Seymour
Flood Mitigation
Communication Investigation

Final Consultants Report to Council
February 2006

Prepared For:	Mitchell Shire Council
Prepared By:	WBM Oceanics Australia

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	Synopsis:	This report details the Flood Mitigation Communication Investigation undertaken for Seymour. It documents the investigation of flood mitigation options for the town and the selection of a preferred option.

REVISION/CHECKING HISTORY

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EXECUTIVE SUMMARY

The Seymour Flood Mitigation Communication Investigation report details flood management options for Seymour. The options aim to reduce the impact of flooding at Seymour from the Goulburn River, and lower reaches of Whiteheads Creek, and to manage flood damages by controlling the flood risk.

Options have been selected based on the investigation, modelling, mapping and consultation work completed for the Seymour Floodplain Mapping Study (WBM, 2001) and Seymour Flood Mitigation Communication Investigation Study. Selected options were deemed acceptable by the overseeing Technical Steering Committee (TSC). The preferered option of an outer town levee was modelled under flood conditions using a two-dimensional numerical model to determine impacts to existing flood risk and flood damages. Detailed maps illustrating the impacts of the preferred mitigation option been produced.

Project Objectives

The objective of the study was to communicate flood risk to the community and seek their input, and then to develop and test flood mitigation options for the town. The study specifically excluded the investigation of flood warning and land-use planning, and it was expected that the flood mitigation options were most likely structural measures (eg levees). Key objectives of the Flood Mitigation Communication Investigation were to:

1. Communicate existing flood risk to the community (via a flood information brochure).

2. Seek community input into further development of the range of potential mitigation options (via a questionnaire and Community Reference Group and open community meetings).

3. Develop a shortlist of options for further assessment and to select (in consultation with the TSC and CRG) an option(s) for detailed assessment.

4. Assess the preferred mitigation option(s) utilising state-of-the-art computer models produced for the Seymour Floodplain Mapping Study (WBM 2001), with consideration given to social, ecological and economic factors.

5. Provide a consultants report to Council recommending a preferred mitigation option.

Options

All full range of structural and non-structural mitigation measures were developed and reviewed. A screening process eliminated all options except for levees and floodplain modification works. Through discussions with the TSC, CRG and community, 4 discreet options were developed for further consideration, as illustrated in Figure E-1.

1. An Inner Town Levee on the alignment proposed by SRWSC, 1984 study;
2. An Outer Town Levee on the alignment proposed in the SRWSC, 1984 study;
3. An Outer Town Levee with an alternative alignment; and

4. The lowering of Emily Street and associated waterway crossing works.

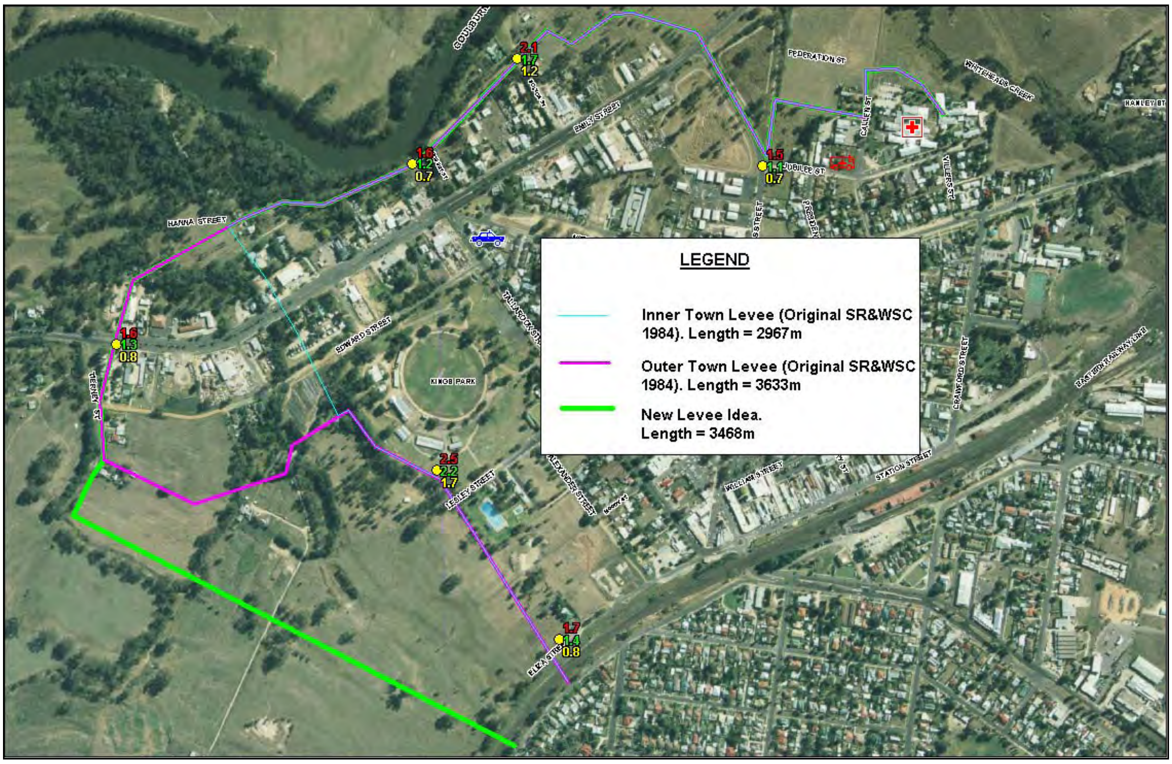

Figure E-1 Levee Alignments

Preferred Option

The levee alignments, and outcomes of the analyses, were presented to the TSC and CRG. The alignments were subsequently walked by the TSC and CRG. From the meetings, it was **agreed that Option 3, an outer town levee, was recommend for further consideration.**

Hydraulic modelling and GIS mapping of the impacts of the preferred option was undertaken and presented to the TSC and CRG. The preferred levee alignment was subsequently amended by the TSC and CRG to include an extension of the levee along Whiteheads Creek to the railway line, as illustrated in Figure E-2.

Modelling and mapping of the preferred levee demonstrated impacts on a number of properties outside the levee alignment. Seven property floors, all flooded in the 100 year flood event under existing conditions, are subject to increased flood frequency and increased flood levels of up to 0.8m. Individual solutions for each of the properties should be determined in consultation with the property owners at the detailed design stage.

The selected design standard for the preferred levee option was the 100 year ARI flood level plus 600mm freeboard. The present value (PV) of the capital cost of construction works is $3.91M, with an associated BCR of 1.54. This means that for every $1.00 spent on construction, there will be $1.54 in saved flood damages.

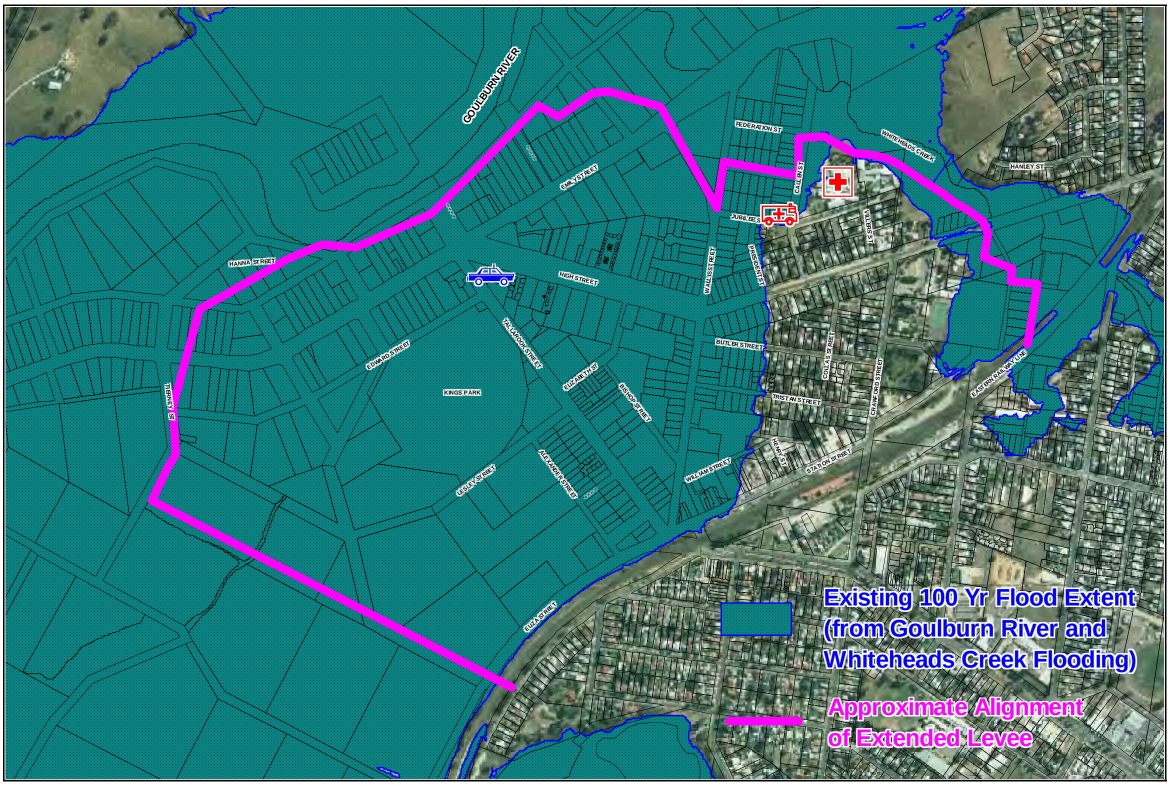

Figure E-2 Extended Preferred Levee Alignment

Conclusions and Recommendations

The preferred levee option has a BCR of 1.54. The BCR shows that the benefits out way the costs, and as such, is economically feasible.

It is recommend that Council adopt the findings of this report and invite community comment through a public exhibition process.

It is recommended that Council adopt the findings of the report and prepared a Floodplain Management Plan by:

1. Consultation and awareness program for all affected landowners of the preferred scheme.

2. Identification and resolution of concept design issues relation to pumping requirements and levee location in consultation with landowners and relevant authorities.

3. Review cost of the scheme.

Preparation of the Floodplain Management Plan for public comment in accordance with Section 223 of the Local Government Act, including information workshops.

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1 INTRODUCTION

In April 2002, Mitchell Shire Council commissioned WBM Oceanics Australia to undertake the Seymour Flood Mitigation Communication Investigation Study. The objective of the study was to communicate flood risk to the community and seek their input, and then to develop and test flood mitigation options for the town. The study specifically excluded the investigation of flood warning and land-use planning, and it was expected that the flood mitigation options were most likely structural measures (eg levees). The study followed on from a comprehensive flood study, *Seymour Floodplain Mapping Study*, undertaken by WBM (WBM 2001).

Key objectives of the Flood Mitigation Communication Investigation were to:

1. Communicate existing flood risk (i.e. likelihood and consequence) and potential flood mitigation options to the community.

