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**BROWN HILL AND KESWICK CREEKS FLOOD  
MITIGATION STUDY  
FLOOD MANAGEMENT MASTER PLAN**

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## EXECUTIVE SUMMARY

### Introduction

Hydro Tasmania Consulting, in association with Australian Water Environments, QED and the SA Centre for Economic Studies was appointed by the Adelaide and Mount Lofty Ranges Natural Resources Management Board to undertake a flood mitigation study for Brown Hill and Keswick Creeks, including Park Lands and Glen Osmond Creeks (Contract No. P05-04) culminating in Flood Management Master Plan for the catchment.

A three stage process was undertaken to produce this Flood Management Master Plan:

#### Stage 1 - Technical assessment for Flood Management Master Plan

Assessment of the hydrology and hydraulics of the catchment was required to provide high level of confidence in the effectiveness of any proposed flood mitigation options. Links were established between mitigation options and the benefits they delivered elsewhere in the catchment. Potential solutions needed to be cost effective otherwise it would be difficult to justify the expenditure of public money.

It was important that a technically robust range of solutions could be developed or discarded through a transparent process, so that decision makers had confidence in the technical merit of each potential solution that was put forward to be part of the Master Plan. This was achieved by a Technical Steering Committee to review the work of the consultants with a range of skills covering engineering, hydrology, environmental assessment, social assessment, and planning.

The outcomes from Stage 1 were documented in the Stage 1 Technical Report.

#### Stage 2 - Consultation

Stakeholders (state government, local government, and private) and decision makers were involved and consulted throughout the project by reports and a series of meetings.

Once a range of technically robust and cost effective solutions had been developed feedback on these solutions and the general approach was sought from the community. Information to the community was distributed through a series of meetings, media releases and involved production of informative documents.

The process and outcomes from Stage 2 were documented in the Stage 2 Community Consultation Report.

#### Stage 3 - Detailed assessment of preferred options and Master Plan

Feedback from the community consultation process was used to finalise the options that make up the priority works components of this Master Plan. Further refinements of these components was then undertaken to verify their effectiveness and then optimise their performance.

### Background

There has been a long history of flooding issues associated with Brown Hill, Keswick, Park Lands and Glen Osmond Creeks. Numerous flood assessment studies have been undertaken and a range of potential solutions tabled and debated. Attempts to initiate coordinated works have proved difficult because agreement could not be reached on the scope of works or cost-sharing arrangements.

Recent work by Hydro Tasmania provided detailed inundation mapping and refined damage estimates for the first time since 1984. It provides a clear 'do nothing' reference point that highlights approximately 5,000 properties would be affected by the 1:100 AEP flood event, with a likely damage cost of around \$200 million if no action is taken. Flood damages are likely to occur as a result of much smaller, more frequent floods. When the damages from all floods are considered along with their likelihood an average annual damage can be calculated. The average annual potential damage as a result of flooding in the Brown Hill and Keswick Creek catchments is \$12.7m, with an equivalent present value of \$168 million (assuming a discount rate of 7% over a 30 year period).

The 2003 mapping was refined following the floods of November 2005 which provided an opportunity to improve the model calibration. The mapping and damage estimates reflect the revised 2006 mapping.

The three stage project focused on creating a climate where there is agreement that a 'do nothing' scenario is not acceptable and there is a need to implement this Flood Management Master Plan.

While the primary focus is flood risk management, in keeping with best practice stormwater management the Master Plan has considered the potential to integrate flood risk and damage reduction with other stormwater management objectives such as improved amenity, water quality, stormwater reuse, including water sensitive urban design.

### **Project Management Framework**

This project has been conceived and implemented by the Flood Management Group. The Flood Management Group was established by the Patawalonga Catchment Water Management Board and is made up of the Senior Executives of the Adelaide, Burnside, Mitcham, Unley and West Torrens Councils as well as representatives from the Department for Water, Land and Biodiversity Conservation, Planning SA, Premier and Cabinet and DTEI. The Technical Steering Committee comprised of technical representatives of the Flood Management Group.

The approach and outcomes from the work of the consulting team during all stages were reviewed through a series of workshops with the Technical Steering Committee and Flood Management Group. Briefings have also been provided to elected members of both state and local governments to ensure that they were aware of the project scope and timeframes.

### **Identification of Flooding Issues and Development of Potential Solutions**

Identification of issues and potential solutions began by gathering information from stakeholders, reviewing flood inundation maps, land use, and the properties of watercourses in the catchment. The watercourses were then subdivided into reaches or segments with similar characteristics. The watercourses were divided into approximately 30 reaches which allowed catchment scale flooding to be assessed on a local scale. Each reach was assessed for potential flooding issues both within the reach and as result of overland flow from upstream. Opportunities to reduce flooding within the reach as well as opportunities to reduce flooding downstream were also identified. Over 300 potential opportunities for reducing flooding were identified in this way.

### **Selection of Preferred Measures for Reducing Flood Damages**

A range of measures were considered on a reach and catchment scale for reducing damages resulting from flooding. The measures included structural works such as increasing channel and bridge capacities, diversions and providing flow detention

measures as well and non-structural actions such as planning measures, flood warning, rainwater tanks, on-site detention and other means of increasing the capacity of the community to prepare for and respond to a flood emergency.

These measures were assessed for their technical viability and economic effectiveness. Opportunities to achieve multi-purpose outcomes were also identified. Technically viable measures were initially assessed using a Multi Criteria Analysis with the following categories: expected cost of works; flooding reduction within the reach; flooding reduction across the catchment; potential for increasing open space/recreation opportunities; water quality and reuse; opportunity to improve biodiversity; degree of 'at source' management; and, likely community acceptance.

The costs and benefits of those measures which rated highest in the Multiple Criteria Analysis were assessed and the most cost-effective of these selected for further analysis. These measures were combined in a variety of ways to form scenarios that could address flooding on a catchment scale. This process enabled the identification of key components within each scenario that were most effective in reducing flood risk and damages. The key components consisted of structural and non structural measures.

The structural measures included:

- Flood control dams in rural portion of Brown Hill Creek.
- Flood detention systems and/or wetlands in the South Park Lands, Ridge Park Reserve and/or Goodwood Orphanage.
- Piped diversions along Anzac Highway to transfer floodwaters from Keswick Creek into Brown Hill Creek.
- Channel widening along Keswick Creek west of Scotland Road to the airport and along Brown Hill Creek downstream of Anzac Highway to the Airport.
- Selected bridge upgrades (Fisher Street, Daly Street and Hampton Street).
- Flood detention within the Wayville Showgrounds;
- Duplication of the existing culvert under the Showgrounds and channel widening to Anzac Highway.
- Modify outlet to Mt Osmond Interchange dam to improve performance.

Non-structural components included:

- Community awareness and flood preparedness including:
  - community information on flood maps;
  - advisory information on flood response for individual properties;
  - flood warnings;
  - flood preparedness for all landholders; and,
  - emergency management response.
- Planning Policy and Development Assessment including:
  - development assessment;
  - land use planning;
  - codes and development guide; and,
  - neighbourhood planning/master planning.

### **Hydrologic Assessments**

The effectiveness of the key components when combined was predicted by re-running hydrological models of the catchment. This work was done by David Kemp of the Department for Transport, Energy and Infrastructure. The hydrologic modelling was based on a projected 30 year catchment condition whereby existing trends in urban consolidation were expected to continue. The revised flows were then used to predict flood damages for the 10, 20, 50, 100 and 500 year floods.

This process enabled the selection of a set of priority works components that could be optimised in Stage 3. Two dimensional hydraulic modelling was done in Stage 3 of the project to verify the effectiveness of the priority works components and to enable flood damage estimates to be estimated assuming the priority works components had been implemented.

### **Multipurpose Benefits**

A number of the components provide opportunities to include multipurpose benefits. These benefits included water reuse, water quality improvements, improvements in biodiversity, passive recreational opportunities and increases in property values as a result of increased amenity. These benefits (and costs) for water reuse and increased amenity were estimated by the South Australia Centre for Economic Studies and were included in the economic analysis for Stage 1 of the project.

### **Community Consultation**

The community consultation process that formed Stage 2 of the Master Plan development was based around two community information days and a range of written material that was designed to inform people so that they could participate in either information day or make a separate written submission.

Information on the priority works components and the means for members of the public to make comment on them was distributed in the following ways:

- Media release and advertising.
- Patawalonga and Torrens Catchment Water Management Board and Council Newsletters.
- Technical Reports - Stage 1 Technical Report, a shorter summary report making information more accessible to the public and a "Community Information Update Brochure". The brochure was a full colour six page A4 brochure used at the community awareness days.
- The floodplain mapping fact sheet produced in 2003.
- Response sheets.
- Telephone information line.
- One on one discussion with members of the Technical Steering Committee and the consulting team during the community information days.

The findings of the consultation indicated that:

- There is support across the catchment for progressing with physical works, in particular temporary flood storage at the South Park Lands and Flood Control Dams in Brown Hill Creek.
- Many respondents were frustrated that no action had taken place as yet.
- People who were flooded in November 2005 wanted more warning and more help with the cleanup.

