Warracknabeal and Brim Flood Investigation - Flood Warning Assessment and Recommendations Report

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-Victoria State Emergency Service
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Executive summary

The objectives of this part of the Warracknabeal and Brim Flood Investigation are to:

1. conduct an assessment of the existing total flood warning system (TFWS) for the investigation area
2. recommend improvements to the existing TFWS based on the assessment.

In Australia, the concept of the TFWS has been used to describe the full range of elements that must be developed if flood warning services are to be provided effectively. Guidance relating to the development and assessment of the TFWS has been provided by the Australian and Victorian governments.

Molino Stewart was commissioned by Water Technology to conduct this part of the investigation. It consulted with communities in the study area along Yarriambiack Creek. It consulted other stakeholders including the Bureau of Meteorology (BoM), Victoria State Emergency Service (VICSES), Wimmera Catchment Management Authority and Yarriambiack Shire Council. It also used data from the 2015 flood investigation conducted by Water Technology and demographic data sources such as the Australian Bureau of Statistics.

Based on the results of this consultation and other data sources, the following components of the TFWS were assessed in relation to the TFWS guidance provided by the Australian and Victorian governments. The following components were assessed:

- Understanding the flood risk
- Emergency management planning
- Community flood education
- Data collection including location and use of rain gauges and stream gauges
- Prediction
- Interpretation
- Message construction
- Message communication
- Response
- Community participation
- Review of the TFWS
- Integration of the TFWS components.

The assessment found that there are several days of potential flood warning lead time for Warracknabeal and Brim based on a gauge near the Yarriambiack Creek offtake to the Wimmera River. This means that there is plenty of time for the BoM to disseminate flood watches and flood warnings including through local radio and other communication mediums. There is also ample time for a local or regional incident control centre to be established, for it to interpret data including from the recent flood study, and construct and communicate warning messages to communities in the study area.

Community flood education was found to be a TFWS component that required significant improvement. A streamflow gauge immediately upstream from Warracknabeal would provide improved accuracy and reliability of flood warnings to Warracknabeal, Brim and outlying properties downstream. An upgraded Municipal Flood Emergency Plan is required based on the recent flood investigation and will provide details of the impact of different flood levels on properties and road closures.

The communities in the area appear to have a high level of social capital (networks, norms and trust), a proven ingredient for successful flood warning response and broader resilience. This was demonstrated in the 2011 flood by the community effort to protect themselves and others. However, the downside of social capital is that some people may be excluded by virtue of their lack of social networks e.g. possibly a section of Brim township, disabled people. It is important that these people are included and engaged in the warning response in the study area.

Even if a permanent levee is constructed in Warracknabeal similar to the temporary levee for the 2011 January flood event, communities along the Yarriambiack Creek system will still require a well-developed TFWS. There is the risk that the levee could fail and/or be overtopped. Furthermore, although people may not be directly affected by flooding they still may be isolated for several days and take risks during that time e.g. attempt to drive through flooded roads. There is also the need to move stock to higher ground early and protect property (e.g. pumps, sheds) if possible.

From this assessment, the following recommendations are made to improve the TFWS in the study area:

Recommendation 1: Provide readily available details to local communities of their flood risk through the Wimmera CMA websites, Section 32 certificates and ongoing community education.

Recommendation 2: The Yarriambiack Shire Council Flood Response Plan be upgraded to a Municipal Flood Emergency Plan and include reference to the latest flood study.

Recommendation 3: The Warracknabeal Caravan Park emergency plan be updated to include reference to the latest flood study.

Recommendation 4: Educate the communities in the study area about aspects of the TFWS including their flood risk, local flood warning triggers for action and the warnings that they will receive if a flood is imminent.

Recommendation 5: A new streamflow gauge with telemetry be installed at the Ailsa Road crossing of Yarriambiack Creek.

Recommendation 6: BOM provide flood forecasting at the Jung and Ailsa Rd (when installed) gauges and, in the interim, provide detailed information to all agencies to determine flood forecasting using charts that relate stream height to AEP, and timing of flood flows to AEP.

Recommendation 7: Combine the old Jung gauge rating (for low flows) with new rating (for flood flows).

Recommendation 8: Further develop the flood crowdsourcing program to enable people to provide real-time flood height observations to the ICC.

Recommendation 9: Establish a 'phone tree' or similar localised communication method for isolated properties in the vicinity and downstream of Brim.

Recommendation 10: Explore the possibility of Warracknabeal CFA siren as an extra warning mechanism.

Recommendation 11: Explore the possible uptake of a localised smartphone flood warning app for the study area.

Recommendation 12: Move the gauge boards at Lah a location that can be viewed during time of flood.

Recommendation 13: Ensure that all people requiring assistance in Yarriambiack Shire are in the Vulnerable Persons Register.

Recommendation 14: Engage (e.g. by doorknocking) with all people in the Brim community if a flood is imminent.

Recommendation 15: Identify and implement ways for community members in the study area to participate in the establishment, operation and review of the TFWS.

Recommendation 16: Describe the integration of the local TFWS at least in the new Yarriambiack MFEP.

Recommendation 17: Ensure that the integration of the TFWS is included as part of future TFWS reviews in the study area.

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1. Introduction

1.1. Total Flood Warning Systems

"Flood warning systems are developed with the fundamental aim of increasing safety and reducing the harmful effects of floods (referred to as 'damages' or 'losses'). The extent of losses avoided as a result of a warning is therefore the key measure of warning system effectiveness." (Molinari and Handmer, 2011, p. 23)

In practice, flood warning systems provide individuals and communities with time to carry out actions to protect themselves, and if possible, aspects of their properties including stock and pets.

As part of best practice in flood risk management in Australia, flood prediction and warning is viewed as an important treatment option for residual flood risk for existing and future development in the floodplain (Australian Emergency Management Institute, 2013, page 82).

In Australia, the concept of the 'total flood warning system' (TFWS) has been used to describe the full range of elements that must be developed if flood warning services are to be provided effectively. The lead guiding document for the development of the TFWS in Australia is Manual 21 – Flood Warning (Attorney-General's Department, 2009).

According to Manual 21 (page 6), at its simplest, the TFWS consists of six components:
1. Prediction - Detecting changes in the environment that lead to flooding, and predicting river levels during the flood.
2. Interpretation - Identifying in advance the impacts of the predicted flood levels on communities at risk.
3. Message Construction - Devising the content of the message which will warn people of impending flooding.
4. Communication – Disseminating warning information in a timely fashion to people and organisations likely to be affected by the flood.
5. Response - Generating appropriate and timely actions from the threatened community and from the agencies involved.
6. Review - Examining the various aspects of the system with a view to improving its performance.

Manual 21 (page 7) stresses that for the TFWS to "work effectively, these components must all be present and they must be integrated rather than operating in isolation from each other."

When designing a TFWS, Manual 21 (pages 7-8) advises that the following points need to be addressed:

- The system must meet the needs of its clients including identifying:
  - levels of flooding at which warnings are required
  - the impacts at the different levels of flooding
  - warning time the community requires and what can be provided
  - appropriate subject matter content for warning messages
  - the ways in which warning messages are to be disseminated
  - the frequency of warning updates.
- The system must be part of the emergency management arrangements established by the relevant State or Territory as defined in disaster or emergency management plans.
- The review of the system must be carried out by all emergency agencies and by the community itself.
- The roles of the emergency agencies must be clearly defined for each component of the system.
- The system must be incorporated into the wider floodplain management.
- The system should be regularly tested and maintained.

Some researchers such as Molino et al (2011) believe that there are additional preliminary components required for an effective TFWS, including understanding the flood risk that the TFWS operates under, the impact of prior community flood education and the guidance provided by emergency management action plans (e.g. Municipal Flood Emergency Plans). This more holistic TFWS framework is shown in Figure 1 and is adopted for analysis in this project.

In relation to Figure 1, Molino et al (2011) note that "it is important to realise that the diagram is imperfect and does not reflect the significant amount of iteration which is required for each of the components to be done well and properly aligned with the others". They add that "each of these warning system parts can work well or can work poorly or at worst, not work at all. The overall effectiveness of the warning can only be as strong as the weakest link in the chain and, unlike a real chain, errors or weaknesses can accumulate as they are passed along the chain e.g. poor data plus poor interpretation can be worse than either poor data or poor interpretation."

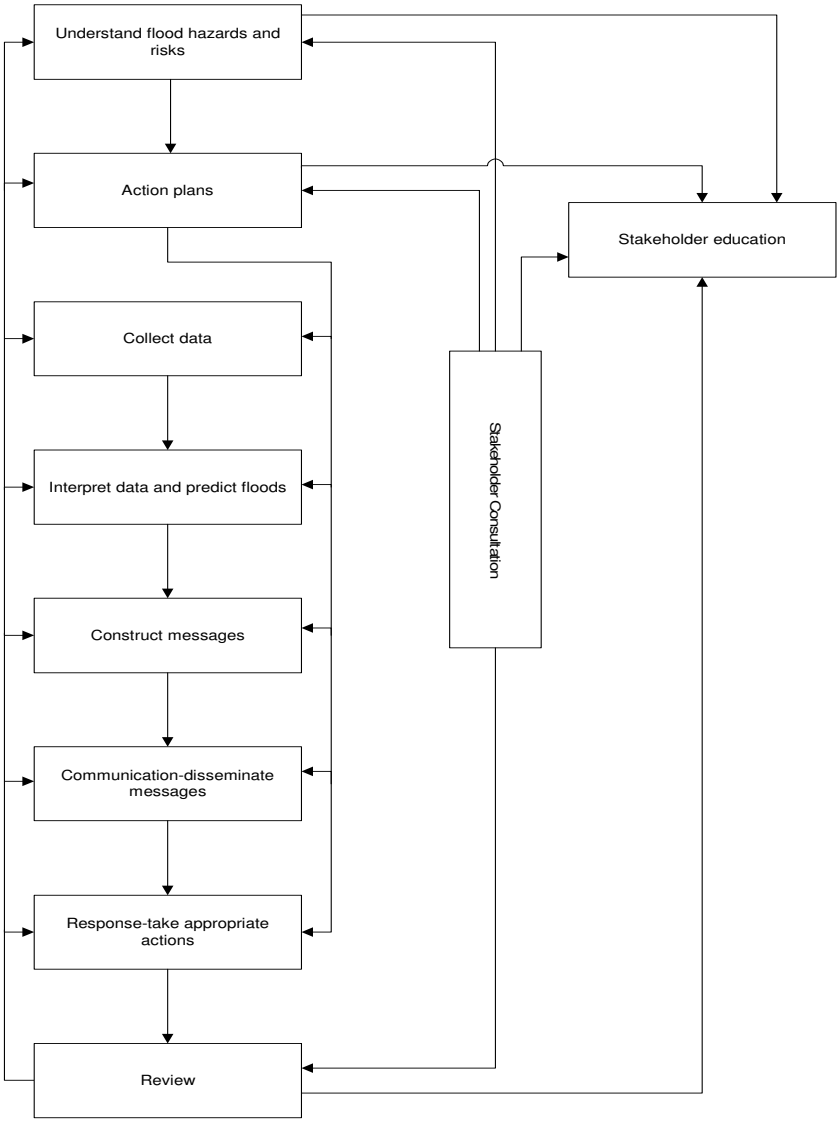

Figure 1: The Total Flood Warning System (source: Molino et al, 2011)