2. Seek community input into further development of the range of potential mitigation options.

3. Develop a shortlist of options for further assessment and to select (in consultation with the TSC and CRG) an option(s) for detailed assessment.

4. Assess the preferred mitigation option(s) utilising state-of-the-art computer models produced for the Seymour Floodplain Mapping Study (WBM 2001), with consideration given to social, ecological and economic factors.

5. Provide a consultants report to Council recommending a preferred mitigation option.

The mitigation options selected and presented in the report are based on the investigation, modelling, mapping and consultation work completed for the Seymour Flood Mitigation Communication Investigation Study and approved of by the study Technical Steering Committee (TSC).

1.1 Locality and Flooding History

The town of Seymour is located in central Victoria on the Goulburn River floodplain. Whiteheads Creek flows along the eastern edge of the township and into the Goulburn River. The town has a history of flooding dating back to the mid 1800's, which has shaped the town into it present day formation. Flooding in 1870, 1916 and 1917 forced relocation of the town commercial centre to Emily St. The 1916 flood event is the most severe flood recorded in the town's history. Major flooding in 1974 caused direct damages to nearly 200 buildings. Today it is estimated that 400 buildings are vulnerable to flooding from a 1 in 100 year ARI event in the Goulbourn River. With the exception of localised flooding in 1993, the 1974 event is the most recent major flood experienced at Seymour.

2 FLOODPLAIN MANAGEMENT PROCESS

The floodplain management process as outlined in "Floodplain Management in Australia – Best Practice Principles and Guidelines" (CSIRO, 2000) is shown in Table 2-1. The floodplain management approach adopted for Seymour to date has closely followed this process, but some additional components have been included. For example, in Stage 1, Floodplain Mapping Study (WBM 2001), a preliminary assessment of some floodplain management measures was undertaken. This is often reserved for Stage 2.

Stage 1 of the process is to determine the existing flooding problem and is documented in the Seymour Floodplain Mapping Study report (WBM, 2001). The report and associated mapping establishes the likelihood and consequences of flooding in Seymour. Sample flood mapping from the study has been included in APPENDIX A for background information.

Stage 2 has been undertaken as the Seymour Flood Mitigation Communication Investigation, documented in this report and in the Option Selection Discussion Paper (WBM Oceanics Australia, 2003) contained in APPENDIX C. This report will form the basis used to further develop Stage 3 and Stage 4 of the floodplain management process.

A summary of Stage 1 and 2 is given in Sections 3 and 4 respectively.

Table 2-1 Floodplain Management Process

Stage	Description
1. Flood Behaviour Definition	The nature and extent of the flood problem are determined.
2. Floodplain Management Measures Investigation	Management measures for the floodplain are investigated in respect of both existing and proposed developments. These options are evaluated based on the impact on flood risk, while considering social, ecological and economic factors.
3. Floodplain Management Plan	Following acceptance of Stage 2 recommendations, the preferred management options are documented in a plan.
4. Implementation of the Plan	Involves formal adoption by Council of the floodplain risk management plan and a process of implementation for the selected flood, response and property modification options.

A Technical Steering Committee (TSC) and Community Reference Group (CRG) were formed to oversee the Study and to ensure that issues important to the Seymour community are addressed. The TSC members were:

- David McCullough, chairman;
- Mitchell Shire Council's project manager, Greg Scott;
- Goulburn Broken Catchment Management representative, Guy Tierney;
- Bureau of Meteorology representative, Peter Zimmermann;
- Department of Primary Industry representative, Bruce Radford; and
- Community Reference Group (CRG) consisting of various community representatives.

Throughout the Seymour Flood Mitigation Communication Investigation Study, regular meetings were held with the TSC to discuss study findings and resolve issues. The findings are documented in discussion papers. The flyer and questionnaire used in the community survey is contained in APPENDIX A.

3 FLOOD BEHAVIOUR DEFINITION

Flood behaviour definition is the first stage of the floodplain management process defined in Section 2. There have been several flood studies undertaken to understand flooding behaviour of the Goulburn River at Seymour. The most recent study is the Seymour Floodplain Mapping Study (WBM 2001). The study examines and defines existing flood behaviour at Seymour in detail through:

- Review of relevant previous studies;
- Review and collation of historical data;
- Identifying the nature and extent of historical floods;
- Developing predictive tools (two-dimensional numerical computer model) that reproduce historical flood behaviour; and
- Defining best estimates of the 2 yr, 5yr, 10yr, 20yr, 50yr, and 100yr ARI design flood extent, depth and velocity; and
- Defining best estimates of flood extent, depth and velocity for a number of intermediate "gauge height" events.

Sample flood maps from the study have been included in APPENDIX A. More detailed information is available in the Seymour Floodplain Mapping Study report and associated mapping (WBM, 2001).

The main intent of the Seymour Flood Mitigation Communication Investigation Study is to communicate the existing flood risks to the community and to develop a range of mitigation measures/options. The approach used to undertake the study is outlined in Section 4.

4 FLOOD MITIGATION COMMUNICATION INVESTIGATION APPROACH

The approach used to undertake the flood mitigation communication investigation was to:

- Communicate existing flood risk to the community through a targetted consultation program, including a community information brochure and questionnaire;
- Identify a full range of structural and non-structural flood mitigation measures for assessment;
- Undertake a preliminary assessment of mitigation measures to determine which combination of measures should form a scheme(s) to undergo a detailed assessment;
- Undertake a detailed assessment of combined flood mitigation measures;
- Determine the flood design standard of the preferred scheme;
- Determine flood impacts of preferred scheme;
- Communication of preferred strategy to the broader community; and
- Detail the findings in a study report.

Upon completion of the study report, the project report will be endorsed by Council and will put on public exhibition.

5 COMMUNICATION OF RISK TO THE COMMUNITY

Flood risk (likelihood and consequences) was established as part of the floodplain mapping study (WBM, 2001). Flood inundation maps derived for the Seymour Flood Study (WBM, 2001) were used in conjunction with ANUFLOOD flood damage assessment guidelines to produce damages estimates. **The estimated Annual Average Damages (AAD) for Seymour is $490,000.** This figure represents on average, the damage bill that the community incurs each year as a result of flooding. In addition to this estimate, there are other non-monetary damages resulting from flooding such as social hardship, stress and anxiety. A summary of flood damages is presented in Table 5-1 below and in Figure 5-1.

Table 5-1 Flood Damages for Seymour Township

Likelihood of Flooding (ARI)	Number of Flood Affected Properties	Number of Buildings Flooded above Floor Level	ANUFLOOD Estimated Total Damages ($ Millions)
1 in 100 years	288	263	14.6
1 in 50 years	282	235	8.7
1 in 20 years	277	147	3.4
Average Annual	NA	NA	0.49

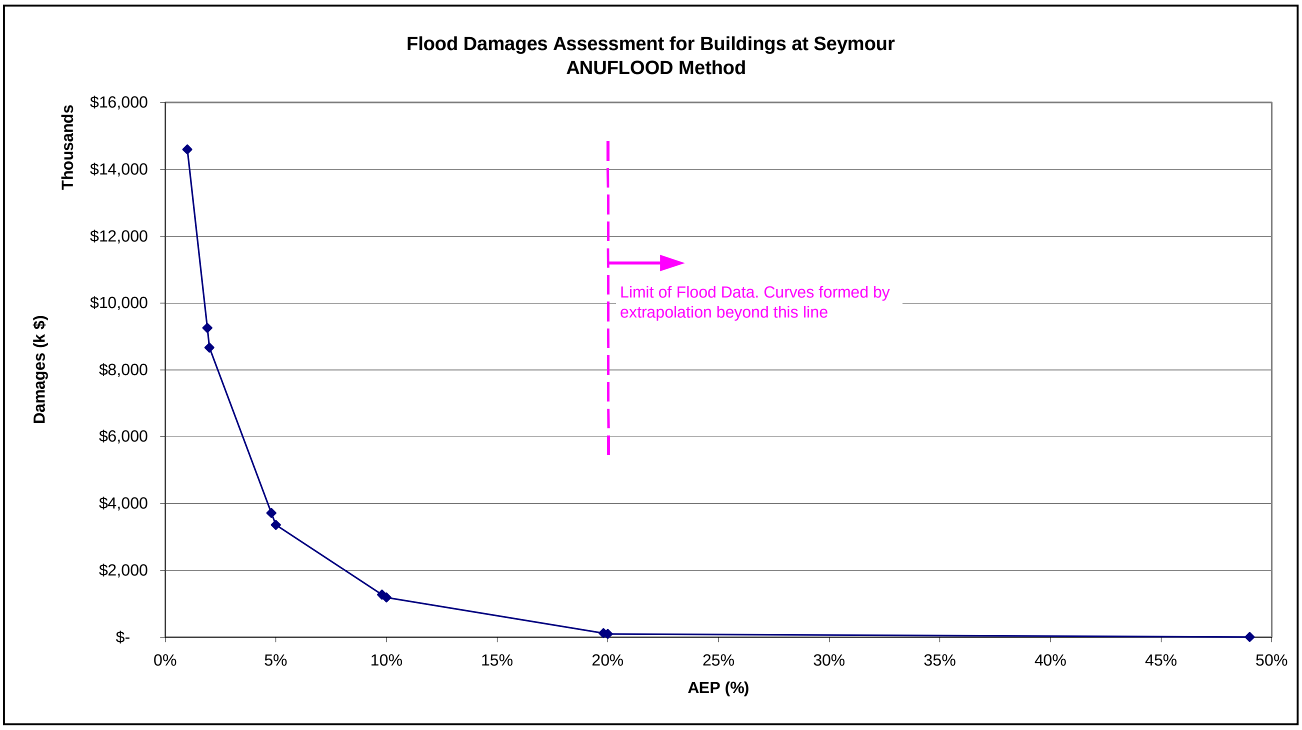


Figure 5-1 Flood Damages for Seymour Township

5.1 Flood Brochure and Questionnaire

Flood risk at Seymour was communicated to the community by distribution of an information flyer (Refer to APPENDIX B). The flyer describes the risk of flooding at Seymour, types of flooding and the potential damages. The information was presented and discussed as apart of TSC/CRG meetings and subsequent open community forums.

A floodplain management questionnaire was also distributed (Refer to APPENDIX B). The questionnaire was designed to seek input from landholders on their preferred risk management treatments, acceptable levels of risk, priority and costs. The questionnaire also provided community members the opportunity to express interest in being more closely involved in the process by nominating to be part of the CRG.

Thirty-four questionnaire returns were received. The responses were summarised and presented to the TSC/CRG and broader community. Summaries of key findings are presented in Table 5-2 to Table 5-4.