- There would be strong objections to a dam(s) in the Brown Hill Creek Recreation Park.
- Some respondents thought the flood preparedness component was being done in lieu of capital works and there should be more capital works to achieve a higher level of flood protection.
- Managers of the Royal Adelaide Showgrounds identified an extensive range of issues that would need to be addressed for the temporary storage to be acceptable to them. Whilst these could be addressed it is likely that they could become cost prohibitive.
- If the flood control dams in Brown Hill Creek were to proceed there would be a range of ecological issues that would need to be addressed. Support from some community groups is unlikely unless these issues are identified and addressed.
- There was some support for a more coordinated approach between landholders and government on the maintenance of channel capacity.
- Some people thought that a temporary flood storage at the Goodwood Orphanage should have been included.

A final set of priority works components were then recommended to the Flood Management Group in October 2006. The final set excludes the Wayville Show Grounds Arena Temporary Storage in favour of a diversion between Keswick and Brown Hill Creeks. The Goodwood Orphanage temporary storage had previously been investigated but found to be of limited value. It was therefore not included.

A map of the location of the individual mitigation options can be found in Figure 5.2.

The final set of priority mitigation components was as follows

Mitigation Component	Expected Capital Cost (\$ million)
Upgrade Fullarton Rd/Greenhill Rd culvert	\$2.7
Series of detention basins in the South Park Lands	\$10.0
Modify Mt Osmond Interchange Dam outlet.	\$0.1
Develop an inline flood detention system in Ridge Park Reserve and rehabilitate stream	\$0.6
Upgrade culverts under Fisher St	\$4.0
Goodwood Road Diversion from Keswick Creek to Brown Hill Creek (approximate capacity 14 m <sup>3</sup> /s)	\$16.0
Railway diversion from Keswick Creek to Brown Hill Creek (approximate capacity 11 m <sup>3</sup> /s)	\$16.0
Flood Control Dams Brown Hill upstream of the Recreation Park	\$17.0
Increase channel capacity between Hampton Rd & Cross Rd	\$2.0
Upgrade Brown Hill Creek channel from downstream of Anzac Hwy to confluence	\$37.0
Planning measures	-
Flood preparedness	\$0.1
<b>TOTAL SCENARIO CAPITAL COST</b>	<b>\$105.5</b>

### Indicative Economic Outcomes

The results of the economic analysis assuming that the priority works components had been implemented are presented in the table that follows.

Given the scale of priority works required it has been assumed that these would be implemented over a ten year timeframe.

	No Works	Ten year build program
Average Annual Damages (\$m)	12.7	2.7
Present Value Residual Damage (\$m)	168	74
Present Value Damage Reduction (\$m)	0	94
Present Value Costs (\$m)	-	83
Benefit Cost Ratio	-	1.13
Net Present Value (\$m)	-	11

**Notes:**

1. Calculated over a 30-year life span at a discount rate of 7% per annum.
2. Costs and benefits increase linearly over the ten-year implementation period.
3. The residual damages are the damages that would still occur as a result of flooding once the priority works components were fully implemented. The residual damages, like the average annual damages takes into account the likelihood that a particular flood will occur.

### Indicative Level of Protection

Flows for the 1:100 AEP event were estimated for the priority works components for major sections of streams in the catchment from the hydrological and hydraulic modeling carried out in Stage 3. The levels of protection from flooding for key sections of streams were then estimated and the results are presented in the table that follows.

Reach	Level of Protection (AEP) <sup>1,2</sup>	
	Do Nothing	Priority Works Components
Park Lands Creek	1:10	1:50
Glen Osmond Creek	1:10	1:50 <sup>3</sup>
Keswick Creek Anzac Hwy to Richmond Rd	1:10	1:100
Keswick Creek downstream Richmond Rd	1:10	1:50 <sup>3</sup>
Brown Hill Creek upstream Cross Rd	1:10	1:100
Brown Hill Creek between Cross Rd & Anzac Hwy	1:10	1:50 <sup>4</sup>
Brown Hill Creek downstream Anzac Hwy	1:10	1:100

**Notes:**

1. Level of protection is flood when one or more properties may experience flooding. Flood preparedness by owners and occupiers would prevent damage in most of these cases.
2. This table makes allowance for the plus future infill flow scenarios are modelled.
3. Some nuisance flooding is expected for the 1:50 AEP flood event with minor damage to infrastructure.
4. A small proportion of properties could experience flooding from the 1:20 AEP, but the vast majority would not.

Even with the implementation of engineering works, flooding is still expected in some limited areas from the 1:20 or 1:50 AEP flood event. The components here have been developed with a view to minimising social impacts and



ensuring the costs of works are outweighed by the benefits, if funding allowed, it would be technically possible to provide higher levels of flood protection everywhere but this would require the acquisition of large numbers of properties and tracts of land to either increase the capacity of the channel or to provide enough open space to provide adequate flood storage. This was assessed and, irrespective of social consequences was found to be very costly and uneconomical.

Community awareness and flood preparedness measures can substantially help to ensure that physical and emotional damages are minimised with little cost outlay compared to the structural options. Hence non-structural components have a key role to play even if all the structural components are implemented.

### Costs, Benefits & Funding Arrangements

A cost sharing framework has been proposed that is based on sharing cost in the according to the following principles:

- Recognising that Commonwealth, State and Local Government all have a stakeholding in reducing flood damages and therefore sharing the costs. A starting point for cost share across the three spheres of government should be equal cost sharing (i.e. a 1/3 each).
- Costs between councils should be shared based on a combination of the potential flood damage savings and the benefits achieved from urban development that increases flood risk.

The proposed apportionment of costs between local councils is as follows.

Council	Percentage share of costs
City of Burnside	10.9%
City of Adelaide	7.2%
City of Unley	19.7%
City of Mitcham	8.7%
City of West Torrens	53.4%

### Staged Implementation of the Master Plan

An implementation program has been developed that would see the works implemented in five stages over ten years. The ten year timeframe has been selected to balance expenditure to less than \$20 million in any one year. It would be possible to fast track the works into a shorter seven year timeframe and if this were done then the economic analysis would be even more favourable.

The proposed work schedule (assuming the necessary administrative arrangements have been established) is as follows:

- Stage 1 and Ongoing:
  - flood preparedness; and,
  - planning measures.
- Stage 2: Completion by Year 4
  - Brown Hill Creek Flood Control dams;
  - Ridge Park temporary flood storage;
  - Mount Osmond Interchange temporary flood storage; and,

- temporary flood storages in the South Park Lands.
- Stage 3: Completion by Year 6
  - upgrade Brown Hill Creek channel downstream of Anzac Highway; and,
  - increase capacity of Fullarton Road/Greenhill Road culvert.
- Stage 4: Completion by Year 8
  - install diversions between Keswick and Brown Hill Creeks.
- Stage 5: Completion by Year 10
  - increase channel capacity at Fisher Street; and,
  - increase channel capacity at Hampton Street.

### **Next Steps**

The next stage is to establish the preferred administrative arrangements and finalise the agreed funding arrangements between the key stakeholders. It is proposed that non-structural components be implemented immediately. These can be implemented by councils without the need for new administrative arrangements.

Detailed design of the individual structural components is still required. Included in the detailed design stage will be the collection of key survey, hydraulic and geotechnical parameters and in some cases requires location and negotiations with service providers for relocation of services that clash with the work alignments assumed in the concept designs.

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# 1. INTRODUCTION

## 1.1 Background

This Flood Management Master Plan for the Brown Hill and Keswick Creek system, which also includes Park Lands and Glen Osmond Creeks, was undertaken to reduce the impact of flooding in the catchment and to promote flood mitigation strategies that provide opportunities for multiple outcomes.

The Master Plan was developed at the request of the Flood Management Group. The Flood Management Group comprises senior executives from commonwealth, state, and local government with a stakeholding in the management of flooding issues in the Brown Hill and Keswick Creek catchments.

There is a long history of high flood risk and a low level of flood protection associated with Brown Hill, Keswick, Park Lands and Glen Osmond Creeks. A major flood (1:50 AEP or larger) has not occurred since 1930; however there have been numerous “close calls” and most recently flooding in Mitcham and Unley occurred (November 2005) as a result of heavy rains in the upper portions of the Brown Hill Creek catchment.

Large scale realignment and channel works conducted in the 1930s as part of the State Government’s Metropolitan Floodwaters program followed major floods of 1925 and 1930. The works were designed to reduce the flood risk to the western areas of Adelaide and thus enabled more areas to be developed. Whilst these works reduced the risk of flooding, it was recognised in the 1950s that flooding remained a major issue.

Subsequent advances in reducing the impact of flooding have largely been made on a council by council basis (e.g. Glenside Detention Basin, Urrbrae Wetlands) with few examples of coordinated action across councils. A notable exception includes the installation of a flood forecasting/warning service for Brown Hill Creek and the lower reaches of Keswick Creek by the Bureau of Meteorology and local councils during the 1990s.