1.2. Flood warning in Victoria

Specific control and coordination arrangements during an emergency, including flood, are outlined in the Emergency Management Manual Victoria (EMMV). It responds to the *Emergency Management Act 1986* and the *Emergency Management Act 2013*.

This manual contains procedures for dealing with emergencies of all sizes and includes arrangements that cater for those events requiring multi-agency action, including those requiring participation from both state and commonwealth agencies. The EMMV identifies the Victoria State Emergency Service (VICSES) as the agency nominated to control response activities to a flood in Victoria. It outlines the responsibilities of local councils in preparing Municipal Emergency Management Plans. The EMMV also details the responsibilities of several other agencies involved in flood management such as the Bureau of Meteorology (BoM), Department of Environment, Land, Water & Planning (DELWP) and Catchment Management Authorities (CMAs).

The responsibility for issuing flood warnings resides with the BoM and VICSES. Under the current institutional arrangements, the BoM is the organisation charged with the primary responsibility for weather forecasting and flood prediction. The BoM constructs flood warning messages for selected streams throughout Victoria with the exception of those streams within the area delegated to Melbourne Water. The nature of these predictions or warnings depends on

the quality of the information available to the BoM or Melbourne Water, including data from rainfall and stream gauges owned by others (water corporations, local government, DELWP) throughout Victoria. VICSES issues subsequent information as Flood Bulletins which relate flood predictions to possible impacts on communities. Where stream gauges have no formal arrangement for the BoM to provide flood warnings, CMAs can provide flood intelligence advice derived from flood investigations to VICSES.

The Victorian Warning Protocol was established in 2009 and updated in 2013 to provide emergency response agencies with coordinated and consistent direction on advice and/or warnings to inform the Victorian community of a potential or actual emergency event.

"The Protocol is based on the all-hazards approach. Taking such an approach will reassure the community that regardless of the emergency type, any alerts or warnings disseminated will be authoritative, consistently constructed, timely and appropriate" (Victorian Government, 2013, page 7). This is achieved through the fire agencies and VICSES use of the common warnings platform OSOM (One Source One Message).

The Protocol is in line with national warning guidelines and consists of seven elements which are similar to those in Manual 21 and the extended TFWS framework (section 1.1) to be used in this report. The seven elements are:
1. Community preparedness
2. Situational awareness and analysis
3. Decision-making and authorisation
4. Message construction and dissemination
5. Management of warning consequences
6. Real-time monitoring
7. Real-time closure.

There are several Standard Operating Procedures (SOPs) derived from the Protocol which guide warning activities particularly in relation to the state, regional and local Incident Control Centres (ICCs).

At the time of writing this report, the Victorian Government was seeking public feedback on the Revised Draft Victorian Floodplain Management Strategy (Department of Environment, Land, Water and Planning, 2015). There is a section on flood warning in the Revised Draft Strategy including a description of the TFWS based on Manual 21 (see above).

The Revised Draft Strategy states that the Victorian Government has made DELWP accountable for the coordination of TFWS services at the state level. It is also accountable for documenting a state-level TFWS service development plan. DELWP will do this in consultation with VICSES, BoM, Melbourne Water, CMAs, LGAs, water corporations and other stakeholders as required.

"The TFWS service development plan will be informed by the rolling three-year implementation plans coming out of the regional floodplain management strategies. In preparing those regional strategies, the CMAs and Melbourne Water will systematically assess the existing TFWS services provided to the flood-prone communities in their region, using the state-wide assessment framework currently being developed by DELWP. They will also assess the TFWS service needs of each flood-prone community" (Department of Environment, Land, Water and Planning, 2015, page 47).

1.3. Project objectives

This project is part of the Warracknabeal and Brim Flood Investigation commissioned by the Wimmera CMA and conducted by Water Technology Pty Ltd.

The Warracknabeal and Brim Flood Investigation was commissioned to increase the flood understanding and resilience for Warracknabeal and Brim and the Yarriambiack Creek floodplain. The investigations primary purpose is to ensure the community and government agencies are aware and prepared for a flood event to occur. This involves improvements to flood intelligence, planning and structural mitigation.

The objectives of this part of the project are to:
1. conduct an assessment of the existing TFWS for the investigation area
2. recommend improvements to the existing TFWS based on the assessment.

1.4. Study area

The original project extent included from immediately upstream of Warracknabeal to downstream of Brim (Galaquil E Road – Wimmera CMA/Mallee CMA boundary). This was extended at the upstream (southern) end to the Wimmera Highway Bridge on Yarriambiack Creek. The original and extended study area extents are shown in Figure 2.

1.5. Communities

Warracknabeal is the principle service centre for the Yarriambiack Shire and is located 290 kms north west of Melbourne. Brim is a smaller rural town, also on the Yarriambiack Creek downstream of Warracknabeal.

According to the 2011 census data (Australian Bureau of Statistics, 2012), **Warracknabeal** had a population of 2,745 in 2011 comprised of approximately 51.0% females and 49.0% males. With little observable urban growth, there will probably have been little population change since 2011.

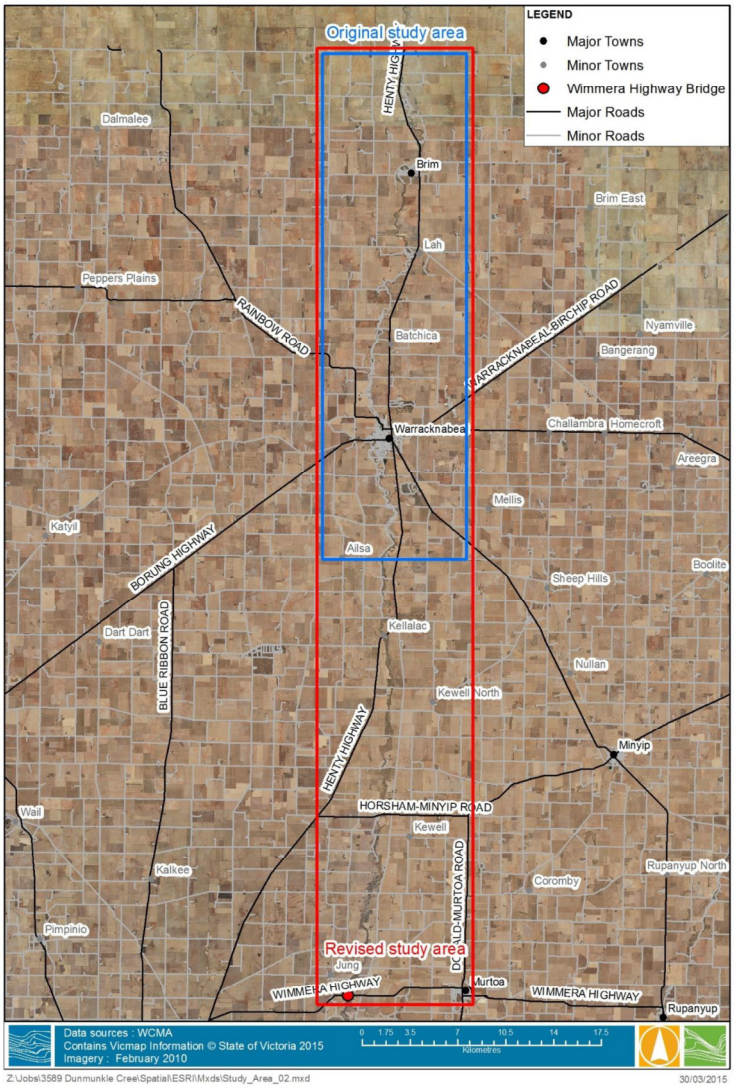

Figure 2: Study area (source: Water Technology, 2015a)

The following indicators from the 2011 census have direct relevance to the community aspects of this assessment and are referenced in Section 4 of this report.

1. Age. The average age of the people in Warracknabeal is 48 years of age. This is a relatively old population compared to the Victorian average which is 37 years. Table 1 provides a breakdown of population for each age cohort.

2. Language. A large proportion (91.4%) of the Warracknabeal population speak English only. Ninety-seven percent speak English at home.

3. Household size. The average household size in Warracknabeal is 2.2 persons.

4. Type of living. Almost all (96%) of the permanent residences in the town are separate houses, with a few flats, townhouses and other (possibly the caravan park). Only a relatively small proportion of residences (24%) are rented.

5. Internet connection. About one-third (36%) of residences that have no internet connection (compared with the Victorian average of 21% that have no internet connection).

6. Assistance required. Approximately 10% of the population require some form of core assistance (e.g. due to disability, older age).

