to achieve reasonable re-production of the observed peak flow and general hydrograph shape.

The initial loss/uniform continuing loss model was found to provide a good fit of observed and modelled flood hydrographs and was adopted for use in this hydrologic analysis. A summary of calibration results are provided in Table 5-2.

Table 5-2 URBS Model Calibration Results

Event	Routing Parameters		Rainfall Loss Parameters	Wimmera River upstream Dimboola		Wimmera River at Lochiel Railway		Wimmera River at Tarranyurk	
				Recorded Peak flow	Modelled Peak flow	Recorded Peak flow	Modelled Peak flow	Recorded Peak flow	Modelled Peak flow
	α	β		(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)
Aug-92	0.3	2.5	IL = 30 mm CL = 0.8 mm/hr	98.9	96.2	88.4	88.1	--	--
Jun-95	0.3	3.5	IL = 80 mm CL = 4.1 mm/hr	34.4	35.8	32.3	32.8	32.7	30.4
Sep-96	0.3	3.5	IL = 30 mm CL = 2.2 mm/hr	207.9	224.0	204.3	205.4	188.5	193.1

Figure 5-2, Figure 5-3 and Figure 5-4 shows comparison of the recorded and modelled hydrographs for the calibration events.

As discussed, the September 1996 event is significantly larger than the other calibration events. Given the focus of this study on the estimation of large flood estimation, it was considered appropriate to adopt the URBS routing parameters, α of 0.3 and β of 3.5, from the September 1996 event for design flood estimation.

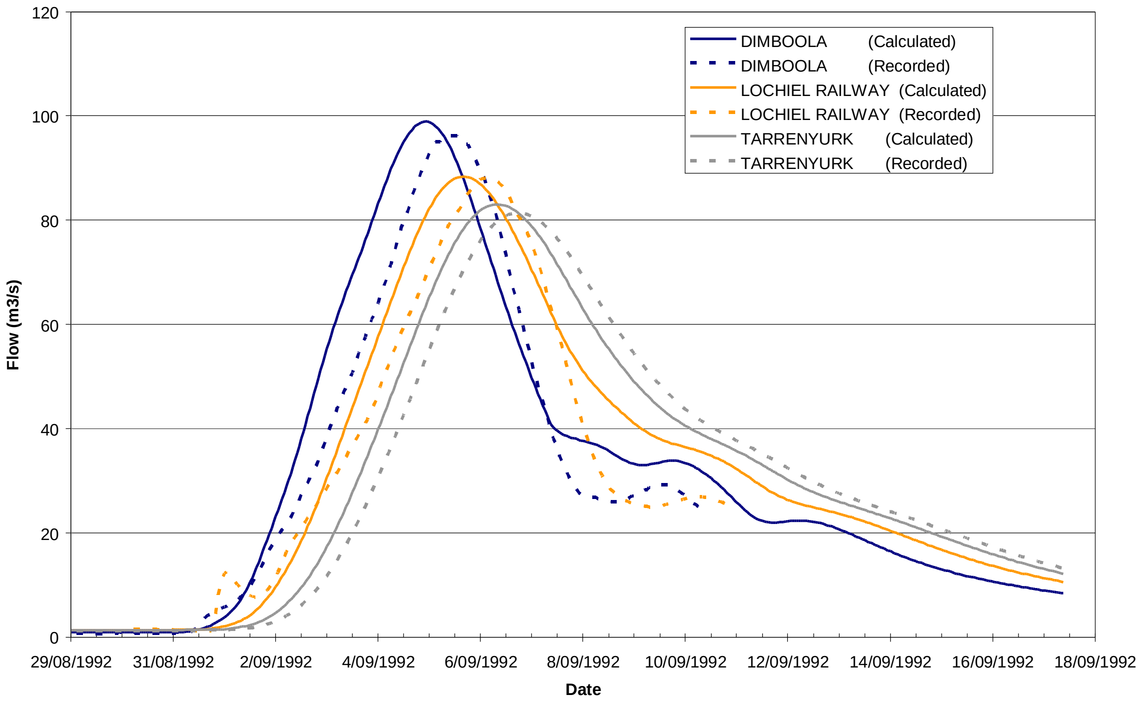

Figure 5-2 Wimmera River – URBS model calibration – August 1992 flood

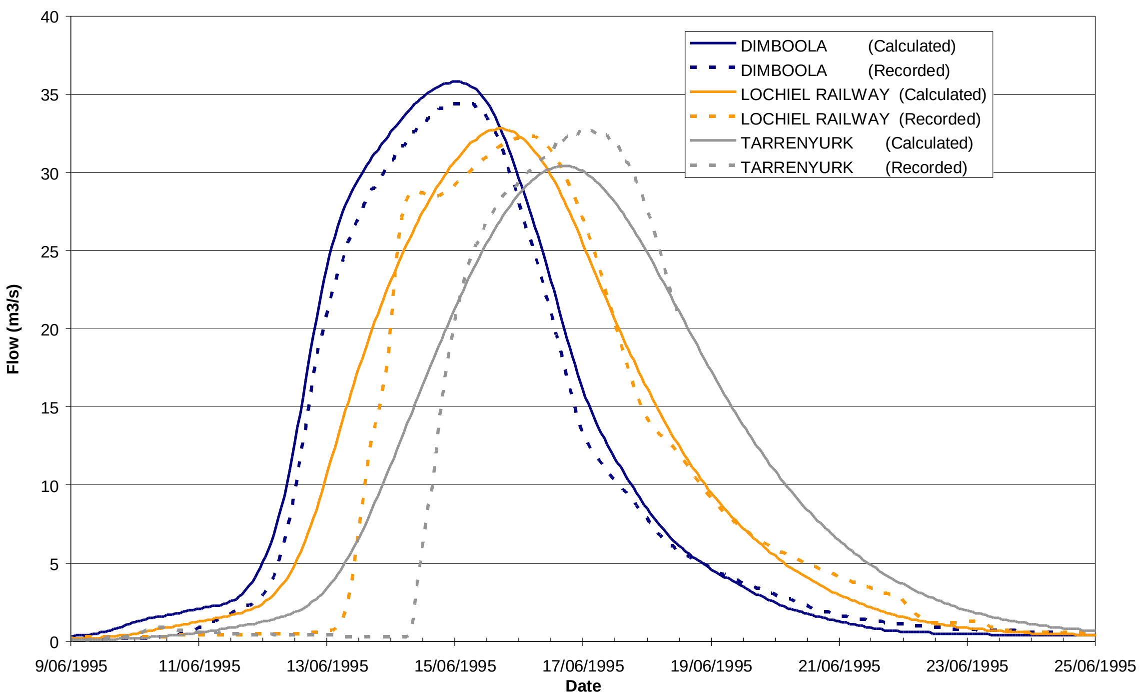

Figure 5-3 Wimmera River – URBS model calibration – June 1995 flood

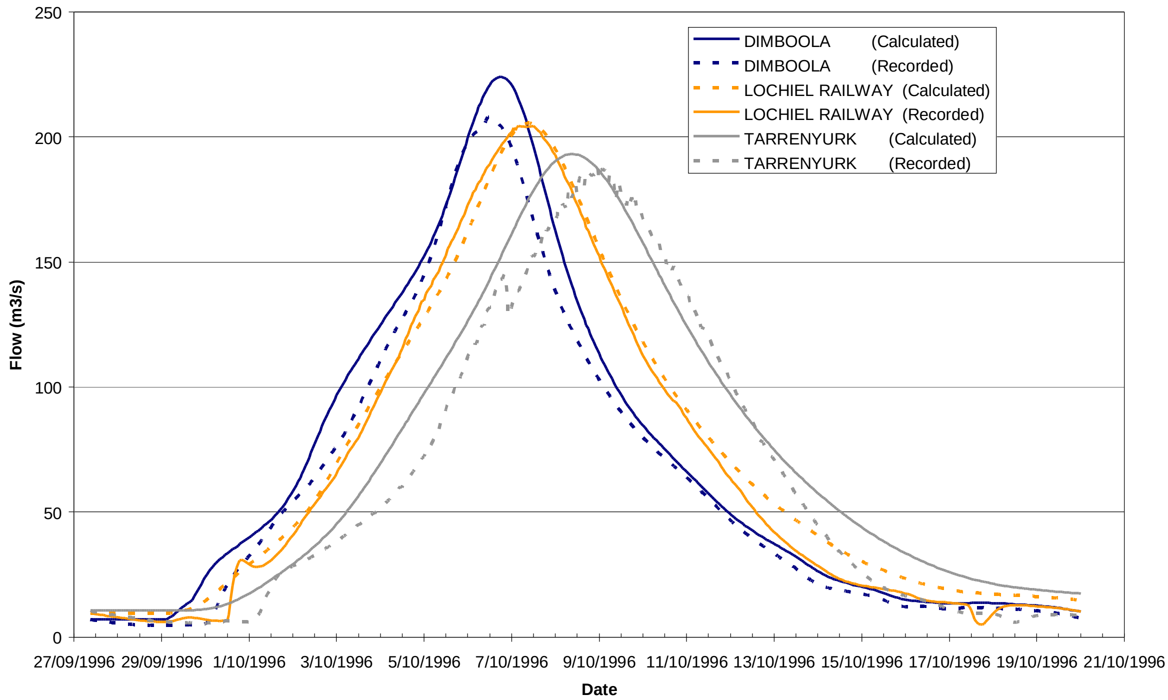

Figure 5-4 Wimmera River – URBS model calibration - September 1996 flood

5.4 URBS model verification for design flood estimation

The URBS model parameters determined above need to be checked for their suitability in design flood estimation. The URBS model parameters were combined with the design rainfall information from Australian Rainfall and Runoff (IEAust 1987) to produce design flows. The URBS design peak flows were compared to the design peak flows at Dimboola from the Dimboola Flood Study (Water Technology 2003). The URBS model parameters were adjusted to maintain consistency with the previous design flow estimates at Dimboola.

5.4.1 Dimboola Flood Study design peak flows

Water Technology (2003) adopted the design peak flows for the Wimmera River at Dimboola, as listed in Table 5-3.

Table 5-3 Wimmera River at Dimboola - Design peak flows

Average recurrence interval (years)	Wimmera River at Dimboola	
	Design peak flow (ML/d)	Design peak flow (m^3/s)
5	12,900	149
10	18,100	209
20	23,700	274
50	31,200	361
100	37,000	428
200	43,000	498

5.4.2 Design parameters verification

The design rainfall information contained in Australian Rainfall and Runoff (IEAust 1987) was combined with the adopted URBS routing parameters to derive design peak flows. These design peak flows were compared to Dimboola Flood Study (Water Technology 2003) design estimates.

The rainfall losses parameters, initial loss (IL) and continuing loss (CL), were adjusted to achieve consistency between design peak flows at Dimboola from the URBS model and the Dimboola Flood Study (Water Technology 2003). Using an initial loss of 25 mm and a continuing loss of 3 mm/h provided consistency in design peak flows at Dimboola as seen in Table 5-4.

Table 5-4 Wimmera River at Dimboola - URBS model design peak flow verification

Location	Design peak flow for the Wimmera river at Dimboola (m^3/s)					
	5 Year ARI	10 Year ARI	20 Year ARI	50 Year ARI	100 Year ARI	200 Year ARI
Dimboola Flood Study (Water Technology 2003)	149	209	274	361	428	498
URBS Model $\alpha = 0.3$ & $\beta = 3.5$ IL 25 mm CL 3.0 mm/h	149	210	276	362	429	498

5.5 Design flood hydrographs

The design flood hydrographs for the Wimmera River at Jeparit were estimated using model parameters outlined in Section 5.4. A range of storm durations was required to ensure the critical storm durations were determined throughout the study area.

Table 5-5 displays the URBS model design peak flows and critical storm durations for Wimmera River at Jeparit. The 72 hour design storm duration was found to produce the maximum peak flows for 20, 50, 100 and 200 year events, with the 30 and 36 hour storm durations found to be critical for the 5 and 10 year events respectively.

Table 5-5 Wimmera River - URBS model design peak flows

Location	Design peak flow (m^3/s)					
	5 Year ARI	10 Year ARI	20 Year ARI	50 Year ARI	100 Year ARI	200 Year ARI
Wimmera River at Jeparit	118	172	232	308	386	429

Appendix B contains the design flood hydrographs for the Wimmera River at Jeparit.

To place the design peak flows in a historical context, approximate ARIs of significant historical flood events are provided in Table 5-6. Estimation of ARIs for historical flood events requires long term streamflow record. Given the lack of long term streamflow data for the lower Wimmera River, the approximate ARIs have been determined by comparison of observed peak flows at Horsham (Walmer gauge). ***As such, the approximate ARIs for the historical event should be treated with caution.***

Table 5-6 Wimmera River – Approximate ARIs for significant historical flood events

Historical event	Approximate ARI (based at Horsham) (years)
1909	Greater than 190 years
1956	Greater than 70 years
1974	Greater than 40 years
1981	Greater than 25 years

5.6 Discussion

The hydrologic analysis for this study was required to estimate design flood hydrographs for the Wimmera River at Jeparit. As detailed in Sections 5.2, 5.3 and 5.4, the hydrologic analysis employed the URBS model to estimate the required design flood hydrograph.

Limited observed streamflow data was available at Tarranyurk and upstream of Dimboola. This observed streamflow data enabled a broad verification of the URBS model parameters to one significant event (September 1996) at Tarranyurk. No observed streamflow data suitable for use in URBS model calibration/verification was available at Jeparit. As a result, the reliability of the flood hydrographs estimated at Jeparit can not be verified.

The validation of the URBS model peak flows at Dimboola with Water Technology (2003) is consistent with previous flood investigations along the lower Wimmera River. Although consistent, the study team notes that actual stream flow data is required to verify flood extent estimates for Jeparit. The study team acknowledges considerable uncertainty surrounding the design flood estimates developed by this study due to the absence of stream flow data for historic flood events at Jeparit. Rigorous calibration and/or validation of the approach is restricted by the absence of streamflow data. The study team considers, while the absolute reliability of design estimates is unknown, the relativity of design estimates is considered reasonable.

As discussed in Section 3.2.1, continued collection of streamflow data at the three gauges in the lower catchment will provide reduced uncertainty surrounding design flood estimates.

The design flood estimates and in turn flood extents, could be revised for Jeparit when streamflow records become available for a range of different size flood events. Such refinement would reduce the uncertainty surrounding the flood estimates,

6 EXISTING CONDITIONS HYDRAULIC ANALYSIS

6.1 Overview

The hydraulic analysis has been undertaken to determine the flood behaviour at Jeparit under the existing waterway and floodplain conditions. The flood behaviour was assessed for flood events originating from both the Wimmera River (river flooding) and local catchment rainfall (stormwater flooding).

The flood behaviour, due to river flooding, was assessed for the 10, 20, 50, 100, and 200 year flood events plus an indicative probable maximum flood. The design flood hydrographs for the Wimmera River, outlined in Section 5.5, were utilised as inflows to Jeparit study area.

The flooding behaviour, due to stormwater flooding, was only assessed for the 100 year flood event from the local catchments. The 100 year local flood event was chosen to align with the land use planning standard for the delineation of flood related overlays.

The linked one dimensional and two-dimensional unsteady hydraulic model, MIKEFLOOD, was the principal tool for the hydraulic analysis. MIKEFLOOD is a state of the art tool for floodplain modelling that has been formed by the dynamic coupling of Danish Hydraulic Institute's well proven MIKE 11 river modelling and MIKE 21 fully two-dimensional modelling systems. Through this coupling it is possible to extend the capability of the 2D MIKE 21 model to include:

- A comprehensive range of hydraulic structures (including weirs, culverts, bridges, etc);
- ability to accurately model sub-grid scale channels;
- ability to accurately model dam break or levee failures.

For this present study, a two-dimensional (2D) MIKE 21 model has been set up to model the overall floodplain flows. A coupled one dimensional (1D) MIKE 11 model has been utilised to explicitly model waterway (bridge and/or culvert) crossings within the study area.

This section details the input data, methodology and outputs for the existing conditions hydraulic analysis. Section 6.2 outlines the hydraulic analysis for flooding originating from the Wimmera River with Section 6.3 discussing the stormwater flooding due to the local catchment rainfall.

6.2 Wimmera River flooding

6.2.1 Model Structure

The base data used to undertake the hydraulic analysis was a 5m topographic grid. The topographic grid was sourced from the DTM discussed in Section 3.3.4. Figure 3-8 displays the hydraulic model topography for Jeparit.

The variation in hydraulic roughness within the study area has been schematised as a hydraulic roughness grid, representing various hydraulic roughness's (eg. open grassland, roads, thick vegetation). The hydraulic roughness grid was defined using the aerial photo's of Jeparit supplied by Wimmera CMA.

The levees adjacent to the Museum and the football ground are key features influencing flood behaviour. The Jeparit Nhill Road bridge was included as a MIKE11 structure and dynamically linked to the MIKE21 two dimensional domain.

6.2.2 Lake Hindmarsh water levels

As outlined, the water levels in Lake Hindmarsh strongly influence the flood behaviour, peak flood levels and flood duration, in Jeparit.

A hydrologic analysis of the Lake Hindmarsh water level behaviour was undertaken by Ecological Associates (2004). This analysis considered water level behaviour for the historical period January 1903 to June 2000 under both natural and existing catchment conditions.

Under the natural scenario, Lake Hindmarsh always contained water, except for the first five months, January 1903 to May 1903, due to starting conditions and assumptions in the analysis (Ecological Associates (2004)). For the natural conditions, Lake Hindmarsh filled 35 times over the modelled period with an average duration of each event of 24 months (Ecological Associates (2004)). In contrast, under current conditions Lake Hindmarsh filled 21 times, with each event 10 months on average. The lake failed to reach the full level for 22 years following 1928 (Ecological Associates (2004)). Figure 6-1 displays the modelled Lake Hindmarsh storage volumes under the natural and current conditions.

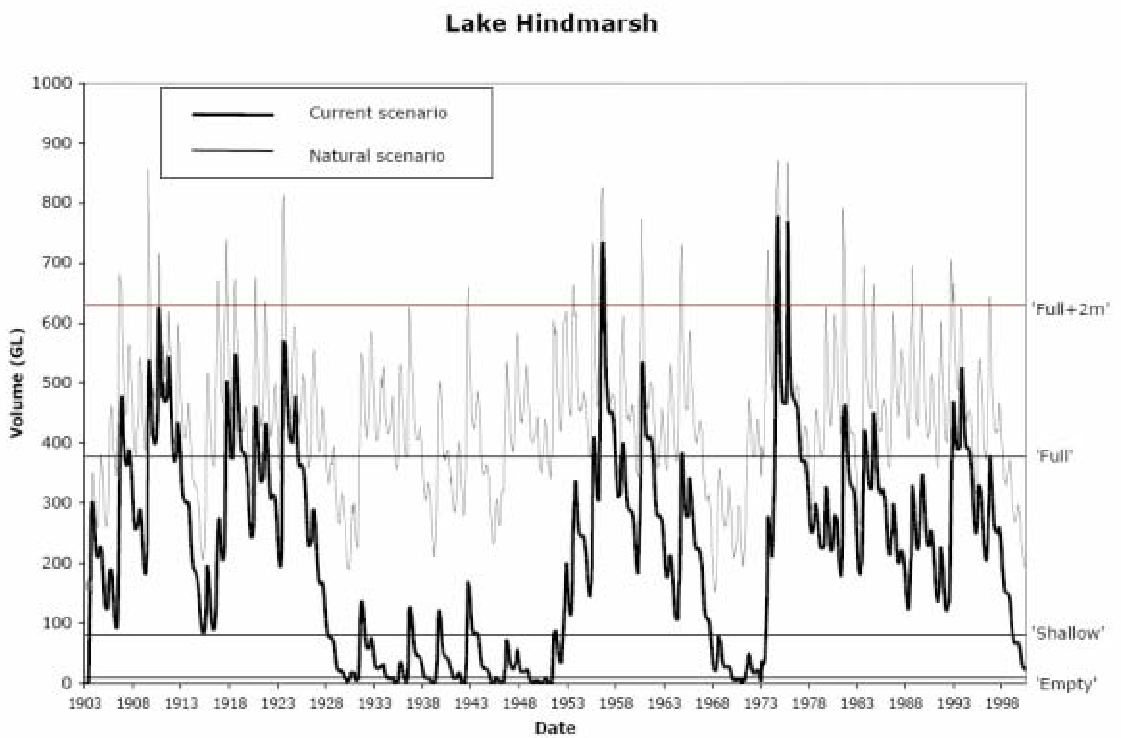

Figure 6-1 Lake Hindmarsh storage volumes under natural and existing conditions (after Ecological Associates 2004)

Further hydrological analysis was undertaken to assess the impacts of Lake Hindmarsh storage volumes due to increased environmental flows arising from the Wimmera Mallee Pipeline Project. Figure 6-2 displays the modelled Lake Hindmarsh storage volumes under the enhanced flow scenarios.