A number of catchment wide flood mitigation studies have been undertaken over the years and a range of potential solutions tabled and debated, but there has not been any catchment wide action to deal with the flooding problem. Attempts to initiate catchment wide, coordinated works have floundered since the 1930s because

agreement could not be reached on the scope of works or cost-sharing arrangements.

Work in 1972 by consultants BC Tonkin and Associates identified a number of opportunities and barriers associated with reducing flooding in the catchment. They recommended a number of initiatives including securing the watercourses in public ownership or easements. Like many studies before and those that followed, most of their recommendations were not implemented.

Investigations undertaken by Hydro Tasmania in 2001 on behalf of the Patawalonga Catchment Water Management Board provided detailed inundation mapping and refined damage estimates for the first time since 1984. Their work highlighted that 5,000 properties would be affected by a 1:100 AEP flood. These maps and damage estimates have been updated as part preparing this Master Plan. It is now estimated that potential damage bill from a 1:100 AEP flood would exceed \$200 million.

## **1.2 Scope of the Master Plan**

This Master Plan is intended to address issues resulting from major floods in the Brown Hill and Keswick Creek catchments. For the purposes of preparing this Master Plan a major flood was considered to be a flood with a 1:10 AEP or larger. The Master Plan deals with major drainage paths associated with trunk drains that transcend administrative boundaries as well as flow over the floodplain. It is not intended to address localised “nuisance” flooding associated with stormwater drainage systems within council areas.

A whole of catchment approach has been adopted in developing the Master Plan with flooding issues considered from the very upper portions of the catchments to their outlet in the Patawalonga Lake. Actions presented in the Master Plan were developed from a catchment wide perspective irrespective of administrative boundaries. Actions that from part of the Master Plan are those considered providing the greatest benefit across the catchment.

Whilst a primary focus of the project has been to reduce flood damages and flood hazards, opportunities to incorporate multiple benefits were investigated for each flood mitigation action considered. These multiple benefits included water harvesting and reuse, improving water quality, riparian rehabilitation, enhancing biodiversity, recreational opportunities, transport corridors, and aesthetic improvements to the urban environment.

### **1.3 Process for Developing the Master Plan**

In developing the Master Plan it was important to recognise that much effort previously taken place on technical assessments, but when it came to decision-making time the process has been halted because agreement could not be reached on the cost-sharing arrangements. The Master Plan was developed in three stages that were designed to ensure that it would not only describe an effective solution, but also that the solution would be one that stakeholders could agree to implement.

#### **Stage 1 – Technical assessment for Flood Management Master Plan**

A detailed knowledge of the hydrology and hydraulics of the catchment was required to provide high level of confidence in the effectiveness of flood mitigation options. It was important to establish which actions would work best in achieving catchment wide benefits; the scale of those benefits; and, to establish the links between actions at one end of the catchment and the benefits they may deliver elsewhere in the catchment. Potential solutions needed to be cost effective otherwise it would be difficult to justify the expenditure of public money.

It was also important that a technically robust range of solutions could be developed through a transparent process so that decision makers had confidence in the technical merit of each potential solution that was put forward to be part of the Master Plan. Similarly, the reasons behind discarding options also had to be transparent.

Transparency in the assessment process was achieved by establishing a Technical Steering Committee which comprised representatives from Commonwealth, State and Local Government. Committee representatives were nominated by each respective organization based on their technical skills. Collectively the committee had a range of skills covering engineering, hydrology, environmental assessment, social assessment and planning. The outcomes from Stage 1 were documented in the Stage 1 Technical Report (HTC, AWE, QED & SACES, 2005).

#### **Stage 2 – Consultation**

Stakeholders and decision makers were involved and consulted throughout by reports to the Flood management Group and a series of meetings with the Technical Steering Committee. Briefings for elected members (across all spheres of government) were held.

Once a range of technically robust and cost effective solutions had been developed feedback on these solutions and the general approach was sought from the community. This was done through a range of mediums and approaches.

A Summary Report and Brochure were developed from the Stage 1 Technical Report and these used as the main documents with which to supply information to the community. Stage 2 of the Master Plan preparation process was documented in the Stage 2 Community Consultation Outcomes Report (QED, 2005).

### **Stage 3 – Detailed assessment of preferred options and Master Plan**

Feedback from the community consultation process was used to finalise the options that would make up the preferred components of the Master Plan. Further assessments of these preferred components was then undertaken to firstly verify their effectiveness and then optimise their performance.

The final results are documented in this Master Plan.



## 2. CATCHMENT DESCRIPTION

### 2.1 Geographic Area

The Brown Hill and Keswick Creek catchments are illustrated in Figure 2-1. They both start near Eagle on the Hill and flow westwards across the Adelaide plains towards the Adelaide Airport, before discharging to the sea through the Patawalonga Lake.

Brown Hill Creek has a catchment area of 32.0 km<sup>2</sup> (upstream of the Airport) and flows through the suburbs of Crafers West, Mitcham, Westbourne Park, Millswood, Ashford, Kurrulta Park, and then Netley.

Keswick Creek starts at Anzac Highway but is fed by Glen Osmond and Parklands Creeks; the combined catchment area of these creeks is 36.7 km<sup>2</sup>. Glen Osmond Creek starts near Eagle on the Hill and flows through the suburbs of Leawood Gardens, Highgate, Parkside, Unley and Wayville. Parklands Creek starts at Mount Osmond and flows through the suburbs of Glen Osmond, Glenunga, and Glenside before flowing through the South Park Lands. Park Lands Creek leaves the Park Lands near Peacock Road and joins Glen Osmond Creek in Goodwood.

### 2.2 Land Use and Catchment Characteristics

Whilst the catchment areas of Brown Hill and Keswick Creeks are similar, the land use within each catchment, and as a result their behaviour during floods, is quite different.

The Brown Hill Creek catchment consists mainly of rural land in the Hills Face Zone. As such it is mainly vegetated and rain falling on the catchment can infiltrate into the soil. The upper reaches of the catchment have median grades and defined riverine channels which retard flow and limit the spread of floodwaters. The middle and lower reaches have defined channels, but flatter grades and a more curvilinear form, which contributes to the spreading of the floodwater out of the channel. The types of storms that cause major flooding in Brown Hill Creek involve long periods of rainfall of relatively low intensity. It is expected that these storms would last a day or longer with flood flows peaking over the course of the storm.

The Keswick Creek catchment has a much larger proportion of urban development within its area. Development of land for housing, industry, and roads contributes to increased runoff. These urban areas also include an efficient network of drains and pipes that collect water from roads and houses and feed the water into the streams.

As a result Keswick Creek responds rapidly to rainfall events. The types of storms that cause flooding problems in Keswick Creek are short periods of heavy rainfall. Flood flows in Keswick Creek can be expected to occur within two hours of the onset of heavy rain.

Most of the catchment, except for the very upper reaches of Brown Hill and Glen Osmond Creeks, has been the subject of urban development. Development is predominately residential in the middle and upper reaches and mixed commercial and residential in the lower reaches. As much of the development is more than 50 years old considerable redevelopment is occurring throughout the catchment, with further redevelopment potential consistent with the above pattern.

Intensification of development can be anticipated over the next 10 years given market interest and the State Government's Planning Strategy for metropolitan Adelaide that introduces an urban containment boundary, promotes urban regeneration, urban densification, transit orientation and business and industry cluster. Such intensification could result in an additional 10% area of hard surfaces contributing to increased runoff. The amount of increased runoff and the effect on peak flow will very much depend on the stormwater management measures taken at the neighbourhood and site level.

## **2.3 The Drainage System**

### **2.3.1 Park Lands Creek**

Park Lands Creek originates in the City of Burnside and collects drainage from the suburbs of Hazelwood Park, Linden Park, St Georges, Glenunga, Frewville and Glenside. There is no defined creek channel until water is diverted under Glenside Hospital at Conyngham Street by twin culverts. At the downstream end of the culvert, the creek flows into the Glenside Stormwater Basin and then under Greenhill Road and into the South Park Lands. An unlined channel conveys water through South Park Lands before the creek flows through a culvert under Greenhill Road. The creek then follows a concrete lined channel through the suburb of Unley to its confluence with Glen Osmond Creek downstream of King William Road.

Park Lands Creek has a largely urban catchment and is therefore susceptible to flooding in short duration storms. Hydrologic analysis by DTEI indicates that the critical duration storm which produces the maximum peak flows for the 1:100 AEP flood event is 90 minutes.

### **2.3.2 Glen Osmond Creek**

Glen Osmond Creek originates in Leawood Gardens in the foothills around Mount Osmond. It flows along the alignment of the South East Freeway until it gets to Cross Road and is piped underneath into Ridge Park Reserve. It then flows north-west in an unlined channel through a series of reserves until it reaches Fisher Street in Fullarton, where it flows through an under-capacity culvert and into a concrete lined channel. The creek then flows west until it reaches a long underground culvert at Windsor Street, which flows north for approximately 1100 m. A concrete lined channel then conveys water west to the confluence with Park Lands Creek.

The Glen Osmond Creek catchment is a mixture of rural and urban areas and consequently storms of both short and long duration can cause significant flooding. As the majority of the lower catchment is in urban areas, the lower reaches of the creek experience more flooding in shorter duration storms (90 minute critical duration).