Table 5-2 Q1 - Flooding Concerns

Rank	What are your Flooding Concerns?	Percentage of Total Reponses
1	Damage or potential damage to your house or business	24%
2	Warning time	18%
3	Personal financial hardship	17%
4	Economic effects on the community	15%
5	Personal Safety	14%
6	Damage or potential damage to other property (eg Community Facilities)	13%

Table 5-3 Q2 - Preferred Mitigation Measures

Rank	Preferred Mitigation Measures	Percentage of Total Reponses
1	Community education and awareness programs	17%
2	Flood proofing or raising of individual buildings	17%
3	Land acquisition	16%
4	Land use planning	14%
5	Floodways	10%
6	Levees or floodwalls	9%
7	Vegetative cleaning of waterways to increase hydraulic capacity	9%
8	Enlargement of existing waterways	8%

Table 5-4 Q5 - Desired Level of Protection

Rank	Preferred Mitigation Measures	Percentage of Total Reponses
1	Once in 20 year flood	50%
2	Once in 50 year flood	40%
3	Once in 100 year flood	10%

The conclusions that could be drawn from the questionnaire returns were that the community were most concerned with flood damages to their homes or businesses, ranking 24% of all responses. Most respondents felt that non-structural flood management measures were preferred, with the exception of *flood proofing or raising of individual buildings*, which ranked equal highest to *community education and awareness programs*. Levees ranked 6th overall, with 9% of total responses. The community was also prepared to live with only a 20 year level of flood protection from potential mitigation measures.

6 MITIGATION OPTIONS

6.1 Identification and Preliminary Assessment of Options

The mitigation Option selection process was documented in the *Technical Steering Committee - Option Selection Discussion Paper* (WBM, 2003). The paper detailed the methodology, mitigation option screening process, the selection of mitigation options for further assessment, and the selection and recommendation of a preferred option for detailed analysis. Brief details are presented in the following sections, however for more detail, the reader is referred to the full report contained in APPENDIX C.

A list of all common mitigation elements, aimed at reducing the impact of flooding on both existing and future floodplain development, was compiled and presented to the TSC. This list was augmented and adjusted to take into consideration responses from the community questionnaire. This list was reduced significantly by removing measures that were either not feasible or already in place (asterixis in the below list). The full range of measures that were considered is as follows:

- Levees
- Floodplain Modification (lowering of roads etc.)
- Channel Improvement
- Floodwalls
- Floodways
- Removal of Obstructions
- Flood Storage* (prohibitive scale)
- Diversions* (nowhere to divert to)
- Purchase and Relocation
- Individual Property Flood proofing
- Floodplain Education Programs
- Flood Insurance
- Flood Warning System* (In Place)
- Land Use Planning* (In Place)
- Information and Data Collection* (Done)
- Planning Scheme Amendments* (In Place)
- Regulation and enforcement* (N/A)

A more detailed, matrix style analysis was then carried out on the remaining measures. This process involved assigning a rank for each of hydraulic and economic benefits along with any adverse environmental and social effects associated with each measure. This analysis was presented and fine-tuned with the TSC and CRG to give the ranking of measures in Table 6-1.

Table 6-1 Seymour Mitigation Option Screening

SEYMOUR Mitigation Option Screening		Weighting					
		10	10	8	5	2	
Rank	Strategy Elements	Hydraulic Benefit	Economic Benefit	Cost	Environmental Impact	Social Consequence	Weighted Score
1	Levees	10	10	7	3	4	121
2	Floodplain Modification (lowering of roads etc.)	5	5	4	2	1	56
3	Floodplain Education Programs	0	4	1	0	0	32
4	Floodwalls	4	4	6	3	2	13
5	Individual Property Flood proofing	0	6	7	0	3	-2
6	Flood Insurance	0	7	8	0	4	-2
7	Purchase and Relocation	0	8	10	0	5	-10
8	Floodways	2	2	5	2	1	-12
9	Channel Improvement	1	1	5	8	7	-74
10	Removal of Obstructions	1	1	5	10	8	-86

A discussion was then held with the TSC and the CRG in relation to which of the options would be considered in further detail. From this discussion, it was clear that the top two options (Levee's and Floodplain Modification) were the preferred measures for detailed analysis, however the precise alignment and configuration of the measures was variable and required further discussion.

It was also noted that, although various levee alignments were being discussed, it was not proposed that any of these alignments would be the final design alignment. It was envisaged that if a levee scheme were to be recommended, it would be constructed approximately along one of the alignments considered. The exact alignment would be decided upon in consultation with the community as part of detailed design of the levee works.

6.2 Selection of Preferred Option

From the above process, WBM along with the TSC, developed 4 discreet options for further consideration. The options selected for detailed assessment and modelling were:

1. An Inner Town Levee on the alignment proposed by SRWSC, 1984 study;
2. An Outer Town Levee on the alignment proposed in the SRWSC, 1984 study;
3. An Outer Town Levee with an alternative alignment; and
4. The lowering of Emily Street and associated waterway crossing works.

These were all variations on the two measures that ranked highest on the multi-criteria screening process. The four options are discussed further in Sections 5-1 to 5-4 of the *Technical Steering Committee - Option Selection Discussion Paper* (WBM, 2003) contained in APPENDIX C. The three levee alignments, with typical 20, 50 and 100 year levee heights, are illustrated in Figure 6-1.

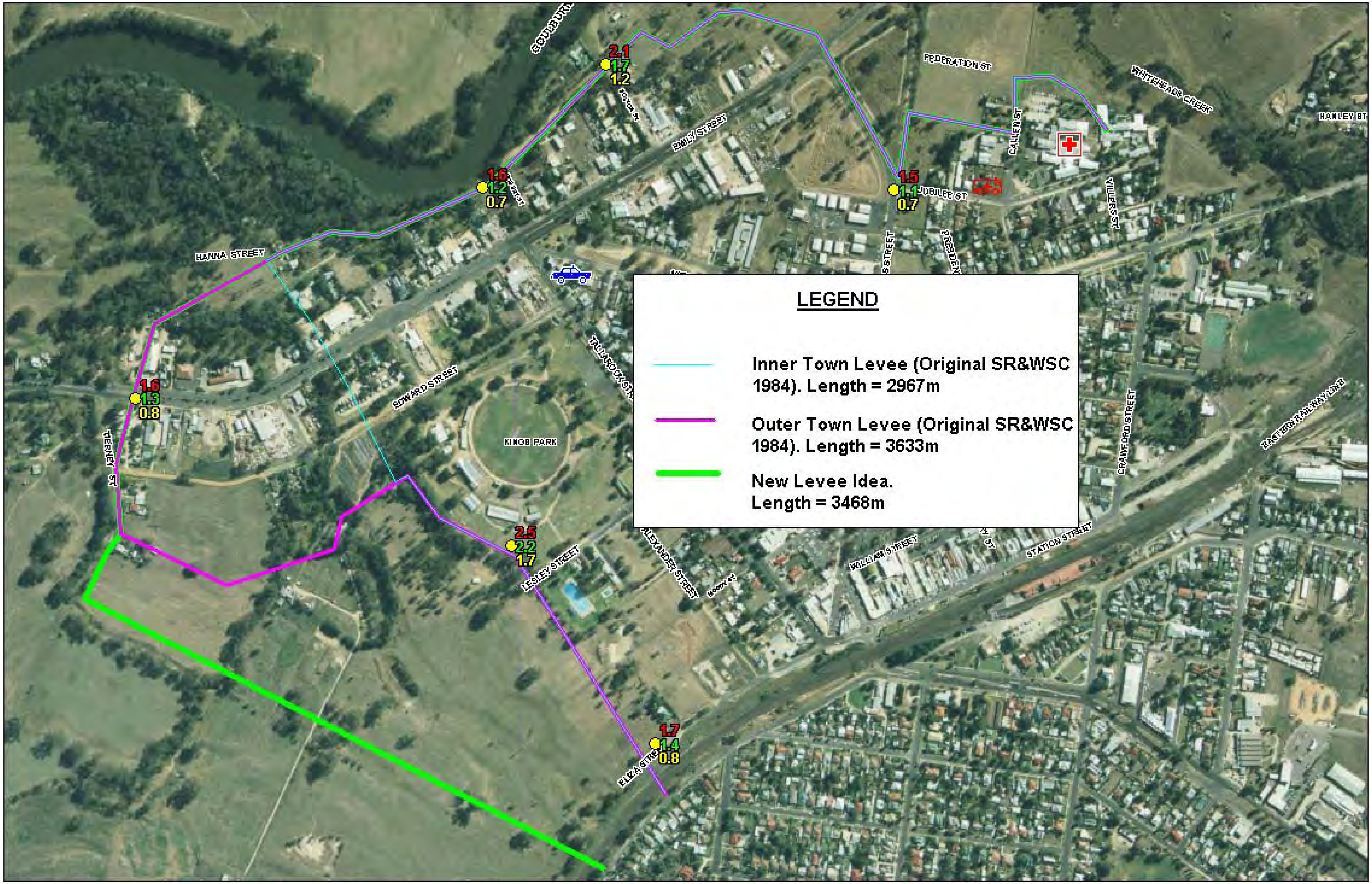


Figure 6-1 Levee Alignments

The levee alignments, and outcomes of the analyses, were presented to the TSC and CRG. The alignments were subsequently walked by the TSC and CRG. From the meetings, it was **agreed that Option 3, an outer town levee, was recommend for further consideration.**

6.3 Analysis of Preferred Option

The preferred management option of an outer town levee was hydraulically modelled using the TUFLOW model established for the Seymour Flood Mapping Study (WBM, 2001). The approximate levee alignment was entered into the model, and Goulbourn River 20, 50 and 100 year ARI flood events were analysed. The resulting flood levels were used to determine the required levee heights for each alternative level of protection. The results were used to determine earthworks volumes and costings, as described in the Section 6.3.4, and later to select the optimal design standard for the levee.

Following presentation of the draft modelling results, the TSC and CRG proposed a modification of the preferred levee option alignment. The levee alignment was amended to include an extension of the Goulburn River levee from Villers St to the Eastern Railway Line along Whiteheads Creek. While Whiteheads Creek flooding was not part of the original scope of work, flood levels from the Seymour Flood Mapping Study were deemed appropriate for determining approximate levee heights along the creek with an approximate allowance for flood afflux. This extension provided 100 year ARI flood protection from Whiteheads Creek, and has been included in the economic assessments. The revised levee alignment with existing Goulbourn River and Whiteheads Creek 100 year flood extents are illustrated in Figure 6-2. The long-section is illustrated in Figure 6-3.