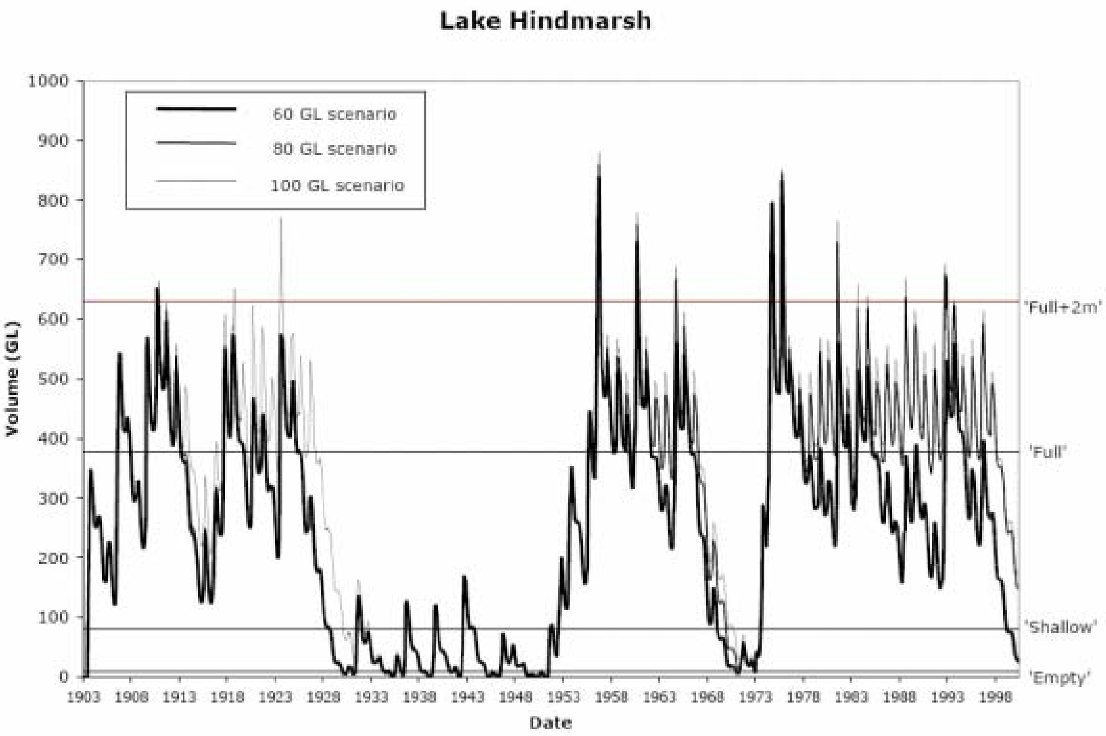

Figure 6-2 Lake Hindmarsh storage volumes under enhanced flow scenarios (after Ecological Associates 2004)

Examination of the available ALS data, outlined in Section 3.3.2, concluded an approximate "full" level in Lake Hindmarsh around RL (Reduced Level) 80 m AHD (Australian Height Datum). It should be noted that this approximate "full" level is indicative and further on-ground surveying of the lake outlet is needed to verify this assumed "full" level.

Ecological Associates (2004) noted:

> The period between flow events in the terminal lakes is significant, and there is potential for flow paths to become obstructed by sand drifts or vegetation. Inspection of the outlet of Lake Hindmarsh to Outlet Creek in this study suggested that a significant volume of sand had accumulated, significantly raising the sill level, and therefore the storage volume required in Lake Hindmarsh before flow to Outlet Creek and Lake Albacutya could begin. … Residents near Lake Hindmarsh report that in 1975 excavations were required at the outlet of Lake Hindmarsh to remove accumulated sand and vegetation to facilitate flow and reduce the risk of flooding at Jeparit.

Visual inspection of Figure 6-2 suggests the median storage volume in Lake Hindmarsh under the various enhanced flow scenarios is approximately 380 GL or "full". Given the current pipelining construction, the realisation of water savings and enhanced environmental flows is likely over the coming years.

When undertaking the hydraulic analysis for each design flood event for Jeparit it has been assumed that the downstream water level in Lake Hindmarsh was 80 m AHD (equivalent to "full").

6.2.3 Design Flood Modelling

Design flood levels and inundation extents were determined using the MIKEFLOOD model for the 10, 20, 50, 100 and 200 year ARI events. The design inflow hydrographs for the

Wimmera River as determined by the hydrologic analysis were used as model inflow boundary conditions. Table 6-1 displays the predicted peak design flood levels at the Nhill - Jeparit Road bridge

Table 6-1 Predicted Design Flood Levels in Wimmera River at the Nhill - Jeparit Road bridge

Design flood event ARI (years)	Depth (m)	Surface elevation (m AHD)
10	3.66	80.35
20	3.89	80.58
50	4.17	80.86
100	4.43	81.12
200	4.51	81.20

Flood inundation maps for Jeparit are collated in Appendix C.

6.2.4 Discussion

The hydraulic analysis of the Wimmera River through Jeparit shows largely that the existing flood mitigation measures (Museum and football ground levees) put in place during and in the immediate aftermath of the 1956 flood generally protect the township. There is however some overtopping of the Museum levees in the larger events (~ > 1 in 70 year flood event). The football ground levee is overtopped in 1 in 50 year flood event. This could be due to some localised lowering of the levee in these areas. Appendix A shows the levee crest survey. In particular, breakouts can be seen to the south of the museum and along the football ground levee. The breakout adjacent to the Museum may limit access to Jeparit along the Dimboola Rainbow Road.

A key factor influencing the model sensitivity is the water level of Lake Hindmarsh. Several model conditions were trialled to find the most probable lake level based on historical events. For this study it was assumed that the water level in Lake Hindmarsh was full. In times of lower lake levels, such as the present, much lower flood levels would be experienced in Jeparit.

It should be noted that the model cannot predict the condition of the levees and therefore during an actual event localised washout of structurally inadequate areas may cause unpredicted affects. This possibility became particularly clear during field visits to the levee structure. The levee's structural integrity may have been affected by the growth of several trees with their roots weakening the levee embankment, and numerous rabbit burrows

The operation of the Jeparit Weir is designed to reduce the afflux caused by the weir during flood events. The removal of the weir boards allows flow through the weir structure with minimal afflux during frequent flood events (< 1 in 5 year ARI). For large flood events the weir is drowned out due to the downstream flood levels. Under these conditions a minimal afflux results. The capture of debris by the weir structure may give rise to local increases in flood levels during frequent flood events (< 1 in 5 year ARI). For larger flood events, the drowned condition of the weir will mitigate any local increase in flood events due to capture of debris.

The Nhill Road Bridge crosses the Wimmera River about 5 kilometres upstream from the Jeparit Weir. The hydraulic analysis revealed that it has little impact of local flood levels.

Formal calibration of the hydraulic model for Jeparit was limited by the absence of systematic concurrent streamflow and flood level information. The study team undertook a broad validation of the modelled design flood extents through community consultation and a comparison to flood photos. There was general community agreement that the modelled design flood extents were achieved.

Some backwater flooding can occur along stormwater drainage outfalls to the river. Anecdotal evidence suggests residents have informally blocked outfalls with sand bags. The study team considers that the HSC locate drainage outfalls and install flap values. Further discussion is provided in Section 8.3.3.

The study team acknowledges considerable uncertainty surrounding the reliability of the flood extents for Jeparit. This uncertainty arises from the lack of streamflow data for model calibration/verification. Flood extents may be reviewed following future flood events.

6.3 Stormwater flooding

6.3.1 Background

Through the consultation phase of this study, local stormwater flooding was put forward as a possible flooding risk. To simulate these conditions, the hydraulic analysis was modified to enable the examination of stormwater flooding from local rainfall. The study team assessed the flood behaviour for the 100 year stormwater flooding event. The 100 year local flood event was chosen to align with the land use planning standard for the delineation of flood related overlays.

6.3.2 Model structure

The existing model topography, with defined levee structures, was used for the stormwater flood modelling.

6.3.3 Design rainfall determination

The design rainfall depths were obtained for Jeparit from the application of the Intensity Frequency Duration (IFD) procedures in Australian Rainfall and Runoff (IEAust 1999). Table 6-2 displays the IFD parameters applied.

Table 6-2 Design rainfall (IFD) parameters

Geographic Coordinates		***Rainfall Intensities***	
36.140	141.9796	1 hour 2 year	17.74
Geographical Factors		12 hour 2 year	2.99
Skew	0.18	72 hour 2 year	0.78
F2	4.4	1 hour 50 year	37.70
F50	14.88	12 hour 50 year	6.10
		72 hour 50 year	1.50

The design temporal patterns for Zone 2, outlined in Australian Rainfall and Runoff (IEAust 1999), were applied.

The net design rainfall was determined by applying an initial loss of 15 mm and continuing loss of 3 mm/hour. For a range of storm durations, Table 6-3 displays the net design rainfall depths (i.e. after rainfall losses).

Table 6-3 – Design 100 year local rainfall excess

Storm duration (hours)	**Rainfall excess (mm)**
	Jeparit
3	47
4.5	50
6	48
9	49
12	47

The application of the above rainfall losses results in the 4.5 hour storm duration yielding the greatest rainfall excess. As a result, the 4.5 hour storm duration was adopted for the stormwater flooding analysis for Jeparit.

6.3.4 Stormwater drainage infrastructure

Limited underground drainage infrastructure has been constructed in Jeparit. Given the limited nature of the drainage infrastructure, for this study, the drainage infrastructure has not been incorporated into the hydraulic analysis.

6.3.5 Design local flooding modelling

The rainfall excess from the 100 year 4.5 hour design storm, outlined in Table 6-3 , was applied as direct rainfall in the MIKEFLOOD model for Jeparit.

The use of the MIKEFLOOD model in this manner allows the determination of overland flowpaths and ponding areas arising from local runoff.

The 100 year flood extents, depths, and elevations were mapped, and are provided in Appendix C.

6.3.6 Discussion

The results of the stormwater flood modelling show that in general the lowest areas of Jeparit can expect predominately less than 250mm of pooling during the 100 year ARI local rainfall event. As a general statement this might be classified as "nuisance flooding" and does not present any immediate threat to property owners. Some limited deeper pooling is experienced in more defined low points surrounding the township which generally correlate to the areas flooded during levee overtopping. A large pool is also experienced at the intersection of Broadway and Lower Roy Street, refer to Figure 6-3. The local stormwater drainage network may be able to remove much of this flooding. Appendix C contains the flood inundation map resulting from local stormwater runoff.

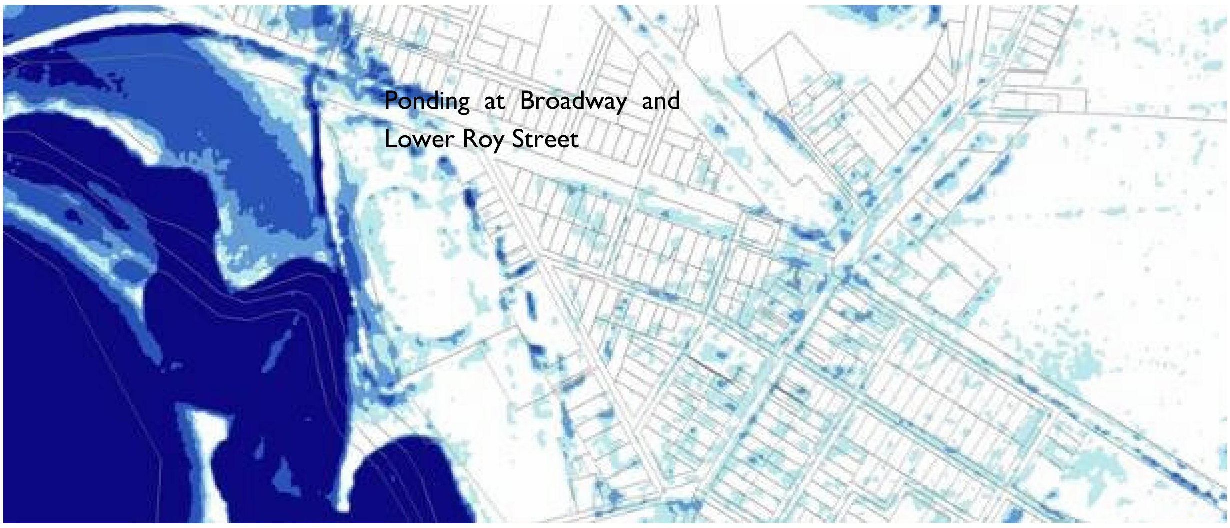

Figure 6-3 Jeparit 100 year local rainfall event – Ponding at Broadway and Lower Roy Street

The study team recommends HSC investigate potential measures to reduce local flooding impacts, particularly adjacent to the intersection of Broadway and Lower Roy Street

7 FLOOD DAMAGE ASSESSMENT

7.1 Overview

A flood damages assessment has been undertaken for the study area under existing conditions. The flood assessment determined the monetary flood damages for design flood hydrographs as determined by the hydrologic and hydraulic models. The Average Annual Damages (AAD) was also determined as part of the flood damage assessment.

Damages from flooding can be sub-divided into a number of categories. Figure 7-1 shows the various categories commonly used in flood damage assessments.

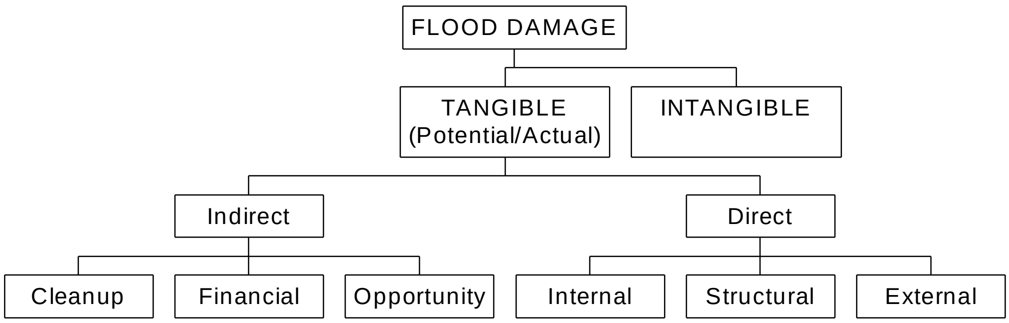

Figure 7-1 Flood Damage Categories

Tangible flood damages are those to which a monetary value can be assigned and include property damages, business losses and recovery costs. Intangible flood damages are those to which a monetary value cannot be assigned and include anxiety, inconvenience and disruption of social activities. Both are a function of flood magnitude. This flood damages assessment focuses on the tangible flood damages. Intangible damages are important but have not been directly accounted for in this flood damage assessment.

Tangible damages can be sub-divided into direct and indirect damages. Direct damages are those financial costs caused by the physical contact of flood waters and include damage to property, roads and infrastructure.

Property damages can be sub-divided into internal and external damages. Internal damages include damage to carpets, furniture and electrical goods. External damages include damages to building structures, vehicles and in rural areas, crops, fencing and machinery.

Tangible direct damages are further defined as either potential or actual damages. Potential damages are the maximum damages that could occur for a given flood event. In determining potential damages, it is assumed that no actions are taken (whether months or hours) prior to or during the flood to reduce damage by, for example, lifting or shifting items to flood free locations, shifting motor vehicles or sandbagging. Actual damages are the expected damages for a given flood event, allowing for some degree of community flood damage control. The actual damage is calculated as a proportion of the potential damage, based on the community's flood preparedness, a function of community awareness and the lead-time of flood warnings.

Indirect damages are those additional financial costs generally incurred after the flood during clean-up and include the cost of temporary accommodation, loss of wages, loss of production for commercial and industrial establishments and the opportunity loss caused by the closure or limited operation of business and public facilities. Indirect damages are often extremely hard to estimate.

The remainder of this section details the input data required and the methodology adopted for this flood damage assessment.

7.2 Available Information

This section outlines the range of information utilised within the flood risk assessment including property and floor level data, infrastructure data and flood data.

7.2.1 Property and Floor Level Data

The following property data were collected for 43 buildings:

- Building location:- property address (Street Number and Street Address) and ground coordinates.
- Building type:- urban and rural residential, commercial, industrial and public
- Ground and floor levels: ground and floor level data including location (i.e. coordinates)

Price Merrett undertook the required field survey to obtain the above property information.

7.2.2 Infrastructure Data

For this study, as detailed in the report '*Rapid Appraisal Method (RAM) for Floodplain Management*' (NRE, 2000), total damage to infrastructure was based on the length of road infrastructure inundated. NRE (2000) considers this assumption reasonable, as much of the service infrastructure follows the paths of road reserves and the quantity of other infrastructure might be expected to be broadly a function of the length of road. Damage to bridges is also incorporated into the NRE (2000) infrastructure damage cost estimates.

Roads were identified using the cadastral information supplied by HSC and by inspection of aerial photos.

7.2.3 Flood Data

The hydraulic analysis provides a regular grid of flood elevations and flood depths for the Jeparit study area. By overlaying the flood elevations and depths onto the property data, a flood level can be assigned to each flood affected building, similarly lengths of road inundated can easily be calculated. The 10, 20, 50, 100 and 200 year ARI design floods were assessed in this study, with a 5 year ARI flood assumed to result in no significant flood damage cost.

7.3 Approach

The flood damage assessment was based on the RAM (NRE, 2000) and current best practice. The Bureau of Transport Economics report '*Economic Costs of Natural Disasters in Australia*' (BTE, 2001), provides an excellent source of information regarding methodology and cost estimates for flood damage assessments. Wimmera CMA supplied additional infrastructure damage costs.

The flood damage assessment first estimated costs associated with direct flood damage (e.g. structural building, contents, external property, and infrastructure damage), then considered the costs associated with indirect flood impacts (e.g. emergency services, clean-up costs, alternative accommodation costs).

7.3.1 Direct Flood Damage

Property Damage

For each property in the study area it was first decided if the building was inundated above floor level or below floor level by querying the design flood depths and the floor level from the property survey. Adjusted ANUFLOOD (Smith & Greenway, 1992) stage-damage curves were then applied to each property for above floor flooding and an adjusted stage-damage curve from report '*Floodplain Management in Australia*' (DPIE, 1992), was used for properties with below floor flooding.

The ANUFLOOD stage-damage curves were factored up by 60% to bring them up to a 1999 flood damage cost level as recommended by the RAM (NRE, 2000). The ANUFLOOD stage-damage curves were further adjusted by the Consumer Price Index (CPI) ratio to September 2007, to bring them all up to a September 2007 flood damage cost level.