7. Volunteerism. Twenty-eight percent of the population say they volunteer in some way.

Table 1: Warracknabeal population by age range (source: Australian Bureau of Statistics, 2012)

Age cohort	Total	% Total
0-4	149	5.4
5-14	303	11.0
15-19	161	5.9
20-24	116	4.2
25-34	201	7.3
35-44	302	11.0
45-54	443	16.1
55-64	384	14.0
65-74	292	10.6
75-84	266	9.7
85+	127	4.6

Brim had a population of 261 in 2011.

1. Age. The average age of the people in Brim is 43 years of age. There is a slightly younger distribution than that shown in Table 1 for Warracknabeal.

2. Language. A large proportion (96.1%) of the Brim population speak English at home.

3. Household size. The average household size in Brim is 2.5 persons.

4. Type of living. Almost all (96%) of the permanent residences in the town are separate houses, with a few flats. Only a relatively small proportion of residences (16%) are rented.

5. Internet connection. Approximately 30% of residences that have no internet connection.

6. Assistance required. Approximately six percent of the population require some form of core assistance (e.g. due to disability, older age).

7. Volunteerism. Fifty-five percent of the population say they volunteer in some way.

Community Indicators Victoria (CIV) also provides an insight into some sociological aspects that are relevant to the TFWS. CIV is a collaborative project within the Place, Health and Liveability Research Program at the McCaughey VicHealth Centre, within the School of Population & Global Health, at the University of Melbourne.

CIV provides indicators for **Yarriambiack Shire** which includes the study area. Indicators of relevance include:

1. Feeling part of the community. Community Connection was measured in the 2011 VicHealth Survey. Respondents were asked to rate their satisfaction with feeling part of their community and answers are presented according to a 0-100 range.

Normative data indicates that the average Community Connection score for Australians is approximately 70. In comparison, the average Community Connection score for persons living in Yarriambiack was 79.8 in 2011, the Victorian State average was 72.3.

2. Perceptions of safety. Perceptions of Safety were measured in the 2011 VicHealth Indicators Survey. Respondents were asked to rate how safe they felt when walking alone in their local area during the day and at night.

When walking alone in their local area during the day, 99.1% of persons in Yarriambiack felt safe or very safe, compared to the Victorian State average of 97%.

When walking alone at night 85.6% of persons in Yarriambiack felt safe or very safe, compared to the Victorian State average of 70.3%.

3. Participation in Citizen Engagement. Data on the participation of Victorians in selected forms of Citizen Engagement were collected in the 2011 VicHealth Indicators Survey. Respondents were asked if they had attended a town meeting or public hearing, met, called or written to a local politician, joined a protest or signed a petition in the previous 12 months.

73.2% of persons in Yarriambiack had engaged in at least one of the selected activities in the previous year, compared to the Victorian State average of 50.5%.

1.6. Flood risk

During high flows in the Wimmera River, flow is distributed along Yarriambiack Creek between Glenorchy and Horsham, near Longerenong.

The distribution of flood flows to Yarriambiack Creek has caused several large floods along the waterway and in the townships of Warracknabeal and Brim. The most recent of these was during January 2011, other significant flood events include 1909, 1981,1983 and 2010. The January 2011 event was the largest historic event in living memory.

According to Water Technology (2015a, page 1), “prior to the January 2011 floodwaters arriving at Warracknabeal and Brim significant effort was put into the construction of earthen levees and sandbagging. These levees prevented significant damage to both townships, particularly in Warracknabeal where the number of properties inundated above floor during the 1% AEP design event was estimated at 79. It is understood this was reduced to approximately 5 in the January 2011 event with the aid of the temporary mitigation works implemented. Some of the levees constructed during January 2011 in both Warracknabeal and Brim remain in place; some have been moved and formally constructed and maintained by Yarriambiack Shire Council”. The estimates made prior to January 2011 were based on the 2007 Warracknabeal and Beulah estimates.

There are numerous contributing catchment areas between the Yarriambiack Creek offtake and Warracknabeal, as well as between Warracknabeal and Brim. There is also a direct storm water catchment area for both townships. This results in potentially three separate potential flood mechanisms within the study area: local stormwater runoff, Yarriambiack Creek catchment runoff and Wimmera River distributary flow (Water Technology 2015a, page 36).

Yarriambiack Creek is a distributary system and as such the hydrology is quite complex. Water Technology (2015a) conducted a detailed hydrologic and hydraulic investigation of the system to ascertain the flood risk to the study area. As a result it was able to map flood extents and floor heights for different level floods. Modelling of the 1% AEP event showed approximately 22 properties with dwellings or commercial premises are flooded above floor in Warracknabeal and none in Brim. The 1% AEP flood extent for Warracknabeal is shown in Figure 3.

Design flow estimates for Yarriambiack Creek at the Wimmera Highway Bridge streamflow gauge indicated the January 2011 flood was between a 1% to 0.5% AEP event.

1.7. Mitigation options

Water Technology conducted a preliminary assessment of potential structural flood mitigation measures for the study area (Water Technology, 2015b). The options were made up of community suggestions as well as options suggested by the Project Steering Committee, Wimmera CMA, Yarriambiack Shire Council and Water Technology.

Each mitigation option was assessed against a number of criteria: potential reduction in flood damage, cost of construction, feasibility of construction and environmental impact.

As mentioned previously, a significant levee was constructed protecting Warracknabeal during January 2011. Thus, one of the mitigation options is the construction of a levee that protects Warracknabeal 1% AEP flood event in a similar alignment to that constructed during January 2011. Part construction of the levee was also assessed and received the top ranking in the assessment. The 1% AEP flood extent for Warracknabeal with the levee is shown in Figure 4.

Modelling showed that the levee constructed during January 2011 during a 1% AEP event reduced the impact from 22 to one building flooded above floor, and from 103 to two below floor level.

Other mitigation options that received high rankings related to improving stormwater drainage in and around Warracknabeal.

Figure 3: Extent of the 1% AEP flood in Warracknabeal (source: Water Technology, 2015b)

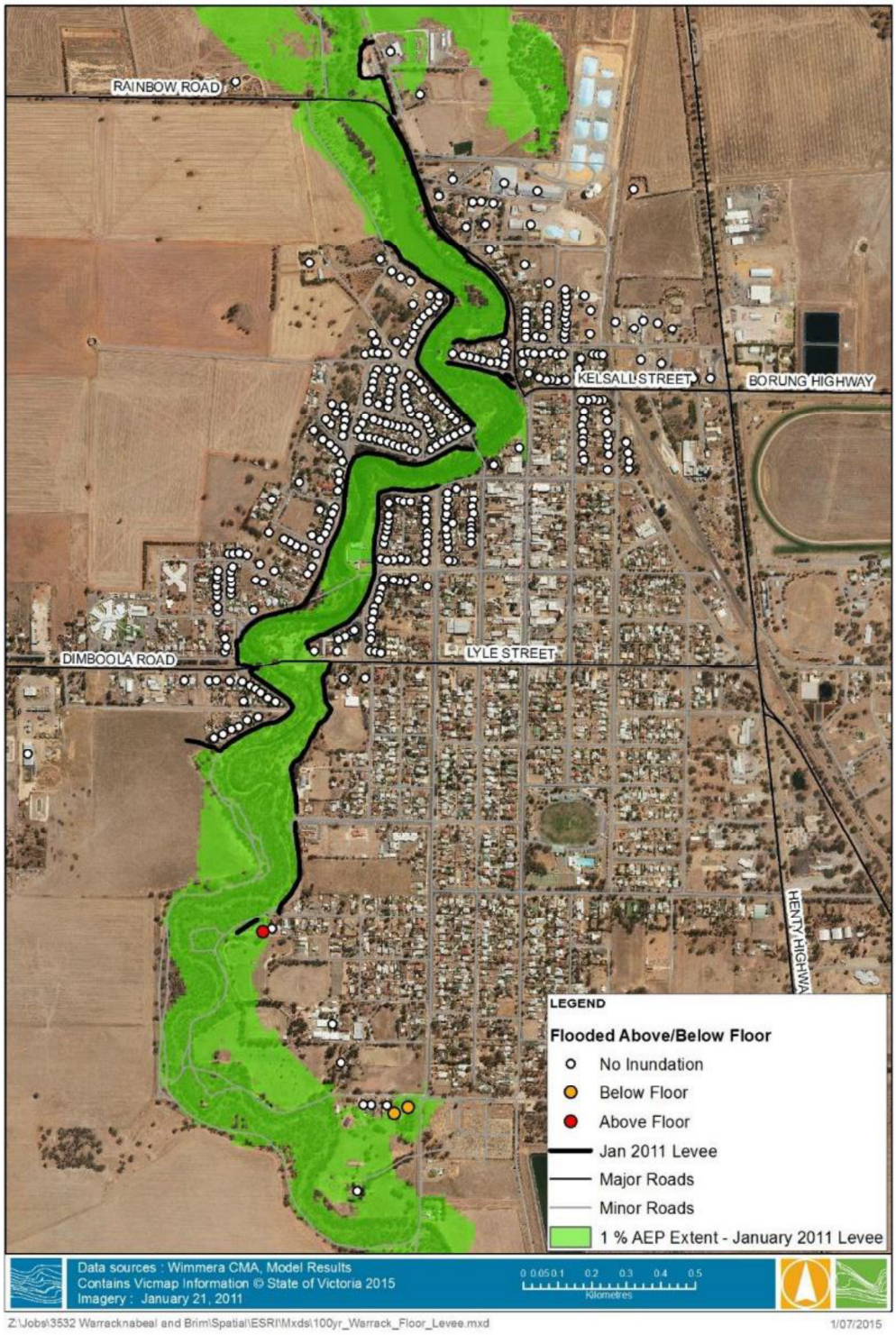

Figure 4: Extent of the 1% AEP flood in Warracknabeal with the January 2011 levee (source: Water Technology, 2015b)

2. Methodology

2.1. Community and other stakeholder consultation

For this TFWS assessment, Neil Dufty of Molino Stewart visited the study area to investigate community views regarding aspects of flood warning including those relating to the January 2011 flood event. He participated in the following meetings:

- 29 July 2015 Drop-in community meeting at Brim (Five community members in attendance)
- 30 July 2015 Meeting with a Warracknabeal family impacted by the January 2011 flood event
- 30 July 2015 Meeting with Yarriambiack Shire Council
- 30 July 2015 Warracknabeal Flood Investigation Community meeting (30 community members in attendance).