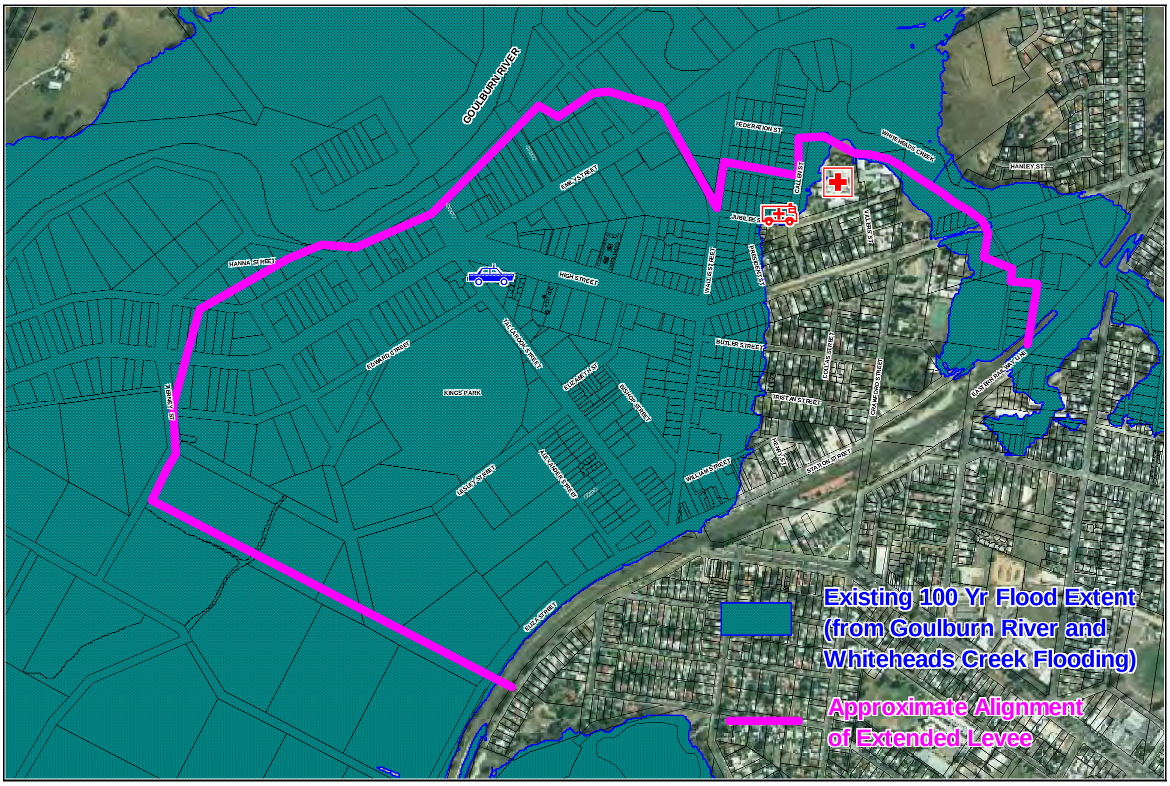


Figure 6-2 Extended Preferred Levee Alignment

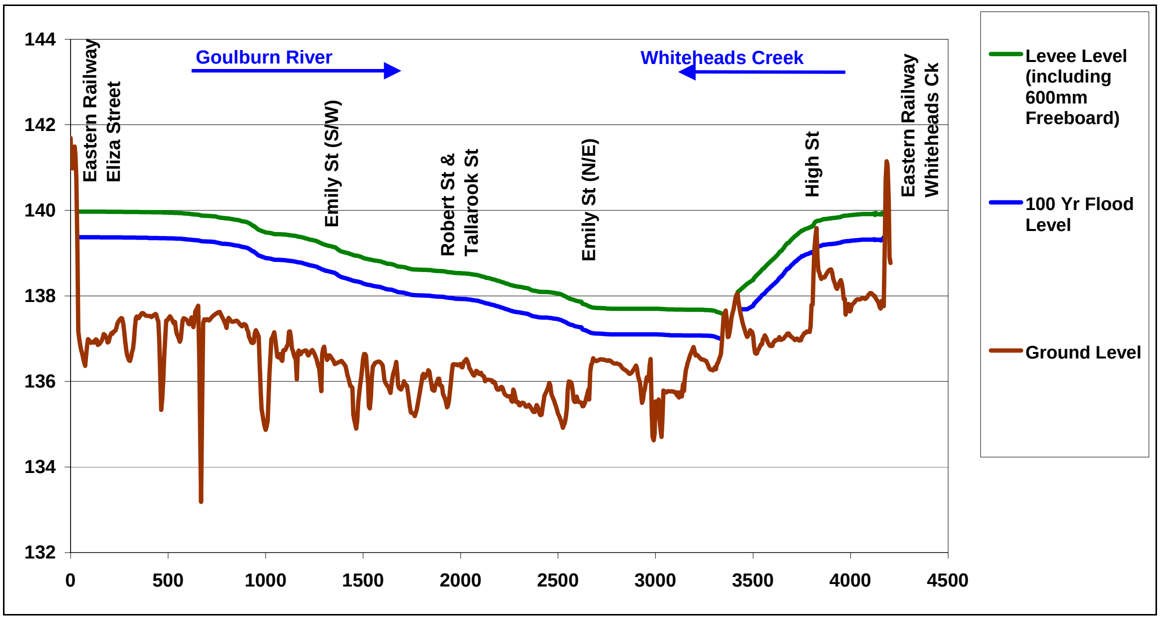


Figure 6-3 100Year ARI Levee Long-Section

6.3.1 Flood Impacts

The hydraulic modelling results were mapped in GIS and the impact on peak 100 year flood levels and flow speeds were determined. Construction of the preferred levee would result in increases in flood levels upstream of the town of approximately between 0.6 to 0.8 metres. There were relatively small isolated areas immediately adjacent to the levee near Eliza Street that experienced increases of more than one metre. Changes in peak flow speed were generally between 0 to 0.2 m/s. The flood impacts were mapped and are presented in APPENDIX A.

There are 7 properties outside the preferred levee alignment as illustrated in Figure 6-4. These properties are flooded in the 100 year flood event under existing conditions, and will be subject to an increase in flood levels as a result of the levee. They will also be subject to an increase in the frequency of flooding. These properties were discussed with the TSC and CRG, and it was agreed that it was not feasible to protect these properties by amending the levee alignment. Individual property solutions should be considered as part of detailed design.

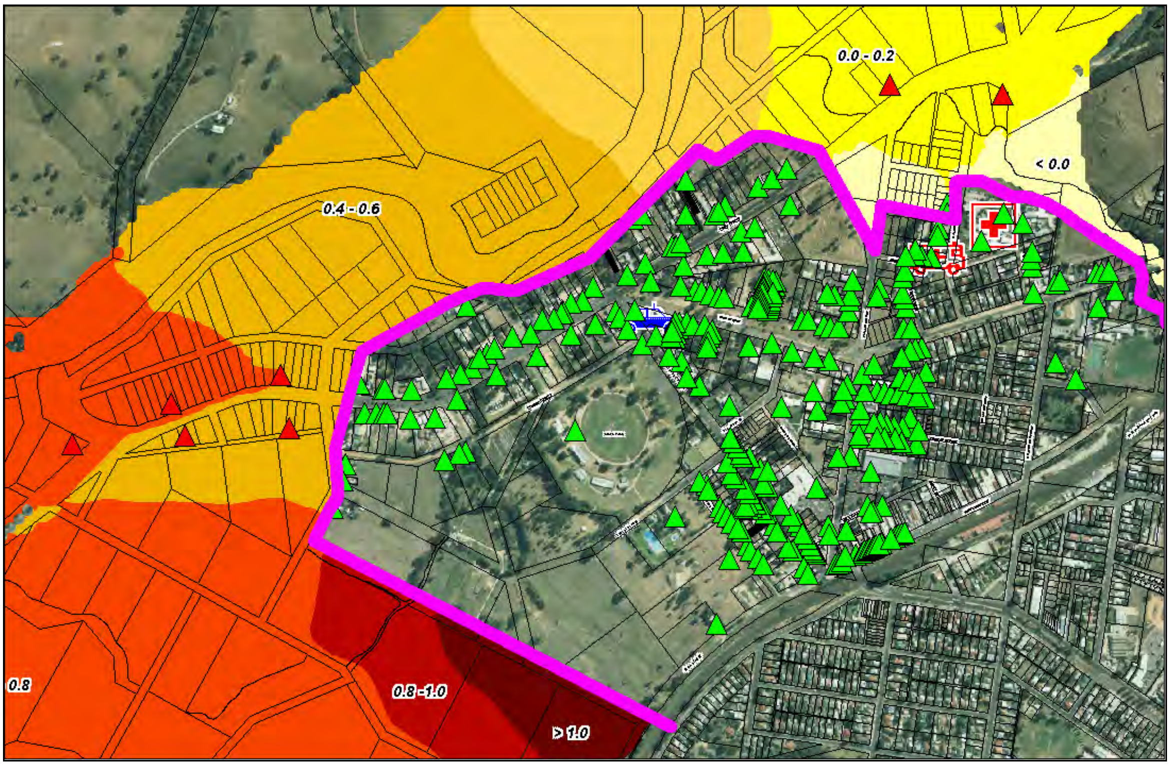


Figure 6-4 Flooded Property Floors - 100Year Flood With Levee

6.3.2 Local Drainage

It has been assumed that existing drainage system will be able to discharge local flows beneath the proposed levee under normal operating conditions i.e. when the Goulburn River is not in flood. The drainage system should be checked however, for the effects of the levee on local flooding events of greater capacity than the underground drainage system, in order to determine if additional pipes are required. This has not been investigated, as it is outside the scope this study.

In the advent of a 1 in 100 year ARI localised flood event behind the levee, it has been assumed flows will be able to pass under the levee in pipes fitted with flap gates. If flap gates are installed on existing drains, their capacity may be reduced and should be checked. Costs for additional pipes and flap gates are not included in the cost estimates in Section 6.3.4.

In the event of local flooding behind the levee coinciding with significantly elevated flood levels in the Goulburn River, some form of stormwater pumping will be required. While investigation of such issues were outside the scope of the investigation, due to the cost of such systems, an attempt was made to quantify what pump rates and costs may be involved.

The 1 in 10 year ARI local catchment peak flows were selected as a guide to the likely stormwater pump-rates required. Local flow rates were determined using the rational method applied to three sub-catchments as shown in Figure 6-5. The pumps will be required to lift water three vertical metres at most to the 100 year ARI flood surface outside the levee.

Costings for pumps were sourced from Thompsons Kelly & Lewis Pty Ltd (TKL) and KSB Ajax Pumps Pty Ltd Australia and include installation. Associated works such as electrical and civil works for pump houses are accounted for by a 40% contingency of the pump cost. It should be noted that a detailed analysis of the hydrology and hydraulics within the catchment of the Seymour flood levee would need to undertaken to determine the exact location, loadings and hence type of pumps. Design flow rates and hence pump costs may be reduced if storage or attenuation can be provided for local flows.

The pump options investigated are summarised in Table 6-2. A duty and a standby pump would be required for Catchments A and B. The lower reaches of Catchment C are undeveloped, so it has been assumed that water may be allowed to pond there and no pump is required.

Table 6-2 Local Drainage Pump Costs and Flow Rates

Catchment	Existing Drain System Capacity	Local Flow (10 year ARI)	Approximate Design Pump Flow (m^3/s)
A – East (drains to Whiteheads Creek)	Not known	1.2	1.2
B – Central (drains to Goulburn River)	2 to 3 m^3/s	6.0	4.0
C – West (drains to Goulburn River)	Open channel	NA	No pump required.