In this study, properties that contain buildings have been designated either residential medium value or commercial medium value. Essentially, all non-residential properties are designated as commercial, irrespective of their use, so that shops, Council premises and light industry etc. are assigned the same flood-depth to damage curve. The medium value residential damage curves have been adopted for residential properties and the medium value class two commercial damage curves have been adopted for commercial properties. The survey team used to collect this data were experienced in these types of surveys and categorised the majority of the buildings as medium quality. It is recognised that this approach is an approximation, but is considered appropriate given the lack of individual and detailed building size, age, use, value and quality information.

The DPIE stage-damage curve for external damages was factored up by the CPI ratio to September 2007, to bring them all up to a September 2007 flood damage cost level. Note that there is no distinction between residential and commercial external damages. It was found that many of the properties inundated below floor level were only partly inundated. The flood damage cost was reduced by the ratio of the flooded area and the property area.

The stage-damage curves used in this study are displayed in Figure 7-2.

The stage-damage curves were applied to each inundated property and the costs summed to calculate the total direct potential flood damage cost.

The total direct potential flood damage cost is the cost that would be incurred if no mitigation measures are taken prior to or during a flood. In reality communities generally have some degree of warning, and particularly if a community has had previous flood experience, it may reduce the effect of the flood significantly. Measures such as evacuation, doorstep sandbagging or the removal of valuable items to a safe level above flood waters have the potential to reduce the flood damage cost. Jeparit residents are considered an inexperienced community. Further, due to recent dry conditions along the Wimmera River community awareness of flooding has reduced. A potential to actual direct flood damage reduction factor from RAM (NRE, 2000) of 0.7 was adopted. This conservatively assumes that the community has no flood experience and have greater than 12 hours warning time, as shown in Figure 7-3.

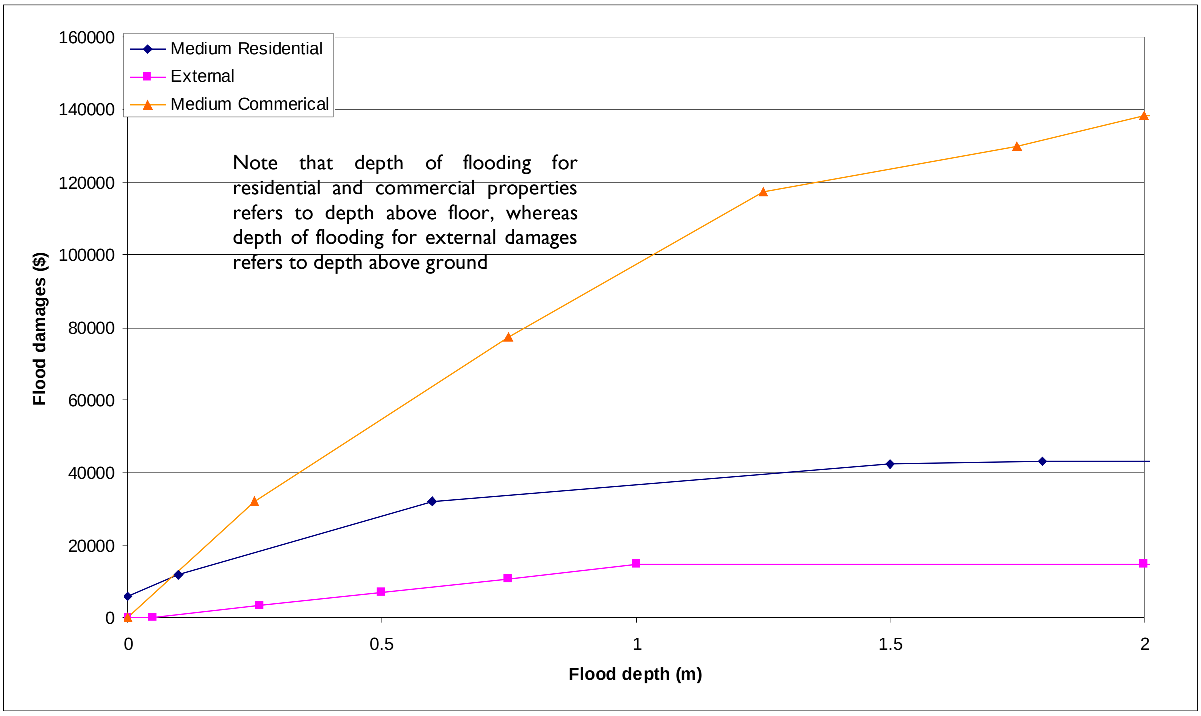

Figure 7-2 Adopted Stage-Damage Curves for Residential, Commercial and External Flooding

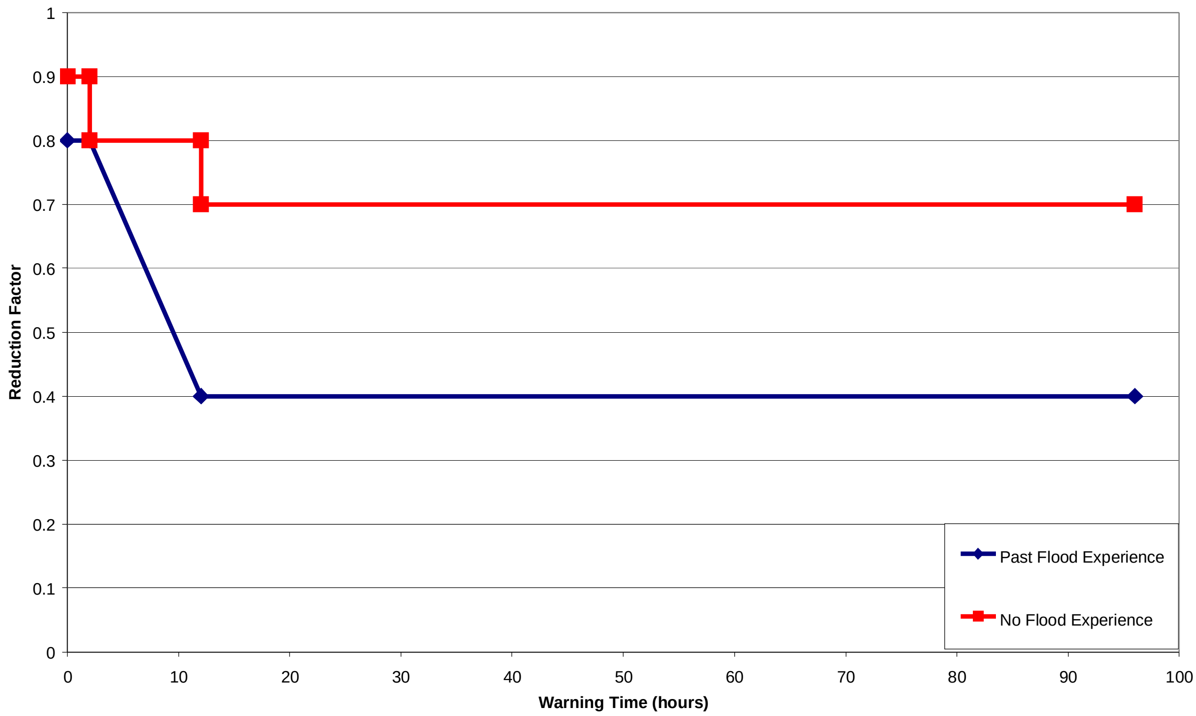

Figure 7-3 Reduction Factor Curves for Potential to Actual Direct Damage Ratio

Infrastructure Damage

Damage to infrastructure includes street and road repairs (including restoration of weakened subgrades), bridge repairs, telephone and telecommunications facilities, electrical connections, water supply and sewerage infrastructure and resulting higher maintenance costs.

For this study, as detailed in the RAM (NRE, 2000), total damage to infrastructure was based on the length of road infrastructure inundated. NRE (2000) considers this assumption reasonable, as much of the service infrastructure follows the paths of road reserves and the quantity of other infrastructure might be expected to be broadly a function of the length of road.

While it is appreciated that using the length of road inundated as the primary measure of total damage to infrastructure is a coarse approximation, it is considered reasonable, as it is the best estimate that we have due to lack of data and as it is only a small portion of the total damage cost.

Roads are subdivided into three categories in NRE (2000) – highway, sealed road and unsealed road. Roads inundated were identified as sealed roads from cadastral information supplied by HSC and by inspection of aerial photos.

Wimmera CMA provided road damages estimates based on VicRoads tenders in the Wimmera region. In the absence of other definitive infrastructure damages estimates, this study adopted these estimates provided by Wimmera CMA. The adopted flood damage rates for infrastructure are shown in Table 7-1. The length of inundated road for each design flood event was then multiplied by the adopted flood damage rates.

Table 7-1 Adopted Infrastructure Flood Damage Rates

Infrastructure	Flood Damage Rates (per km of road inundated)
Initial Road Repairs	$250,000
Accelerated Road Deterioration	$500,000
Bridge Repairs and Maintenance	$1,000,000
Total	$1,750,000

Estimates adopted from VIC Roads Web site for contracts awarded http://webapps.vicroads.vic.gov.au/VRNE/tenconin.nsf/webCntrctAwdDateAwded?OpenView&Start=1

7.3.2 Indirect Flood Damage

Indirect flood damages are damages incurred as a consequence of a flood but are not due to the direct impact of the flood itself (e.g. emergency services, clean-up costs, alternative accommodation, lost business opportunity, etc.). Indirect damages are extremely hard to estimate and are often calculated by assuming they equal 30% of the total actual direct flood damage cost (including damage to properties and infrastructure), as in the RAM (NRE, 2000), however it is recommended that this be revised to best suit population density. BTE (2001) suggests adopting a more rigorous approach, and provide estimates on the cost of post flood clean-up, relocation and emergency response actions. BTE (2001) suggest that post flood residential clean-up may cost approximately $424 (adjusted by September 2007 CPI) for materials and approximately 160 hours in labour (an average weekly wage of $1,294 for June 2007 was adopted from the Bureau of Statistics website). The total commercial clean-up was estimated as $3,080 (adjusted by September 2007 CPI - $2,400) for inundated properties (BTE, 2001). It was assumed that for external damages (below floor flooding) that the indirect damage cost was equal to one weeks labour. BTE (2001) estimates the cost of residential relocation per property as $68 (adjusted by September 2007 CPI - $53) per house for relocation of household goods. Wimmera CMA suggested $100 per person per night for alternative accommodation (assuming an average of 2.6 people per household from Bureau of Statistics, and a requirement of seven nights accommodation). BTE (2001) also suggest that volunteer emergency response costs be considered and that estimates of volunteer hours be made. It has been assumed for this study that for the 100, 50 and 20 year ARI design flood events that 50, 40 and 30 volunteers respectively worked for fifteen hours (assuming average weekly wage above). The BTE (2001) cost estimates were based on figures from 1999, they were adjusted by a ratio of CPI for 1999 to September 2007.

To put all these figures into perspective, when applying the above indirect flood damage estimates to each design event it works out that the total indirect flood damage cost is approximately 43% of the total actual direct flood damage cost for the 100 year ARI event and approximately 37% for the 20 year ARI event. This is perhaps higher than the recommended 30% as suggested in the RAM (NRE, 2000). The above indirect flood damage rates are deemed to provide a good estimate of indirect flood damage costs. The BTE (2001) estimates are adopted in this study.

Table 7-2 Adopted Indirect Flood Damage Rates

Indirect Flood Damage Item	Flood Damage Rates
Residential Clean-up Costs	
- Materials	$424 per household (1)
- Labour	$5,175 per household (1,2)
Commercial Clean-up Costs	
- Total	$3,080 per building (1)
Below Floor Flooding Clean-up Costs	
- Total	$1,294 per property (3)
Residential Relocation Costs	
- Relocation of household items	$68 per household (1)
- Alternative accommodation	$700 per household (1,4)
Emergency Response Costs	
- 100 year ARI	$24,259 (5)
- 50 year ARI	$19,407 (5)
- 20 year ARI	$14,555 (5)

1 Estimate adopted from BTE (2001) and adjusted to a September 2007 cost level by a ratio of CPI.

2 Residential labour cost based on 160 hours of labour and an average weekly wage of $1,294.

3 Below floor flooding cost based on one weeks labour and an average weekly wage of $1,294.

4 Alternative accommodation cost assumes an average of 2.6 people per household at $100 per night for 7 nights.

5. Emergency response costs assume that for the 100, 50 and 20 year ARI event that 50, 40 and 30 volunteers respectively worked for 15 hours each at an average weekly wage of $1,294.

7.3.3 Total Flood Damage

The total flood damage cost was calculated as the sum of the direct actual property flood damage cost the direct infrastructure flood damage cost and the indirect flood damage cost.

The AAD was also calculated. The AAD is a measure of the flood damage per year averaged over an extended period. It is calculated by the area under the flood frequency and total flood damage curve. It assumes that no flood damage is incurred at the 5 year ARI flood event, and considers floods up to the 200 year ARI event. The flood damage assessment was conducted for the 10, 20, 50, 100, and 200 year ARI flood events.

7.4 Summary

The methodology, as described in Section 7.3, was adopted for this flood risk assessment. The results are summarised in Table 7-3 for Jeparit.

Table 7-3 Jeparit Flood Damage Assessment Costs for Existing Conditions

Design flood event ARI (years)	200y	100yr no levee	100yr	50yr	20yr	10yr
Properties Flooded Above Floor (total)	16	16	4	2	0	0
Properties Flooded Above Floor (residential)	6	6	0	0	0	0
Properties Flooded Above Floor (public/commercial)	10	10	4	2	0	0
Properties Flooded Below Floor	19	19	13	4	2	1
Total Properties Flooded	**35**	**35**	**17**	**6**	**2**	**1**
Direct Potential External Damage Cost	$91,638	$88,664	$66,150	$5,445	$171	$47
Direct Potential Residential Damage Cost	$119,566	$119,566	$0	$0	$0	$0
Direct Potential Public/Commercial Damage Cost	$484,742	$484,742	$184,471	$41,988	$0	$0
Total Direct Potential Damage Cost	**$695,946**	**$692,972**	**$250,620**	**$47,433**	**$171**	**$47**
Total Actual Damage Cost	**$455,481**	**$453,846**	**$165,512**	**$32,386**	**$94**	**$26**
Infrastructure Damage Cost	**$449,750**	**$449,750**	**$118,750**	**$50,000**	**$17,000**	**$2,247**
Indirect Clean Up Cost	$81,399	$81,647	$20,880	$7,245	$35	$19
Indirect Residential Relocation Cost	$11,328	$11,328	$0	$0	$0	$0
Indirect Emergency Response Cost	$24,259	$24,259	$24,259	$19,407	$14,555	$9,704
Total Indirect Cost	**$116,986**	**$117,234**	**$45,138**	**$26,652**	**$14,591**	**$9,723**
Total Cost	**$1,022,217**	**$1,020,830**	**$329,400**	**$109,038**	**$31,685**	**$11,996**

The AAD was calculated to be approximately **$13,370** per year with the existing levee.

It is worth noting no residential properties experience above floor flooding for events up to the 1 in 100 year. The four properties experiencing above floor flooding are public buildings including the clubrooms and adjacent service buildings at the football grounds and two buildings at the Museum. Five residential properties experience below floor flooding during the 1 in 100 year event. These residential properties are located on Rainbow Dimboola Road (Charles Street) and Tullyvea Street. The remaining eight properties flooded below floor level in the 1 in 100 year event were public buildings.

The flood damages were estimated for the 1 in 100 year event without the Museum and football ground levees at approximately $1,000,000. This damage estimate represents an increase of about 300 % from the existing condition damages. Without the levee, above floor flooding would occur for six residential properties.

8 STRUCTURAL MITIGATION MEASURE ASSESSMENT

8.1 Overview

Mitigation measures provide a means to reduce the existing flood risk (and AAD). Mitigation measures can reduce existing flood risk by lowering the likelihood of flooding and/or lowering the flood damages (consequences) for a given flood depth. Mitigation measures can be broken into:

- Structural – Physical barriers or works designed to prevent flooding up to a specific design flood standard. Structural measures aim to reduce existing flood risk flood by lowering flood likelihood at given locations. Structural works include levees, floodways waterway works, and improvements to hydraulic structures.
- Non-structural- Management and planning arrangements between relevant authorities designed to reduce related flood damages. Non-structural measures aim to reduce existing flood risk flood by lowering flood damage. Non-structural measures include land use planning, flood warning and flood response.

This section deals only with structural mitigation measures. Non-structural measures are discussed in Section 9. Further, this section identifies and provides a preliminary assessment of potential structural mitigation measures. This assessment identified potential mitigation measures as feasible or non feasible based on a preliminary assessment of hydraulic, economic, environmental and social aspects.

8.2 Non-feasible structural measures

8.2.1 Upstream flood storage

An upstream storage would provide and results in lower flood magnitudes by providing additional attenuation of flood peaks. The construction and operation of an upstream storage requires significant land at a suitable location. It is likely the costs of an upstream storage would be significant. Further the availability of suitable land is limited and the environmental impacts are likely to be considered significant. The benefits of an upstream storage would be limited, given the relatively low flood damages.

Given benefits and costs, the study team considers an upstream flood storage is not a feasible mitigation measure for Jeparit.

However, the study team notes the current floodplain storage located along the Wimmera River upstream of Jeparit, provides attenuation for catchment runoff. The removal of this upstream floodplain storage may influence flood magnitude at Jeparit.

8.2.2 Floodways

Floodways provide additional flood flow paths, and reduce flood levels by providing additional flow carrying capacity and by diverting flow away from areas susceptible to flooding and damage. Ideally, floodways should make use of existing natural depressions in the floodplain. One of the main limitations of floodways is their often limited effectiveness in significant flood conditions where the bulk of the flow is carried in the floodplain. In these events, floodways provide little additional flow capacity. Their benefit is usually in small to medium floods. This was reflected somewhat in the likely lower design standards of the floodway based mitigation options.

The nature of the floodplain in Jeparit does not lend itself to the siting of a floodway. It is likely little additional flow capacity could be achieved with a constructed floodway.

The study team consider the construction of floodways for Jeparit is not a feasible mitigation measure.

8.2.3 Waterway management works

Waterway management works can include local widening, deepening, re-shaping and clearing of channels and verges. It also includes clearing of in-channel debris and mostly non-native riparian vegetation. Such works increase the flow capacity of the channels and floodplain, although the benefits are dependent on the existence or severity of channel and floodplain constrictions. Local works are likely to have only local benefits. Generally the benefits of waterway management works will be most evident in small to medium floods. In larger floods, where the waterway carries only a small proportion of the flow, improvements will provide only minor benefit. Such waterway works may involve the removal of native riparian vegetation and habitat. The removal of large wood from the waterway may lead to a loss of habitat, and corresponding reduction in some aquatic species. Changes to the waterway form, by enlarging and/or deepening, can lead to a change in local hydraulic behaviour. Increases in local flow velocity and stream power can initiate bed and bank erosion. This erosion contributes to stream sediment load and may lead to local bank failure.

The study team considers further widening and deepening is not feasible due to potential environmental concerns.

8.3 Feasible structural measures

8.3.1 Levees

Levees or floodwalls can restrict the extent of flooding and limit the area subject to flooding up to a given design flood. Levees are usually earth embankments, and can be landscaped to present an attractive appearance through grassing, planting with native shrubs, and/or variation to the alignment, width and height of the embankment. Floodwalls are usually constructed of concrete and/or stone, are more expensive but are convenient where space for levees is restricted or cost of land acquisition is high. Potential disadvantages of levees/floodwalls include:

- Overtopping/ failure in large flood events
- Failure of levees due to poor construction and/or lack of ongoing maintenance
- Loss of floodplain storage and obstruction to flood flows
- Loss of visual amenity
- Inequality due to increased flood levels elsewhere within the floodplain.

