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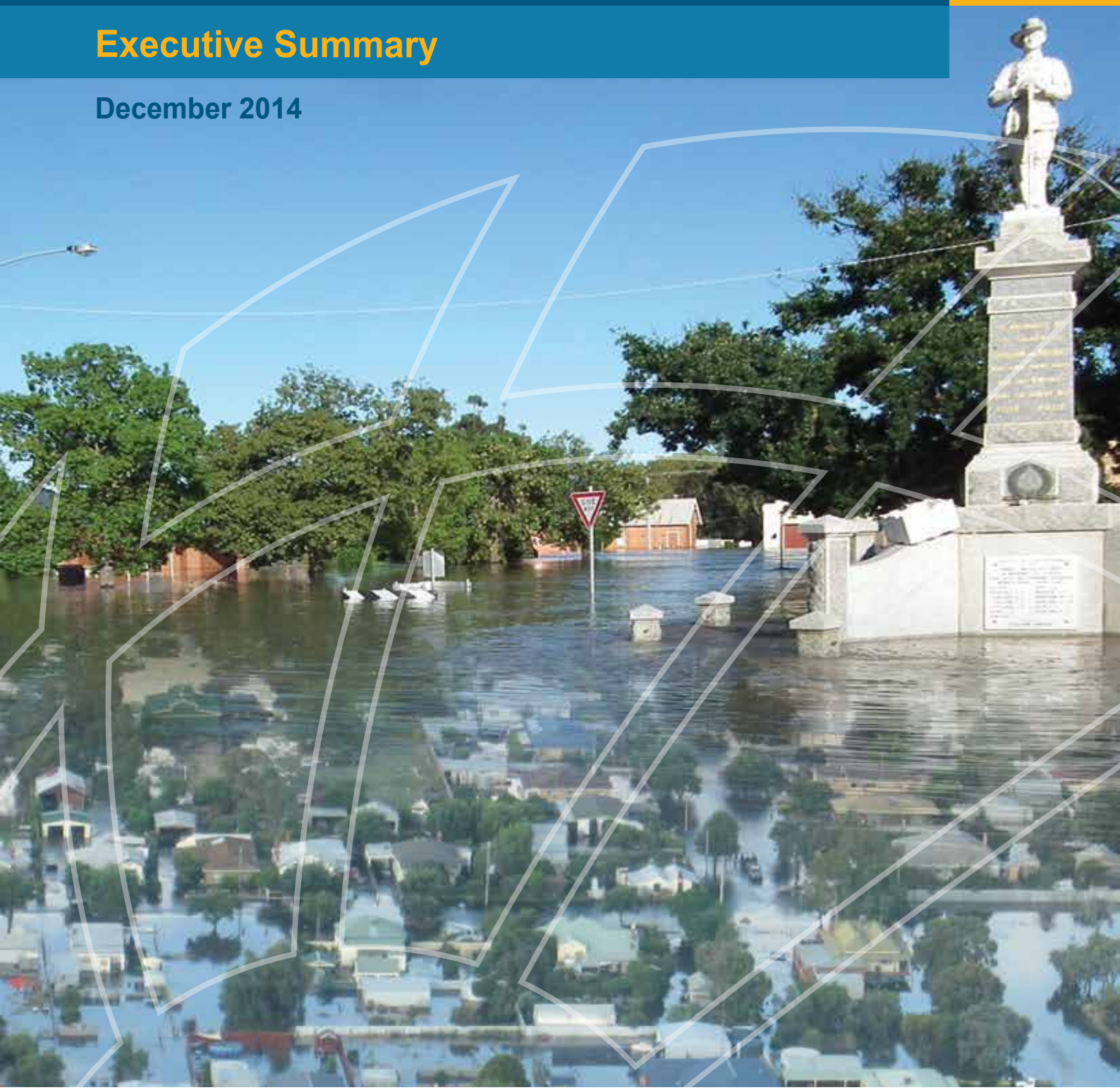
Charlton Flood and Drainage Management Plan

Executive Summary

December 2014



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Charlton Flood and Drainage Management Plan

Executive Summary

Prepared For:	North Central Catchment Management Authority
Prepared By:	BMT WBM Pty Ltd (Member of the BMT group of companies)

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1 INTRODUCTION

This Executive Summary outlines the objectives, methodology and key outcomes of the Charlton Flood and Drainage Management Plan (CFDMP). This Executive Summary is designed to accompany; *Volume 1: Flood Study*, *Volume 2: Management Study* and *Volume 3: Flood Mapping* of the CFDMP. These volumes contain detailed reporting and mapping undertaken for the CFDMP, including:

Volume 1: Flood Study – Data collection, stakeholder engagement, flood modelling, quality assurance as well as existing conditions flood mapping and results.

Volume 2: Management Study – Existing conditions flood damages assessment, management options assessment, recommended structural and non-structural management options and the flood and drainage management plan.