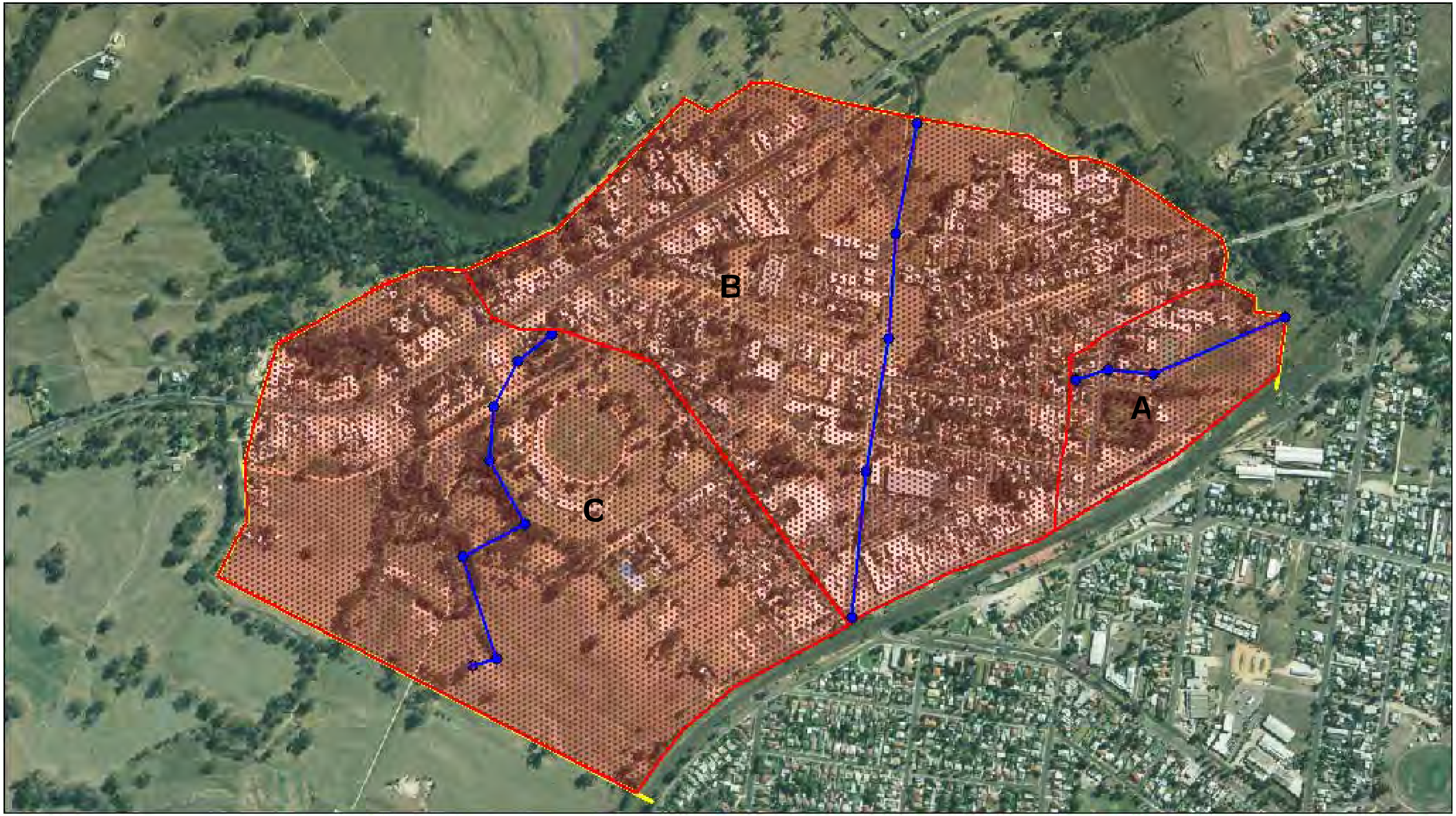


Figure 6-5 Local Sub-catchments within Levee

6.3.3 Emergency Spillways

Given the possibility of a sudden breach of the levee, emergency spillways may also be required with design of relief channels at an additional cost to the estimates in Section 6.3.4. Emergency spillways can reduce the risk of sudden failure and provide warning of an imminent levee breach. This is an important consideration if the effects of a sudden breach of the levee are potentially greater than no levee protection.

6.3.4 Costing of Preferred Option

The preferred outer town levee, for each of the considered design standards (20, 50 and 100 year ARI flood in the Goulburn River) and a 1 in 100 year ARI flood in Whiteheads Creek, were costed. Cost estimates used the following criteria:

- Rates and items used in previous studies, and as supplied by Goulburn Murray Water and GBCMA for similar projects;
- Australian Bureau of Statistics consumer price index (CPI) based conversion factor to adjust rates to 2004 dollars;
- Soil volumes calculated from modelled flood level surface plus freeboard design level and the photogrammetric determined ground surface DTM;
- General contingencies rate of 40%;
- Batter slopes of 1:3;
- Ramp construction at the Hume Highway to facilitate road travel;
- Design Life of 30 years; and
- Discount Rate of 0.08 (8%).

The estimated construction costs for the preferred levee for each design standard (i.e. level of flood protection), with and without freeboard, are shown in Table 6-3.

Table 6-3 Levee Construction Costs Excluding Pumps*

Design Standard of Levee (Flood Event ARI)	Cost of Levee -No Freeboard	Cost of Levee - 0.6m Freeboard
1 in 100 Year	$2.35 M	$3.08 M
1 in 50 Year	$1.86 M	$2.49 M
1 in 20 Year	$1.38 M	$1.88 M

* Note: Costs do not include modifications to local drainage or emergency spillways

Cost estimates including an approximate allowance for internal drainage pumps are shown in Table 6-4.

Table 6-4 Levee Construction Costs Including Pumps*

Design Standard of Levee (Flood event ARI)	Cost of Levee - No Freeboard	Cost of Levee – 0.6m Freeboard
1 in 100 Year	$3.19 M	$3.91 M
1 in 50 Year	$2.70 M	$3.32 M
1 in 20 Year	$2.21 M	$2.71 M

* Note: Costs do not include modifications to local drainage other than pumps

Benefit Cost Ratios (BCR) for the three design standard levees were calculated. Revised total and average annual damages were calculated using ANUFLOOD with the option in place. The present values of the reduced flood damages (i.e. benefits) were calculated using a 30 year design life and 8% discount rate.

The BCR for the preferred levee option (with pump system with 0.6m freeboard) are shown in Table 6-5. The option with the greatest BCR is a 1 in 100 year ARI design standard levee with a BCR of 1.54.

Table 6-5 Preferred Option BCR

Design Standard of Levee (Flood event ARI)	Cost of Levee with 0.6m Freeboard and Pump	Existing AAD Estimate	AAD Estimate With Preferred Option	Present Value of Benefit	BCR (Cost / PV of Benefit)
1 in 100 Year	$3.91 M	$0.49 M	$0.02 M	$6.04 M	1.54
1 in 50 Year	$3.32 M	$0.49 M	$0.20 M	$3.73 M	1.12
1 in 20 Year	$2.71 M	$0.49 M	$0.48 M	$0.06 M	0.02

6.4 Selection of Design Standard for Preferred Option

The preferred management option of an outer town levee was hydraulically modelled and costed to determine the optimum design standard. Options for 1 in 20, 50 and 100 year ARI levels of protection were modelled, and the resulting levee costed and the saving in flood damages analysed.

The optimum design provides the highest benefit cost ratio (BCR). The optimum design standard was determined to be the 100 year ARI levee, with a BCR of 1.54, as illustrated in Table 6-5. This means that for every $1.00 spent on construction, there will be $1.54 in saved flood damages.

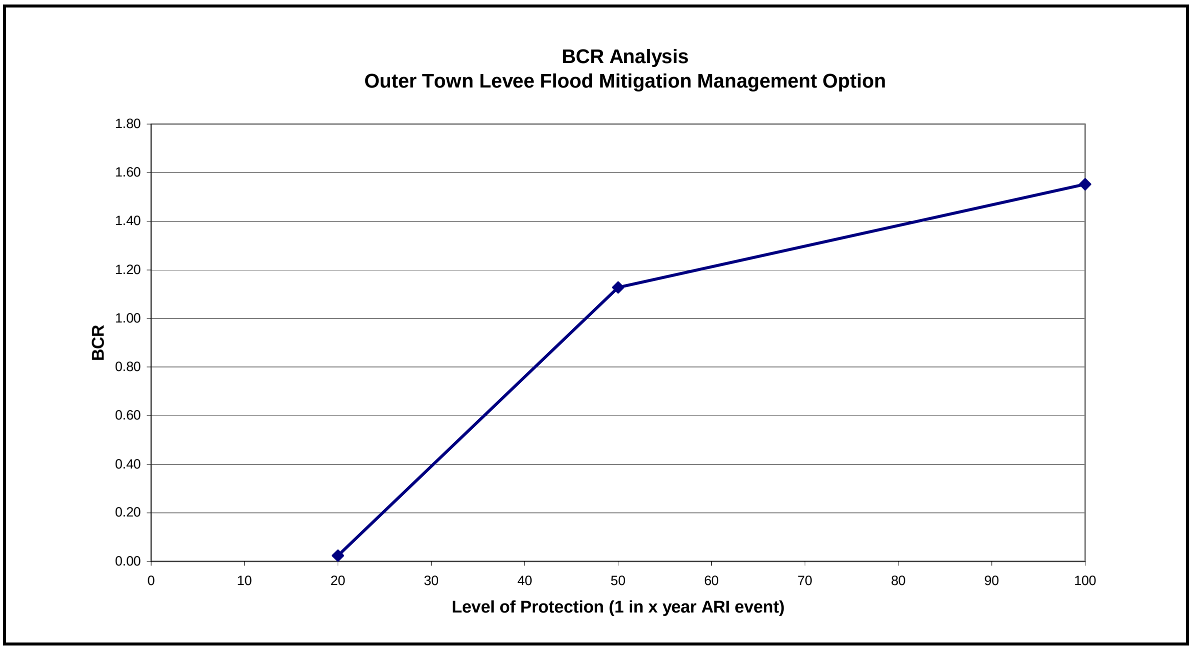


Figure 6-6 Plot of BCR versus Level of Protection for Preferred Option

6.5 Communication of preferred strategy

The final option was presented to the TSC and at an open community meeting.

7 CONCLUSION AND RECOMMENDATIONS

The investigation identified 4 discreet options for further consideration.

1. An Inner Town Levee on the alignment proposed by SRWSC, 1984 study;
2. An Outer Town Levee on the alignment proposed in the SRWSC, 1984 study;
3. An Outer Town Levee with an alternative alignment; and
4. The lowering of Emily Street and associated waterway crossing works.

After carefully considering each option, the TSC and CRG adopted Option 3 – *The Revised Outer Town Levee Alignment* as the preferred mitigation option. Key points in deciding on this course of action included:

- The Inner Town Levee does not protect a significant area of development on Emily Street. This may cause social and political problems.
- The Inner Town Levee has a significantly lower BCR than the Outer Town Levee
- The Outer Town Levee on the original alignment is longer, hence more costly, than the new alignment, protects less area and will therefore have a lower BCR than the New Alignment.
- Lowering Emily Street, while lowering flood levels, will not provide adequate protection to the town. It has been shown through past studies to have a BCR well below 1, and is therefore not considered feasible.