### **2.3.3 Keswick Creek**

Whereas the physical start of Keswick Creek is at Anzac Highway, for all practical purposes it can be considered to commence at the confluence of Park Lands Creek and Glen Osmond Creek, where those flows combine and feed into Keswick Creek. The channel is almost entirely concrete lined. Keswick Creek flows west through Wayville and then into a culvert that flows under the Showgrounds. The creek then flows around the Keswick Military Barracks and then through Keswick, Mile End, Hilton, Richmond and finally around the eastern side of Adelaide Airport to its confluence with Brown Hill Creek. The Keswick Creek Catchment is an urban catchment. Flooding in this creek is greater during short duration storms (90 minute critical duration).

### **2.3.4 Brown Hill Creek**

Brown Hill Creek has its headwaters in the Adelaide Hills. The creek flows north-west in an unlined channel before entering the urbanised area at Old Belair Road. The channel remains unlined until it reaches Heywood Avenue in Unley Park, after which point, the channel is concrete lined for the majority of its length. Major constrictions in the channel occur at Cross Road, at the Glenelg-Adelaide Tramway and at Daly Street in Kurrulta Park.

Brown Hill Creek has a large rural catchment, so longer duration storms cause more damage resulting from the flooding of Brown Hill Creek. Hydrologic analysis by

DTEI indicates that the critical duration storm which produces the maximum peak flows for the 1:100 AEP flood is 36 hours.

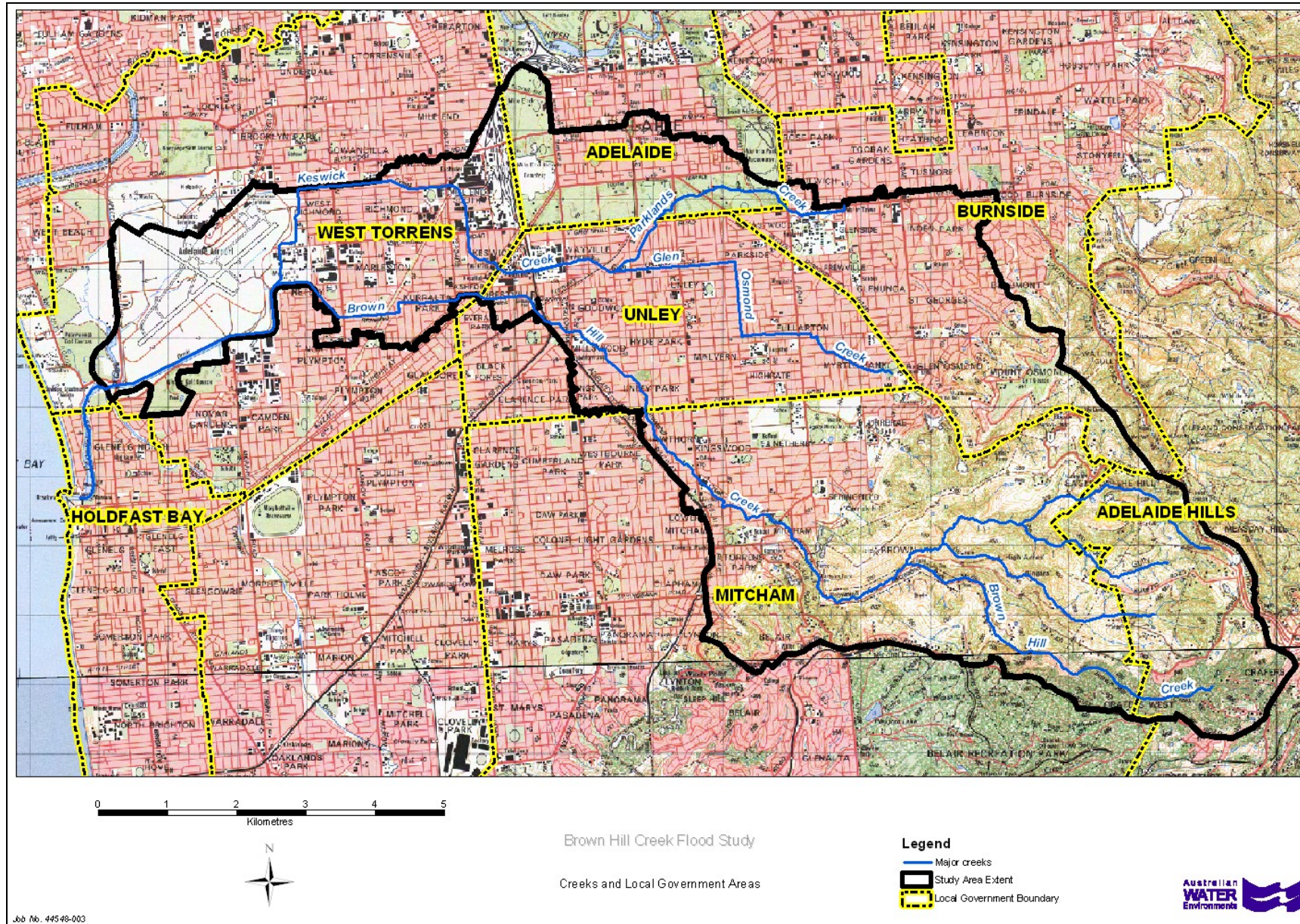


Figure 2-1 Catchment plan depicting creeks and local government boundaries.

### 3. FLOOD MANAGEMENT OBJECTIVES

The overarching objective for flood mitigation in the Brown Hill and Keswick catchments is to reduce the economic and social impact of flooding of the major drainage system, in a cost effective manner, using a catchment wide approach and a variety of structural and non-structural mitigation measures.

The flood mitigation measures should incorporate multi-purpose measures wherever practicable including opportunities for enhancing biodiversity, and storage and reuse of stormwater.

The above overarching objective statement is more specifically described by a comprehensive set of well founded principles that were prepared to guide the development of the Master Plan. These principles were established by the Flood Management Group:

- The standard of flood capacity that the major stormwater drainage system should have is to be determined based on an economic assessment.
- Flood management will require the integration of structural and non-structural risk mitigation.
- There is no requirement that the standard of flood capacity within the various reaches of the creek systems needs to be the same, however social equity issues will need to be considered as well.
- An objective is to provide a standard of flood protection for buildings equivalent to a 1:100 AEP standard or better, however this needs to be economically justifiable.
- Flood forecasting and warning should be considered as a risk mitigation measure, and integrated with structural measures, particularly for severe and rare floods.
- The protection of buildings can be achieved by a number of measures including:
  - control over the flood level of new development;
  - individual flood protection measures; and,
  - major structural works (e.g. flood detention, channel upgrades, and/or diversions).

- The network of roads and open space is a legitimate component of the major flood carrying network subject to consideration of the impact of a flood on roads, services and adjacent properties.
- High and extreme hazard areas need to be considered in terms of safety and risk to life.
- There is some value to the community of multi-objective flood management including opportunities for:
  - passive recreation;
  - pedestrian and cycle paths;
  - water quality improvements;
  - biodiversity improvements;
  - water reuse; and,
  - increased property values.
- Any structural mitigation works need to be cognisant of the possible increased flows over the design life of the works. Increases may occur due to increasing catchment imperviousness (infill development) and climate change.
- The cost of implementation of flood mitigation work needs to be spread across the community in a way that not only reflects the direct benefit to those who enjoy an increased level of protection, but also to those who already enjoy the benefit of the urban development that contributes to the quantity of flood flows.
- Flood mitigation works need to be justifiable on socio-economic grounds taking into account all tangible and intangible costs.
- The community needs to be fully consulted and engaged in decisions about what works should be implemented.

## 4. PROBLEMS AND OPPORTUNITIES

### 4.1 Description of Present Flood Risk in the Catchment

There is a long history of high flood risk and a low level of flood protection associated with Brown Hill, Keswick, Park Lands and Glen Osmond Creeks. Under the present scenario, the catchment has an indicative level of flood protection equivalent to about a 1:10 AEP only.

The following sections describe existing flooding in the catchment for the 1:100 AEP flood event. Catchment flood inundation and flood hazard maps for the 1:100 AEP are provided in Appendix A.

#### 4.1.1 Park Lands Creek

The shorter duration storms (90 minute and 6 hour duration) are the main cause of flooding in Park Lands Creek since it has a responsive, urban catchment.

- *Park Lands Creek at Conyngham Street, Glenside.* Floodwaters break the banks of the creek channel due to a constriction in the form of a culvert that passes under Glenside Hospital. Flooding extends westward through the Glenside Hospital into Eastwood and also along Conyngham Street and a small amount along the Greenhill Road business district.
- *The intersection of Fullarton Road and Greenhill Road, Eastwood.* The culvert under this intersection causes water to back up and overtop the road. Water flows down Greenhill Road until it reaches the intersection with Glen Osmond Road. Only minor flooding extends beyond this intersection.
- *Park Lands Creek, Park Lands.* Flooding occurs through the Park Lands due to Park Lands Creek being under capacity. Flooding begins immediately below the Fullarton Road Culvert and extends over both the left and right banks so that most of the Park Lands is inundated between Fullarton Road and Unley Road. Flooding extends as far as South Terrace. Some water also travels north towards the Victoria Park Racecourse. Generally, the inundated area is bordered by Fullarton Road, Greenhill Road, South Terrace and King William Road. Most of this water is picked up by drains in the Park Lands and returned to Park Lands Creek.
- *Between Unley Road and Greenhill Road.* Most of the floodwater is collected in the creek channel. There is flooding across the Greenhill Road and Unley Road intersection due to the culvert beneath the intersection being under



capacity. Some flood water crosses the tramline and continues through the street network north of the creek system.