Mr Dufty also consulted with the following organisations in this assessment:

- Wimmera CMA
- VICSES
- Emergency Management Victoria
- BoM.

2.2. Data sources

This assessment is based primarily on data derived from studies (Water Technology, 2015a; Water Technology, 2015b) conducted for the Warracknabeal and Brim Flood Investigation.

Other data that was used in the assessment included:

- Warracknabeal and Beulah Flood Study (Water Technology, 2007)
- 2011 census data (Australian Bureau of Statistics, 2012)
- Community Indicators Victoria (CIV)
- Yarriambiack Shire Council Flood Response Plan (Yarriambiack Shire Council, 2009).

2.3. Assessment of the existing TFWS

Using the community and other stakeholder consultation (Section 2.1) and the data sources (Section 2.2), the following components of the TFWS were assessed based on the more holistic TFWS framework outlined in Section 1.1. The following components were assessed:

- Understanding the flood risk
- Emergency management planning
- Community flood education
- Data collection including location and use of rain gauges and stream gauges
- Prediction
- Interpretation
- Message construction
- Message communication
- Response
- Community participation
- Review of the TFWS
- Integration of the TFWS components.

The findings of the assessment are provided in Section 3.

2.4. Improvements for the TFWS

Based on the assessment in Section 3, improvements to each TFWS component are identified in Section 4. The improvements are identified by comparison with good TFWS practices outlined in Manual 21 and also those elsewhere in the literature.

3. Assessment of the existing TFWS

3.1. Understanding the flood risk

From the Water Technology (2007) and Water Technology (2015a) studies, there is a good agency and council understanding of risk in a range of flood scenarios for Warracknabeal, Brim and outlying properties along Yarriambiack Creek. The January 2011 event was used to calibrate flood models.Modelling has been undertaken for flood levels up to the 0.5% AEP event with September 2010 used as verification. According to Water Technology (2015a), the January 2011 flood was between a 1% and 0.5% AEP event.

It is critical to the success of the TFWS that those living in the floodplain (and particularly landholders) also understand the flood risk. Currently, when Yarriambiack Shire Council receives an enquiry from the community regarding flooding they refer them to the Wimmera CMA which provides property flood advice. Landholders and other members of the community can access flood risk data themselves through the Wimmera CMA website.

Yarriambiack Shire Council is committed to undertake a planning scheme amendment which involves sending a letter to every landholder affected, publicly advertising the changes in newspapers and exhibiting these changes for six weeks in council and Wimmera CMA offices. Once this amendment is completed details of the Land Subject to Inundation Overlay (LSIO) will be on the landholders' Section 32 certificate.

3.2. Emergency management planning

Local councils are required to prepare a Municipal Flood Emergency Plan (MFEP) pursuant to Section 20 of the *Emergency Management Act 1986* (as amended). The MFEP is a sub plan to the council's Municipal Emergency Management Plan (MEMP), and should be consistent with the EMMV and the Victoria Flood Emergency Plan (Victoria State Emergency Service, 2012).

In 2009, Yarriambiack Shire Council prepared the Yarriambiack Shire Council Flood Response Plan, a sub plan of the Yarriambiack MEMP. The objectives of the Plan are to:

- Bring about the implementation of measures to prevent or minimise the causes and impacts of flood incidents within Yarriambiack Shire
- Document arrangements for the utilisation and implementation of resources from within the Municipality when required for flood response activities
- Outline the management of support that may be provided to or from adjoining Municipalities during a flood event
- Complement other Local, Regional and State emergency and wider planning arrangements with specific emphasis on those relevant to flood.

In relation to flood warning, the Plan includes a series of flood intelligence cards providing details of triggers (e.g. road inundation, property inundation, above flood inundation) for depths at the Glenorchy gauge, and suggested emergency actions (closing roads, warning residents, evacuating residents). The Plan also includes details about flood warning arrangements (e.g. roles of BoM, VICSES).

There are several deficiencies with the Yarriambiack Shire Council Flood Response Plan, mainly due to its age. The deficiencies include:

- The Plan is not based on VICSES's current MFEP template (provided in 2011)
- The Plan does not include a section on flood relief and recovery arrangements
- Flood intelligence cards are based on the Water Technology (2007) report prepared prior to the January 2011 flood event.

Warracknabeal Caravan Park is located on the banks of Yarriambiack Creek and is flood prone. According to Yarriambiack Shire Council which manages the Park, it has an emergency plan including procedures for evacuation. However, the emergency plan is based on response triggers relating to the Water Technology (2007) report and requires updating to relate to the Water Technology (2015a) study and new MFEP.

3.3. Community flood education

Community flood education helps people learn how to prepare for and respond to floods (including to flood warnings). The prime outcome is public safety, with a secondary outcome being protection of property.

According to VICSES, and Wimmera CMA up to now there has not been a concerted effort of community education and engagement around floods in Warracknabeal and Brim. Activities to date include:

- the occasional feature in the local paper during FloodSafe week
- a pamphlet titled 'Flood Information Warracknabeal' produced in 2008 by Wimmera CMA which includes a table relating flood probability to impact on the town. The table appears to be related to the Water Technology (2007) report.
- during the 2007 Warracknabeal Flood Study, a lot of time was spent communicating flood risks at community information sessions and meetings with individual landholders. Also the community were shown how real time stream gauge information from the BoM web site relates to flood magnitudes for Warracknabeal. Following the completion of this and other flood studies, all reports and flood extent maps for a range of flood magnitudes were available on the Wimmera CMA web site.
- the Wimmera CMA spent time with landholders along Yarriambiack Creek to form a Water Watches Group. These landholders have been trained how to take stream gauge board readings to assist with stream data collection during flood events. They have also been shown how the telemetered stream gauge network data and how this information relates to flood magnitudes for Warracknabeal and along Yarriambiack Creek. Property-specific charts were distributed to all landowners in Warracknabeal with buildings subject to flooding up to a 0.5% in 2008. These charts were developed to allow residents and business owners to better understand how flood warnings relate to the flood risk of their building. These charts show how to access real time stream gauge information on the BoM web site, and what stream height their floor level is likely to be subject to flooding. This detailed information allows individuals to be aware of their flood risk, and provides them plenty of warning time to action to protect their belongings.

The 2008 pamphlet provides the following advice to the community about flood warning: "Flood information including generalised flood forecasts, road closures and advice on evacuations and property protection will be broadcast over local TV and AM radio station ABC 594.

"It is likely that you will have several days' notice of a coming flood. You should use this time to prepare your business and family home. Don't leave precautions until it is too late."

Stream gauge heights of historic flood levels are provided for the Yarriambiack Creek stream gauge at the Wimmera Highway, at Jung. It also provides a description of flood behaviour for different size flood events.

All flood report and flood extent maps for a range of flood magnitudes are available on the Wimmera CMA web site.

After the January 2011 flood, Yarriambiack Shire Council organised a town celebration and acknowledgement of effort. Four interpretive signs (Figure 5) were erected around Yarriambiack Creek to describe the community response to the 2011 flood, including the construction of the temporary levee.

Figure 5: 2011 Floods Warracknabeal interpretive signage (N.Dufty)

3.4. Data collection

Manual 21 (page 15) provides guidance regarding data collection from rain and river level gauges. According to Manual 21, effective routine monitoring of the potential for flooding requires “sufficient rainfall and river flow data to provide a representative picture of what is happening over the river basin” and “close liaison between meteorological and hydrological forecasting groups.”

The Revised Draft Victorian Floodplain Management Strategy (page 48) states that “Across Victoria, there are some 780 active river level and rainfall gauges maintained through the relevant Regional Water Monitoring Partnership. The partnerships involve DELWP, LGAs, CMAs or Melbourne Water, and other water corporations with an interest in the use of gauge data. The partnership approach allows data to be collected to a well-defined standard once, but used for multiple business needs, such as allocation management, compliance monitoring, flood warning, water resource assessment and river health management. DELWP manages the Regional Water Monitoring Partnership contracts and Melbourne Water manages equivalent contracts within the Port Phillip and Westernport region”.

According to Water Technology (2015a), there are several streamflow gauges that provide information on the inundation potential along Yarriambiack Creek (see Figure 6 for locations of gauges). The gauge most specific to the study area is Yarriambiack Creek at Wimmera Highway Bridge (Wimmera Highway) followed by Wimmera River at Glenorchy (Tail Gauge). The Wimmera Highway gauge is downstream of Two Mile Creek which returns flood water back to the Wimmera River from Yarriambiack Creek and provides a good representation of the flow escaping from the Wimmera River and entering the Yarriambiack Creek system. The Glenorchy gauge is the closest upstream Wimmera River gauge to the Yarriambiack Creek offtake and gives an indication of the Wimmera River flow prior to the offtake, excluding tributaries downstream of this point.

According to Manual 21 (page 18), 'warning lead time' is the time between the issuing of a message containing a prediction and the time when the predicted height is reached.

Analysis based on modelling from Water Technology (2015a), shows that there should be considerable warning lead times (Table 2) for Warracknabeal and Brim. For example, in a 1% AEP flood there is an estimated 67 hours for the flood peak to move from the Glenorchy gauge to Warracknabeal and a further 33 hours for the flood peak to arrive at Brim.

Table 3 provides times for the movement of 2010/11 flood peaks as a comparison with the modelled results in Table 2. The January 2011 estimates show that the flood peak took 99 hours to move from the Glenorchy gauge to Warracknabeal and a further 38 hours to move to Brim.

As noted previously, Yarriambiack Creek is a distributary system and as such the hydrology is quite complex. There are numerous contributing catchment areas between the Yarriambiack Creek offtake and Warracknabeal, as well as between Warracknabeal and Brim. With the Glenorchy gauge over 50 kilometres from Warracknabeal, it is difficult under the present streamflow gauge network to have accurate and reliable flood warning data for Warracknabeal and Brim. This is highlighted by the January 2011 flood peak taking a similar time to arrive in Warracknabeal to the 10% AEP modelled event when, as noted in Section 1.6, the January 2011 flood was between a 1% and a 0.5% AEP event.