The preferred levee alignment was subsequently amended by the TSC and CRG to include an extension of the levee along Whiteheads Creek to the railway line.

Modelling and mapping of the preferred levee demonstrated impacts on a number of properties outside the levee alignment. Seven property floors, all flooded in the 100 year flood event under existing conditions, are subject to increased flood frequency and increased flood levels of up to 0.8m. Individual solutions for each of the properties should be determined in consultation with the property owners at the detailed design stage.

The selected design standard for the preferred levee was the 100 year ARI flood level plus 600mm freeboard. The capital construction cost of the works (NPV) is $3.91M, with an associated BCR of 1.54. This means that for every $1.00 spent on construction, there will be $1.54 in saved flood damages. The BCR shows that the benefits out way the costs, and as such, is economically feasible.

It is recommended that Council adopt the findings of the report and prepared a Floodplain Management Plan by:

4. Consultation and awareness program for all affected landowners of the preferred scheme.
5. Identification and resolution of concept design issues relation to pumping requirements and levee location in consultation with landowners and relevant authorities.

6. Review cost of the scheme.

7. Preparation of the Floodplain Management Plan for public comment in accordance with Section 223 of the Local Government Act, including information workshops.

8 REFERENCES

DNRE 2000, Rapid Appraisal Method (RAM) for Floodplain Management, Department of Natural Resources and Environment, May 2000.

CSIRO 2000, *Floodplain Management in Australia – Best Practice Principles and Guidelines*, Commonwealth Industrial & Scientific Research Organisation (CSIRO), 2000.

IEAust 2001, *Australian Rainfall & Runoff,* Institution of Engineers Australia, 2001.

WBM 2003, *Seymour Flood Mitigation Communication Investigation, Technical Steering Committee - Option Selection Discussion Paper,* March 2003, prepared by WBM Oceanics Australia for Mitchell Shire Council.

WBM 2001, *Seymour Floodplain Mapping Study, Final Report,* March 2001, prepared by WBM Oceanics Australia for Goulburn Catchment – Eildon to Seymour Flood Warning Group.

9 GLOSSARY

Annual Exceedance Probability (AEP)	The chance of a flood of a given size (or larger) occurring in any one year, usually expressed as a percentage. For example, if a peak flood discharge of 500 m^3/s has an AEP of 5%, it means that there is a 5% chance (i.e. a 1 in 20 chance) of a peak discharge of 500 m^3/s (or larger) occurring in any one year. (See also average recurrence interval)
Australian Height Datum (AHD)	National survey datum corresponding approximately to mean sea level.
Average Annual Damage (AAD)	Depending on its size (or severity), each flood will cause a different amount of flood damage. The average annual damage is the average damage in dollars per year that would occur in a designated area (e.g. the Innisfail area) from flooding over a very long period of time. In many years there may be no flood damage, in some years there will be minor damage (caused by small, relatively frequent floods) and, in a few years, there will be major flood damage (caused by large, rare flood events). Estimation of the average annual damage provides a basis for comparing the effectiveness of different floodplain management measures (i.e. the reduction in the annual average damage).
Average Recurrence Interval (ARI)	The long-term average number of years between the occurrences of a flood as big as (or larger than) the selected event. For example, floods with a discharge as great as (or greater than) the 20yr ARI design flood will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event. (see also annual exceedence probability)
Benefit Cost Ratio (BCR)	A ratio of the financial benefits or savings as a result of an action or works to the costs of implementing those action or works.
Cadastral data	Property boundary data
Catchment	The catchment at a particular point is the area of land that drains to that point.
Design Floor Level	The minimum (lowest) floor level specified for a building.
Design Flood	A hypothetical flood representing a specific likelihood of occurrence (for example the 100 year or 1% probability flood). The design flood may comprise two or more single source dominated floods.
Development	Existing or proposed works that may or may not impact upon flooding. Typical works are filling of land, and the construction of roads, floodways and buildings.
Discharge	The rate of flow of water measured in terms of volume over time (i.e. the amount of water moving past a point). Discharge and flow are interchangeable.
DEM/DTM	Digital Elevation Model or Digital Terrain Model - a three-dimensional model of the ground surface.
Effective Warning Time	The available time that a community has from receiving a flood warning to when the flood reaches them.
Flood	Relatively high river or creek flows, which overtop the natural or artificial banks, and inundate floodplains and/or coastal inundation resulting from super elevated sea levels and/or waves overtopping coastline defences.

Flood Awareness	An appreciation of the likely threats and consequences of flooding and an understanding of any flood warning and evacuation procedures. Communities with a high degree of flood awareness respond to flood warnings promptly and efficiently, greatly reducing the potential for damage and loss of life and limb. Communities with a low degree of flood awareness may not fully appreciate the importance of flood warnings and flood preparedness and consequently suffer greater personal and economic losses.
Flood Damage	The tangible and intangible costs of flooding.
Flood Behaviour	The pattern / characteristics / nature of a flood.
Flood Frequency Analysis	An analysis of historical flood records to determine estimates of design flood flows.
Flood Fringe	Land that may be affected by flooding but is not designated as floodway or flood storage.
Flood Hazard	The potential risk to life and limb and potential damage to property resulting from flooding. The degree of flood hazard varies with circumstances across the full range of floods.
Flood Level	The height or elevation of floodwaters relative to a datum (typically the Australian Height Datum). Also referred to as "stage".
Flood Liable Land	See flood prone land
Floodplain	Land adjacent to a river or creek that is periodically inundated due to floods. The floodplain includes all land that is susceptible to inundation by the probable maximum flood (PMF) event.
Floodplain Management	The co-ordinated management of activities that occur on the floodplain.
Floodplain Management Options	A range of techniques that are aimed at reducing the impact of flooding. This can involve reduction of: flood damages, disruption and psychological trauma.
Floodplain Management Plan (FMP)	A document outlining a range of actions aimed at improving floodplain management. The plan is the principal means of managing the risks associated with the use of the floodplain. A floodplain risk management plan should be developed in accordance with the principles and guidelines contained in the CSIRO (2000). The plan will usually contain both written and diagrammatic information describing how particular areas of the floodplain are to be used and managed to achieve defined objectives.
Floodplain Management Scheme	A floodplain management scheme comprises a combination of floodplain management measures. In general, one scheme is selected by the floodplain management committee and is incorporated into the plan.
Flood Planning Levels (FPL)	Flood planning levels selected for planning purposes are derived from a combination of the adopted flood level plus freeboard, as determined in floodplain management studies and incorporated in floodplain risk management plans. Selection should be based on an understanding of the full range of flood behaviour and the associated flood risk. It should also take into account the social, economic and ecological consequences associated with floods of different severities. Different FPLs may be appropriate for different categories of landuse and for different flood plans. The concept of FPLs supersedes the "standard flood event". As FPLs do not necessarily extend to the limits of flood prone land, floodplain risk management plans may apply to flood prone land beyond that defined by the FPLs.

Flood Prone Land	Land susceptible to inundation by the probable maximum flood (PMF) event. Under the merit policy, the flood prone definition should not be seen as necessarily precluding development. Floodplain Management Plans should encompass all flood prone land (i.e. the entire floodplain)
Flood Proofing	Measures taken to improve or modify the design, construction and alteration of buildings to minimise or eliminate flood damages and threats to life and limb.
Flood Source	The source of the floodwaters. In this study, the Johnstone River catchment is the primary source of floodwaters.
Flood Storages	Floodplain areas that are important for the temporary storage of floodwaters during a flood.
Floodway	A flow path (sometimes artificial) that carries significant volumes of floodwaters during a flood.
Freeboard	A factor of safety usually expressed as a height above the adopted flood level thus determing the flood planning level. Freeboard tends to compensate for factors such as wave action, localised hydraulic effects and uncertainties in the design flood levels.
Historical Flood	A flood that has actually occurred.
Hydraulic	The term given to the study of water flow in rivers, estuaries and coastal systems.
Hydrograph	A graph showing how a river or creek's flow changes with time.
Hydrology	The term given to the study of the rainfall-runoff process in catchments.
MEMP	The Municipal Emergency Management Plan (MEMP) is the document used by council to plan for and act on during an emergency such as flooding or fire. The MEMP may include such things as contact names, numbers and maps.
Peak Flood Level, Flow or Velocity	The maximum flood level, flow or velocity occurring during a flood event.
Photogrammetry	The technology used to obtain reliable measurements, maps, digital elevation models, and other GIS data primarily from aerial photography.
Probable Maximum Flood (PMF)	An extreme flood deemed to be the maximum flood likely to occur.
Probability	A statistical measure of the likely frequency or occurrence of flooding.
Runoff	The amount of rainfall from a catchment that actually ends up as flowing water in the river or creek.
Stage	See flood level.
Stage Hydrograph	A graph of water level over time.
TUFLOW	Fully two-dimensional unsteady flow hydraulic modelling software
Velocity	The speed at which the floodwaters are moving. Typically, modelled velocities in a river or creek are quoted as the depth and width averaged velocity, i.e. the average velocity across the whole river or creek section.
Water Level	See flood level.

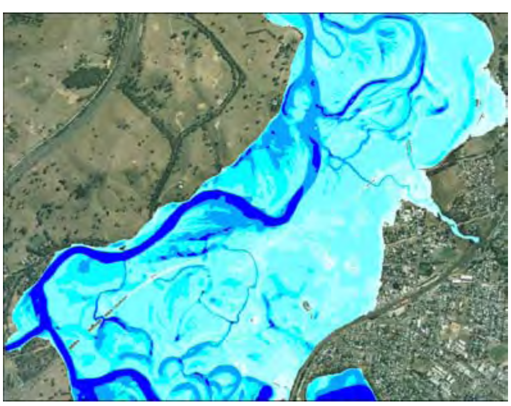
APPENDIX A SEYMOUR FLOODPLAIN MAPPING STUDY – SAMPLE MAPPING

APPENDIX B FLOODPLAIN MANAGEMENT QUESTIONNAIRE AND FLYER

Community Input Into
Seymour Flood Mitigation Investigation

Aim of Investigation. Further to recent technical findings into flooding at Seymour, the aim of this study is to provide the community with information specifically relating to existing flood risk (likelihood and consequence). This information will form the basis of your informed feedback (through the attached questionnaire) on possible flood mitigation measures to reduce the impacts of flooding on the town. The questionnaire also provides an opportunity for community members to be involved throughout the study process as part of a Community Reference Group.

Background: Being located on the banks of the Goulburn River, Seymour has a history of flooding dating back to its establishment in the 1800's. Initial development within the township occurred on the floodplain of the Goulburn River within the vicinity of Emily Street. The 1870 flood resulted in significant inundation of the entire town, demonstrating the vulnerability of the area to flooding impacts. In 1974 the town suffered major flooding from the Goulburn River, with nearly 200 buildings suffering direct damage from floodwaters. This event was the most recent major flood the township has experienced, with the 1993 flood resulting in localised flooding of low lying areas.