The levees adjacent to the Museum and the football ground provide flood protection from the Wimmera River flooding for lower areas of the township. Discussions with Wimmera CMA and HSC, as well as comments provided by community members have questioned the structural integrity of the levees. Overtopping of the museum levee occurs for the 1 in 70 year flood event with the football ground overtopped by the 1 in 50 year flood event. Overtopping of the levees is likely to result in erosion of the levee bank and possible significant loss of levee bank. The hydraulic analysis, discussed in Section 6, did not consider significant erosion of the levee bank during overtopping. As such, the flood extent simulated for the 1 in 100 year is likely to increase due to the levee erosion, and therefore may increase flood damage estimates for a 1 in 100 year flood.

Refurbishment of these levees to increase the level of flood protection (to 1 in 100 year) and the improved structural integrity has been assessed.

This preliminary assessment does not equate to an endorsement but rather provides a basis from which a future comprehensive floodplain management study could be undertaken.

As discussed, this option involves the refurbishment of the Museum and football levees. Both levees require raising to provide a 1 in 100 year level of flood protection with a 600 mm freeboard.

Generally the increases in levee crest range from 0.2 m to 1.0 m (including freeboard). A detailed assessment is required to identify structural and geotechnical constraints, as well as social and environmental concerns.

A hydraulic analysis was undertaken, incorporating the refurbished levee for the 1 in 100 year flood event. Figure 8-1 displays differences in the flood levels for the 1 in 100 year flood event between the existing levee and refurbished arrangements. In Figure 8-1, the area "Was dry now wet" is negligible. This is due to the minor increases in flood levels (less than 50 mm) resulting in negligible increase in flood extent.

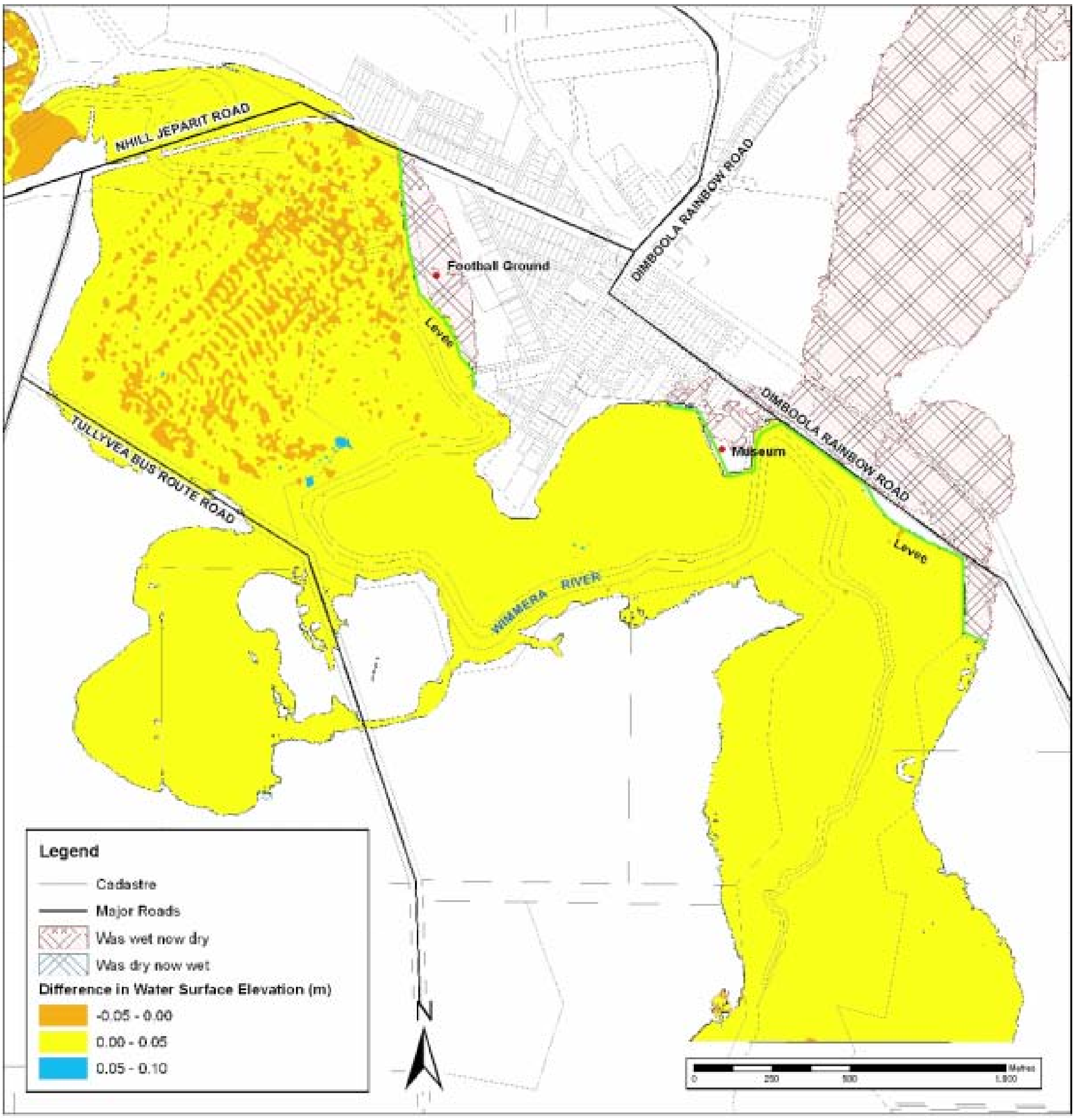

Figure 8-1 Jeparit – Mitigation Option 1 – 100 year flood level difference plot

The study team considers the refurbishment of the Museum and the Football ground levees warrants further investigation. This investigation has been undertaken as part of the Floodplain Management Plan.

8.3.2 Improvements to waterway structures

Improvements to waterway structures (e.g. culverts, bridges, road and rail embankments, weirs) can reduce upstream flood levels. Waterway structures within the flood flows potentially act as a barrier or constriction to flood flows and impact on flood levels. The hydraulic performance of bridge/culvert/weir structures can be expressed as afflux. The afflux is the change in the flood levels from downstream to upstream across the structure. The magnitude of the afflux reflects the degree to which the structure obstructs the flood.

Key structures located in the study area include:

- Jeparit Weir
- Nhill Road Bridge over the Wimmera River

The operation of the Jeparit Weir is designed to reduce of the afflux caused by the weir during flood events. The removal of the weir boards allows flow through the weir structure with a minimal afflux during frequent flood events (< 1 in 5 year ARI). For large flood events the weir is drowned out due to the downstream flood levels. Under these conditions a minimal afflux results. The capture of debris by the weir structure may give rise to local increases in flood levels during frequent flood events (< 1 in 5 year ARI). For larger flood events, the drowned condition of the weir will mitigate any local increase in flood events due to capture of debris.

The study team understands works to improve the passage of environmental flows through the Jeparit Weir have been recently completed.

The Nhill Road Bridge crosses the Wimmera River about 5 kilometres upstream from the Jeparit Weir. The hydraulic analysis as part of this flood study found the Nhill Road Bridge has little impact of local flood levels.

8.3.3 Stormwater system (Backwater flooding only)

The inundation can occur due to backflow of the river along the stormwater system during flood events. Various measures have been undertaken in an informal manner to combat this backwater flooding. The study team considers worthy further discussion and investigation of possible measures to prevent stormwater backwater flooding. The measures may include the installation of flap valves on stormwater outfalls to the river.

8.3.4 Summary of feasible structural mitigation measures

A number of potential structural mitigation measures were identified with the refurbishment of the existing levee considered a feasible mitigation option. Further, measures (flap valves) to prevent backwater flooding along the stormwater system should be considered.

9 NON-STRUCTURAL MITIGATION MEASURES ASSESSMENT

9.1 Overview

This section discusses a range of non-structural mitigation measures for Jeparit. As discussed in Section 8.1, non-structural mitigation measures include land use planning, flood warning and flood response.

9.2 Revised flood related provisions and overlays delineation

The current Hindmarsh Shire Planning Scheme applies Land Subject to Inundation Overlay (LSIO) in Jeparit, as seen in Figure 9-1. The LSIO extent is based on the 1 in 100 year ARI flood extent estimated from historical flood information (SKM 2000), in particular the 1909 flood. The existing conditions hydraulic analysis, discussed in Section 6.2, provides considerable refinement of the current LSIO.

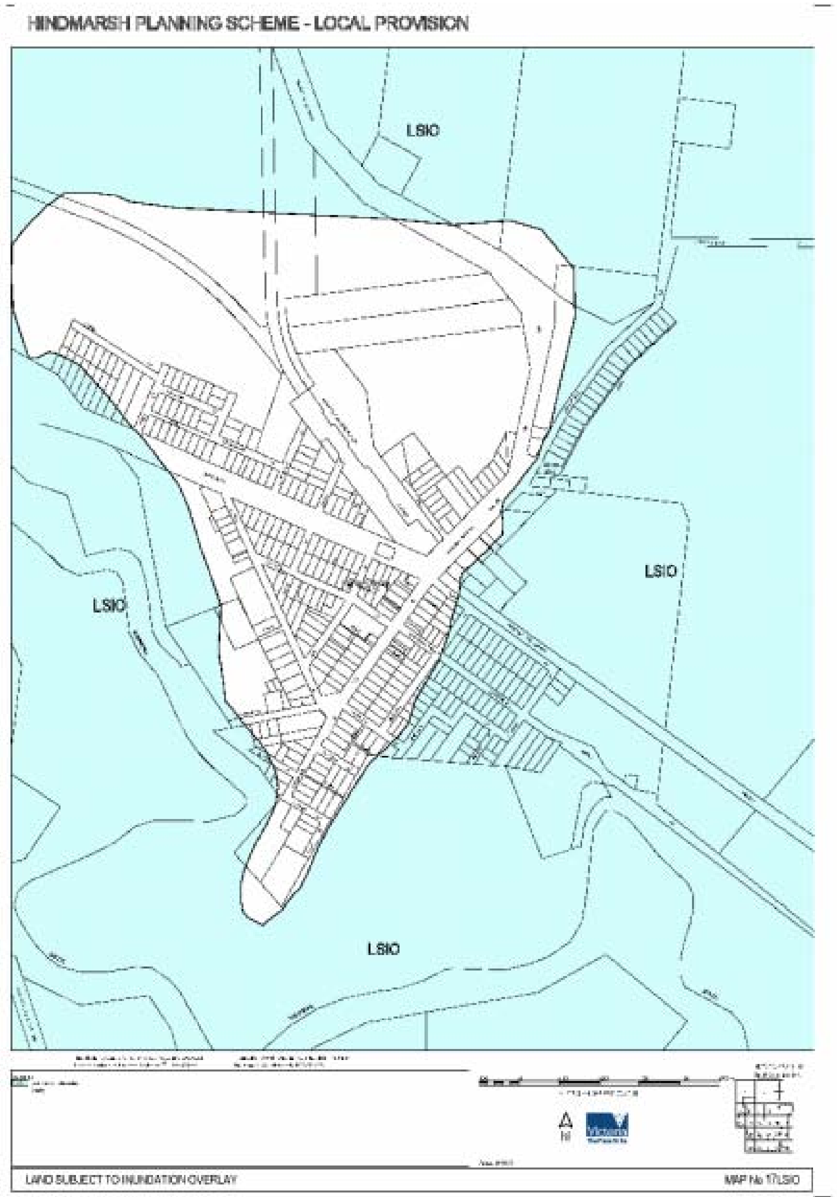

Figure 9-1 Hindmarsh Planning Scheme – Current LSIO

In addition to LSIO, the Victorian Planning Provisions enable the delineation of the Floodway Overlay (FO). The FO is intended to delineate land subject to higher flood risk. The study team utilised guidelines provided by DNRE (1998) to investigate possible delineation of FO. The guidelines provide three approaches to the delineation of FO as follows:

- Flood frequency
- Flood depth
- Flood hazard

For **flood frequency**, DNRE (1998b) suggest areas which flood frequently and for which the consequences of flooding are moderate or high, should generally be regarded as floodway. The 10 year ARI flood extent was considered an appropriate floodway delineation option for Jeparit.

Flood hazard combines the flood depth and flow speed for a given design flood event. DNRE (1998b) suggest the use of Figure 9-2 for delineating the floodway based on flood hazard. The flood hazard for the 1 in 100 year ARI event was considered for this study. Figure 9-2 displays the flood hazard criteria for floodway delineation.

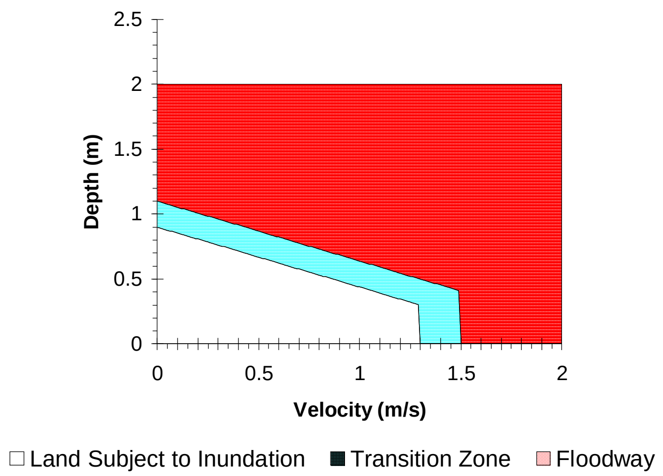

Figure 9-2 Floodway overlay flood hazard criteria

For **flood depth**, regions with a flood depth in the 1 in 100 year ARI event greater than 0.5 m were considered as FO based on the flood depth delineation option.

Figure 9-3 displays possible FO delineation options for consideration by Wimmera CMA and HSC. From these FO delineations, Wimmera CMA and HSC prepared a draft FO delineation, as shown in Figure 9-4.

Figure 9-5 shows two alternative LSIO delineations based on the 100 year flood extents with and without the museum-football levees. Given low structural integrity of the levee, there is considerable potential of levee failure, in the case of the 100 year flood event. There are a number of areas along both levees, which have been eroded and weakened by tree growth and rabbit burrows. To reflect this likelihood of failure, the draft LSIO without the levee is recommended as the draft LSIO.