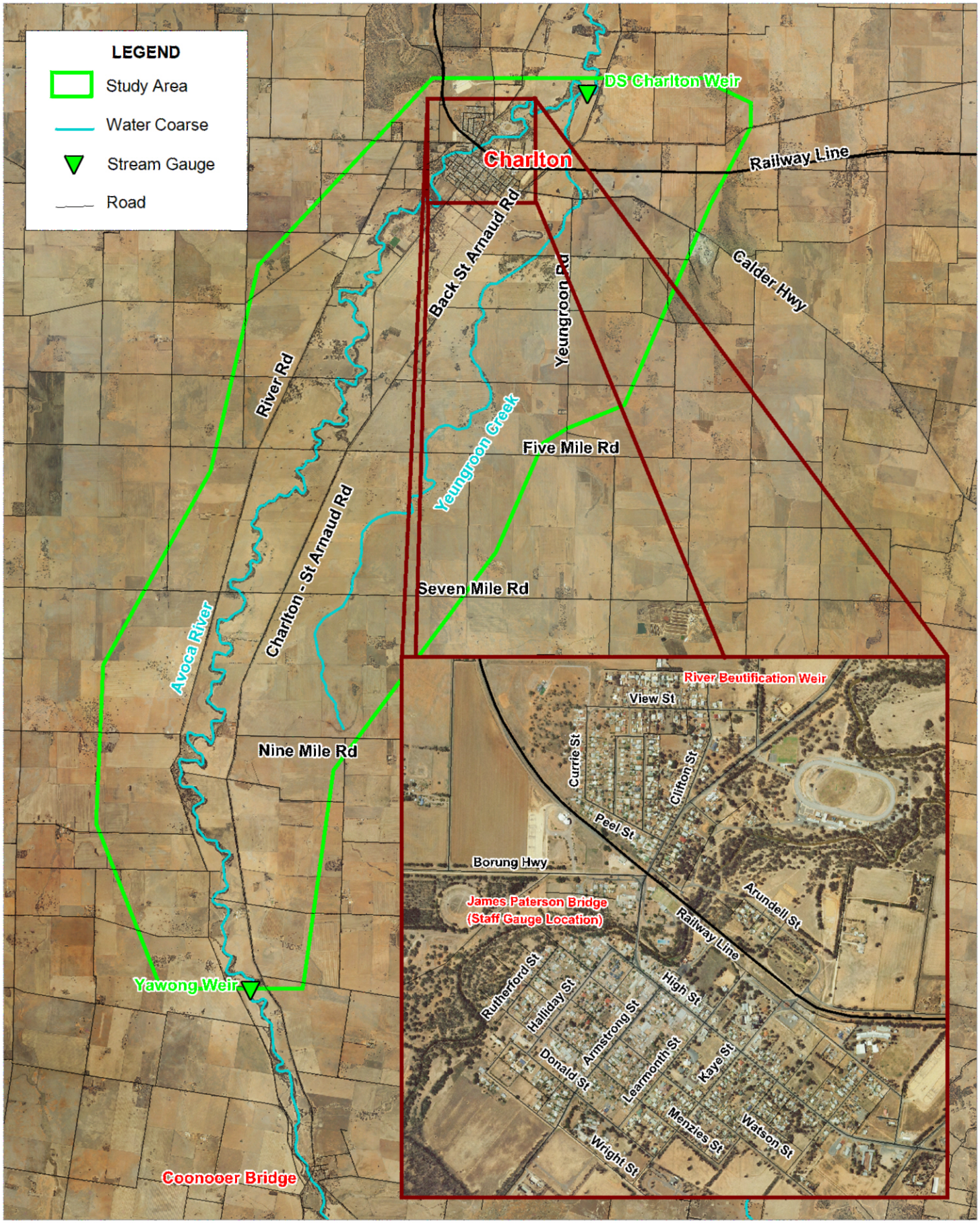
Volume 3: Flood Mapping – Presents the flood mapping associated with Volumes 1 and 2.

1.1 Study Background

In response to the widespread flooding across Victoria in September 2010 and January 2011 on the 29th March 2011 the Minister for Water announced funding for the Charlton Flood and Drainage Management Plan (CFDMP). The North Central Catchment Management Authority (NCCMA), in partnership with the Department of Sustainability and Buloke Shire Council, has commissioned the development of this plan.

The town of Charlton, in northern Victoria, located on the banks of the Avoca River, as shown in Figure 1-1. Charlton has a long history of flooding dating back to the 18th Century and has suffered from three separate flood events in the recent past. These events occurred between September 2010 and February 2011 emphasising the need for a flood and drainage management plan. The NCCMA engaged BMT WBM Pty Ltd (BMT WBM) to undertake a flood investigation for the township of Charlton.

In order to ensure the best outcomes for the community of Charlton, the project was overseen and guided by a Steering Committee and Technical Working Group, which were established for the CFDMP.



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Study Area and Town Area

Figure: 1-1

Rev: A

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1.2 Key Objectives

The key objectives of this study were as follows:

1. Review available data and historic flood information.
2. Engage with the community and stakeholders in order to understand their experiences of flooding and desired outcomes.
3. Calibrate a flood model (hydrologic and hydraulic) to past flood events through the town.
4. Determination and documentation of flood levels, extents, velocities and depths (and thus flood risk) for a range of flood events.
5. A review of the Shire of Buloke Planning Scheme's current flood zone and overlays.
6. Preparation of digital and hard copy floodplain maps for 1% AEP flood events showing both floodplain and floodway extents, suitable for incorporation into municipal planning schemes.
7. Assessment of flood damages.
8. Identification and preliminary feasibility assessment of management options to alleviate intolerable flooding risk.
9. Costing, assessment and recommendation of structural management options.
10. Preparation of flood intelligence and consequence information.
11. A review and update of the Buloke Shire's Flood Response Plan that resides under the Municipal Emergency Management Plan.
12. Delivery of all flood related data and outputs including fully attributed VFD compliant datasets.
13. Transparently report the outcome of the study together with the process followed and the findings.
14. Engage the community in all stages of the drainage and flood management plan to ensure that the most appropriate outcomes are achieved.

1.3 Floodplain Management Plan Process

The process adopted by the CFDMP to manage the risk of flooding is shown in Figure 1-2. This floodplain management process has been adapted from *The Victoria Flood Management* Strategy (DNRE 1998) and is consistent with approaches adopted throughout Australia and has been documented in *Floodplain Management in Australia Best Practice Principles and Guidelines* (CSIRO 2000).