Technical Study: As part of the recent Eildon to Seymour Flood Warning System development, WBM Oceanics Australia prepared a comprehensive set of high quality Flood Inundation Maps to provide a basis for responding to emergency flooding situations. This study included new detailed ground surface level information that represents current conditions for Seymour, and the establishment of a state of the art full two-dimensional hydraulic model that enables complex floodplains to be modelled without having to assume flow paths. Flood risks were also determined.

Background Technical Findings

Figure 1 - Flood Effected Areas in Seymour During a 1 in 100 Year Flood Event

Figure 1 outlines flooding expected from the Goulburn River in a 1 in 100 year event (ie. an event that would be expected to occur on average once every 100 years or a flood that has a 100 to 1 chance of happening in any one year). As a guide, **Table 1** shows the number of properties likely to be affected and the resulting damage from a number of different sized floods. This is a guide only and damages associated with these events may, in a real event, be different to those shown here.

Table 1 - Flood Damages for Seymour

Likelihood of Flooding	Goulburn River Gauge Height (m)	Number of Buildings Flooded Above Floor Level	Total Number of Flood Effected Properties	Total Damage ($)
1993 Size Event	6.1	5	186	0.1 m
Once in 20 Years	7.3	147	277	3.4 m
1974 Size	7.6	176	279	6.7 m
Once in 50 Years	8.0	235	282	8.7 m
Once in 100 Years	8.4	263	288	14.6 m

Average Annual Damage (AAD) is the average damage bill that faces the community every year as a result of the flood risk under current conditions. It is effectively the money that must be set aside each year to cover the cost of flood damages when floods occur. It is therefore a useful single measure of the size of the flood risk. **The AAD for Seymour has been calculated at $490,000.** This figure does not however include matters such as social hardship, stress and anxiety.

Seymour Floodplain Management Questionnaire

WBM Oceanics Australia for the Mitchell Shire Council has produced this questionnaire, seeking information from local residents regarding mitigation strategies for the floodplain at Seymour. Your input will provide important information to assist in the investigations. Thank you for your contribution.

Personal details are optional. The address of the resident completing this form will assist in defining a geographical spread of responses. Please provide attachments or sketches to answer questions in greater detail (if necessary).

Name	....		
Address	....		
	....	Telephone Number	....
email		Facsimile	

1. From the information contained on the attached bulletin and map (figure 1), what are your flooding concerns? (please tick the appropriate box/es).

- ☐ Personal safety
- ☐ Damage or potential damage to your house or business
- ☐ Damage or potential damage to other property (eg. community facilities)
- ☐ Personal financial hardship
- ☐ Economic effects on the community
- ☐ Warning time
- ☐ Other (please specify)

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2. The following are possible flood protection measures of a structural and non-structural type. Please rate them in order of preference (numbered 1 to 8).

Structural Measures

- ☐ Enlargement of existing waterways
- ☐ Vegetative clearing of waterways to increase hydraulic capacity
- ☐ Floodways
- ☐ Levees or floodwalls
- ☐ Flood proofing or raising of individual buildings

Non-Structural Measures

- ☐ Land use planning
- ☐ Land acquisition
- ☐ Community education and awareness programs

3. Can you suggest other measures that could be used to mitigate against floods? Please attach a separate sheet if required.

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4. Can you suggest any combination of measures that may help relieve flooding in Seymour?
(Please describe them. You may wish to sketch the scheme on the enclosed map and return it with the questionnaire)

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……………………………………………………………………

5. Considering the cost of such works, what level of protection would you like to be provided by the chosen measures? (Please tick only one).

- ☐ Once in 20 year flood
- ☐ Once in 50 year flood
- ☐ Once in 100 year flood
- ☐ Other (please describe below)

Note funding of flood mitigation schemes are currently funded equally between the Commonwealth, State and Local Government (ie, the one-third contribution will need to be provided locally).

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……………………………………………………………………………

6. Do you have any other concerns regarding social, economic and environmental impacts? (eg. Are there any areas which should be protected or even remain unprotected for social or environmental reasons?)

- ☐ Yes
- ☐ No

Please specify (please feel free to attach additional sheet(s) if space is insufficient)

……
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……………………………………………………………

7. Would you be interested in discussing flooding issues with the study team at a number of targeted workshops (2-3)? These meetings would be held in Seymour, most likely in the evening with representatives from Council, GBCMA, DNRE and the consultant.

- ☐ Yes (please ensure that your name and contact details are provided)
- ☐ No

Please feel free to add any further comments or sketches.

Thank you for your assistance.
Please return before <u>Friday 2nd August 2002</u> using the enclosed self addressed envelope.

WBM
OCEANICS AUSTRALIA

APPENDIX C OPTION SELECTION DISCUSSION PAPER

10 INTRODUCTION

Mitchell Shire Council has embarked on a process of communicating flood risk to the community of Seymour (in central Victoria) and developing flood mitigation options to treat these risks. The study will be developed to assist in minimising the effects of flooding on the township through investigating a range of possible options.

The primary aims of the study are to communicate the existing flood risk to the community and to use a consultation program to involve members in the development of possible flood mitigation options for the town. The key output from the study is a floodplain management plan that makes recommendations on flood mitigation, if determined suitable. The study will also deliver revised flood inundation and planning maps, coupled with a progressive consultation program to ensure community ownership of the outcomes.

10.1 Aim of this Discussion Paper

The aim of this discussion paper is to outline:

- The process to date and document the findings of the multi criteria analysis of all mitigation measures identified;
- The consultation program and reasons behind selection of four measures for further analysis; and
- Discussions on each of these four options and to recommend a final option for detailed testing.

11 STUDY METHODOLOGY

The process adopted at Seymour aims at gaining community input and support for the scheme via a progressive consultation program. The program comprises three distinct consultative approaches; a questionnaire, a community reference group and an open, community meeting.

The components of the current study process completed to date includes:

- Communication of Risk to the community;
- Investigation of a wide range of mitigation elements;
- Narrowing down of these elements to 4 options for further consideration.

The remaining components will include:

- Selection of the preferred mitigation scheme (from the four options selected), which is the primary aim of this discussion paper;
- Detailed testing of the preferred scheme (hydraulically and economically)
- Selection of a design standard based on data from detailed assessment;
- Communication of preferred strategy to the broader community;
- Detailing of effects on flooding (response plans, planning maps etc.); and
- Reporting and finalisation of Floodplain Management Plan.

A detailed breakdown of the study methodology, in line with the Terms of Reference set out in the project brief and detailed in our proposal, is presented in Figure 11-1. Note the current study progress is at TOR 4.

TOR 1 - Prepare Community Brochure
1. Nature of Flooding
2. Levels of risk
3. Damage Figures
4. Typical Risk Treatment
5. Questionnaire
6. Artwork
7. PROVISIONAL ITEM Printing of 500 brochures

TOR 2 - Questionnaire Review / Identification of Options
1. Review and summarise responses of questionnaire
2. Identify flood mitigation measures, both structural and non-structural
3. Assemble CRG

TOR 3 - Identify Risks / Review Options
1. Identify areas of environmental significance in consultation with NRE and Mitchell Shire
2. Identify land uses, infrastructure services and relevant land use studies
3. Carry out **preliminary** assessments of the appropriateness and effectiveness of identified measures as in TOR 2

TOR 4 - Detailed Assessment of Options
1. With TSC and CRG develop a maximum of two flood mitigation options from the measures identified in TOR 3
2. Carry out detailed assessment of the two options from above
3. Document beneficial and adverse impacts
4. In conjunction with TSC and CRG, determine preferred option

TOR 5 - Analysis of Preferred Strategy
1. Assess the benefit cost of the preferred option for a range of floods
2. With the TSC and CRG, select the appropriate design standard for the preferred scheme

TOR 6 - Impacts of Recommended Strategy
1. Quantify changes of hydraulic conditions for the **chosen design standard and the 100yr event**
2. Provide suitable information for the determination of land use planning provisions for the 100yr event post development

TOR 7 - Communication of final strategy
1. Press release to be written
2. Community meeting
3. Consider comments from Community and TSC

TOR 8 - Land use planning
1. Provide new information on 100yr flood flow distribution on suitable plans

TOR 9 - Flood response plans
1. Provide relevant advice for the preparation of a flood response plan
2. Determine threshold ARI for scheme
3. Prepare maps of effected areas

TOR 10 - Institutional arrangements
1. Detail timetable, funding arrangements, responsibility and cost sharing arrangements to implement plan

Figure 11-1 Project Work Breakdown Structure

12 STUDY PROGRESS

Study inception occurred on the 28th of June 2002. The inception meeting was held between Mitchell Shire project officer, Greg Scott, Goulburn Broken Catchment Management representative, Guy Tierney and WBM project staff, Lloyd Heinrich and Michael Turnley. The meeting served to discuss the project methodology, the consultation approach, project timing and to draft an outline for the community questionnaire.

The questionnaire and associated background information was developed in consultation with the Technical Steering Committee (TSC) and mailed out to residents and business on the floodplain. The questionnaire results were collated and reviewed by WBM and a wide range of useful data was gathered. Responses from the questionnaire were used to develop a full list of mitigation measures to be considered. All of these measures were then assessed by WBM to form the basis for determining a number of options for further detailed consideration.

As part of the questionnaire, residents wishing to be involved throughout the process and attend a number of targeted workshops were identified. These residents were contacted to form the Community Reference Group (CRG). They were invited to a meeting held on the 5th of February with the TSC and the project engineers to review and discuss the initial assessment of the mitigation measures undertaken by WBM. The aim of the meeting was to identify possible measures that could be included into a number of mitigation strategies for detailed testing and analysis.

13 MITIGATION OPTION SCREENING

A list of ALL flood mitigation measures used in a wide range of applications was developed by WBM. This list was augmented and adjusted to take into consideration responses from the community questionnaire. This list was reduced significantly by removing measures (asterixis) that were either not feasible or already in place. The full range of measures that were considered is as follows:

- Levees
- Floodplain Modification (lowering of roads etc.)
- Channel Improvement
- Floodwalls
- Floodways
- Removal of Obstructions
- Flood Storage* (prohibitive scale)
- Diversions* (nowhere to divert to)
- Purchase and Relocation
- Individual Property Floodproofing
- Floodplain Education Programs
- Flood Insurance
- Flood Warning System* (In Place)
- Land Use Planning* (In Place)
- Information and Data Collection* (Done)
- Planning Scheme Amendments* (In Place)
- Regulation and enforcement* (N/A)

A more detailed, matrix style analysis was then carried out on the remaining measures (shown on the last page of this Appendix). This process involved assigning a rank for each of hydraulic and economic benefits along with any adverse environmental and social effects associated with each measure. This analysis was presented and fine-tuned with the TSC and CRG to give the following ranking of measures:

1 Levees

2 Floodplain Modification (lowering of roads etc.)

3 Floodplain Education Programs

4 Floodwalls

5 Individual Property Floodproofing

6 Flood Insurance

7 Purchase and Relocation

8 Floodways

9 Channel Improvement

10 Removal of Obstructions

A discussion was then held with the TSC and the CRG in relation to which of the options would be considered in further detail. From this discussion it became clear that the top two options (Levee's and Floodplain Modification) were the preferred measures for detailed analysis, however the precise alignment and configuration of the measures was variable and required further discussion.