3.5. Prediction

In the study area, BoM maintains and funds the prediction services for the locations defined in the BoM Service Level Specification for Flood Forecasting and Warning Services. Maintenance includes continually improving prediction techniques.

As part of its prediction services, the BoM issues Flood Watches and Flood Warnings.

A Flood Watch provides early advice of potential riverine flooding to emergency services and communities at risk of flooding. Flood Watches are issued when the combination of forecast rainfall and catchment or other hydrological conditions indicate that there is a significant risk of potential flooding.

Flood Warnings are issued by the BoM to advise that flooding is occurring or expected to occur in a geographical area based on defined criteria. Flood Warnings may include either qualitative or quantitative predictions or may include a statement about future flooding that is more generalised. The type of prediction provided depends on the quality of real-time rainfall and river level data, the capability of rainfall and hydrological forecast models and the level of service required.

A quantitative or qualitative flood warning of Minor, Moderate or Major flooding is provided in areas where the BoM has specialised warning systems. They provide advanced warning about the locations along river valleys where flooding is expected, the likely class of flooding and when it is likely to occur. Predictions of expected water levels and the timing of flood peaks are provided at key forecast locations.

For the study area, the BoM currently uses the Jung river height gauge on Yarriambiack Creek and the Glenorchy gauge to provide flood predictions including flood warnings.

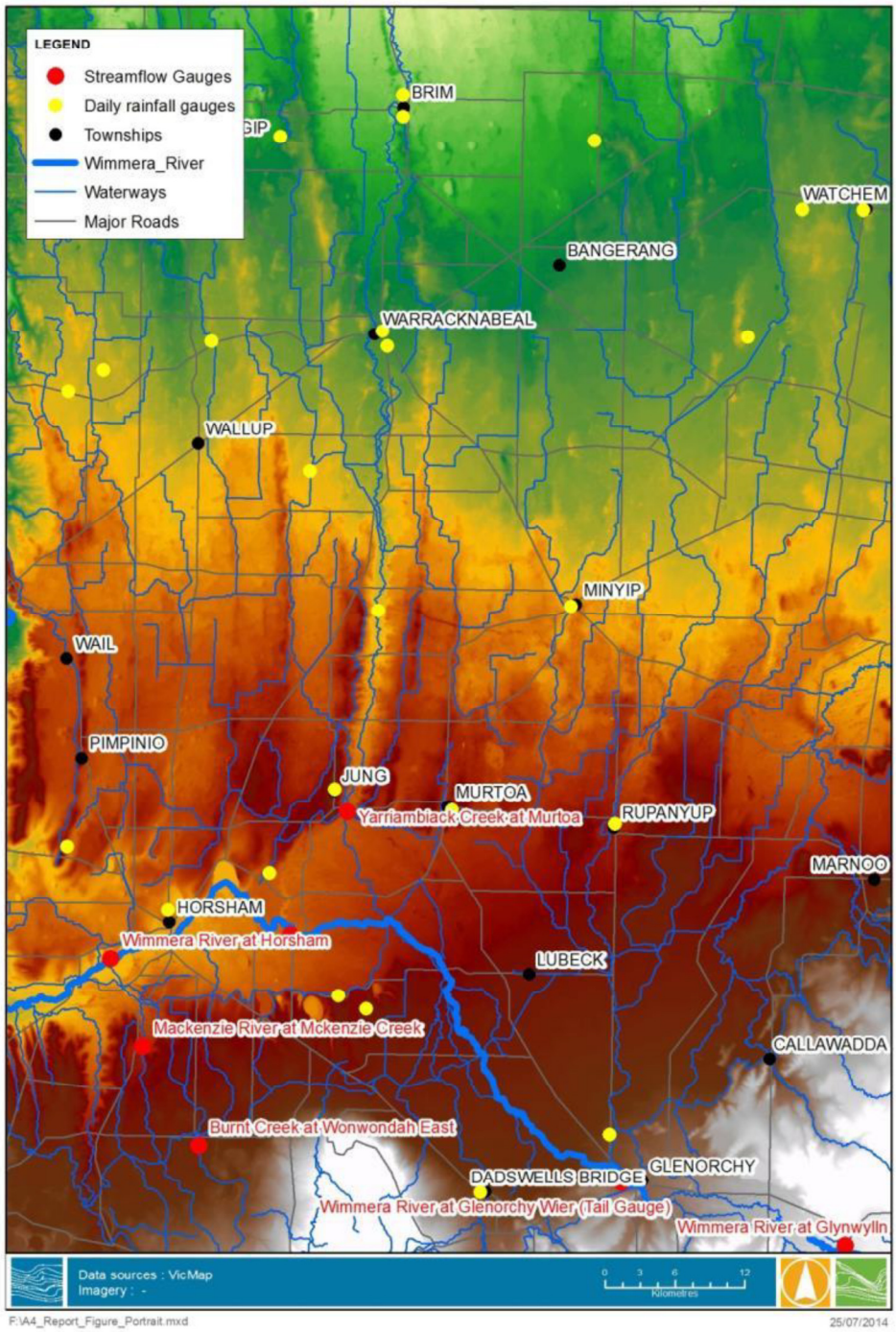

Figure 6: Streamflow gauges relevant to the study area (source: Water Technology, 2015a)

Table 2: Analysis of the movement of flood peaks based on Water Technology (2015a)

Event	0.5% AEP (hours)	1% AEP (hours)	2% AEP (hours)	5% AEP (hours)	10% AEP (hours)	20% AEP (hours)
Wimmera River at Glynwylln	-	-	-	-	-	-
Wimmera River at Glenorchy	0	0	0	0	0	0
Yarriambiack Creek at Wimmera Highway	35	31	35	23	47	53
Yarriambiack Creek at Ailsa Road	53	56	72	72	85	89
Yarriambiack Creek at Warracknabeal	61	67	86	85	97	107
Yarriambiack Creek at Brim	86	100	135	133	150	161

Table 3: Estimated movement of flood peaks for September 2010 and January 2011 flood events

Event	Jan-11 (hours)		Sep-10 (hours)	
Wimmera River at Glynwylln	14/01/2011 22:15		5/09/2010 4:15	
Wimmera River at Glenorchy	15/01/2011 7:30	0	5/09/2010 17:30	0
Yarriambiack Creek at Wimmera Highway	17/01/2011 12:40	53	8/09/2010 8:45	63
Yarriambiack Creek at Ailsa Road	19/01/2011 0:00	89	11/09/2010	127
Yarriambiack Creek at Warracknabeal	19/01/2011 10:45	99	12/09/2010	151
Yarriambiack Creek at Brim	21/01/2011	137	15/09/2010	223

3.6. Interpretation

Local flood studies produce updated flood mapping that can be used in prediction and the communication of flood warnings to affected communities. DELWP includes updated flood mapping and flood behaviour information in the flood intelligence platform.

According to Manual 21 (page 21), "operational coordination and communication are essential between the prediction agency and the lead response agency involved in the reception and interpretation of predictions. Onsite reports provide valuable feedback to the prediction agency on the impacts of flooding and on the accuracy of the predictions. Information on forecast accuracy can be used to adjust hydrological prediction models so future forecasts can be made more accurate."

For a flood in the study area, the BoM as the prediction agency would liaise with lead response agency (VICSES) at the state, regional and local level. Both agencies would interpret flood data through the appropriate level of Incident Control Centre (ICC).

According to Manual 21 (page 36), "when a flood prediction is received, a primary task of the response agency (usually the local council, local SES or catchment management authority) should be to link the predicted conditions to potential impacts within the local area. This will then determine and direct response and recovery operations and the messages communicated to the community. As flood effects ultimately impact on the community itself, it is worthwhile for response agencies to develop knowledge of the local conditions and potential reactions, both within the physical and social environments."

The Yarriambiack Shire Council Flood Response Plan (albeit with its deficiencies – see Section 3.2), coupled with data from the flood study (Water Technology, 2015a), provides flood intelligence that links flood peaks at the Glenorchy and Jung streamflow gauge to impacts in the study area. This information can be used by the ICC to interpret flood predictions prior to the issuing of Flood Bulletins and other warning information.

An issue that was raised in the community consultation was the perceived lack of use of local knowledge by the agencies in interpretation and on-ground emergency operations such as sandbagging.

It should be noted that DELWP has recently developed a web-based tool that provides a range of flood information, before, during and after floods. FloodZoom brings together flood forecasts, flood mapping, real-time river height gauges and property data to provide flood response agencies with improved knowledge of likely flood impacts. Details of this and other flood warning system improvements are available at http://www.delwp.vic.gov.au/water/flood-warning-improvements?remap=dewlp.vic.gov.au/floodzoom#sthash.Vt6xiDhb.dpuf

3.7. Message construction

According to Manual 21, "the warning message is the critical link between flood prediction and interpretation on the one hand, and the taking of protective action on the other. It must be 'user friendly', it should explain what is happening and what will happen, where, how the flood will affect the recipient of the message and what he or she can do about it. The message must come from a credible source, be informative and persuasive and be clearly understood by those receiving it. The message may be either in written form or communicated verbally."

As noted previously, warning messages will be released by the BoM as Severe Weather Warnings, Flood Watches and Flood Warnings. VICSES through the ICC will release messages as Flood Bulletins that provide details of the likely impacts on communities and what people should do. Evacuation messages could also be sent specifically to those residents in danger.

It is recommended in Victoria for messages to be 'timely, relevant and tailored' (Fire Services Commissioner, 2011). Message construction is strongly addressed through the State Flood Response Plan, the Victorian Warning Protocol and several Standard Operating Procedures (SOPs) for the ICC.

Consultation with local ICC public information officers shows that message construction for Flood Bulletins has improved (through clarity, level of language) since the January 2011 floods.

3.8. Message communication

According to Manual 21 (page 50), "the best predictions, the best interpretive material and the best warning messages are of little value if they have no impact on damages or safety. Failure is guaranteed if warning messages based on flood predictions and interpretations of them are not conveyed effectively to those expected to respond. In essence, a warning which is not communicated effectively is no warning at all, if it is not heard or heeded."