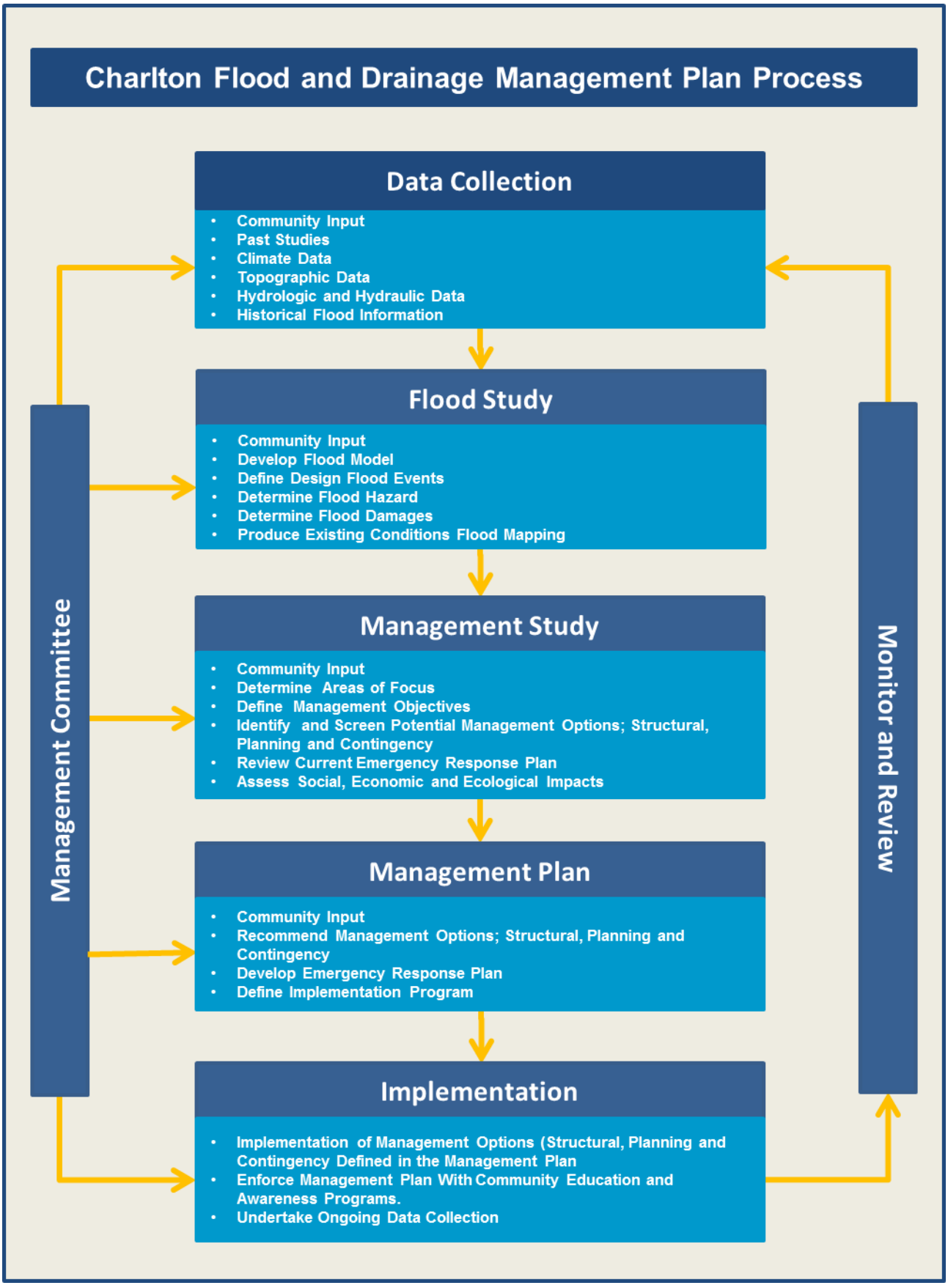


Figure 1-2 Charlton Flood and Drainage Management Plan Process

2 DATA COLLECTION AND FLOOD STUDY (VOLUME 1)

2.1 Data Collection

As part of the CFDMP, datasets and information were obtained from a variety of organisations. The datasets obtained included:

- **Topographic Data** – Including: Vicmap Elevation DTM 10m, Wimmera Mallee Pipeline Project LiDAR, DSE's Rivers Project LiDAR, topographic survey and Permanent Survey Marks.
- **GIS Data** – Including: aerial photography, flood overlays, historical flood extents, cadastral information, planning zones and other government zones.
- **Infrastructure Data** – Including: drainage network details and floodplain control structure details.
- **Rainfall and Streamflow Data** – Including: daily rainfall, pluviograph, stream stage and stream flow records.
- **Historic Flood Levels** – Including: staff gauge readings, surveyed flood levels and surveyed floor levels.

In addition to collecting data from external sources, site inspections and community surveys were also undertaken as part of the CFDMP.

2.2 Stakeholder Engagement

Community consultation was undertaken throughout the development of the CFDMP. The consultation included community meetings, dissemination of information via a web site developed specifically for the CFDMP and through community surveys. The community surveys were issued at community meetings, through the studies web site, by post, at Council's offices in Charlton and by request from the NCCMA.

The NCCMA formed a community based Technical Working Group (TWG) and Steering Committee (SC) to oversee the development of the CFDMP. The TWG provided assistance and technical guidance throughout the course of the study. The SC provided governance and management of the CFDMP and ensured that issues important to the Charlton community were properly considered. Throughout the study, regular meetings were held in Charlton with the TWG and SC at which the findings documented in the papers and presentations were discussed and issues were resolved.