It also must be noted that, although various Levee alignments are being discussed here, it is not proposed that any of these alignments will be the final design alignment. It would be envisaged that if a levee scheme was to be recommended as part of the final plan, it would be constructed approximately along one of the alignments considered. The exact alignment would be decided on in consultation with the community as part of the detailed design.

14 SELECTION OF OPTIONS

From the above process, WBM along with the TSC, developed 4 discreet options for further consideration. The options are shown in Figure 6-1 and described as follows:

- An Inner Town Levee on the alignment proposed by the State Rivers and Water Supply Commission study of 1984;
- An Outer Town Levee on the alignment proposed in the 1984 study;
- An outer Town Levee with an alternative alignment; and
- The lowering of Emily Street and associated waterway crossing works.

These were all variations on the two measures that ranked highest on the multi-criteria screening process. The four options will be discussed further in Sections 5-1 to 5-4.

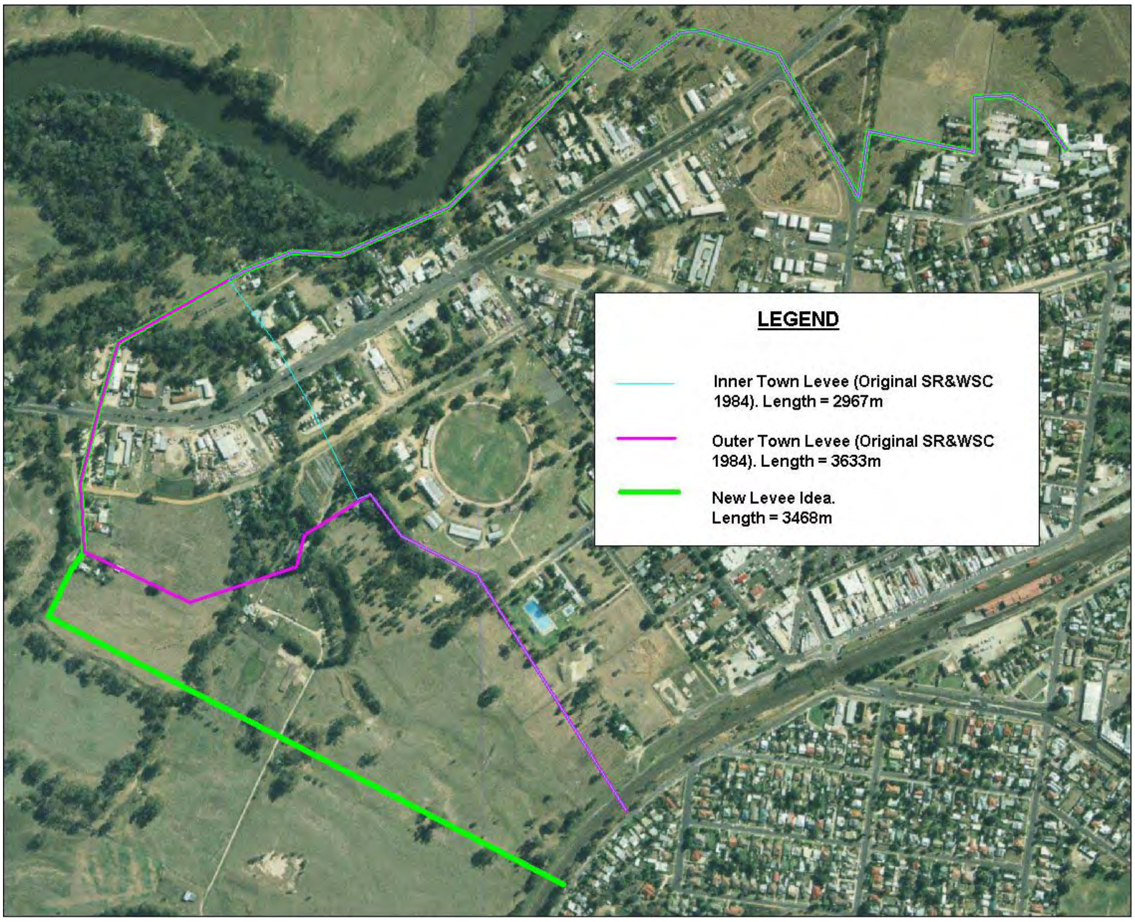

Figure 14-1 Levee Alignments

14.1 Option 1 – Inner Town Levee (1984 alignment)

The Inner Town Levee option proposed in the 1984 study encloses much of the urban area on the floodplain at Seymour. It does not however provide protection for all of the houses/buildings on the floodplain and misses a significant area of the town on the western end of Emily Street.

This option has been investigated in both the 1984 study for the SR&WSC and the 2001 study carried out by WBM. Both assessments suggest that no significant reductions in effects or additional benefits are seen from this option as compared to the Outer Town Levee. The data shows that the Benefit to Cost Ratio (BCR) of this option is significantly lower (i.e. less feasible) than the outer town levee. This alignment offers less protection, hence less benefit, and has a comparable capital cost to the outer town levee.

The key environmental concerns are related to the component of the levee to be constructed in the riparian zone close to the banks of the river. This area of key concern would be similar in all of the proposed alignments so there appears to be limited environmental reasons to adopt the shorter levee route.

In terms of social impact, it is seen as quite detrimental to leave a significant component of the town outside of the levee. The effect on this area could be quite significant and any rise in floodwaters associated with the levee will effect these buildings directly. Therefore, this alignment may have a much greater social impact than the outer town levee.

There will be visual amenity issues associated with levees, particularly if directly adjacent to residential and/or recreational areas.. However, this will not change with levee alignment, as it is a common concern to all levee options. All three of the levee alignments will affect visual amenity to varying degrees, depending on levee height, proximity to dwellings, or open space, its design (shallow earthen moulding or steep masonry or concrete walls), etc.

From this analysis there are no prevailing reasons (economic, social, environmental or other) why this option should be investigated before an outer town levee, which provides better protection to the town with only a small rise in capital cost.

14.2 Option 2 - Outer Town Levee (1984 Alignment)

The outer town levee follows a very similar path to that of the Inner levee apart from the additional component at the western end of Emily St. This additional component makes up approximately 650 metres of additional levee embankment whilst protecting an additional 20 properties. This in turn increases the BCR and makes the option significantly more economically feasible.

With the outer town levee, some minor additional flood afflux will be noticed outside of the levees when compared to the inner town levee. These increases in flood height are however minimal, as the constriction to the width of the flow path, between the town and the Northern side of the floodplain, are primarily the same in all levee alignments. The outer Town Levee does maintain the constriction for a slightly longer distance along the river. This is offset by the fact that far fewer properties are left outside the levee to suffer the consequences of flooding.

Socially and environmentally, the additional effects the outer town levee will have on the town when compared to the inner levee, would mainly be associated with length. The longer the levee the more land that needs to be utilised and the more people affected by the proximity to the levee itself. The additional effects of the outer town levee blocking a tributary of Deep Creek must also be considered.

Based on the limited additional environmental and social effect, coupled with the benefit of protecting more properties with a higher BCR, an outer town levee would be preferred over the inner town levee.

14.3 Option 3 – Outer Town Levee (New Route)

The original proposed outer town levee (Section 5-2) followed an alignment that attempted to hug the edges of the town so as to protect developed land and not vacant land. The simple principle followed was that the floodplain manager(s) were not in the business of protecting vacant land. This stands to reason except where more land can be protected (some of it vacant) by not trying to hug the fringe of the urbanised area and actually reducing the length of the levee, and hence the cost.

This levee alignment is principally the same at the original outer town levee alignment except that, where the outer town levee goes back in towards Kings Park on the western edge, this alignment runs straight across the floodplain to the railway embankment (see Figure 6-1). This alternative alignment is approximately 230 metres shorter and actually protects additional property.

Due to the protection of additional property the benefit of the option will rise slightly. Because the embankment is shorter, the cost will come down, thus increasing the BCR and making the option more economically feasible than both the alignments proposed in the 1984 study.

There would be very few differences in social, environmental and hydraulic effects from this option compared with the outer town levee proposed in the last example. For this reason it is recommended that the outer town levee with the adjusted alignment is a better option than the original alignment.

14.4 Option 4 – Lowering Emily Street

The lowering of Emily Street has been investigated by past studies to test its effect on flooding in the town. The 2001 WBM study showed that a noticeable head drop occurs across the road in most floods. This would suggest that some benefit could be derived from lowering Emily Street back to the level of the original floodplain. This would, in theory, allow water to pass through the town unimpeded rather than building up behind Emily Street.

The testing of lowering a section of the road (WBM 2001) showed however that the small reduction in flood levels achieved using this method was far outweighed by the capital cost of construction of such a measure. At best, lowering flood levels by one to two hundred millimetres may be achieved using this method. In terms of damages, this would equate to a small reduction for each flood event, but would not free a significant number of floors from flooding.

The environmental consequences involved in this option would primarily be constrained to erosion and sedimentation associated with constructing the works. There would be short-term social interruption involved with this option as the road is reconstructed and waterway crossings reinstated. Lowering the road would result in more frequent flooding, road closures and potentially more maintenance.

This option has been proven to yield little protection for the larger floods and hence provides little return for a significant capital cost. This option is not recommended as a likely, successful flood mitigation scheme.

15 RECOMMENDATIONS

After carefully considering each of the four options set out in Section 5, we would recommend that the only option that warrants further consideration is **Option 3 – The Revised Outer Town Levee Alignment**. Key points in deciding on this course of action include:

- The Inner Town Levee does not protect a significant area of development on Emily Street. This may cause social and political problems.
- The Inner Town Levee has a significantly lower BCR than the Outer
- The Outer Town Levee on the original alignment is longer, hence more costly, than the new alignment, protects less area and will therefore have a lower BCR than the New Alignment.
- Lowering Emily Street, while lowering flood levels, will not provide adequate protection to the town. It has been shown through past studies to have a BCR well below 1, and is therefore not considered to be feasible.

SEYMOUR Mitigation Option Screening

		Weighting			
		10	10	8	5
Rank	**Strategy Elements**	Hydraulic Benefit	Economic Benefit	Cost	Environmental Impact
1	Levees	10	10	7	3
2	Floodplain Modification (lowering of roads etc.)	5	5	4	2
3	Floodplain Education Programs	0	4	1	0
4	Floodwalls	4	4	6	3
5	Individual Property Floodproofing	0	6	7	0
6	Flood Insurance	0	7	8	0
7	Purchase and Relocation	0	8	10	0
8	Floodways	2	2	5	2
9	Channel Improvement	1	1	5	8
10	Removal of Obstructions	1	1	5	10

APPENDIX A ANALYSIS OF FINAL PREFERRED MITIGATION OPTION