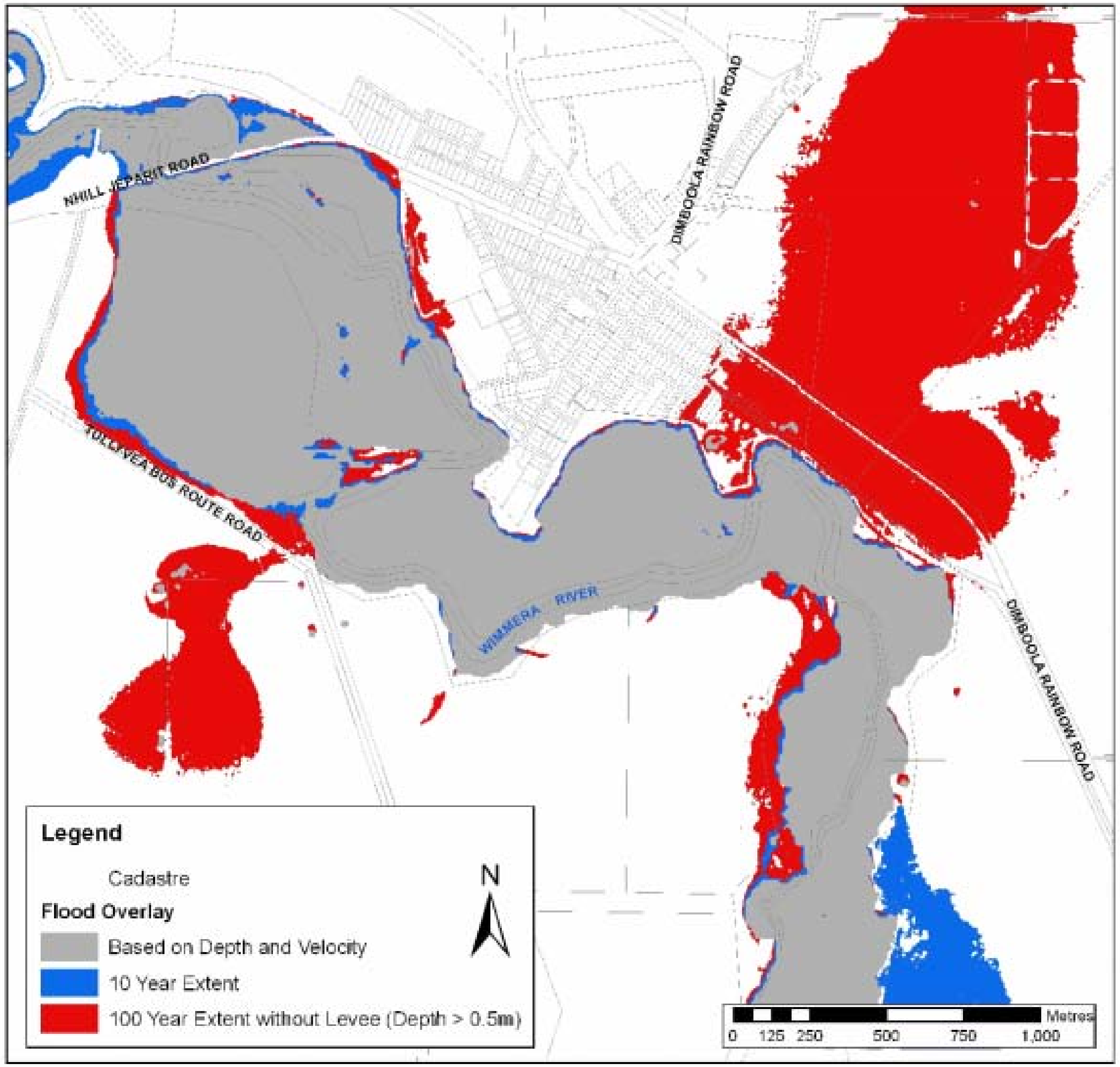

Figure 9-3 Jeparit - FO delineation options

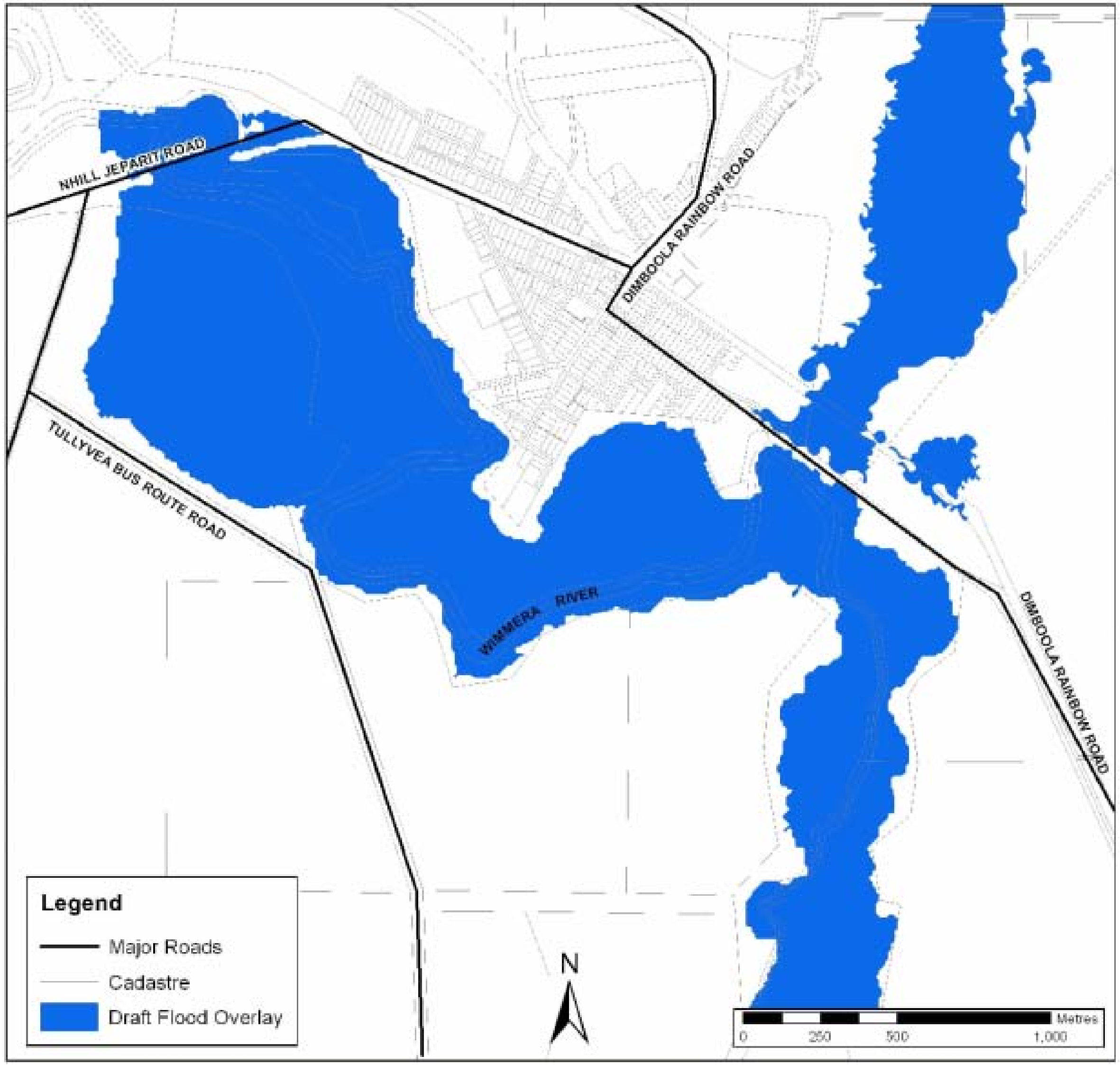

Figure 9-4 Jeparit – Draft FO

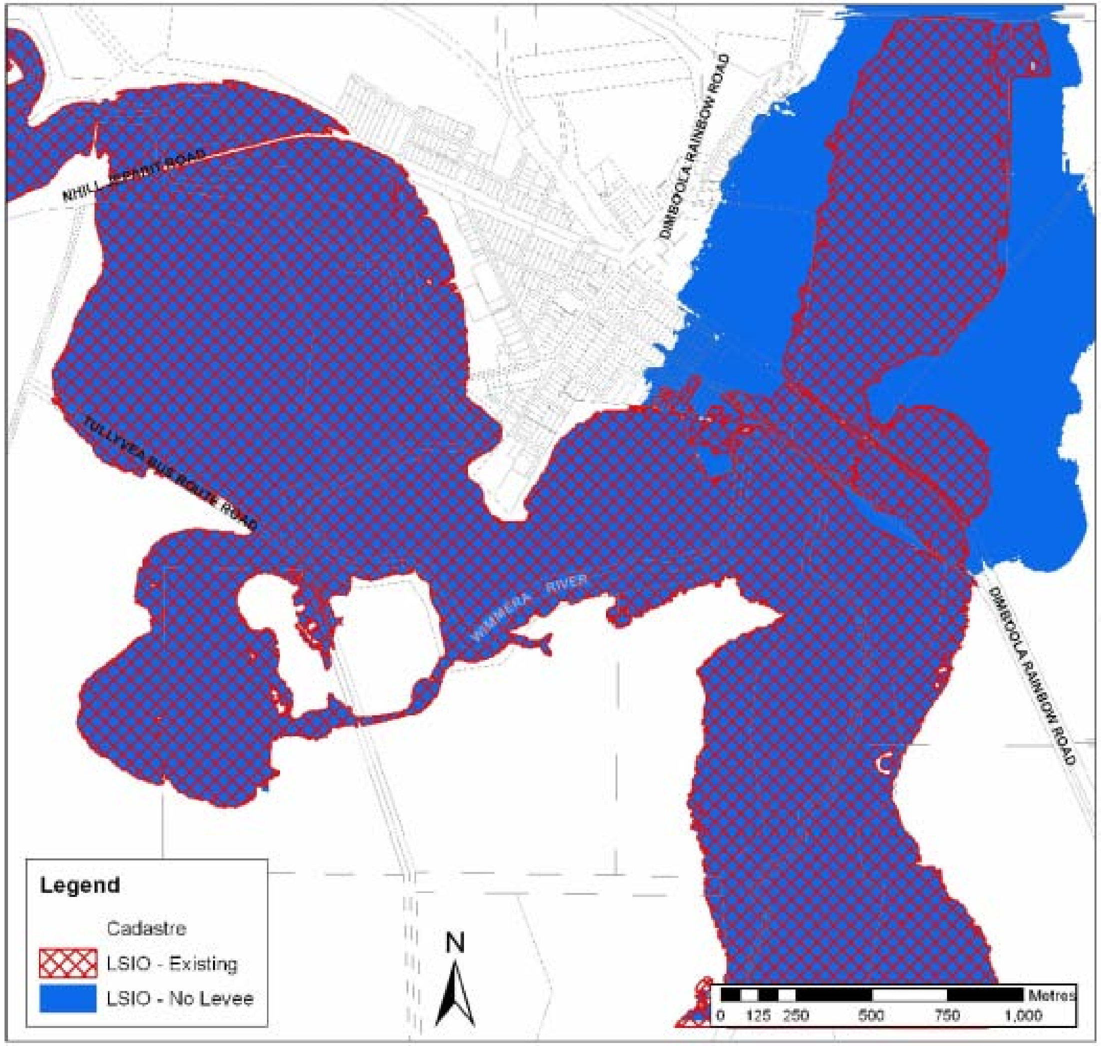

Figure 9-5 Jeparit – Draft LSIO delineation options

Note: LSIO – no levee is recommended as LSIO delineation to be included in Planning Scheme amendment

Planning and Environmental Design has prepared a Draft Amendment for the Hindmarsh Shire Planning Scheme to enable the revised delineation of the flood related overlays determined by this study. Further, this Draft Amendment has revised the related provisions using outcomes from this flood study. The revised provisions aim to provide a clear and consistent basis of the assessment of development across the Wimmera CMA. The draft amendment enables the application of flood related planning overlays and provision across the entire Hindmarsh Shire.

The study team recommends that HSC adopt the draft LSIO and FO as the basis for a Planning Scheme Amendment. This Amendment will be prepared as part of the Floodplain Management Plan. Further, the study team recommend that Wimmera CMA provide the appropriate assistance to HSC to enable the timely adoption of the Planning Scheme Amendment.

9.3 Flood forecasting and warning

VFWCC (2005) identified flood warning system development priorities throughout Victoria and ranked the Wimmera River catchment second on a list of ten priority catchments.

The study team understands Wimmera CMA, in conjunction with local authorities in the Wimmera River catchment, including HSC, is undertaking a project to address a number of the concerns raised in VFWCC (2005) for the Wimmera Catchment.

The study team recommends that HSC and Wimmera CMA continue to actively pursue the completion of the Wimmera Flood Warning Upgrade project.

Given Jeparit's location, at the downstream end of the Wimmera River catchment, significant lead time is available before flooding commences. The hydrologic analysis showed that travel times for peak flows from Horsham (Walmer gauge) to Jeparit is generally 80 – 90 hours.

The flood maps prepared by this study have been linked to gauge heights and flows at the following gauges:

- Wimmera River at Walmer (Horsham)
- Wimmera River at Quantong Bridge
- Wimmera River at Upstream Dimboola
- Wimmera River at Lochiel Railway Bridge
- Wimmera River at Tarranyurk

The locations of the above gauges, which are close to Jeparit are shown in Figure 9-6.

Appendix D provides the flow correlations. This enables the interpretation of likely flood impacts from upstream flood data with improved flood response potential.

As part of the Wimmera Flood Warning Upgrade (2007/8) radio telemetry stream gauges are being installed/upgraded on the Wimmera River at Quantong and Dimboola (Wail). This will provide enhanced reliable real-time access increasing warning lead times and accurate prediction of flood levels.

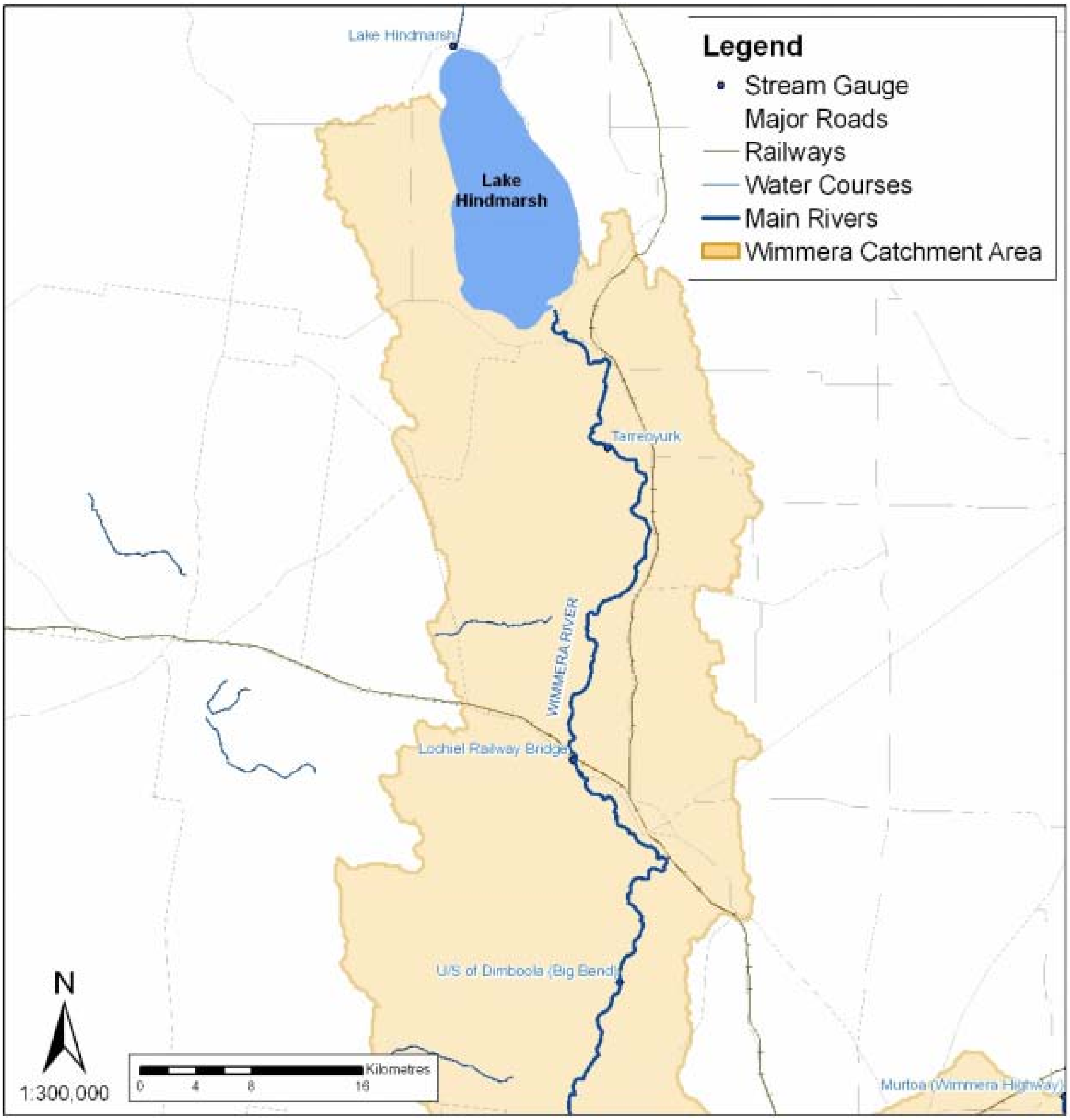

Figure 9-6 Lower Wimmera Catchment – Flood warning gauges

9.4 Flood response

Flood response for Jeparit is outlined in the Hindmarsh Municipal Emergency Management Plan (MEMP) and the accompanying Flood Sub-plan.

A revised Hindmarsh Shire sub-plan will be developed by Michael Cawood and Associates, and includes relevant information on local flood behaviour and intelligence from the existing conditions hydraulic analysis. In particular, the Flood Sub-plan will incorporate the flow correlations detailed in Section 9.3 and Appendix D.

The study team recommends that the study outcomes form the basis of a revised Flood Sub-plan as an integral part of the Hindmarsh MEMP.

10 STUDY CONCLUSIONS AND RECOMMENDATIONS

This section summarises the conclusions and recommendations arising from this study.

Hydrologic analysis

The study team acknowledges considerable uncertainty surrounding the design flood estimates developed by this study. Rigorous calibration and/or validation of the approach is restricted by the absence of streamflow data. The study team considers, while the absolute reliability of design estimates is unknown, the relativity of design estimates is considered reasonable.

Hydraulic analysis

Formal calibration of the hydraulic model has been limited, given the lack of reliable concurrent streamflow and flood level information. The study team undertook broad validation of the modelled design flood extents through community consultation and a comparison to flood photos. General community agreement with the modelled design flood extents was achieved.

A key factor influencing the model sensitivity is the water level of Lake Hindmarsh. Several model conditions were trialled to find the most probable lake level based on historical events. For this study it was assumed that the water level in Lake Hindmarsh was full. In times of lower lake levels, such as the present, much lower flood levels would be experienced in Jeparit.

The study team acknowledges considerable uncertainty surrounds the reliability of the flood extents for Jeparit.

Stormwater drainage

Generally, stormwater flooding is considered as "nuisance flooding" and does not present any immediate threat to property owners. Some limited deeper pooling is experienced in more defined low points surrounding the township which generally correlate to the areas flooded during levee overtopping. A large pool is also experienced at the intersection of Broadway and Lower Roy Street. The local stormwater drainage network may be able to remove much of this flooding.

The study team recommends HSC investigate potential measures to reduce local flooding impacts, particularly adjacent to the intersection of Broadway and Lower Roy Street

Structural mitigation measures

The study team considers the refurbishment and raising of the Museum levee warrants further investigation. This investigation will be undertaken as part of the Jeparit Floodplain Management Plan. Further, to limit backwater flooding, the HSC should consider installation of flap valves on stormwater drainage outfalls to the river.

Land use planning

The study team recommends that the draft flood related planning overlays form the basis of a draft Planning Scheme Amendment. This Amendment will be prepared as part of the Jeparit Floodplain Management Plan. Given low structural integrity of the levee, there is considerable potential of levee failure, in the case of the 100 year flood event. There are a number of areas along both levees that have been eroded and weakened by tree growth and rabbit burrows. To reflect this likelihood of failure, the draft LSIO without the levee is recommended as the draft LSIO.

Flood Warning

The study team recommends that HSC and Wimmera CMA continue to actively pursue the completion of the ***Wimmera Flood Warning Upgrade project.***

Flood Response

The study team recommends that the outcomes of this study form the basis of a revised Flood Sub-plan as an integral part of the Hindmarsh MEMP. This revised Flood Sub-plan will be prepared as part of the Jeparit Floodplain Management Plan.