2.3 Flood Model Development

The fully calibrated flood model developed for the CFDMP, to define flood behaviour within the study area and assess mitigation options, incorporates both hydrologic and hydraulic modelling techniques. Flood frequency analyses was undertaken using the FLIKE package to determine the magnitude of predicted peak discharges for a given level of risk or probability. Hydrologic modelling was

undertaken using the RORB hydrologic modelling package to determine the rainfall-runoff characteristics of the catchment.

The catchment flows derived from the hydrologic modelling were then used as input flow boundaries for the TUFLOW hydraulic model. The TUFLOW hydraulic model was used to generate the required flood mapping and define the flooding characteristics of the study area.

The flood model was calibrated to the January 2011 flood event and validated against the September 2010 flood event. To assess the impacts of flooding on Charlton the flood model was run for the following Annual Exceedance Probability (AEP) events: 20%, 10%, 5%, 2%, 1% and 0.5% along with the Probable Maximum Flood (PMF) event.

2.3.1 Hydrologic Modelling

Flood Frequency Analysis

Flood frequency analysis (FFA) has been undertaken using the methods outlined in the draft version of Australian Rainfall and Runoff (ARR) Book IV Peak Flow Estimation. FFA of the Archdale Junction and Yawong Weir gauges has been undertaken using the FLIKE software. The results of the FFA for the Yawong Weir gauge provided peak flow estimates for a given AEP event for Avoca River. The resulting peak flows verses return period at Yawong Weir are shown in Table 2-1.

Table 2-1 Yawong Weir Flood Frequency Analysis Results

AEP	Expected Quantile (m^3/s)	90% Quantile Probability Limits	
20%	233	197	277
10%	344	285	426
5%	474	378	630
2%	678	510	1022
1%	861	611	1441
0.5%	1070	715	1996

Hydrologic Modelling

The purpose of the hydrologic modelling was to characterise the catchment's runoff response to rainfall. This modelling produces time-series of discharge data (i.e. hydrographs) and was undertaken using the RORB hydrologic modelling software. The RORB model covered the entire Avoca River catchment to downstream of the Downstream of Charlton Weir; an area of approximately 2,970 km^2.

To establish a degree of confidence that the hydrologic modelling was suitably representing the runoff behaviour of the catchment, model calibration and validation was undertaken at the Archdale Junction and Yawong Weir stream flow gauges. The RORB model was calibrated against three flood events and summary statistics were reviewed to assess the fit of the model. The model was then validated against a further two flood events using the calibrated parameters. The RORB model was then used to derive flow hydrographs to provide inputs into the TUFLOW hydraulic model for the AEP

events listed above. The derived hydrographs at Yawong Weir were factored to match the magnitude of the design flows adopted in the FFA as these were considered to be more accurate.

2.3.2 Rating Curve Analysis

The FFA and the RORB model calibration are based on gauged flows at the Archdale Junction and Yawong Weir stream gauges, the rating curves used to translate the recorded station levels into flows are vital in defining the accuracy of the flood modelling. As part of the hydraulic modelling process a rating curve analysis was undertaken at the Yawong Weir and DS Charlton Stream gauges as they fall within the study area. This analysis resulted in the significant increases in the estimated discharge at higher river heights at both gauges.

2.3.3 Hydraulic Modelling

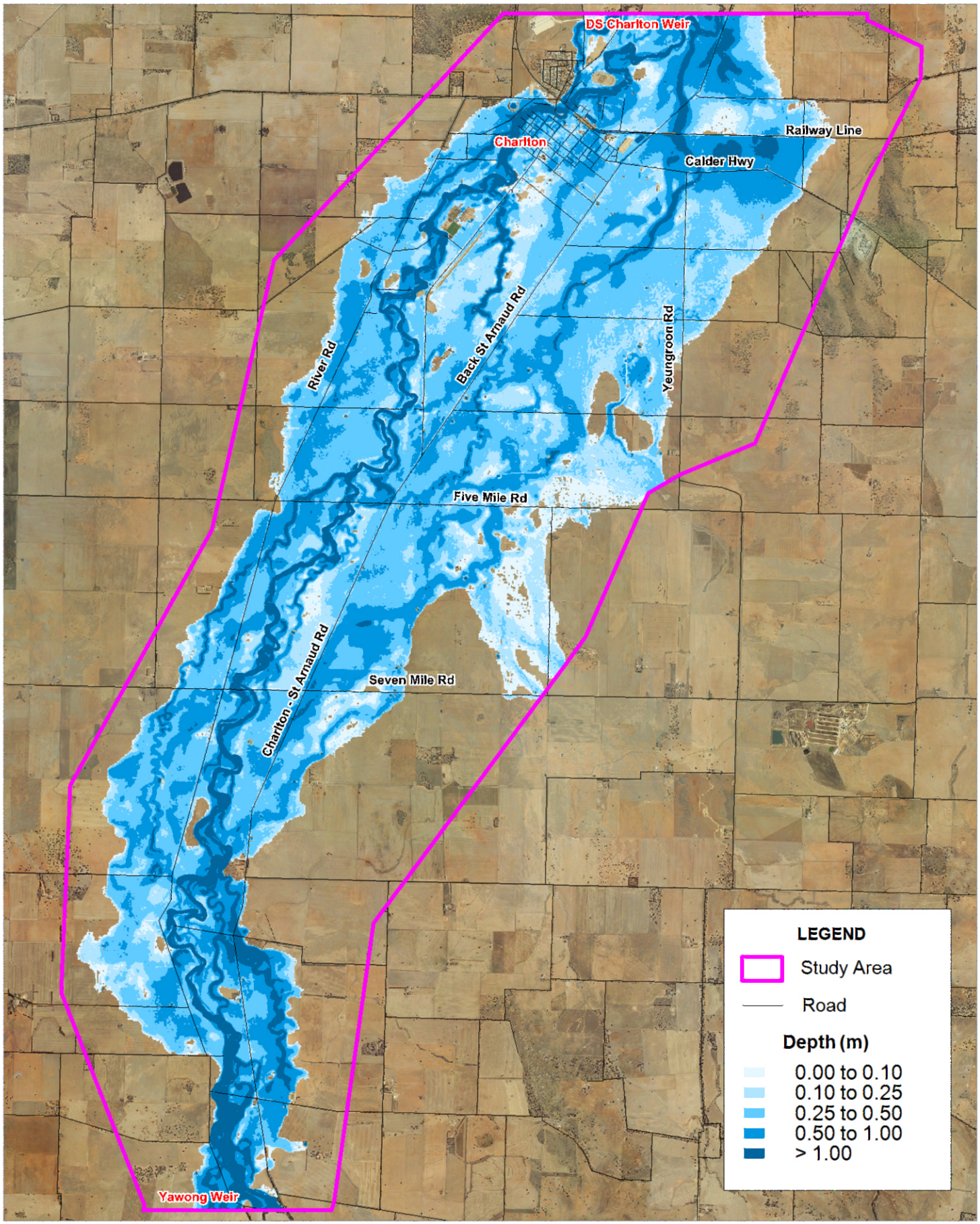
In order to produce flood extents, depths, velocities and other hydraulic properties for the study area a 1D/2D linked hydraulic model was developed using TUFLOW. The floodplain, including the town of Charlton, was represented in the 2D domain with watercourses, drainage and hydraulic structures modelled as 1D elements. The town of Charlton was modelled at a higher resolution than the surrounding floodplain by incorporating a fine grid 2D domain into the model. The model domain extends from approximately two kilometres upstream of Yawong Weir to approximately three and a half kilometres downstream of the Downstream of Charlton stream gauge, covering 157 km^2 of the Avoca River floodplain. The model also extends four kilometres east of Back St Arnaud / St Arnaud Roads allowing for Yeungroon Creek to be represented in the hydraulic model.