Manual 21 (page 51) identifies two different types of message communication based on target audience:

1. General warnings are disseminated ('broadcast') to whole communities or regions.
2. Specific warnings are intended for individuals or parts of communities, and reflect the need for 'narrowcasting' to specific audiences who may have specific characteristics or be at different kinds of risk.

General warnings are communicated by VICSES through the appropriate level ICC using One Source One Message (OSOM) which links to the media, emergency service websites, the VICSES Flood and Storm Information Line and social media.

Specific warnings are communicated by the ICC using Emergency Alert (providing location warning messages to mobile phones and landlines). VICSES (or delegated authority such as the Country Fire Authority) also use local and personal communication methods such as doorknocking, community meetings, and community bulletins.

All of these communication mediums were used in the study area during the January 2011 flood event. From the community consultation, most local residents believed that they received good warning information during the flood. This enabled them to prepare themselves, and to help others if required. However, two issues were identified:

1. A local resident living outside the floodplain received an Emergency Alert message to evacuate. It should be noted that the precision of Emergency Alert in reaching flood-prone residents has improved since January 2011.
2. A local resident from Brim noted that he did not own a computer or smartphone and thus did not access warning information from the internet. This concern is supported by analysis in Section 1.5 that shows that approximately one-third of residents in the study area do not have internet access (although this rate may have decreased since the 2011 census).

From the community consultation, the main way in which people in the study area received flood warning information was through regional ABC radio.

A concern raised at the Brim community consultation was warning communication with outlying properties along Yarriambiack Creek that could become isolated by floodwaters for several days. It was suggested that a 'phone tree' or similar localised communication method be used to augment the mediums described above. However, phone trees only work if the person/people at the top of the phone tree are available.

Advice from VICSES notes that it is transitioning from OSOM to the Victorian Emergency EM-COP system. The Emergency Management Common Operating Picture Project (EM-COP) runs on any device with a modern browser including desktop computers, laptops, tablets and smartphones and is designed to provide users with a simple way to gather, organise, create, and share emergency management information between emergency managers at no cost to agencies. According to the Emergency Management Victoria website, "When fully realised, it means that no matter where they are – any control centre, shire council, not-for-profit relief organisation, essential service provider or on the ground – members will be able to understand and add to current situational awareness more quickly and more effectively than ever before".

3.9. Response

In the January 2011 flood event, the Warracknabeal community worked together to construct a temporary levee that in the end protected the town from floodwaters. From community consultation, temporary levees and sandbags were used to protect individual houses outside of the town temporary levee. In Brim there were no buildings that were directly impacted by floodwaters in the January 2011 event.

Although this was viewed as a success and was commemorated by the community, several sociological and psychological issues that impact on response to flood warning were identified in the community consultation and demographic data analysis (Section 1.5).

1. Situational awareness. Situational awareness enables people to make safe decisions themselves, sometimes regardless of centralised warning messages. One way to become aware of the rise of floodwaters is through roadside flood markers and gauge boards. According to Wimmera CMA, people have raised that the gauge boards

at Lah are difficult to view during a flood. They are attached to the side of the culverts on the southern side of the crossing.

2. Local knowledge. Several people in the consultation felt that they local knowledge was not used as much as possible during the 2011 flood event. For example, there was a perception in the community that 'outside influences' such as the ICC in Horsham and Melbourne 'experts' did not listen to local knowledge during flood. Some community members did not have trust in VICSES staff from elsewhere in the state that were making emergency management decisions.

3. Indirectly affected communities. The flood investigation (Water Technology, 2015b) shows that in a 1% AEP event almost no properties in Warracknabeal will be impacted if a permanent levee is constructed similar to the temporary one constructed for the 2011 flood. However, although Warracknabeal and Brim are then not directly impacted by floodwater in a 1% AEP event, they still will be isolated (as will outlying properties). As floodwaters rise, the greatest risk is driving through floodwaters. According to a Queensland University of Technology (QUT) study, use of a motor vehicle was involved in almost half (48.5 per cent) of the 73 deaths found to be directly related to flooding in Australia from 1997 to 2008 (Queensland University of Technology, 2010).

The study also found that more than 90 per cent of the flood-related deaths resulted from individual choices to either engage in inappropriate risk-taking or enter flooded waterways on foot or in a vehicle. Most were not trapped by floods.

According to Haynes et al. (2009), up to 75% of flash flood deaths in Australia occur while people are outside buildings attempting to leave or return, and directly exposed to floodwater.

It is also important for people in the study area to stock adequate food and water to be isolated for up to 72 hours.

4. Vulnerability. Section 1.5 highlights some social vulnerabilities that may impact on response to flood warning in the study area. The average age of the population in the study area is considerably higher than the Victorian average. Table 1 shows that about one-quarter of the population in Warracknabeal is over 65 years of age. Older age may cause issues such as restricted movement (e.g. to evacuate) and lessened situational awareness.

Another vulnerability is the reasonably high level (10%) of the population that require assistance. Yarriambiack Shire Council is unsure if it has all people requiring assistance in its Vulnerable Persons Register as required by the Vulnerable People in Emergencies Policy (Victorian Government, 2015).

5. Social capital. There is also a growing body of evidence (e.g. Aldrich, 2012; Chamlee-Wright, 2010) that shows that social capital (networks, norms, trust) is a critical component of appropriate response and recovery leading to resilience. Social capital translates into assistance for others in response to a flood warning.

Section 1.5 provides some indication of high levels of social capital in the study area. For example, 28% of those living in Warracknabeal and 55% of those in Brim say they volunteer. The Community Connection score for the study area is significantly higher than the Victorian average. People in the study area had been engaged in far more community activities than the average across the state.

6. Social isolation. Although the indicators generally show a connected community (high levels of social capital), from the community consultation there is a pocket of the Brim community that appear to live in relative isolation from others in the community. This group needs to be engaged in response to flood warnings even if flooding does not occur in the township.

7. Critical awareness. According to Paton (2006), critical awareness is a main predictor of preparedness and response. Critical awareness is the extent to which people perceive hazard issues as important enough to think about them and to discuss them with others on a regular basis. From the Section 1.5 analysis, there is a very high perception of safety in the study area. This may mean that as memories of the January 2011 flood fade, due to this feeling of safety, critical awareness may decline over time thus causing an apathetic response to flood watches and warnings.

8. Levee paradox. If a permanent levee is constructed at Warracknabeal (Section 1.7), a psychological phenomenon called the 'levee paradox' might arise. According to Wagner (2007) if a levee is built, people behind the levee, as well as the local officials, tend to think that they are now "safe". Thus, without binding building restrictions the area behind the levee will be developed as if it was really safe. This leads to an increased damage potential which will be realised when the levee is eventually overtopped. It can also lead to those behind the levee not responding or responding slowly to warnings because they think they are safe. People living behind a levee should be educated about the frailties of a levee: they can overtop and/or fail.

An emergency management issue that was identified through stakeholder consultation related to sandbagging during the January 2011 flood. Yarriambiack Shire Council was providing residents with a larger quota of sand bags from its depot in comparison to the VICSES quota. This inconsistency appeared to have caused frustration with some community members.

3.10. Community participation

The National Strategy for Disaster Resilience promotes the concept of 'shared responsibility'. The Victorian Bushfires Royal Commission (2010, p. 352) uses the expression shared responsibility "to mean increased responsibility for all. It recommends that state agencies and municipal councils adopt increased or improved protective, emergency management and advisory roles. In turn, communities, individuals and households need to take greater responsibility for their own safety and to act on advice and other cues given to them before and on the day of a bushfire".

An important way of attaining shared responsibility is through community participation in disaster management. There is a growing body of evidence to show that community participation is critical in the development of effective early warning systems. For example, the United Nations International Strategy for Disaster Reduction provides a checklist for developing early warning systems (ISDR, 2006). It states that "should be actively involved in all aspects of the establishment and operation of early warning systems; be aware of the hazards and potential impacts to which they are exposed; and be able to take actions to minimize the threat of loss or damage".

Community members had participated in any aspects of the establishment and operation of the TFWS in the study area through the Wimmera CMA community engagement meetings held for both the 2007 and 2015 Warracknabeal and Brim flood investigations. There was evidence of interest in a 'flood observers' (crowdsourcing) program where range of people in the community had agreed to monitor various road crossings and provide this real-time intelligence to the ICC in a flood event. According to Wimmera CMA, before the 2011 event people were identified to do this in the Yarriambiack system. However, in the 2011 flood all of these people were not actually around to do the thing that they had said they would. This was due to them assisting their friends and neighbours in the management of the flood.

3.11. Review of the TFWS

According to Manual 21 (page 67), "flood warning systems need regular attention to ensure they will function as intended and to continue to improve their performance." It adds that review should be conducted both at the strategic and operational level.

Furthermore, in relation to Section 3.10 on the need for community participation, Manual 21 (page 68) stresses, "a key point about the review process is that all relevant agencies should be involved to ensure organisational changes can be implemented. Similarly, the process must be open to input from the flood-affected community, members of which are likely to have ideas about how warning systems and services can be more effectively implemented. The views of community members are essential to improving warning systems, and people should be actively encouraged to put forward their opinions on system performance and ways to improve it."

Outside of this flood investigation, there was no evidence that the TFWS was being reviewed regularly (e.g. through a system monitoring and evaluation process) in the study area. There also was no evidence of a process (e.g. flood warning committee, community meetings/forum) to show that the local communities were participating in the review of the local TFWS.

3.12. Integration of the TFWS components

Manual 21 stresses the need for integration of the components of the TFWS. "For a flood warning system to work effectively, these components must all be present and they must be integrated rather than operating in isolation from each other. The view that any one component of the system represents all of it, or is an end in itself, impairs the system's effectiveness". (page 7)

There was no strong evidence (e.g. in the Yarriambiack Shire Council Flood Response Plan) found that the linkages across the components of the TFWS were well understood for the study area. An example of how this could be visualised is provided in Figure 7 (page 47) of the Revised Draft Victorian Floodplain Management Strategy.