- *Between Greenhill Road and the confluence of Park Lands Creek with Glen Osmond Creek.* Floodwaters are contained within approximately 50 metres of the Park Lands Creek channel. The water in this section of the creek is quite deep with an average depth of around 1.5 metres and up to 2.5 metres in some areas. Water ponds in the North Unley Play Park due to the low capacity of the culvert under King William Road. Water flows across King William Road and continues on to the confluence confined to a distance of approximately 20 metres of the channel.

#### **4.1.2 Glen Osmond Creek**

Glen Osmond Creek originates in a rural catchment and consequently longer duration storms become more critical as runoff is limited by ground cover. However, in the urbanised downstream reaches of the catchment, shorter duration storms become critical.

- *Glen Osmond Creek at Fisher Street, Fullarton.* The culvert under Fisher Street is the first constriction of the flow in the Glen Osmond Creek. This culvert has a capacity of just 3.5 m<sup>3</sup>/s compared with the flow in the creek channel of 9.3 m<sup>3</sup>/s. This causes floodwaters to spread in a north-westerly direction through Fullarton. The main flow path is through the St. Josephs Centre and the Southern Cross Homes Hostel before being confined to streets in Fullarton and Unley and then being picked up by the Glen Osmond Creek channel in the vicinity of Unley Road.
- *Glen Osmond Creek at Windsor Street, Fullarton.* The inlet to the Fullarton Road culvert and the capacity of the downstream channel is a point where the flow in the Glen Osmond Creek channel overtops the banks of the channel. The flow path for these floodwaters is similar to that described above in that most of the flow is confined to streets in Fullarton and Unley and it flows in a north-westerly direction.
- *Glen Osmond Creek between George Street and Porter Street, Unley.* The Glen Osmond Creek channel is under capacity in this area and floodwaters break out on the northern side of the channel and flow north-west to Park Lands Creek.
- *Glen Osmond Creek downstream of Unley Rd, Unley.* For a distance of approximately 200 metres downstream of Unley Road, the Glen Osmond

Creek channel is under capacity and floodwaters break out on the northern side of the channel and flow north-west to Park Lands Creek.

#### 4.1.3 Keswick Creek

The shorter duration flood (90 minute duration) is the major cause of flooding in Keswick Creek, which is within an entirely urban catchment fed by Parklands Creek and Glen Osmond Creek.

- *Keswick Creek downstream of confluence of Park Lands and Glen Osmond Creeks.* Floodwaters are spread out to approximately 20 metres of the Keswick Creek channel between the confluence of Park Lands Creek and Glen Osmond Creek and the Showgrounds culvert, affecting some residential housing.
- *Keswick Creek at Showgrounds.* Much of the area surrounding the Showgrounds is inundated by water that spills out of the Keswick Creek channel due to the total flow being greater than the capacity of the Showgrounds culvert (25 m<sup>3</sup>/s). After inundating the Showgrounds area, water flows northwards along the railway line to the Keswick Terminal or westwards along Maple Avenue and through the Keswick Military Barracks to join up with the flow coming from the Brown Hill Creek channel and floods the suburbs of Ashford, Keswick and Marleston.
- *Keswick Creek at Richmond Road, Netley.* Water flows out of the creek channel into the adjacent commercial area to the east.
- *Keswick Creek downstream of Manchester Street, Mile End South.* Water spills out of the Keswick Creek channel for the entire section of channel between Manchester Street and Scotland Road, Mile End South. Much of this flooding is due to the flow in the channel exceeding the capacity of the culvert between Scotland Road and South Road. These floodwaters combine with water coming from the Keswick Military Barracks to the east. Floodwaters spilling out of the western side of the channel flow west across Deacon Avenue to Richmond Oval and Milner Road, Richmond.
- *Keswick Creek downstream of South Road, Mile End South.* The creek channel is also overtopped between South Road and Brooker Terrace, Richmond. Much of this water follows a flow path to the north of the channel, through the suburb of Cowandilla. Water depths of up to 1 metre exist in this flow path. This water heads southwards once across Marion Road, Cowandilla. Most is picked up by either the Keswick Creek channel or by the

Airport Drain, which diverts water around the northern and western sides of Adelaide Airport.

- *Keswick Creek at Ellen Street, Hilton.* A constriction in the channel causes significant flooding over both the left and right banks of the creek channel. Water flows in a north-westerly direction causing widespread flooding through Cowandilla.
- *Adelaide Airport.* Water enters Adelaide Airport from two main locations. The first is at Press Road, West Richmond. This water generally flows in a south-easterly direction once inside the airport. The second location that water enters the airport is at the south-east corner of the airport. This water generally pools on the eastern side of the north-east/south-west runway.

#### **4.1.4 Brown Hill Creek**

Brown Hill Creek has its origin in the rural catchment of the Adelaide Hills, making the longer duration storms (36 hours) more critical for this catchment.

- *Upstream of the Torrens Park Shopping Centre culvert.* Flow generally extends to an area of about 20 metres from the creek channel. The exception to this is in the vicinity of the Fife Avenue, where it spreads out to around 50 metres from the Brown Hill Creek channel.
- *Between the Torrens Park Shopping Centre culvert and Hampton Street, Hawthorn.* The flow is contained within the channel apart from a small section between Soldiers Memorial Park and George Street, Hawthorn. The breakout downstream of George Street heads northward on the east side of the channel and continues through Hawthorn towards Cross Road.
- *Brown Hill Creek at Hampton Street, Hawthorn.* Water spills out of the creek channel and flows north-west. This water flows towards Cross Road on the western side of Brown Hill Creek.

Once past Hampton Street, the flow overtops the banks on the eastern and western sides of the channel to Cross Road. Spill from the eastern bank is contained within 20 metres of the creek channel. Flow from the western bank follows two distinct flow paths. The northern flow path sees floodwater flowing within 100 metres of the creek channel before the majority of the flow is picked up before it reaches Victoria Avenue. The western flow path crosses the railway line at Cross Road. It then proceeds in a north-westerly direction through Kings Park. A small amount of water crosses the catchment boundary

into Clarence Park. The Goodwood Road underpass is inundated up to a depth of 2.5 metres. Once past the underpass, the Brown Hill Creek channel between Goodwood Road and the railway line picks up the floodwaters.

- *Between Victoria Avenue, Unley Park and Victoria Street, Goodwood.* Spill occurs from the channel in a number of locations due to the channel being under capacity. Spill from the western bank is generally contained within 50 metres of the channel, while spill from the eastern bank flows north towards the Showgrounds and Keswick Creek.
- *Between Ethel Street, Forestville and Anzac Highway, Everard Park.* A significant amount of spill occurs from both the north and south banks of the channel. Spill from the south bank flows west and south-west inundating large area between Anzac Highway and Brown Hill Creek. Spill from the north bank flows west and north-west inundating large areas between Brown Hill and Keswick Creeks.
- *Brown Hill Creek at Daly Avenue, Kurralta Park.* Where the street crosses the Brown Hill Creek channel water overtops the banks and flows in a north-westerly direction through Kurralta Park and Netley. A significant landmark inundated by this flow is the Netley Commercial Park. Most of this water is picked up by the Brown Hill Creek channel or by the Keswick Creek channel just upstream of its confluence with the Brown Hill Creek channel.
- *Brown Hill Creek near MET Station, North Plympton.* A flow path is created from the Brown Hill and Keswick Creeks outlet channel into Adelaide Airport as the channel fills. Water pools on the southern side of the north-west/south-east runway.

## **4.2 Opportunities for Reducing Flooding in the Catchment**

Intensive investigation of opportunities for reducing the impact of flooding in the catchment were undertaken. These investigations considered both structural and non-structural options.

### **4.2.1 Structural options**

Structural mitigation options that were assessed fell into the following categories:

- temporary flood storages be these dams, detention basin or wetlands;
- diversions;
- bypasses;
- channel capacity increases;

- channel improvements; and,
- miscellaneous options.

### **Flood control dams**

The highly urbanised nature of the catchment generally precludes the option of flood control dams, which require large tracts of land for storage of flood waters. Two notable exceptions investigated were the (existing) Mount Osmond Interchange flood control dam, where there is scope for improvements to be made in its operation, and in the upper (rural) reaches of Brown Hill Creek. From previous reports and catchment inspections four potential dam locations on the upper reaches of Brown Hill Creek were identified.