The Charlton TUFLOW model underwent a calibration process to fit the model to the observed data. The TUFLOW model was calibrated to the January 2011 flood event and validated against the September 2010 flood event. The hydraulic model was successfully calibrated to the January 2011 and validated to the September 2010 flood events. The results demonstrated that the flood model has been effectively calibrated and is suitable for undertaking modelling of existing conditions and flood mitigation scenarios.

2.4 Existing Conditions Flood Mapping and Results

The existing conditions flood model showed that flooding in and around Charlton emanates from the Avoca River and local creeks, including Yeungroon Creek and Gower Creek. Flooding from the Avoca River initially breaks out at known locations inundating ox-bows, billabongs and the like. These breakout flows then inundate low lying agricultural land before initiating flow in floodplain channels and combing with overland flow from local creek systems such as Yeungroon Creek. When this occurs there is extensive flooding across the floodplain with numerous spills from the Avoca River.

The flood model was run for the 20%, 10%, 5%, 2%, 1% and 0.5% AEP design flood events (existing conditions) along with the PMF event. For each of these design flood events a suite of flood mapping outputs was generated including: flood depth, flood level, flood velocity, flood hazard and flood affected properties and buildings. Existing conditions peak flood depth for the 1% AEP event is presented in Figure 2-1 and Figure 2-2.



Title:

Existing Conditions 1% AEP Peak Flood Depth Charlton Floodplain

Figure: 2-1

Rev: A

This map has been prepared using the best available data and modelling techniques at the time of publication. The accuracy of this map however, is not absolute and reflects only the accuracy of the available data and modelling techniques.
No two floods behave in exactly the same manner even though they rise to the same maximum height at a given location. The information in this map represents a 'design flood' as defined in the Charlton Flood and Drainage Management Plan.