4. Improvements to the TFWS

Based on the assessment in Section 3, the following improvements to the TFWS are recommended.

4.1. Understanding the flood risk

As noted in Section 3.1, as a result of this investigation (water Technology, 2015a), there is a good agency and council understanding of flood risk, including with the construction of a permanent levee at Warracknabeal (Water Technology, 2015b).

However, flood risk needs to be communicated to local residents including current and prospective landowners. Wimmera CMA hopes to update all flood maps and report on its web site so current details of property flood risk will be available to the community.

Yarriambiack Shire Council is committed to undertake a planning scheme amendment which once completed will provide details of the Land Subject to Inundation Overlay (LSIO) on the landholders' Section 32 certificate.

Community education (Section 4.3) should also inform the communities in the study area of their flood risk.

Recommendation 1: Provide readily available details to local communities of their flood risk through the Wimmera CMA websites, Section 32 certificates and ongoing community education.

4.2. Emergency management planning

As discussed in Section 3.2, the Yarriambiack Shire Council Flood Response Plan requires updating and upgrading to a MFEP. This should involve:

- Using VICSES's current MFEP template
- Adding details of flood relief and recovery arrangements
- Updating flood intelligence cards based on the Water Technology (2015a) report
- Providing a clear understanding of the integration of the components of the TFWS and how these would work in practice in the LGA (see Section 3.12)

VICSES said that it intended to prepare an operational plan related to the updated MFEP which would identify a roll out of emergency management actions as the floodwaters rose across the study area.

As also discussed in Section 3.2, Yarriambiack Shire Council needs to update the Warracknabeal Caravan Park emergency plan in relation to the Water Technology (2015a) study and updated MFEP.

Recommendation 2: The Yarriambiack Shire Council Flood Response Plan be upgraded to a Municipal Flood Emergency Plan and include reference to the latest flood study.

Recommendation 3: The Warracknabeal Caravan Park emergency plan be updated to include reference to the latest flood study.

4.3. Community flood education

VICSES is the lead agency for community flood education and engagement, with support from Wimmera CMA and Yarriambiack Shire Council.

As outlined in Section 3.3, there has been no concerted effort in community education in the study area including related to flood warning, although some activities have been instigated by VICES and Wimmera CMA. According to VICSES, there is a Local Flood Guide planned for Warracknabeal which will update the flood education pamphlet produced in 2008. This was put on hold to include the outcomes of the levee workshops and flood study. It is planned that the Local Flood Guide is completed by 2016.

It is also planned that a suite of education and engagement accompanies this initiative such as providing home emergency kit guides, local newspaper features, and a launch of the Guide which could include a variety of events such as a community barbeque.

From this TFWS assessment, content of community education activities should include:

- An understanding of flood risk (with and without a permanent levee at Warracknabeal) (Section 3.1)
- Web-based property specific charts that relate property floor levels to real time BoM flood levels and flood magnitudes (Section 3.1)
- Details of local triggers (e.g. gauge heights) and what people should do at these levels (Section 3.2)
- An understanding of evacuation routes and the location of evacuation centres (Section 3.2)
- A map showing the location of local streamflow gauges (Section 3.4)
- Background to flood warnings issued by the BoM and other services (e.g. radar maps) (Section 3.5)
- An understanding of the range of ways that warning messages are sent to the communities in the study area including for those without internet access (Section 3.8)
- Messaging related to not driving etc. in floodwaters (Section 3.9)
- Stock food and water to be isolated for 72 hours (Section 3.9)
- Encouragement to help others including neighbours and those requiring assistance (Section 3.9)
- If the permanent levee at Warracknabeal is build, an understanding that levees can be overtopped and fail and that this should be considered in personal response (Section 3.9)
- Encouragement to participate in the establishment and review of the TFWS (Sections 3.9, 3.10).

Recommendation 4: Educate the communities in the study area about aspects of the TFWS including their flood risk, local flood warning triggers for action and the warnings that they will receive if a flood is imminent.

4.4. Data collection

As noted in Section 3.4, there is a long warning lead time (several days) if predictions are based on flow down the Wimmera River at then into the Yarriambiack Creek system. The current streamflow gauge to provide these predictions is the Glenorchy gauge.

However, as shown in the comparison of the duration for flood peaks to move down the system (Tables 2 and 3), prediction accuracy is lost due to the distance between the Glenorchy gauge and Warracknabeal, and the complex nature of the creek system.

To improve the reliability and accuracy of flood predictions and warnings in the study area, Wimmera CMA has investigated in liaison with the BoM, the installation of a new streamflow gauge at the Ailsa Road crossing of Yarriambiack Creek, approximately 8.5 kilometres upstream (south) from Warracknabeal. The BoM has undertaken a radio path test and found there is no need for another repeater station.

It is difficult to quantify benefits such as reduced damages as a result of the installation of the proposed gauge. However, it does appear from comparison of the modelled 1% AEP flood (Table 2) with the flow duration for the January 2011 flood (> 1% AEP event) (Table 3) that a more reliable understanding of flood timing could be gained by the installation of a gauge close to Warracknabeal.

The BoM has said that they will only provide information (stream height) for the Jung and Ailsa Rd (when installed) gauges. The BoM provide flood forecasting at these locations and, in the interim, detailed information be provided to all agencies to determine flood forecasting using charts that relate stream height to AEP. Timing of flooding for different AEPs should also be provided. It is also recommended to combine the old Jung gauge rating (for low flows) with new rating (for flood flows).

Recommendation 5: A new streamflow gauge with telemetry be installed at the Ailsa Road crossing of Yarriambiack Creek.

Recommendation 6: BOM provide flood forecasting at the Jung and Ailsa Rd (when installed) gauges and, in the interim, provide detailed information to all agencies to determine flood forecasting using charts that relate stream height to AEP, and timing of flood flows to AEP.

Recommendation 7: Combine the old Jung gauge rating (for low flows) with new rating (for flood flows).

4.5. Prediction

Prediction depends largely on the forecast modelling by the BoM and the data collection discussed in Section 3.4. The BoM is regularly improving its forecasting capabilities and no recommendations are made here other than those for data collection in Section 4.4.

4.6. Interpretation

There are mechanisms in place (e.g. in the Revised Draft Victorian Floodplain Management Strategy) to improve the coordination and interoperability of ICCs including interpretation of flood warning data. The Water Technology (2015a) report will provide a basis for interpretation coupled with the new MFEP (e.g. using flood intelligence cards).

As acknowledgement of local knowledge was an issue raised in community consultation, it would be prudent to further develop the flood observers program in the study area. This crowdsourcing program would allow people to provide real-time flood height data to the ICC as one way to participate in the TFWS (Section 3.10). It also helps those in the ICC to check real-time data against flood data including models.

Recommendation 8: Further develop the flood crowdsourcing program to enable people to provide real-time flood height observations to the ICC.

4.7. Message construction

Improvements are being made to further improve messaging (e.g. in Flood Bulletins) emanating from the ICC. According to VICSES, Victoria is aligning respective warning levels, protocols and language with NSW and Queensland to ensure consistency.

No recommendations are made for this component of the TFWS.

4.8. Message communication

Message communication is being improved at a state level including the transfer to the EM-COP system and recent upgrades to Emergency Alert.

The idea suggested at the Brim community consultation of a 'phone tree' or similar localised communication method for isolated properties should be supported to augment the other warning communication mediums.

There also may be merit in using the Warracknabeal CFA siren as an extra warning mechanism although it is viewed as a 'dumb' warning (i.e. it does not provide information, only heads-up of an emergency). CFA requirements are provided at http://www.cfa.vic.gov.au/warnings-restrictions/community-alert-sirens/

Smartphone apps are used by emergency agencies throughout the world to provide warning messages and situational awareness to those at risk. There is already a FireReady app in Victoria providing warning rea-time information to those at risk of fire or wanting to know more. There are also a range of other apps that can provide warning for a range of emergencies across Australia e.g. the Emergency AUS app.

However, there are apps that now provide flood maps and alerts showing the movement of floodwaters relative to properties. These apps could add to the existing centralised warnings by providing detailed risk information as the flood evolves based on data from Water Technology (2015a). An investigation of smartphone usage in the study area should be conducted prior to any decision regarding the uptake of a flood warning smartphone app.

Recommendation 9: Establish a 'phone tree' or similar localised communication method for isolated properties in the vicinity and downstream of Brim.

Recommendation 10: Explore the possibility of Warracknabeal CFA siren as an extra warning mechanism.

Recommendation 11: Explore the possible uptake of a localised smartphone flood warning app for the study area.

4.9. Response

There were several issues relating to response identified (Section 3.9) that could be improved.

Some people informed Wimmera CMA that the gauge boards at Lah are difficult to view during a flood. They are attached to the side of the culverts on the southern side of the crossing. These gauge boards should be moved to a location that can be viewed during time of flood.

As recommended in Section 4.3, there should be community education for several of the issues discussed in Section 3.9 including the risks of moving through floodwaters, understanding of the risks of living behind a levee (if built) and the need to help others in a flood.

Particularly due to the reasonably high level (10%) of the population that require assistance, Yarriambiack Shire Council should ensure that all people requiring assistance are in its Vulnerable Persons Register as required by the Vulnerable People in Emergencies Policy.

Although there appear to be high levels of social capital in the study area communities, efforts should be made to engage (e.g. by doorknocking) with all people in the Brim community, particularly if a flood is imminent.

Recommendation 12: Move the gauge boards at Lah a location that can be viewed during time of flood.

Recommendation 13: Ensure that all people requiring assistance in Yarriambiack Shire are in the Vulnerable Persons Register.

Recommendation 14: Engage (e.g. by doorknocking) with all people in the Brim community if a flood is imminent.

4.10. Community participation

There was little evidence found (Section 3.10) of community participation in the establishment, operation and review of the TFWS apart from some in the 2007 and 2015 flood investigations. Possible processes for this to occur include by crowdsourcing flood observations (Section 4.6), through community membership of existing committees (e.g. Yarriambiack Shire Council Flood Response Plan Sub-Committee) and through community workshops or forums.