### **Detention basins and wetlands**

Detention basins act as a temporary storage for floodwaters during a storm event and reduce peak channel flows downstream. They can be located either off or on-line to the existing creek system. Upstream detention basins are more effective as they reduce downstream flows and have a greater cumulative effect on associated downstream damages.

This type of mitigation is considered a preferred option for this catchment. Potential detention basin locations were investigated catchment-wide with the emphasis placed on the technical viability of any existing open space (parks, reserves, wide open spaces, etc).

### **Diversions**

A diversion is defined as transfer of flow away from the main creek channel into another creek system. Diversions require assessment to ensure that flooding problems in the receiving creek system are not exacerbated.

Opportunities for diversion were assessed across the catchment. Most diversions were initially sized to transfer the maximum allowable flow based on the limiting capacity in the downstream reach, however some diversions were then feasible to transfer the maximum amount of flow and lower capacity flows were investigated.

A potentially favourable diversion option was identified as being one between Keswick and Brown Hill Creeks upstream of Anzac Highway. A correctly sized diversion at this location (in combination with other mitigation options) can potentially reduce flows in Keswick Creek to its capacity and obviate the need to upgrade both Keswick and Brown Hill Creek channels.

## **Bypasses**

A bypass is defined as a diversion of flow away from the main creek channel to reduce flooding, which is returned to the same creek system further downstream. Locations throughout the catchment were investigated for each individual reach with the more likely locations occurring where large under-capacity bridges and potential alignments to shorten the creek occurred.

The size and type of bypass were determined using the HEC-RAS hydraulic model with maximum size of bypass flow being limited by the downstream capacity constraint of either the channel or structures.

Feasible locations for a bypass were identified at Cross Road, Daly Street and the Showgrounds. These are all locations where a substantial reduction can be made in downstream flooding if the flow is managed. Underground culvert bypasses are usually adopted due to the lack of available space to construct open channels.

## **Capacity increases**

Opportunities for increasing channel capacities in the catchment were mainly found along the creeks at problem location (i.e. bridges, etc). Increasing the capacity under bridges addresses both localised flooding and catchment-wide flooding by removing the constriction to flow and allowing flows to remain within the channel.

Bridge upgrades usually also require localised channel upgrades.

## **Channel improvements**

Channel capacity increases in the catchment were investigated at problem locations, usually downstream in the creek systems (i.e. downstream of Anzac Highway for Brown Hill Creek and Richmond Road for Keswick Creek). Increasing channel capacity by widening addresses both localised flooding and catchment-wide flooding by confining the flow within creek lines.

In the majority of the downstream upgrades it was assumed that the whole reach would be upgraded to either a concrete lined or rehabilitated riverine system that would incorporate linear parks for community benefit. It was in some cases necessary to consider property acquisition as the existing drainage corridors are insufficient to accommodate the required width of channel to contain flood waters.

## **Miscellaneous options**

Other mitigation opportunities that were considered during the course of the project included:

### *Under-grounding or covering*

It would be possible to contain the entire flow from existing open channel systems within an underground piped system, however in the majority of cases the existing drainage corridor was not wide enough to accommodate the culvert that would be required. Whilst this option could be accompanied by some form of community benefit above ground, such as a linear park, extensive property acquisitions would be required and the costs were found to be prohibitive. Furthermore under-grounding creeks is not consistent with good Natural Resource Management practices.

### *Channel lining*

Unlined sections of watercourse can be concrete lined to decrease channel roughness and consequently increase capacity. Whilst this is not an ideal policy approach from a natural resource management perspective, it is appropriate for those sections of channel where no other mitigation options are feasible and flooding due to channel under-capacity occurs.

### *Channel maintenance*

Channel maintenance is a contentious issue within the catchment due to the current demarcation between local government, NRM Boards and the public. The responsibility to maintain the public and privately owned sections of the creek network lie with the landowner. Currently this is not been done in a consistent manner, with little maintenance being undertaken by the private landowners on deficient sections of the creek system.

To ensure the modelled hydraulic characteristics of the creek system for the mitigation options and scenarios are maintained it is essential that the creek system be well maintained to reduce the risk of obstructions occurring in the channel or at structures. If obstructions are encountered the hydraulic characteristics of the channel cannot be maintained and it is more likely that flooding will occur at much lower flows than the hydraulic modelled flood events.

### Flow containment – levees and walls

This type of mitigation option assumes that the nominated flow is to be contained wholly within the channel by raising the channel sides above their existing level. The heights of the containment structures depend on both the flow to be contained and the amount of space available to implement the structure.

Two types of flow containment structures have been investigated for this catchment:

- Where there are no space constraints earth fill levees are the most cost effective. With gentle slopes (e.g. 1V:3H) they are safer and can be made to blend into the surroundings. Earth fill levees were considered along the channel for containment and also around detention basins.
- In locations where there is minimal space available for earthfill levees, elevated channels using concrete retaining walls were investigated.

### Road diversions

In the event of a flood, the road network in the catchment would provide some storage of flood water. Water would be partially contained within the road reserve by kerbing and the natural fall of the land.

A potential mitigation option raised was to increase the amount of storage offered by roads by artificially creating areas capable of storing additional volumes of water. While this is a potentially attractive option, it would not be possible to achieve significant storage gains without major structural works and lowering of some road networks, which in turn might increase localised stormwater problems and hazards.

### Raising floor levels

This measure was incorporated into the generic non-structural options as it is more suited to planning policy for new or upgraded properties. In the case of Brown Hill and Keswick Creeks it was not considered cost-effective to raise floor levels for existing properties, but rather use flood preparedness techniques to reduce damages during times of flooding.

New developments should be constructed with floor levels above the 1:100 AEP flood level to reduce the risk of flooding and damage. This is currently a requirement for a number of the councils and is seen as a best practice flood damage reduction measure.



## 4.2.2 Non-Structural options

Non-structural mitigation options fall into four categories:

- increasing flood preparedness;
- improving flood warning;
- improving planning policy and development assessment; and,
- utilising supporting policies and programmes.

### **Flood preparedness**

Experience shows that informing people about the risks facing them and their properties enables them to reduce their vulnerability and increase their resilience against flood damage. Community awareness of flood risk and potential for flood damage in the catchment is possibly at an all time high with the recent publication of flood maps, release of a draft Ministerial Planning Amendment, and the flood event of November 2005. However, public interest tends to focus on recent events and diminishes rapidly thereafter, unless a concerted effort is made to maintain a high level of awareness.

Flood maps provide a best estimate of flood flows that in real life are affected by fences, accumulation of debris, blocked culverts and other unforeseen circumstances. Flood maps, despite their limitations, indicate where water is most likely to travel, and what depth it might reach: vital information for helping landholders to understand the scale of the flood problem, and therefore be able to mitigate the damage.

The flood maps for Brown Hill and Keswick Creeks show that much of the flood-prone area is affected by shallow (less than 150 mm) water. In most cases this will not be deep enough nor the flow fast enough to break through glass doors, or low-level windows. In many cases attention to door seals and wall vents by sand bagging may be sufficient to alleviate the problem.

There is an obligation that flood mapping information be made public through the Natural Resource Management Board and Councils, but understanding flood maps and the implications of flooding as well as options to reduce risks is not necessarily straightforward. Access to technical people with appropriate knowledge of the catchment is necessary to assist people to make informed decisions about property purchase, property development, and appropriate responses to flood risk.

In New South Wales and Victoria Catchment Boards and Councils have the authority to issue a flood report or certificate when a property is in a flood-prone area. Agents, owners or potential purchasers can obtain a report or certificate as part of property enquiries. The content of the certificate is limited and basically advises that the property is within the calculated flood-prone area. An opportunity exists to incorporate similar advice on Section 7 searches required as part of the *Real Property Act 1886*. The purpose of providing such advice would be to inform owners and occupiers of flood-prone land such that they can make informed decisions.

An ongoing program, similar to the wildfire awareness campaigns, is needed to achieve a reasonable and sustainable level of community awareness and raise levels of awareness in emergency management and response procedures. This programme could provide advisory material on flood risk to all people in the 1:100 AEP flood plain and facilitate the provision of dedicated staff who can provide sound technical advice on flood risk in the catchment and minimisation measures.

### **Flood warning**

The Bureau of Meteorology is responsible for flood warnings where systems have a response time in excess of six hours. There is, therefore, a formal flood warning system in place for Brown Hill Creek, but not for Keswick Creek. The Bureau of Meteorology does provide *generalised* warnings for severe weather conditions likely to lead to flash flooding, and is required to provide advice and assistance to local councils in developing flood monitoring and warning arrangements for flash flood catchments.

Flood warning arrangements for the catchment have developed steadily over the past 15 years and are generally advanced, incorporating:

- flood watch notices issued to council and emergency services staff (during business hours) as a precursor to large events;
- ALERT rainfall and river height monitoring reporting to the BoM in real time;
- flood forecasting models; and,
- Bureau of Meteorology issued warnings.

The Bureau of Meteorology provides rainfall and water level information on the web, updated every hour. This service could be improved by updating more frequently, since flash floods by their very nature develop quickly and could occur within the

hour. Improvements could be made in the estimation of the spatial distribution of rainfall across the catchment.