N

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Approx. Scale

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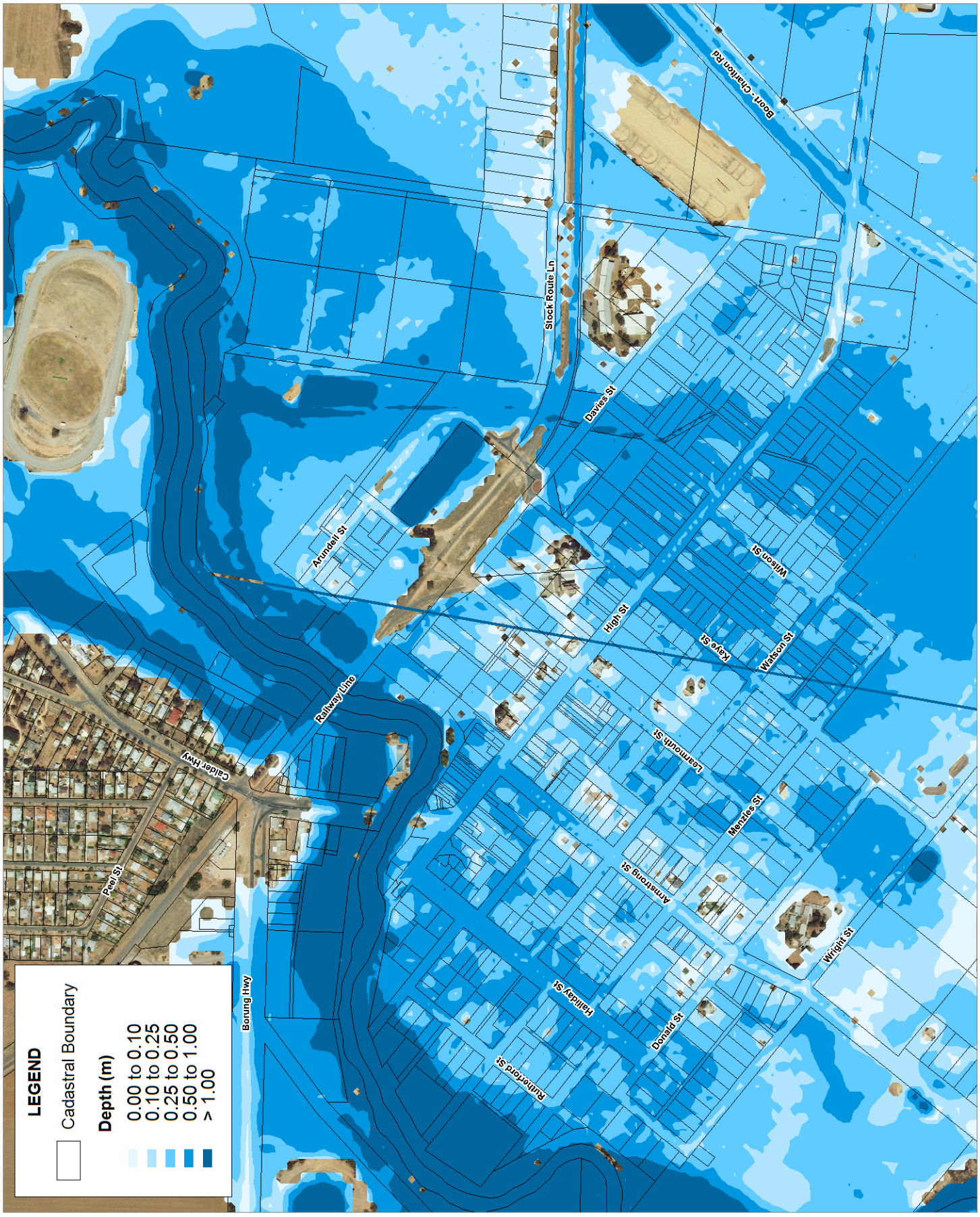

Title:

Existing Conditions 1% AEP Peak Flood Depth Charlton Township

Figure: 2-2

Rev: A

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No two floods behave in exactly the same manner even though they rise to the same maximum height at a given location. The information in this map represents a 'design flood' as defined in the Charlton Flood and Drainage Management Plan.

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Approx. Scale

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3 MANAGEMENT STUDY (VOLUME 2)

This Volume utilised the models and results presented in the Flood Study Report Volume to assess potential floodplain management options and to outline the Charlton Flood and Drainage Management Plan. This included: the existing conditions damages assessment, management options screening, structural management options feasibility assessment, structural management schemes assessment, recommended structural management scheme and non-structural management options.

3.1 Existing Conditions Flood Damages Assessment

The existing conditions flood damages were assessed using a combination of the Rapid Appraisal Method (RAM) and ANUFLOOD methods, both widely adopted throughout Victoria. The ANUFLOOD method was adopted to estimate potential building damages while the RAM method was used to estimate potential agricultural and infrastructure damages.

Flood damages assessments enable floodplain managers and decision makers to gain an understanding of the monetary magnitude of assets under threat from flooding. The information determined in the damages assessment is also used to inform the selection of mitigation measures via a benefit cost analysis. The results of the flood modelling indicated that during the 1% AEP event 266 properties experience above floor flooding, as shown in Table 3-1. The existing conditions Average Annual Damages for the Charlton study area were calculated to be $1,574,000.

Table 3-1 Properties flooded and above floor flooding against AEP event

Event AEP	PMF	0.5%	1%	2%	5%	10%	20%
No. of properties inundated	449	427	426	425	402	270	137
No. of properties with above floor flooding	430	337	266	149	35	4	2

3.2 Flood Management Options Assessment

Through consultation with the community, emergency management authorities and other stakeholders, an understanding of the major factors that influence flood risk in Charlton were identified. This understanding was further enhanced through computer flood modelling and mapping undertaken as part of the CFDMP. These factors relate to the physical characteristics of the floodplain that contribute to flood risk in Charlton and the factors that hamper the community's ability to manage the impact of flooding. The major factors are:

- The location of the town centre (main commercial and residential area) on the east bank of the Avoca River which is lower than the west bank. This results in the town being more frequently inundated.

- The relatively small flow capacity of the Avoca River within the vicinity of Charlton leads to the floodplain becoming active frequently and conveying the majority of flow in larger flood events.
- The obstruction to flow across the entire width of the floodplain caused by the railway line with limited openings.
- The flat topography within the township limiting the effectiveness of local drainage measures resulting in ponding of water in more frequent rainfall events.
- Limited road access to Charlton during flood events, particularly along the Calder Highway from Bendigo.
- The reliability of rain and streamflow gauges within the catchment affecting the dissemination flood warning to the community together with emergency services and limiting their ability to respond to a flood event.
- The lack of an emergency flood response plan for the township of Charlton.

In order to address and manage these factors that contribute to the flood risk in Charlton a comprehensive flood management options assessment was undertaken, including both structural and non-structural management options.

3.2.1 Management Option Screening

As part of the CFDMP a list of all potential mitigation options was complied. This list was compiled from community meetings, surveys of the community, submissions to Council and the NCCMA as well as one-on-one meetings with Charlton residents. In addition, the TWG and SC also tabled management options from community members as well as those developed as part of the CFDMP.

The TWG and the SC screened all management options collated as part of the CFDMP based on the knowledge of the members and the results of the flood modelling and analysis completed by BMT WBM. The screening considered the feasibility of each potential management option in terms of:

- The option's likelihood of delivering the required flood alleviation to Charlton; and
- The economic, social and environmental costs.

In total thirteen structural and eight non-structural management options were screened resulting in six structural and six non-structural management options were recommended for further assessment.