Recommendation 15: Identify and implement ways for community members in the study area to participate in the establishment, operation and review of the TFWS.

4.11. Review of the TFWS

As mentioned in Section 1.2, according to the Revised Draft Victorian Floodplain Management Strategy there is a Victorian Government review of TFWS in catchments across the state.

The Victorian Government has made DELWP accountable for the coordination of TFWS services at the state level. It is also accountable for documenting a state-level TFWS service development plan. DELWP will do this in consultation with VICSES, BoM, Melbourne Water, CMAs, LGAs, water corporations and other stakeholders as required.

The TFWS service development plan will be informed by the rolling three-year implementation plans coming out of the regional floodplain management strategies. In preparing those regional strategies, the CMAs and Melbourne Water will systematically assess the existing TFWS services provided to the flood-prone communities in their region, using the state-wide assessment framework currently being developed by DELWP. They will also assess the TFWS service needs of each flood-prone community.

According to the Revised Draft Victorian Floodplain Management Strategy (page 50), “the Inspector General for Emergency Management has developed an assurance regime to meet its obligation to develop an audit framework for the Total Flood Warning Service. The assurance regime includes:

- a mapping process to describe the Total Flood Warning Service
- a framework to facilitate the collection of consistent, relevant and quantifiable information or data to support rigorous monitoring and assessment of the performance of the Total Flood Warning Service

- a three-year schedule of assurance activities, proactive and reactive reviews to test all aspects of the Total Flood Warning Service."

As well as the proactive reviews undertaken as part of the regional floodplain management strategies, DELWP will monitor and review how each TFWS performs when it is needed. Each TFWS will, as a matter of course, be reviewed after a major flood.

Future reviews of the TFWS in the study area should be undertaken through this centralised process. However, as recommended in Section 4.10, local communities should have the opportunity to participate in any review of the TFWS.

4.12. Integration of the TFWS components

As discussed there is a need to understand how the components of the TFWS are integrated. This could be shown in the new MFEP as a flow chart or graphic such as that in Figure 7 (page 47) of the Revised Draft Victorian Floodplain Management Strategy.

In practice, it is important to consider all TFWS components outlined in this report as a minimum and to ensure in review that all components are well coordinated and linked.

Recommendation 16: Describe the integration of the local TFWS at least in the new Yarriambiack MFEP.

Recommendation 17: Ensure that the integration of the TFWS is included as part of future TFWS reviews in the study area.

5. Conclusion

There are numerous contributing catchment areas between the Yarriambiack Creek offtake and Warracknabeal, as well as between Warracknabeal and Brim. There is also a direct storm water catchment area for both townships. However, Wimmera River distributary flow has the greatest flood impacts on the two townships and outlying properties.

This assessment found that there are several days of potential flood warning lead time for Warracknabeal and Brim based on a gauge near the Yarriambiack Creek offtake to the Wimmera River. This means that there is plenty of time for the BoM to disseminate flood watches and flood warnings including through local radio and other communication mediums. There is also ample time for a local or regional ICC to be established, for it to interpret data including from the recent flood study, and construct and communicate warning messages (e.g. Flood Bulletins) to communities in the study area.

If a permanent levee is constructed in Warracknabeal similar to the temporary levee for the 2011 January flood event, virtually all properties in the township will be protected in a 1% AEP flood. Brim will not be inundated in this level of flood. Some outlying properties will require sandbagging and other protection in this level of flood.

Communities along the Yarriambiack Creek system still require a well-developed TFWS, even if a levee for Warracknabeal is constructed. There is the risk that the levee could fail and/or be overtopped. Furthermore, although people may not be directly affected by flooding they still may be isolated for several days and take risks during that time e.g. attempt to drive through flooded roads. There is also the need to move stock to higher ground early and protect property (e.g. pumps, sheds) if possible.

The communities in the area appear to have a high level of social capital, a proven ingredient for successful flood warning response and broader resilience. This was demonstrated in the 2011 flood by the community effort to protect themselves and others. However, the downside of social capital is that some people may be excluded by virtue of their lack of social networks e.g. possibly a section of Brim township, disabled people. It is important that these people are included and engaged in the warning response in the study area.

Community flood education was found to be a TFWS component that required significant improvement. A streamflow gauge immediately upstream from Warracknabeal will provide improved accuracy and reliability of flood warnings to Warracknabeal, Brim and outlying properties downstream. An upgraded MFEP will provide details of the impact of different flood levels on properties and road closures.

6. Recommendations

From this assessment, the following recommendations are made to improve the TFWS in the study area:

Recommendation 1: Provide readily available details to local communities of their flood risk through the Wimmera CMA websites, Section 32 certificates and ongoing community education.

Recommendation 2: The Yarriambiack Shire Council Flood Response Plan be upgraded to a Municipal Flood Emergency Plan and include reference to the latest flood study.

Recommendation 3: The Warracknabeal Caravan Park emergency plan be updated to include reference to the latest flood study.

Recommendation 4: Educate the communities in the study area about aspects of the TFWS including their flood risk, local flood warning triggers for action and the warnings that they will receive if a flood is imminent.

Recommendation 5: A new streamflow gauge with telemetry be installed at the Ailsa Road crossing of Yarriambiack Creek.

Recommendation 6: BOM provide flood forecasting at the Jung and Ailsa Rd (when installed) gauges and, in the interim, provide detailed information to all agencies to determine flood forecasting using charts that relate stream height to AEP, and timing of flood flows to AEP.

Recommendation 7: Combine the old Jung gauge rating (for low flows) with new rating (for flood flows).

Recommendation 8: Further develop the flood crowdsourcing program to enable people to provide real-time flood height observations to the ICC.

Recommendation 9: Establish a ‘phone tree’ or similar localised communication method for isolated properties in the vicinity and downstream of Brim.

Recommendation 10: Explore the possibility of Warracknabeal CFA siren as an extra warning mechanism.

Recommendation 11: Explore the possible uptake of a localised smartphone flood warning app for the study area.

Recommendation 12: Move the gauge boards at Lah a location that can be viewed during time of flood.

Recommendation 13: Ensure that all people requiring assistance in Yarriambiack Shire are in the Vulnerable Persons Register.

Recommendation 14: Engage (e.g. by doorknocking) with all people in the Brim community if a flood is imminent.

Recommendation 15: Identify and implement ways for community members in the study area to participate in the establishment, operation and review of the TFWS.

Recommendation 16: Describe the integration of the local TFWS at least in the new Yarriambiack MFEP.

Recommendation 17: Ensure that the integration of the TFWS is included as part of future TFWS reviews in the study area.

7. References

Aldrich, D.P. (2012) *Building resilience: social capital in post-disaster recovery*, University of Chicago Press, Chicago.

Attorney-General's Department (2009) *Manual 21 Flood Warning*, Australian Emergency Manuals Series, Commonwealth of Australia.

Australian Bureau of Statistics (2012) *2011 Census data for Warracknabeal and Brim*.

Australian Emergency Management Institute (2013) *Managing the floodplain: a guide to best practice in flood risk management in Australia – Handbook 7*. Attorney-General's Department, Australian Government.

Chamlee-Wright, E. (2010) *The Cultural and Political Economy of Recovery: Social Learning in a Post-Disaster Environment*, Routledge, New York.

Department of Environment, Land, Water and Planning (2015) *Victorian Flood Management Strategy – Revised Draft*. Victorian Government.

Fire Services Commissioner (2011) *Building New Foundations*, Victorian Government.

Haynes, K, Coates, L., Leigh, R., Gissing, A., McAneney, J., Handmer, J., and Opper, S., 2009, *Shelter-in-Place v. Evacuation in Flash Flood Environments*, paper presented to the Joint NSW and Victorian Flood Management Conference, Albury-Wodonga, 16-20 February 2009.

ISDR (2006) *Developing Early Warning Systems: A checklist*. Third International Conference on Early Warning. Bonn, 27-29 March 2006

McCaughey VicHealth Centre (2015) *Community Indicators Victoria – data for Yarriambiack Shire*. Accessed on 4 September 2015 from http://www.communityindicators.net.au/wellbeing_reports/yarriambiack

Molinari, D. and Handmer, J. (2011) A behavioural model for quantifying flood warning effectiveness, *Journal of Flood Risk Management*, Vol. 4, pp. 23-32.

Molino, S., Dufty, N., Crapper, G. and Karwaj, A. (2011) *Are warnings working? Achievements and challenges in getting communities to respond*, paper presented to the Floodplain Management Association Conference, Tamworth NSW, February 2011.

Paton, D. (2006) Disaster resilience: building capacity to co-exist with natural hazards and their consequences, in Paton, D., & Johnston, D., (eds.), *Disaster Resilience: An Integrated Approach*, Charles C Thomas Publishers Ltd, Springfield.

Queensland University of Technology (2010) *Half of flood deaths involve motor vehicles*: study, Blog 15 April 2010 At: https://www.qut.edu.au/news/news?news-id=32086 (1 April 2015)

Royal Commission into the 2009 Victorian Bushfires (2010) *Final Report Volume II, Part 2*, State Government of Victoria, Australia.

Victorian Government (2013) *Victorian Warning Protocol* (amended).

Victoria State Emergency Service (2012) *Victoria Flood Emergency Plan*, Victorian Government.

Victorian Government (2015) *Vulnerable People in Emergencies Policy*.

Wagner, K. (2007) How to avoid the Safe Development Paradox. *Geophysical Research Abstracts*, Vol. 9, European Geosciences Union 2007

Water Technology (2007) *Warracknabeal and Beulah Flood Study*. Study Report produced for Wimmera CMA.

Water Technology (2015a) *Warracknabeal and Brim Flood Investigation – Hydrology and Hydraulics* Report produced for Wimmera CMA.

Water Technology (2015b) *Warracknabeal and Brim Flood Investigation - Mitigation Pre-feasibility*. Memo provided to Wimmera CMA on 15/06/2015.

Wimmera Catchment Management Authority (2008) *Flood Information Warracknabeal pamphlet*.

Yarriambiack Shire Council (2009) *Yarriambiack Shire Council Flood Response Plan.*