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APPENDIX A FIELD SURVEY DATA – LEVEE AND WATERWAY CROSS SECTIONS

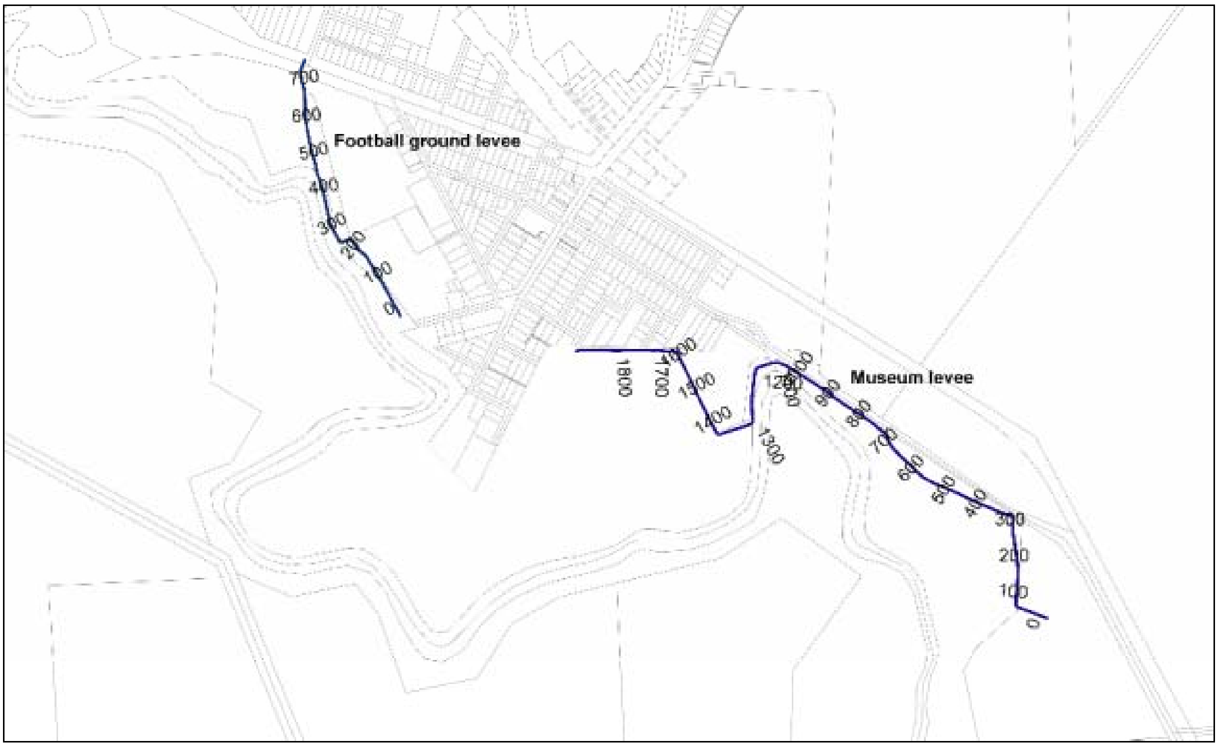


Figure A-1 Levee survey chainage

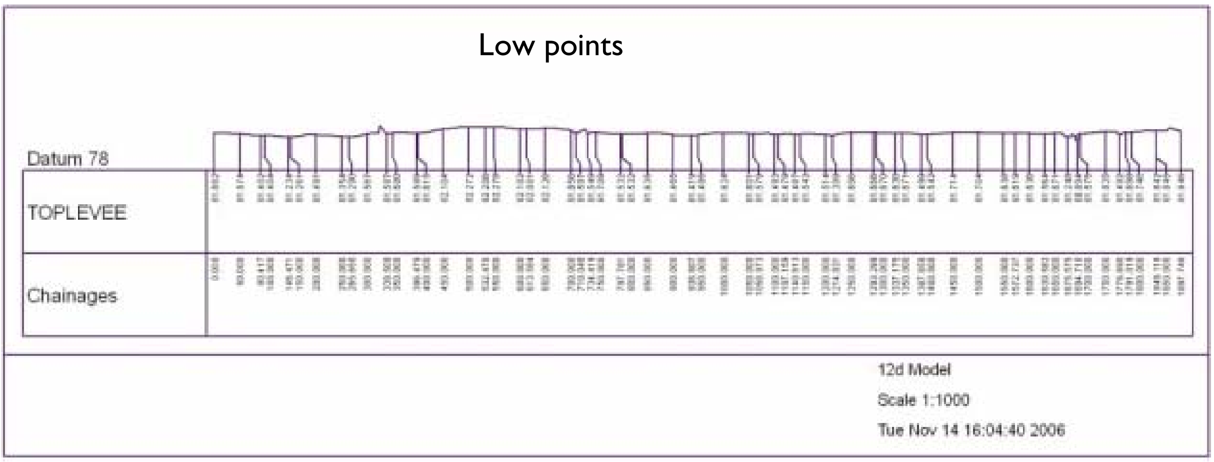


Figure A-2 Museum levee – long section

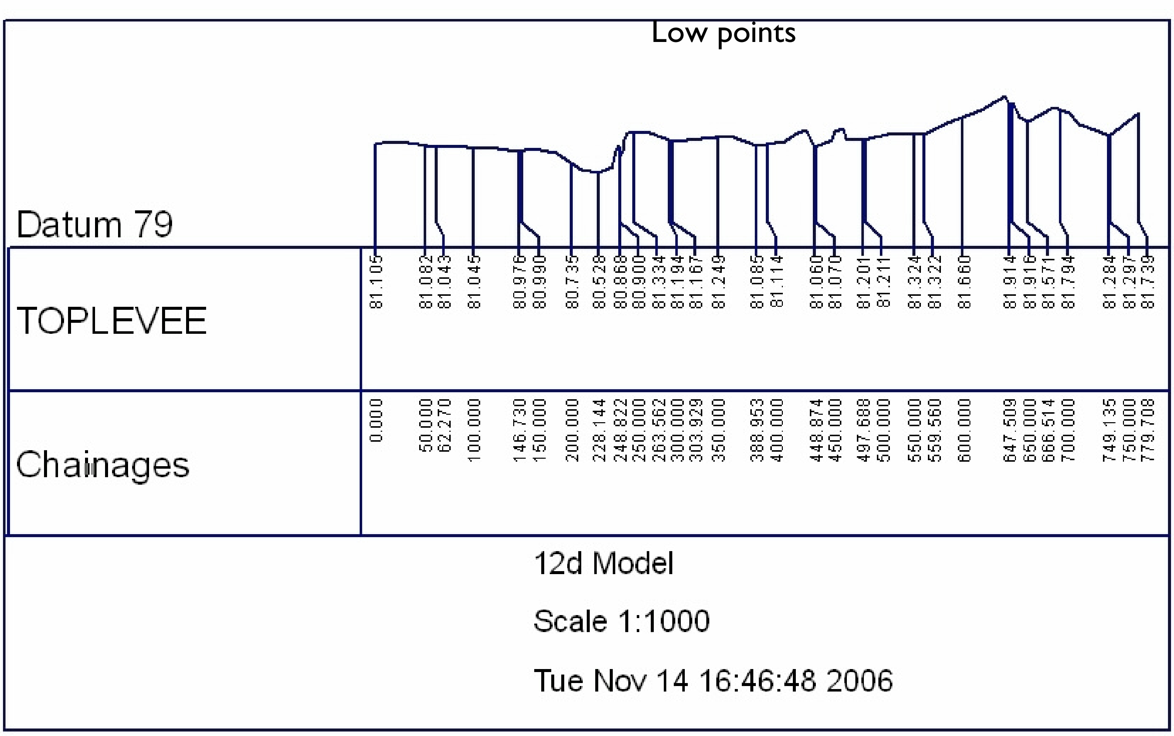


Figure A-3 Football ground levee – long section

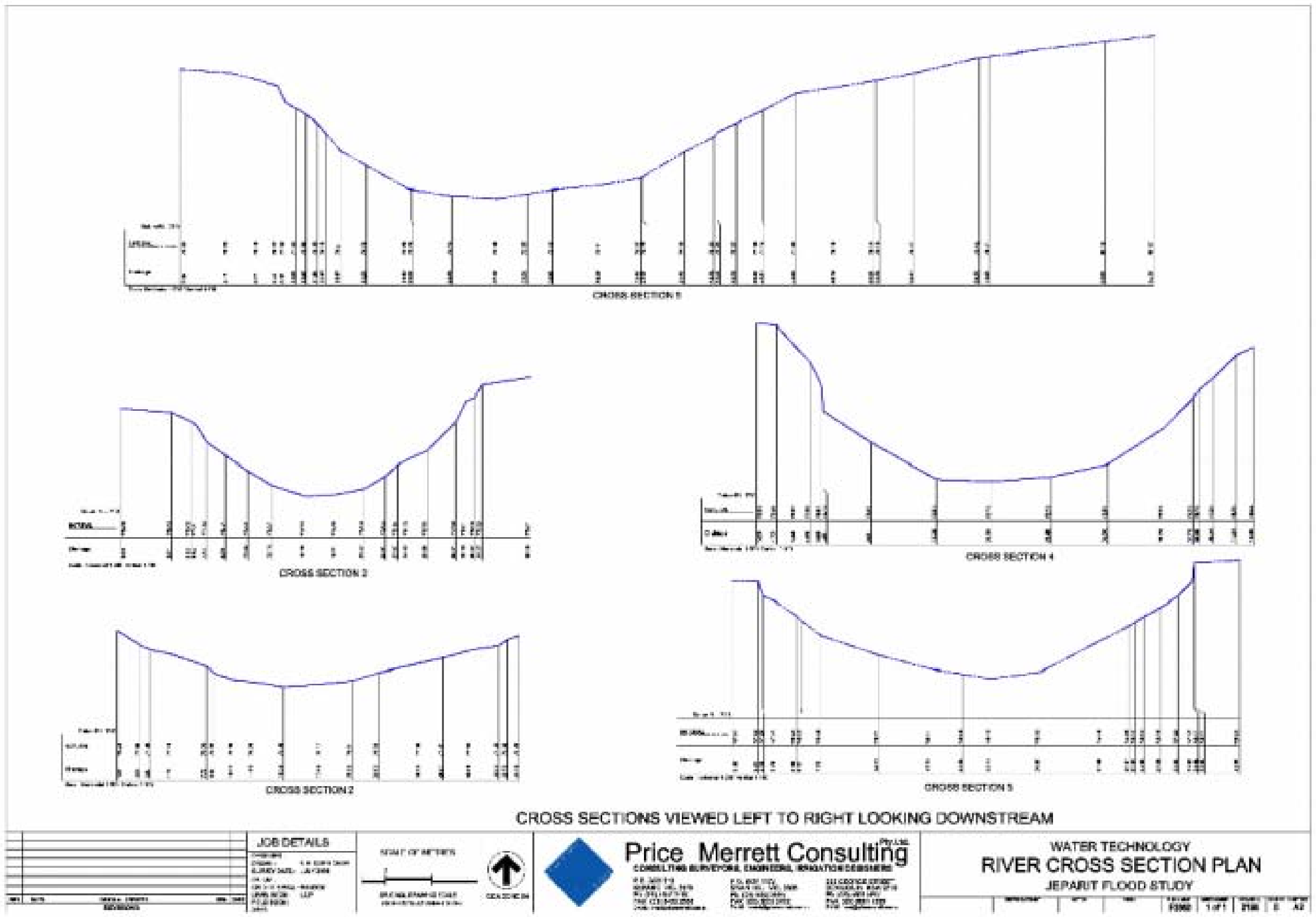


Figure A-4 Wimmera River – Survey cross sections

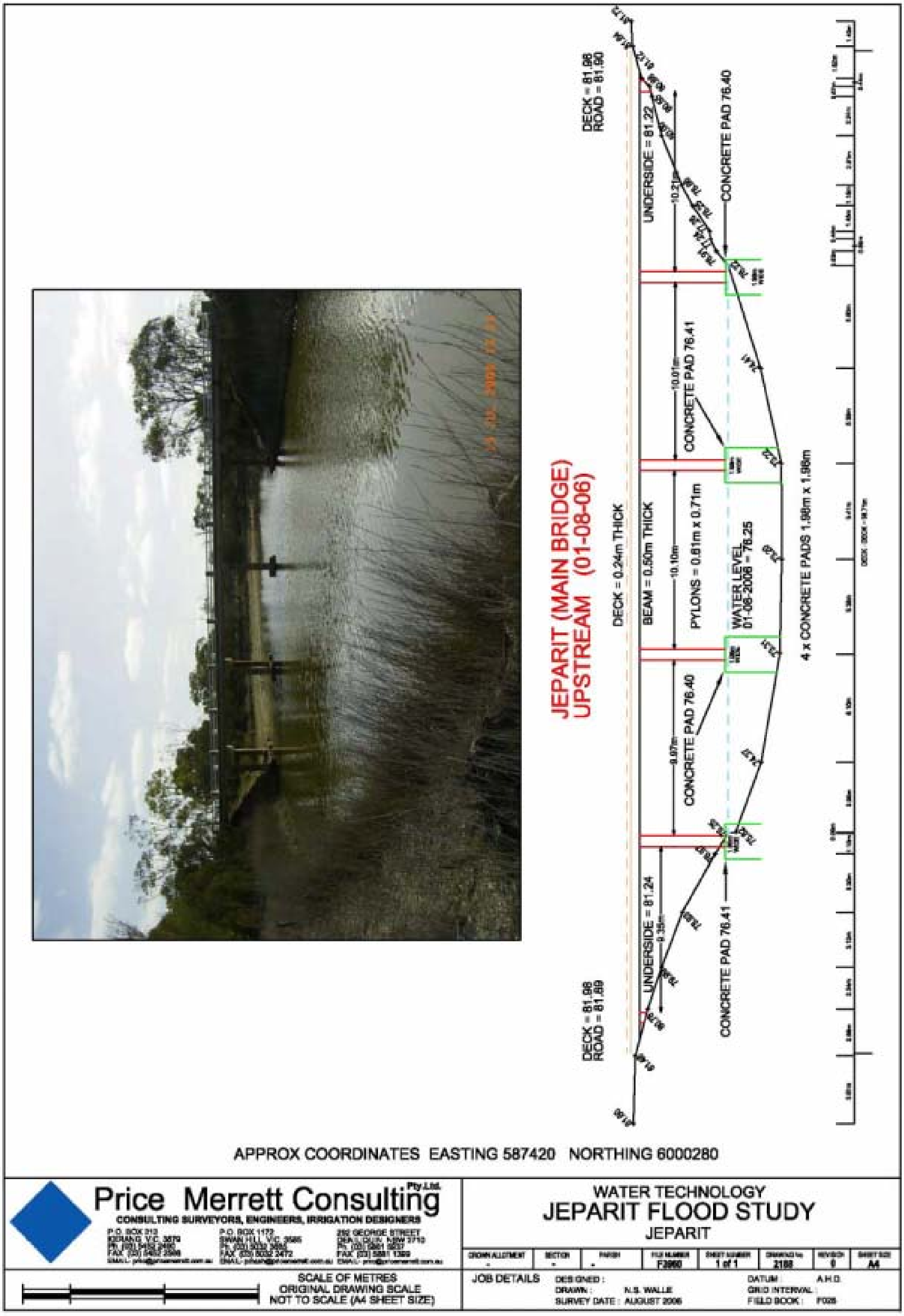


Figure A-5 Jeparit- Nhill Road Bridge

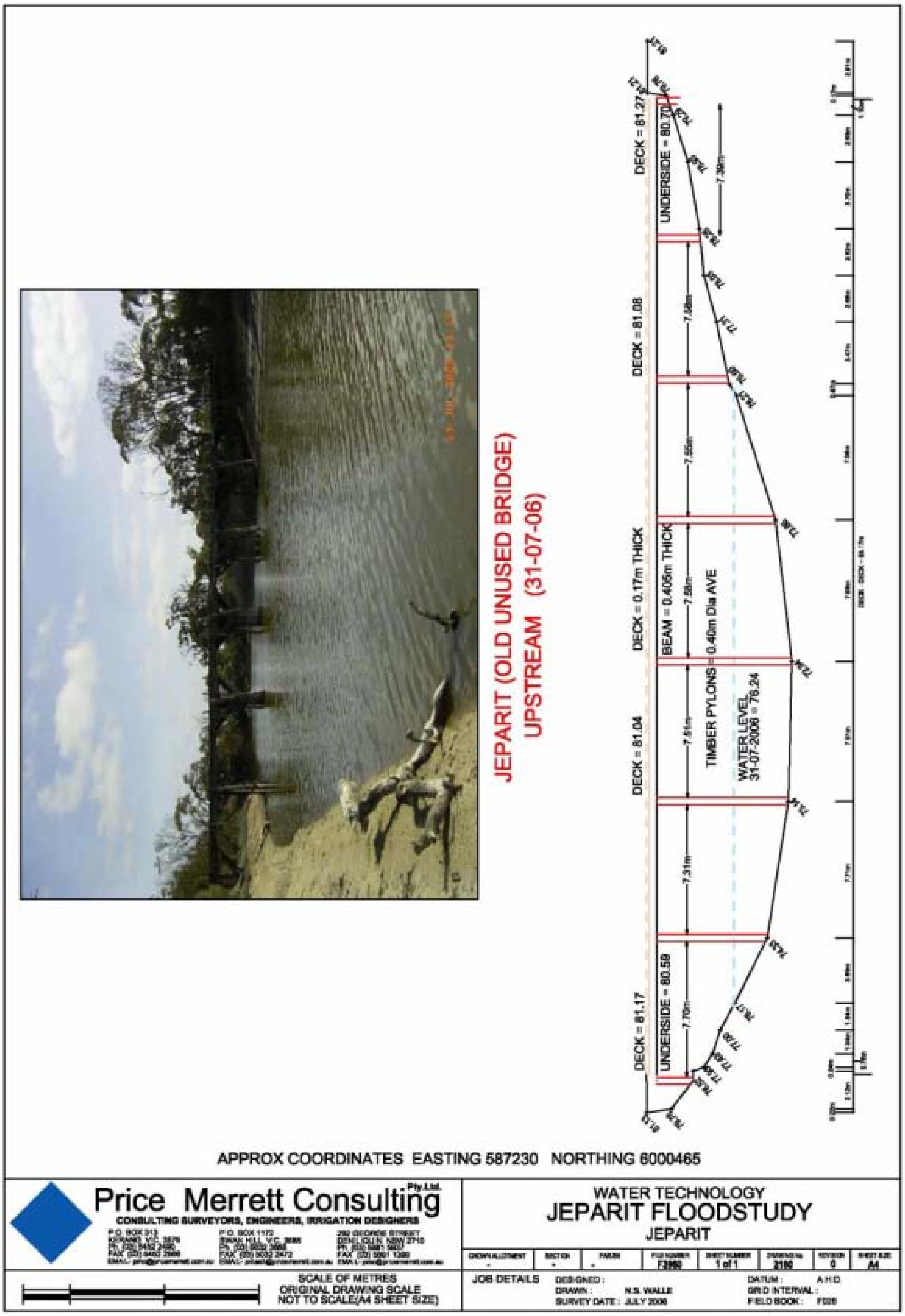


Figure A-6 Old Jeparit- Nhill Road Bridge

APPENDIX B DESIGN FLOOD HYDROGRAPHS WIMMERA RIVER AT JEPARIT

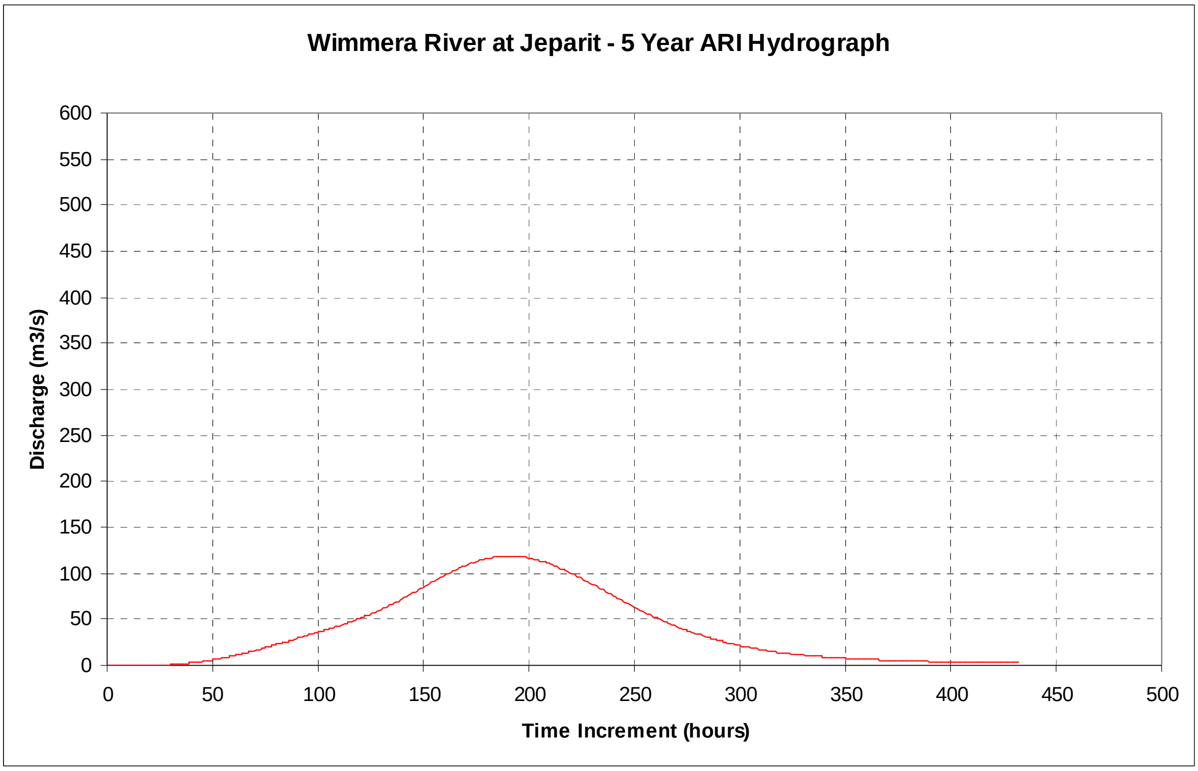


Figure B -1 5 year ARI Design flood hydrographs for the Wimmera River at Jeparit

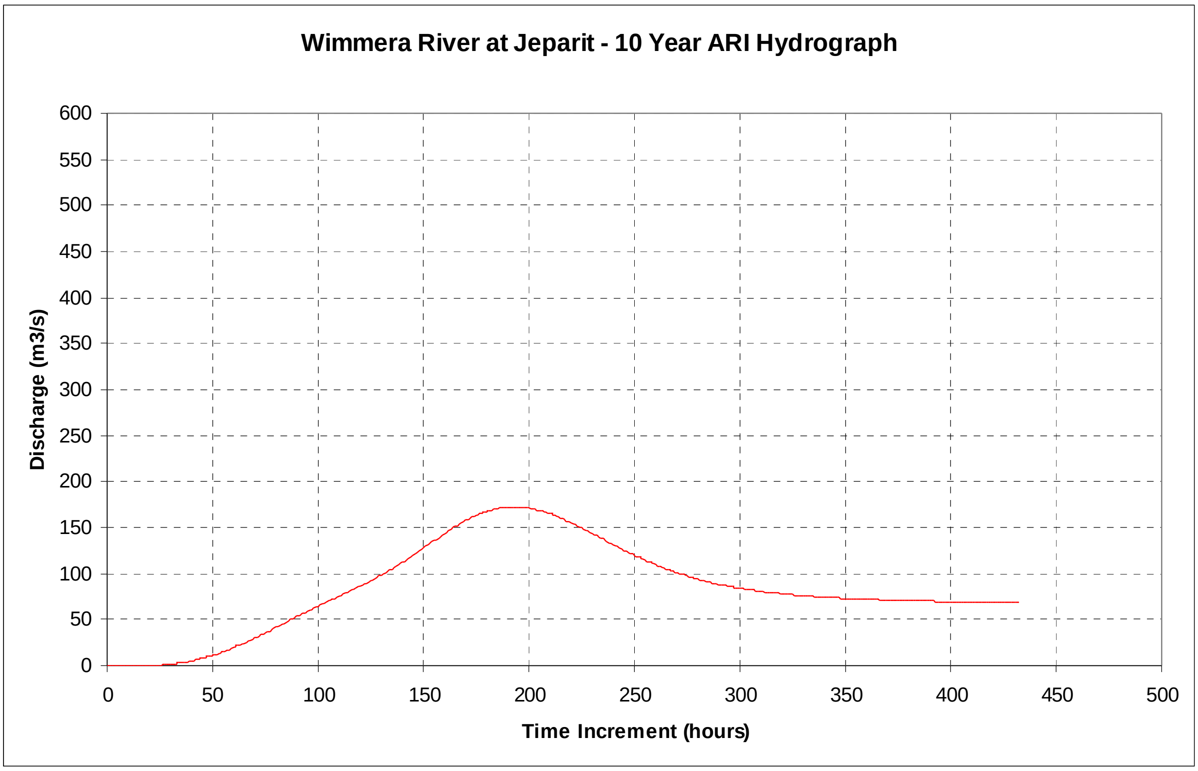


Figure B -2 10 Year ARI Design flood hydrographs for the Wimmera River at Jepairt