3.2.2 Structural Management Options Assessment

Feasibility Assessment

The six structural options recommended for further assessment were assessed as 4 separate hydraulic modelling options, with some options incorporating more than one structural option. The feasibility structural management options were:

- **Feasibility Option 1: Reinstating Historic Floodplain Levels** – This option assessed returning the floodplain to historic levels and was broken into parts. The first part (Option 1a) combines the reinstatement of floodways on roads, including the Charlton-St Arnaud Road, and re-grading the Back St Arnaud Road. The second part, Option 1b, investigates the widening of the railway openings.

- **Feasibility Option 2: Town Levee** - The design of a levee(s) to prevent flow from entering the Charlton Township.

- **Feasibility Option 3: Floodplain Channels** - Improving and enhancing floodplain flows from the Avoca River to the Yeungroon Creek systems upstream of Charlton. This involves the reinstatement of floodways and channel/floodplain works to direct flow toward Yeungroon Creek.

- **Feasibility Option 4: Town Drainage** - Works to improve the efficiency of the current town drainage network.

It became evident during the feasibility option assessment that a town levee was the only option that would provide significant protection to Charlton. Other management options may provide benefits in isolated areas or aid to minimise the negative impacts associated with a levee. As such, a number of town levee schemes were developed for further assessment.

Scheme Assessment

The four structural management schemes assessed were based around a town levee with combinations of other works to minimise the negative impacts associated with a levee. The four management schemes were:

- **Scheme 1: Town Levee** – The design of a levee(s) to prevent flow from entering the Charlton Township.

- **Scheme 2: Town Levee with St Arnaud Road Creek Crossing** - The design of a levee(s) to prevent flow from entering the Charlton Township with the reinstatement of the floodway on St Arnaud Road.

- **Scheme 3: Town Levee with St Arnaud Road Creek Crossing and Floodplain Channels** - The design of a levee(s) to prevent flow from entering the Charlton Township with the reinstatement of the floodway on St Arnaud Road and improving and enhancing floodplain flows from the Avoca River to the Yeungroon Creek system upstream of Charlton. This involves the reinstatement of floodways and channel/floodplain works to direct flow toward Yeungroon Creek.

- **Scheme 4: Town Levee with St Arnaud Road Creek Crossing, Floodplain Channels and Railway Opening** - The design of a levee(s) to prevent flow from entering the Charlton Township with the reinstatement of the floodway on St Arnaud Road, improving and enhancing floodplain flows from the Avoca River to the Yeungroon Creek system upstream of Charlton and widening the railway opening across the Yeungroon Creek.

Hydraulic modelling of the range of design events; that is the 20%, 10%, 5%, 2%, 1% and 0.5% AEP and the PMF events; were used to undertake flood impact and damages assessments. Additionally, a benefit-cost ratio, which is an economic assessment based on preliminary cost estimates, was undertaken.

The resulting reductions in flood risk and Average Annual Damages (AAD) for the four schemes assessed was similar. As a result, the benefit-cost ratios were most heavily influenced by the cost of each scheme, as shown in Table 3-2.

Table 3-2 Structural Management Scheme Benefit-Cost Ratios

Structural Management Scheme	AAD	Capital Cost	Total Scheme Cost	BCR
Basecase	$1,574,000			
Scheme 1	$1,213,000	$4,640,000	$5,586,000	1.02
Scheme 2	$1,208,000	$5,410,000	$6,356,000	0.91
Scheme 3	$1,197,000	$12,100,000	$15,410,000	0.39
Scheme 4	$1,197,000	$37,510,000	$40,820,000	0.15

3.3 Recommended Structural Management Scheme

Scheme 2 was the recommended structural management scheme for implementation in the CFDMP. Scheme 2 comprises the following structural components:

- Town Levee;
- St Arnaud Road Creek Crossing Works;; and
- Minor drainage improvements.

The impacts on the 1% AEP design event peak flood levels for Scheme 2 are shown in Figure 3-1. It is important to note that the modelled alignment shown is not the final levee alignment. This will be determined during a detailed design stage.