Distribution of flood warning messages is currently by fax and email. This service could be extended to mobile phone SMS. Flood warnings could also be sent by recorded telephone message to local residents and businesses. This could be considered for Brown Hill Creek and the lower reaches of Keswick Creek, subject to funds and resources being available.

Response planning for floods is well developed, with good relationships between the Councils and the State Emergency Service, however regular flood exercises should be arranged to ensure that plans do not become dated, and that new staff are trained in flood response procedures.

It is crucial that the existing ALERT monitoring program be continued, and opportunities for its enhancement implemented where practicable.

### **Planning policy and development assessment**

Proper planning policy and development assessment ensures that the built environment is constructed to effectively manage stormwater and that developments are appropriate for the flood risks that they face.

Planning policies can be most effective in reducing flood risks when applied to new developments or areas undergoing intensive urban regeneration as a whole. Planning policies that restrict the development potential of site tend to be objected to by the public.

As part of the Flood Management Master Plan the development plans of the five Council's in the catchment were reviewed with respect to their objectives and principles of development control, as well as supporting state level statutory documents (the *Development Act 1993* and Regulations; the Planning Strategy for South Australia; and, the State Development Plan).

While the 1:100 AEP is used as a common principle of development control for flood management, the requirements for floor levels and set-backs from water courses vary from Council to Council. Furthermore, the process for obtaining development approval in flood prone areas varies with some Council's freely assisting applicants with technical advice on flood risk and stormwater management and others requiring applicants to privately engage a consultant.

There is some argument for more consistency and harmonisation in planning policy and development assessment. The State Government's *Building Better Development Plans* programme may provide the impetus for this, by providing councils with generic policy modules setting minimum standards for flood levels and stormwater management. Specification of suitably generic but robust design techniques would also go some way to addressing inconsistencies in development applications with respect to flood risk and stormwater management.

The State Government's Planning Strategy for Metropolitan Adelaide has been restructured in line with the South Australian Strategic Plan and provides direction on flood protection and stormwater management for councils and State Agencies in preparing future Development Plan Reviews. Notable is the expectation that there will be considerable redevelopment and new development in the inner south-west and west areas of metropolitan Adelaide, which will affect the catchment area. Such development is likely to be denser corresponding with an increase in impervious area and an effect of flooding in the catchment. There is, however, the opportunity to co-ordinate the planning of these higher density residential, regeneration and business focus areas in a way that responds to the flood risk and desired approach to stormwater management through neighbourhood planning and master plans

### **Supporting policies, protocols and programs**

Preparation of the Flood Management Master Plan considered the following supporting policies, protocols and programs and the degree to which they could be applied in support of flood mitigation objectives.

Neighbourhood planning in strategic areas of concern along watercourses and in identified areas of infill and urban regeneration was identified as a means of addressing flooding and stormwater management issues through targeting actions at the regional, neighbourhood and site levels. As the inner south-west and western suburbs of Adelaide, which lie within the catchment, undergo further infill and urban regeneration there are opportunities to address flooding and stormwater issues through developing neighbourhood plans that cover particular areas of risk, rather than local government areas.

There exists a further opportunity to develop policies and programmes related to open space and road reserve management within the five Council's in the catchment, with the intent of providing retention/detention of stormwater within the neighbourhood. Works could be incorporated during reconstruction of roads and footpaths or at the time of development of open spaces.

On site retention through the compulsory fitment of rainwater tanks to residential properties was also considered. An analysis for the catchment agreed with the conclusions of other work elsewhere that rainwater tanks for on-site detention have little effect in reducing peak flows for major flood events, with any effect diminishing with increasing size of flood event.

### **4.3 Opportunities for Multipurpose Outcomes**

There are numerous examples in Adelaide, interstate and overseas where flood mitigation works have been expanded or adapted to provide benefits other than reducing flood damages. The rationale for doing this varies from case to case but there are some inherent reasons why it makes sense to pursue additional outcomes from structural works than just flood mitigation benefits. These include:

- Flood mitigation works are usually designed to deal with large and infrequent flows. This means that the infrastructure created only operates to its design capacity on a very infrequent basis (e.g. once every 20, 50 or 100 years).
  - If the works involve some form of detention system requiring large areas of land then failure to incorporate other outcomes means that large tracts of land could be tied up but not being utilised for the vast majority of the time.
  - If the works involve channel widening then similarly much of the channel will remain dry for all but the most severe (and infrequent) floods.
- Flood mitigation works will usually involve large amounts of public funds much of which will directly or indirectly come from people (taxpayers) who will not receive a direct benefit from the works. Incorporating multiple outcomes from the works will enable a wider range of people to receive benefits from the works.
- Achieving a wider array of outcomes from the works offers the opportunity to attract a wider range of investors in the works and hence the costs can be distributed over a larger funding base.

In the case of Brown Hill and Keswick Creeks, opportunities for achieving multiple outcomes were considered on both a reach-by-reach and catchment scale basis.

For a multiple purpose option to be considered, however, it firstly had to be associated with a practical flood mitigation option. For example the creation of a linear park along a section of watercourse was only considered if there was a

channel capacity issue associated with that section, or if the section of watercourse could provide sufficient flood detention to reduce flood risk downstream.

There are obviously endless sections of watercourse that could be rehabilitated but the primary purpose of the present study is to reduce flood damages and hence any use of open space needed to be firstly justified on that basis and then the scope of additional works were assessed for their value adding contributions.

Using the above approach each flood mitigation option was considered for its potential to provide one or more of the following additional outcomes:

- water quality improvement;
- improved biodiversity;
- passive recreational opportunities;
- formal recreational opportunities;
- water harvesting and reuse opportunities (rainwater tanks and ASR);
- natural infiltration and replenishment of local shallow groundwater;
- transport corridors;
- visual amenity; and,
- opportunities to engage the community.

A brief description of how these opportunities have been incorporated within the priority works components is provided in Section 5.5.

## 5. FLOOD MANAGEMENT STRATEGY

### 5.1 Process for Selecting Priority Works Components

There are a wide range of individual actions that can help reduce flooding in the catchment. Each of these actions can be combined in numerous ways to achieve a catchment wide effect.

It was important that all potential measures were considered and that the potential for each measure was considered throughout the catchment. Furthermore, flooding issues needed to be considered throughout the catchment so that breakout points could be identified and the consequences of each breakout accurately described.

Streams and trunk drains in the catchment were subdivided into segments (reaches) based on their physical and flooding characteristics so that the location of breakout points and flooding problems could be mapped. This enabled the project team to look in detail throughout the catchment for opportunities to implement structural and non-structural flood mitigation.

Over three hundred potential were initially highlighted for investigation. These were checked for their technical and economic viability – a process that eventually resulted in a short list of around 80 technically viable individual options or components that could be combined to form a mitigation solution for the whole catchment.

A Multiple Criteria Assessment technique was used to rank the 80 components. The criteria, determined by the Technical Steering Committee, were:

- expected cost of works;
- flooding reduction within the reach;
- flooding reduction across the catchment;
- potential for increasing open space and recreation opportunities;
- potential for improving water quality and providing reuse opportunities;
- opportunity to improve biodiversity; and,
- degree of 'at source' management.

This process resulted in a further short listing down to around 20. These 20 components were evaluated in more detail by reviewing their expected costs and

assessing the contribution they made individually to reducing flood damages and flood hazards.

The non-structural components proved to be very cost effective and would benefit most areas of the catchment. They could be implemented without structural works and to a large degree could be considered to act independently of the structural works.

However, many of the structural components were found to be closely interrelated and the way in which they were combined would have a significant effect on the scale of hazard and damage reduction as well on the cost effectiveness.

Various combinations of components were assessed so that a clearer understanding of how they are interrelated could be developed. Four different scenarios were assessed in detail so that a set of priority works components could be identified for community consultation.

This process led to the elimination of the lesser performing components. The final short listed components effectively became the priority works components that could be effectively combined to form an effective catchment wide strategy to reduce the impacts of flooding.

A number of the priority works components were then fine tuned to reduce flood damages. The process is presented in flow chart form in Figure 5-1.