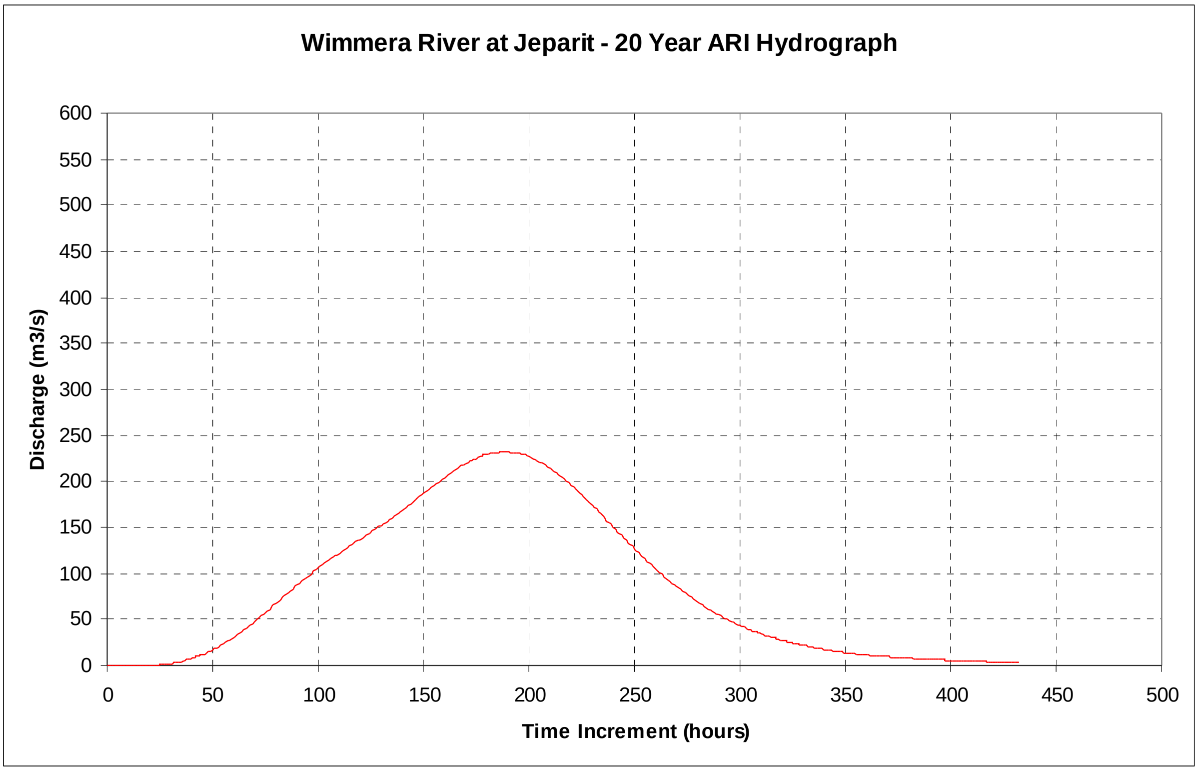


Figure B -3 20 Year ARI Design flood hydrographs for the Wimmera River at Jepairt

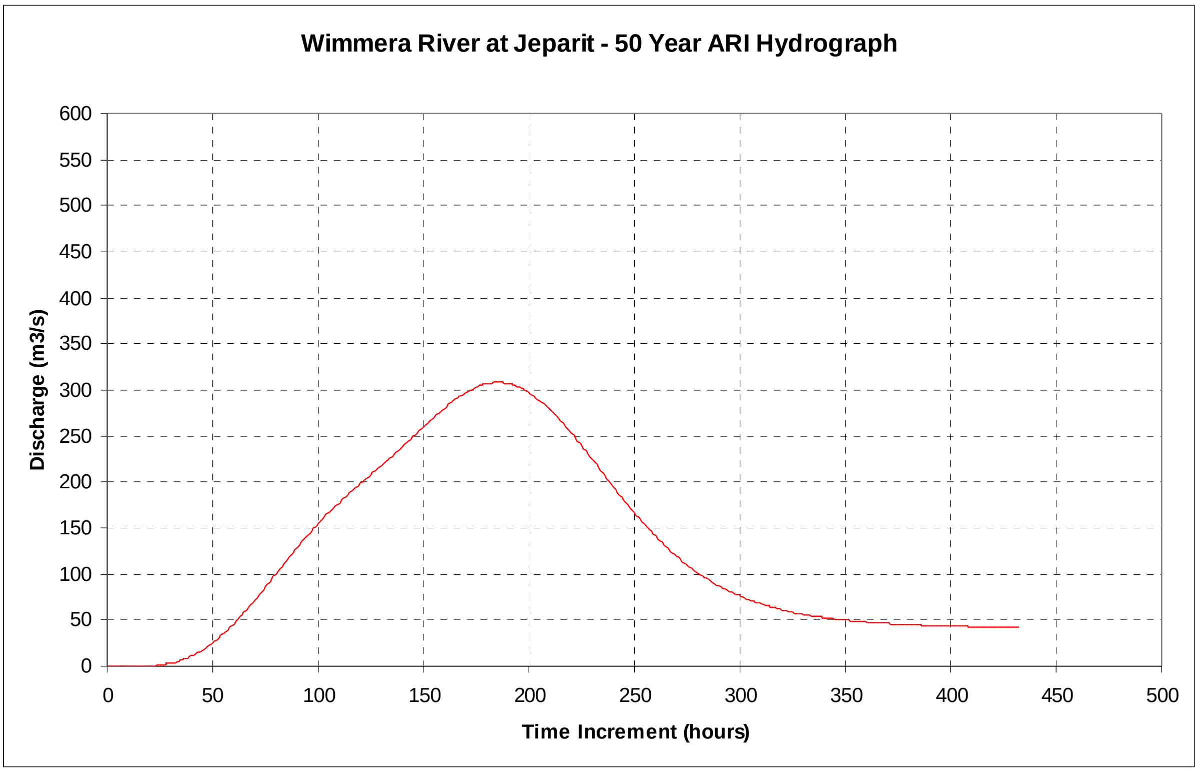


Figure B -4 50 Year ARI Design flood hydrographs for the Wimmera River at Jeparit

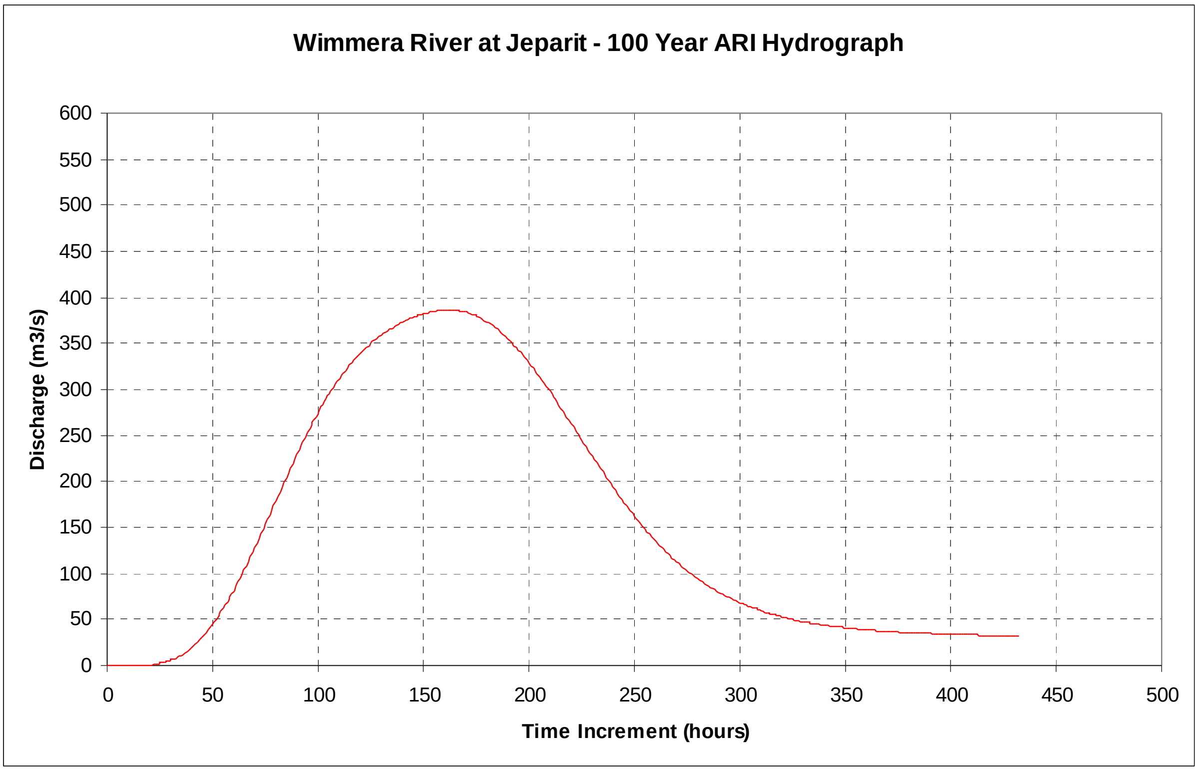


Figure B -5 100 Year ARI Design flood hydrographs for the Wimmera River at Jeparit

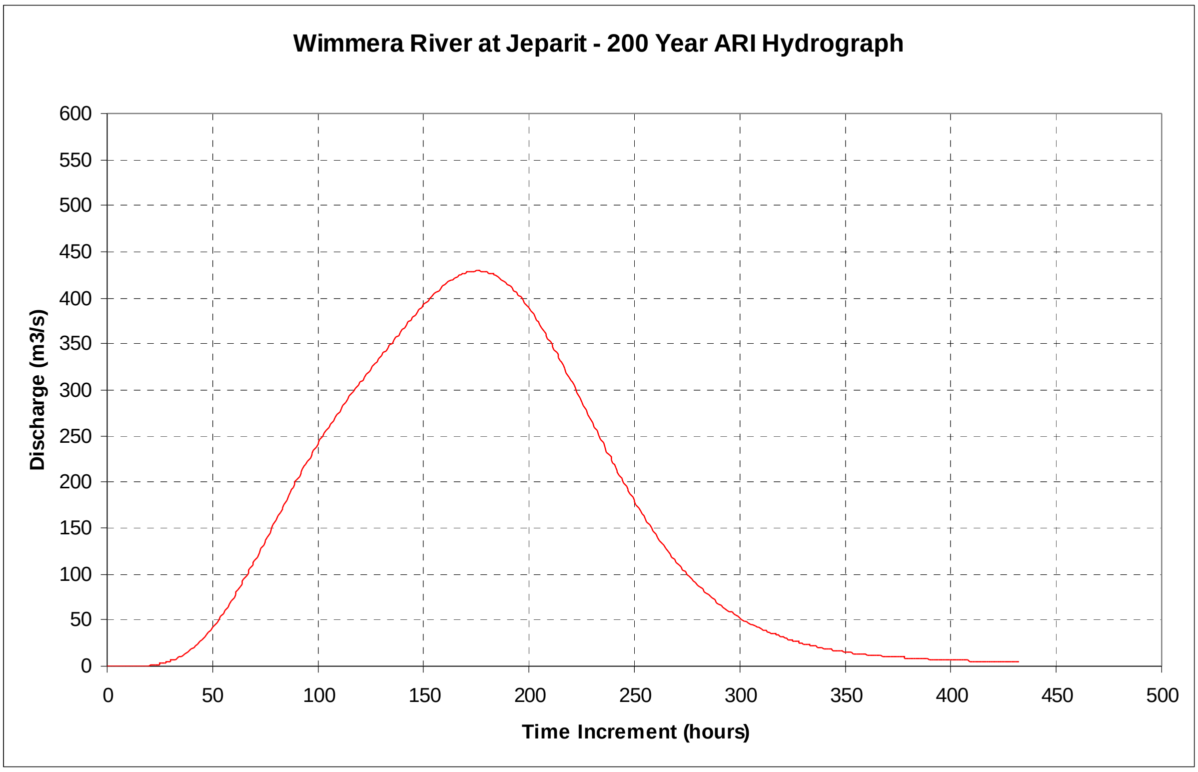
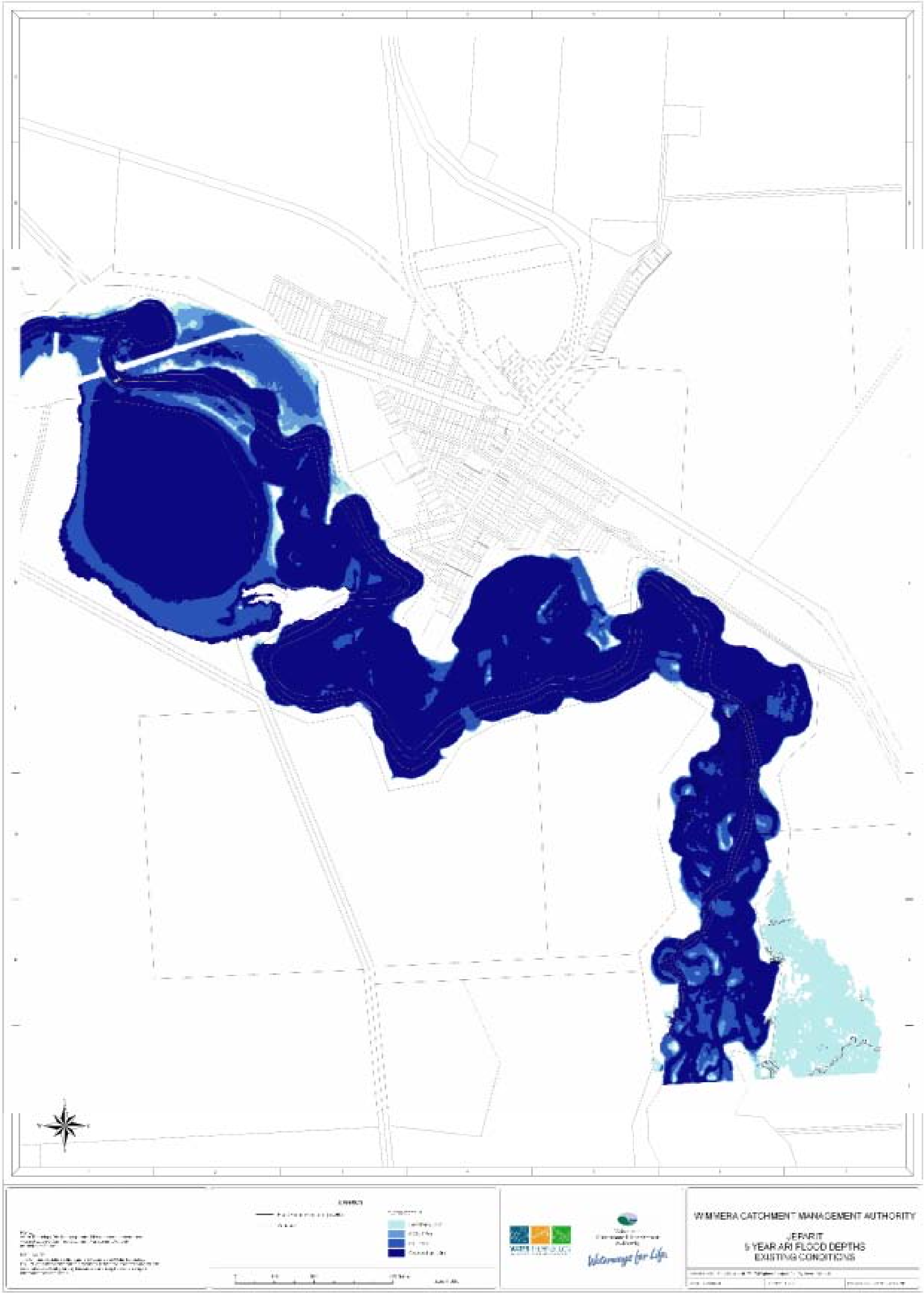


Figure B -6 200 Year ARI Design flood hydrographs for the Wimmera River at Jeparit