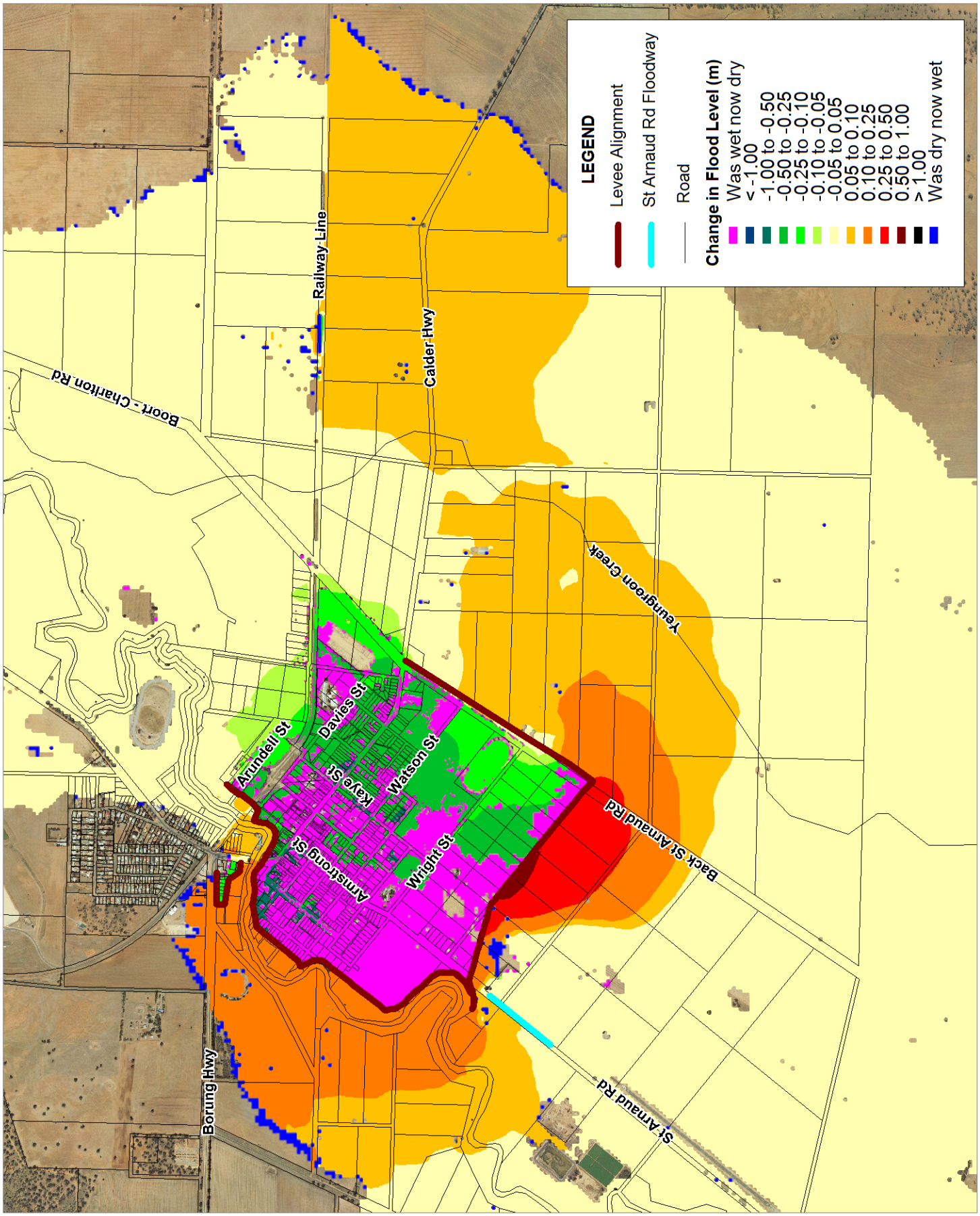
Scheme 2 results in a BCR ratio approaching one. It has advantages over Scheme 1, which has a higher BCR. These advantages include providing additional time for the community to prepare for a flood event as well as addressing a key community concern. Increased warning times will allow more response time for the community to prepare for potential flooding. Preparations may include evacuation, moving valuables to higher locations or for the construction of a temporary levee across St Arnaud Road.

The Buloke Shire Council is currently undertaking drainage improvements, such as placing culverts under driveways and various other works. It is recommended that Council continue these improvements to ensure that runoff generated from rainfall falling within the levee will be managed.

3.4 Recommended Non-Structural Management Options

Six non-structural management options identified during options screening were recommended for implementation in the CFDMP. These were:

- Declaration of flood levels;
- Amendments to planning schemes, including:
    - Planning Overlays; and
    - Building Controls.
- Planning for climate change;
- Flood response plan, including flood intelligence and consequence information.
- Flood warning system;
- Flood wardens; and
- Community education.



Title:

Recommended Scheme
Impacts on 1% AEP Peak Flood Levels

Figure: **3-1**

Rev: **A**

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N

0 0.5 1km

Approx. Scale

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4 FLOOD AND DRAINAGE MANAGEMENT PLAN

The flood and drainage management plan, summarised in Table 4-1, presents the recommended management options, both structural and non-structural, to be implemented in order to reduce the risk of flooding in Charlton.

Table 4-1 Summary of the CFDMP

	Management Measure	Description of Works
Structural Management Measures	St Arnaud Road Creek Crossing Redesign	These works involve the redesign of the existing creek crossing on the St Arnaud Road that was installed when the road was raised removing the Gower Creek floodway. These works will influence the timing of flow by delaying water entering town, thus increasing warning time.
	Town Levee	The town levee is designed to the 0.5% AEP standard. It prevents floodwaters from entering the town from the south and prevents water breaking out of the Avoca River adjacent to the town.
	Town Drainage	Improvements to the town drainage system will be required to ensure the integrity of the levee. This will involve the inclusion of flap valves on the drainage networks that discharge into the Avoca River and flood gates on the Stock Route Lane culverts. Additionally, the town drainage works currently being undertaken by the Buloke Shire Council, such as the driveway works, should be continued along with potential further improvements.
Non-Structural Management Measures	Declared Flood Levels	The 1% AEP flood levels determined by the CFDMP will be adopted as the Declared Flood Levels as prescribed by Section 204 of the Water Act 1989.
	Amendments to Planning Schemes	Flood planning GIS data for Charlton, indicating the extent of Urban Floodway Zone (UFZ), Land Subject to Inundation (LSIO) and Floodway Overlays (FO), has been provided to Council for inclusion into the planning scheme. Building control recommendations consistent with the current recommendations issued by the NCCMA have been provided. NCCMA require a minimum of 300mm freeboard above the declared flood levels.
	Planning For Climate Change	Climate change sensitivity modelling has been undertaken as part of the CFDMP and the results have been made available to Council.
	Flood Response Plan	A MFEP has been completed as part of this study and is available from Buloke Shire Council.
	Flood Intelligence and Consequence Information	Flood intelligence and consequence information has been prepared as part of the CFDMP. This information is presented in the Buloke Shire Council MFEP.
	Flood Warning System	A review of the total flood warning system for Charlton has been undertaken as part of the CFDMP. This review has made a number of recommendations which are listed in *Volume 2: Section 17.5.6*.
	Flood Wardens	It is recommended that community based Flood Wardens are engaged who can provide flood intelligence during times of flood.

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