APPENDIX C FLOOD INUNDATION MAPS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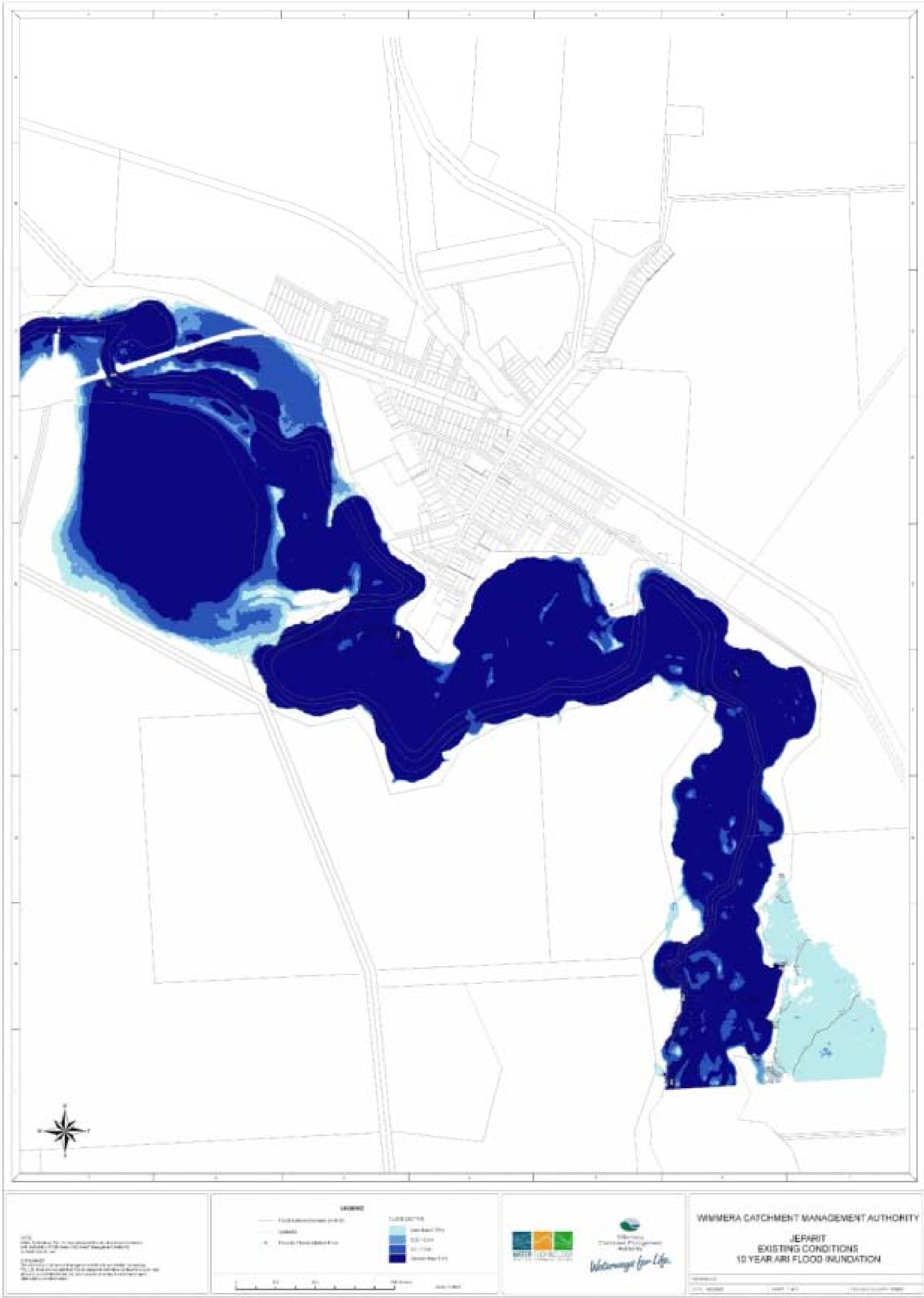
JEPARIT
5 YEAR ARI FLOOD DEPTHS
EXISTING CONDITIONS
Waterways for Life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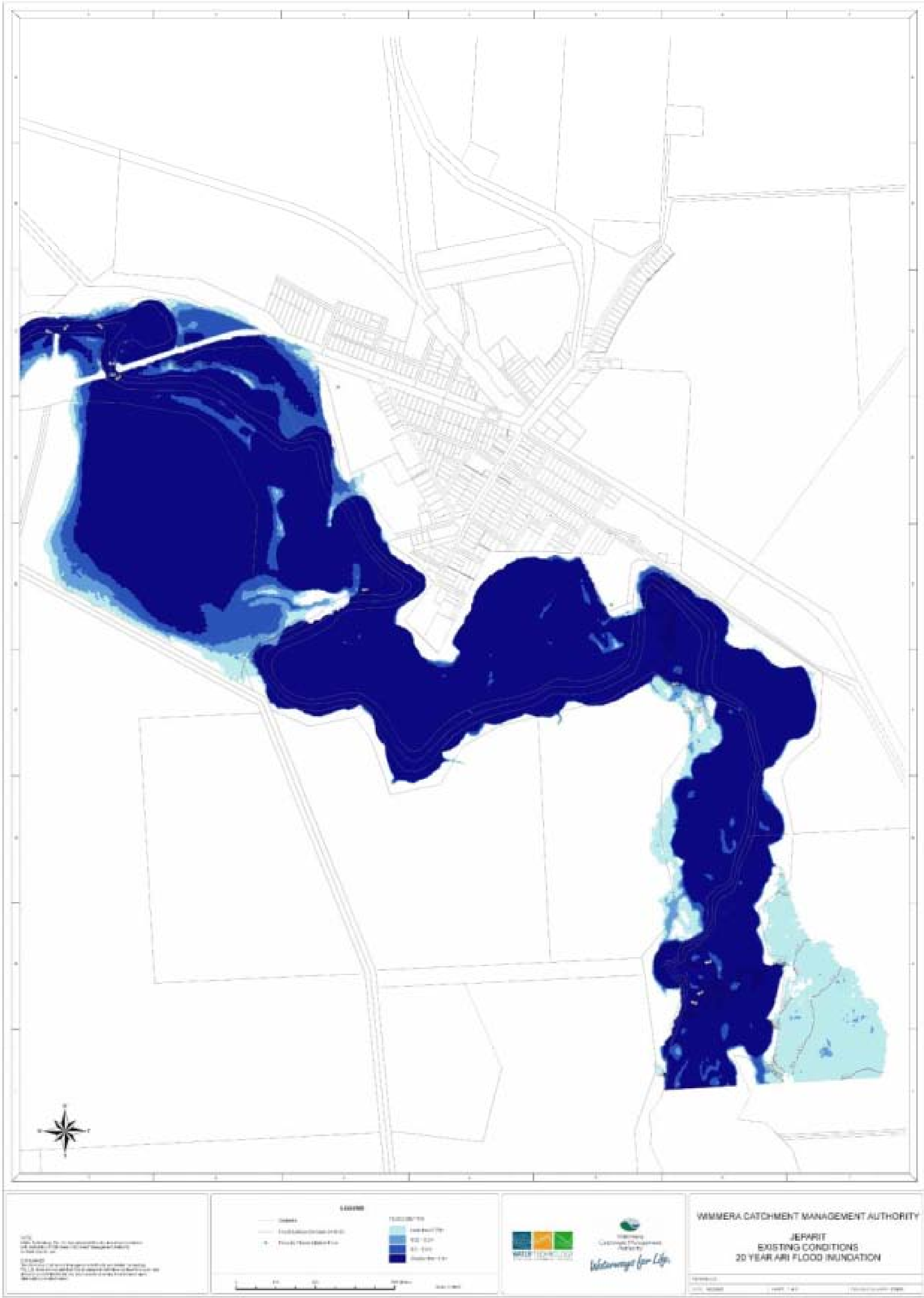
JEPARIT
EXISTING CONDITIONS
10 YEAR ARI FLOOD INUNDATION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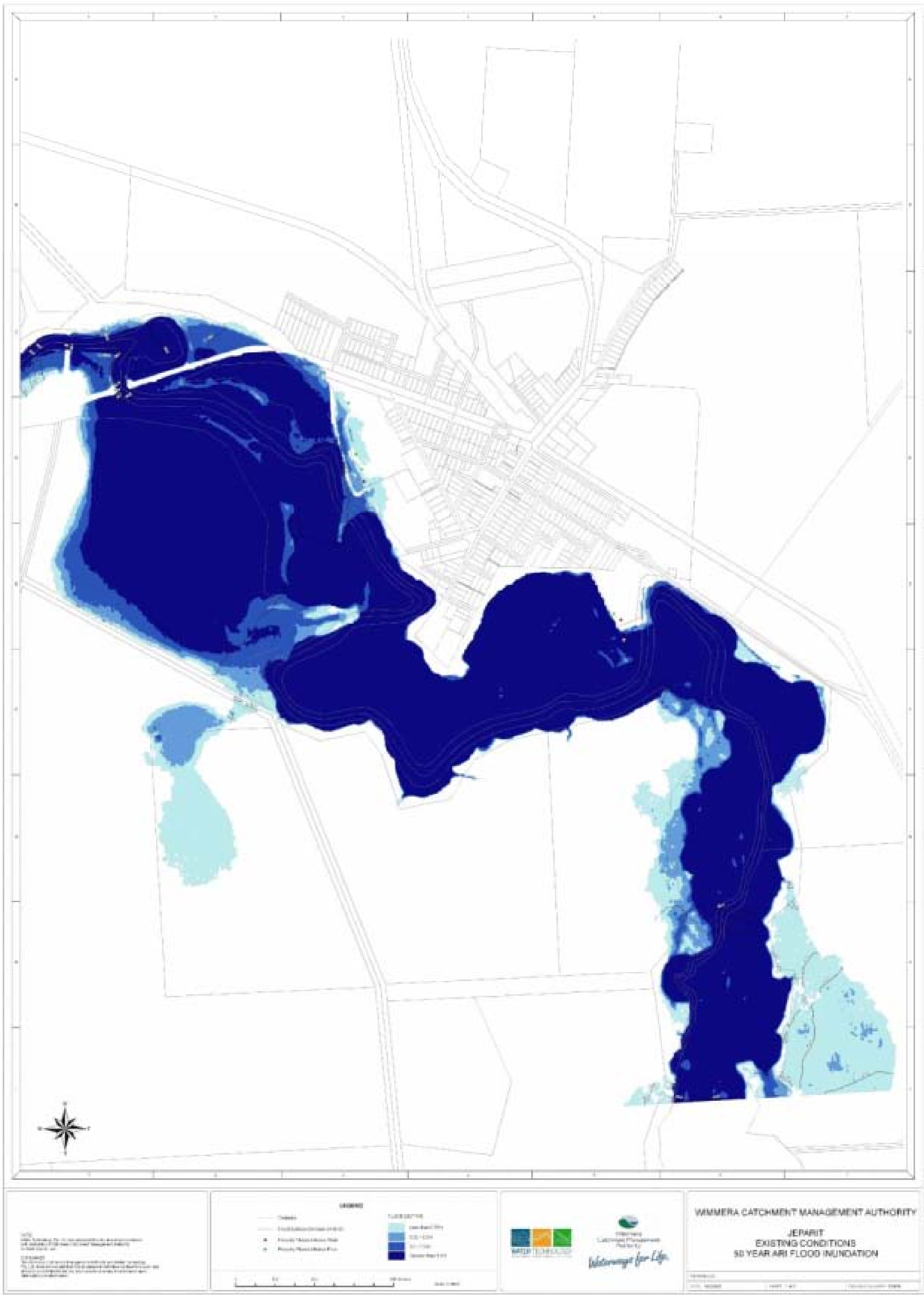
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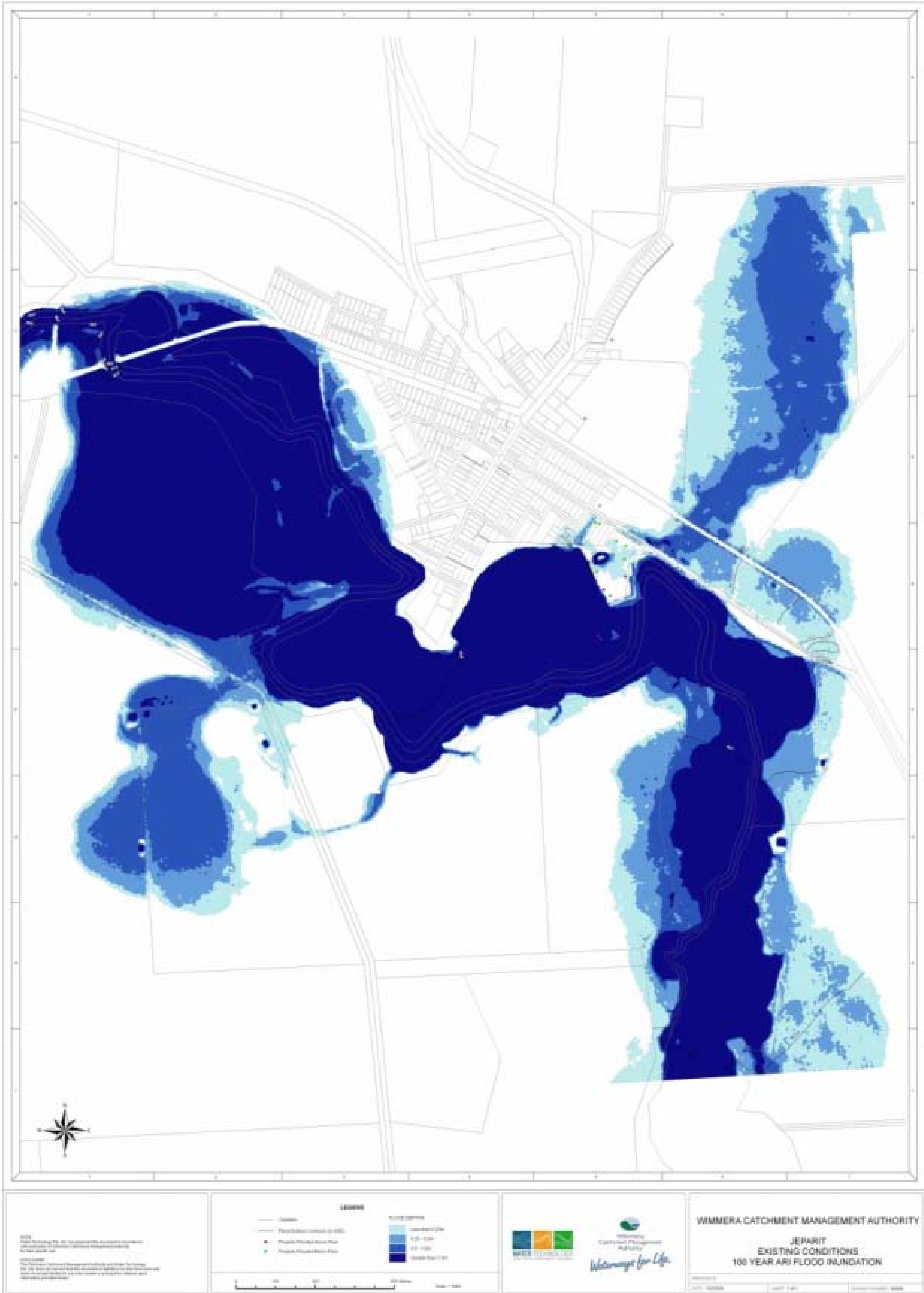
50 YEAR ARI FLOOD INUNDATION
Watercourse for Life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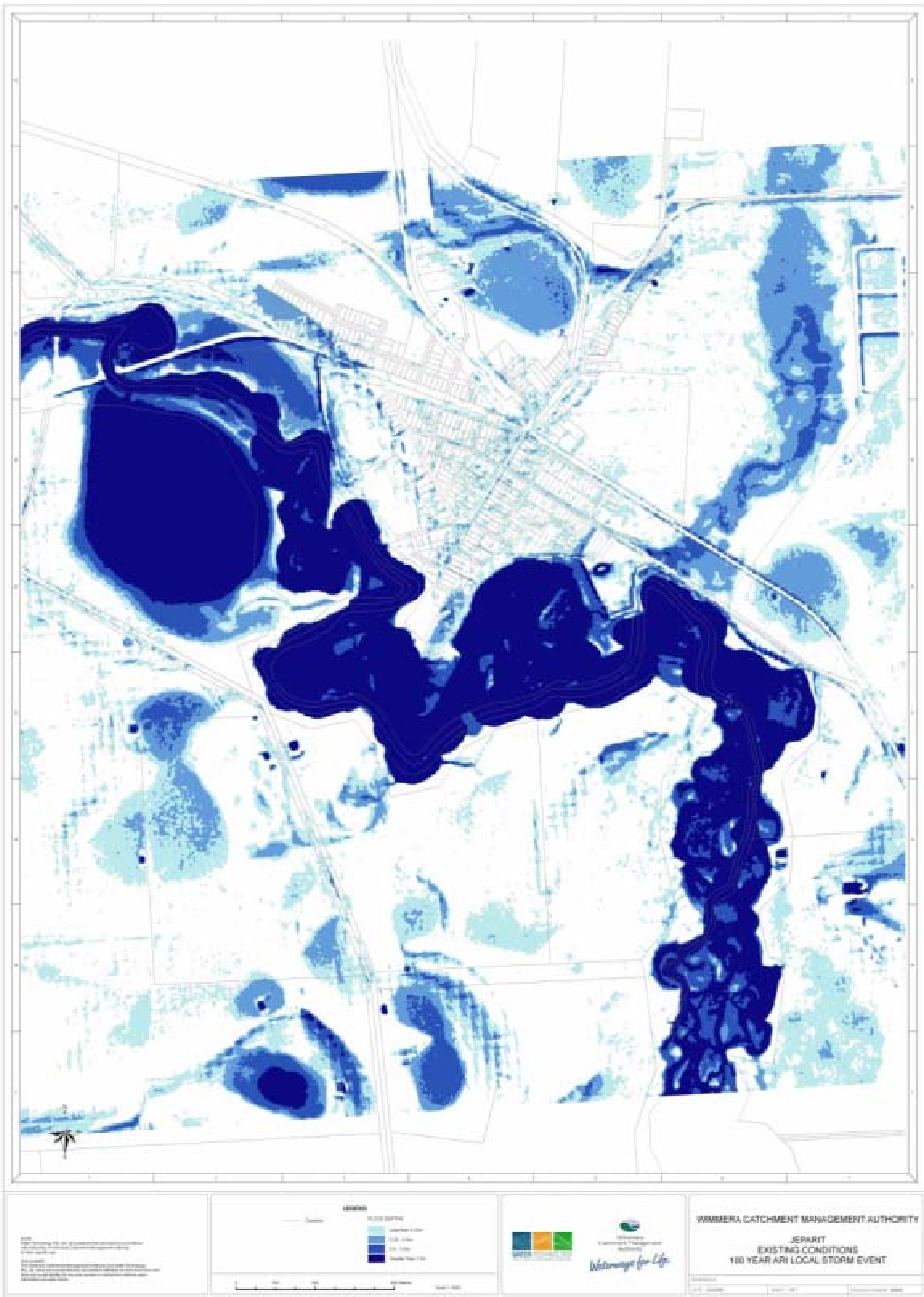
100 YEAR ARI FLOOD INUNDATION
Waterways for Life.


LEGEND
WIMMERA CATCHMENT MANAGEMENT AUTHORITY
JEPARIT
EXISTING CONDITIONS
100 YEAR ARI LOCAL STORM EVENT
Waterways for Life

APPENDIX D FLOOD FORECAST CORRELATIONS

Wimmera River downstream of Horsham
Peak flow corelations

Design event	HORSHAM (C) Flow (ML/d)	HORSHAM (C) Flow (m3/s)	HORSHAM (C) Stage (m)	QUANTONG_BRIDGE (C) Flow (ML/d)	QUANTONG_BRIDGE (C) Flow (m3/s)	QUANTONG_BRIDGE (C) Stage (m)	Travel time for peak flow from Horsham	DIMBOOLA (C) Flow (ML/d)	DIMBOOLA (C) Flow (m3/s)	Travel time for peak flow from Quantong Bridge
5	13066	151	3.3	13206.24	152.85	1.53	16	12862	149	20
10	18293	212	3.47	18551.808	214.72	2.15	16	18120	210	20
20	23872	276	3.61	24382.08	282.2	2.82	15	23872	276	20
50	31163	361	3.72	31923.072	369.48	3.69	15	31279	362	20
100	32408	375	3.74	34979.904	404.86	4.05	15	37040	429	20
200	42391	491	3.85	43855.776	507.59	5.08	15	43034	498	19

Design event	LOCHIEL RAILWAY (C) Flow (ML/d)	LOCHIEL RAILWAY (C) Flow (m3/s)	Travel time for peak flow from Dimboola	ANTWERP (C) Flow (ML/d)	ANTWERP (C) Flow (m3/s)	Travel time for peak flow from Lochiel	TARRENYURK (C) Flow (ML/d)	TARRENYURK (C) Flow (m3/s)	Travel time for peak flow from Antwerp
5	11404	132	18	10708	124	15	10489	121	9
10	16313	189	18	15460	179	15	15460	176	10
20	21773	252	16	20745	240	15	20408	236	9
50	28724	332	16	27466	318	14	27053	313	9
100	34421	398	15	33866	392	13	33644	389	9
200	39844	461	15	38221	442	13	37676	436	9

Design event	JEPARIT (C) Flow (ML/d)	JEPARIT (C) Flow (m3/s)	Travel time for peak flow from Tarrenyurk	Travel time for peak flow from Horsham
5	10246	119	10	88
10	14907	173	10	89
20	20036	232	10	85
50	26598	308	9	83
100	33358	386	8	80
200	37071	429	10	81