## **5.2 Description of Priority Works Components**

### **5.2.1 Non-structural components**

Non-structural measures that from part of this Master Plan are designed to reduce flood damages and the threats to public safety (flood hazard) through:

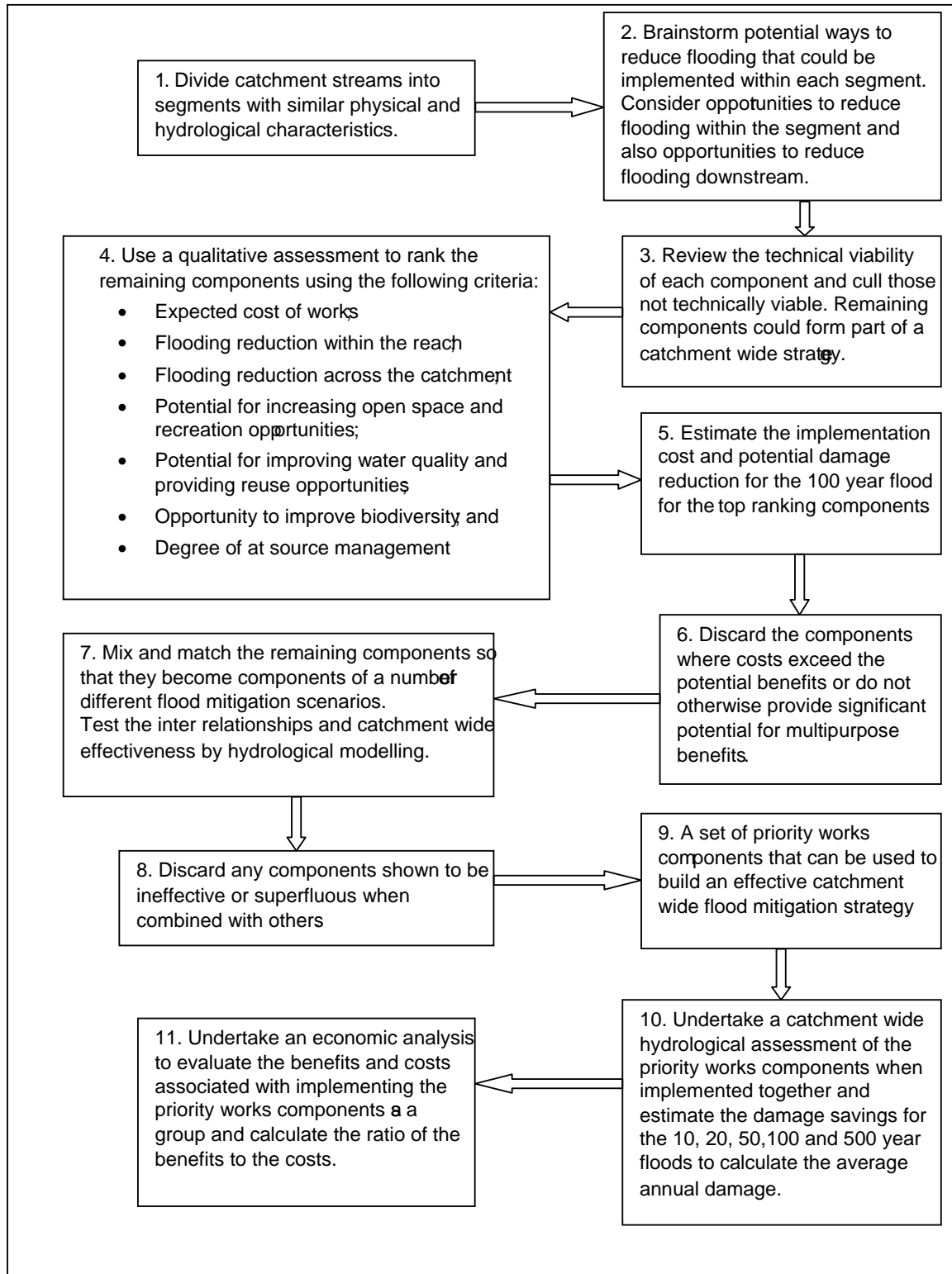
- Community awareness and flood response plans by;
  - raising community awareness, preparedness and capacity to avoid damages and respond during a flood; and
  - developing flood response plans for emergency response organisations.

and,

- Managing new development by;
  - improving planning policy and assessment of new developments within existing council Development Plans;



- codes and development guides; and,
- neighbourhood planning/master planning.



**Figure 5-1 Flow chart for selecting priority works components.**

### **Community awareness and flood response plans**

Raising community awareness about how to prepare for and respond during a flood to reduce damages could be increased by providing information and advice to landholders. It is envisaged that this would be achieved through the employment of two full time staff specifically to:

- ensure that flood inundation maps are widely and readily available and that people understand whether or not they live or work within the floodplain;
- provide information on ways landholders can flood proof their houses and businesses;
- provide information on effective ways of responding during a flood;
- work with the Bureau of Meteorology and local councils to continue to improve the dissemination of flood warnings;
- work with local councils and the State Emergency Service to develop/improve flood response plans;
- work with landholders at a neighbourhood level to provide advice on developing individual flood proofing, response, and recovery plans; and,
- work on a one-on-one basis with schools, hospitals, aged care centres, high risk premises, and other places that may be slow to evacuate, to develop flood proofing strategies and flood response and recovery plans.

### **Managing new development**

Managing new development to reduce future potential damages is a recognised method of avoiding flood damage throughout much of Australia. Existing Council Development Plans in the Brown Hill and Keswick Creek catchments all include provisions to deal with new development in such a way as to reduce the potential for future damages. The way in which this is done does vary however, as do the standards and emphasis placed on the various policies between councils.

There are a number of ways in which councils could enhance their Development Plans should they wish to increase their ability to manage new development in flood prone areas. These include:

- showing high and medium hazard areas and 1:100 AEP flood prone land as an overlay in the Development Plans;

- making provision so that new buildings in the 1:100 AEP flood area have a floor level (or door/window threshold) above the 1:100 AEP flood level;
- having general objectives and principles of development that require all new development including land division, change of land use and building work to respond to stormwater management through water sensitive urban design techniques; and,
- ensuring that new development does not reduce the capacity or functionality of the existing drainage network.

The principles associated with the above opportunities are the responsibility of councils and should be considered by councils in light of their own Development Plans. If considered appropriate by individual councils they could take the appropriate steps to amend their Development Plans to reduce future flood damages.

The above process could also be assisted by the development and provision of guidelines for new development in flood prone areas. Such guidelines would include information on flood proofing as well as council development assessment processes and requirements. This would enable landholders to be aware of their Councils' expectations and how those expectations can be best met.

The management of new development outside of the floodplain is also important. Urbanisation increases the rate at which runoff occurs and can increase the magnitude and frequency of flooding. It is therefore important that new development, anywhere in the catchment, takes place in a manner that does not increase the risk of flooding to others downstream.

Water sensitive urban design provides the opportunity for new development and urban consolidation to occur without necessarily increasing the risk of flooding. The best opportunities lie in precinct scale redevelopment. In these situations neighbourhood master planning provides the opportunity to incorporate flood management within the development at the outset and joint schemes coordinated by council and the owner/developer. Modelling conducted as part of this study indicates that the effects of urban consolidation could be small for these catchments (an 8% increase in flood flow magnitude was estimated) if new development and urban consolidation initiatives are well managed. Whilst small, the need to manage this increase it is still very important because many areas are already subject to a high likelihood of flooding.

## 5.2.2 Structural components

The following components were determined to form the priority works for the Flood Management Master Plan on the basis of their cost effectiveness and technical feasibility.

- Parklands Creek
  - Upgrade the Fullarton Road/Greenhill Road culvert
  - Series of detention basins in the South Park Lands
- Glen Osmond Creek
  - Modification of the Mt Osmond Interchange Dam outlet
  - Ridge Park Reserve flood detention system
  - Upgrade of the Fisher Street culvert
- Keswick Creek
  - Goodwood Road diversion from Keswick Creek to Brown Hill Creek (approximate capacity 14 m<sup>3</sup>/s)
  - Railway line diversion from Keswick Creek to Brown Hill Creek (approximate capacity 11 m<sup>3</sup>/s)
- Brown Hill Creek
  - Flood Control Dams upstream in the rural portions of Brown Hill Creek
  - Upgrade of the channel capacity between Hampton Street and Cross Road
  - Increase channel capacity of Brown Hill Creek downstream of Anzac Highway

Each component has been assessed for its potential to provide multipurpose outcomes. The individual councils may wish to pursue other mitigation options to achieve local benefits or specific outcomes, but it is not envisaged that they would be pursued through the catchment wide Flood Management Master Plan works.

The flows quoted in the adopted mitigation components, unless stated otherwise, are the base case flows plus projected infill scenario flows for the 1:100 AEP event, determined by the DTEI hydrological modelling.

Capital cost estimates are summarised in Table 5-1 below and a location map of the priority works components is provided in Figure 5-2.

**Table 5-1 Summary of estimated capital costs for structural works components only**

<b>Priority Works Component</b>	<b>Capital Cost (\$ million)</b>
Upgrade Fullarton Rd/Greenhill Rd culvert	\$2.7
Series of detention basins in the South Park Lands	\$10.0
Modify Mt Osmond Interchange Dam outlet.	\$0.1
Develop an inline flood detention system in Ridge Park Reserve and rehabilitate stream	\$0.6
Upgrade culverts under Fisher St	\$4.0
Goodwood Road Diversion from Keswick Creek to Brown Hill Creek (approximate capacity 14 m <sup>3</sup> /s)	\$16.0
Railway diversion from Keswick Creek to Brown Hill Creek (approximate capacity 11 m <sup>3</sup> /s)	\$16.0
Flood Control Dams in Brown Hill Recreation Park	\$17.0
Increase channel capacity between Hampton Rd & Cross Rd	\$2.0
Upgrade Brown Hill Creek channel from downstream of Anzac Hwy to confluence	\$37.0
<b>TOTAL SCENARIO CAPITAL COST</b>	<b>\$105.4</b>

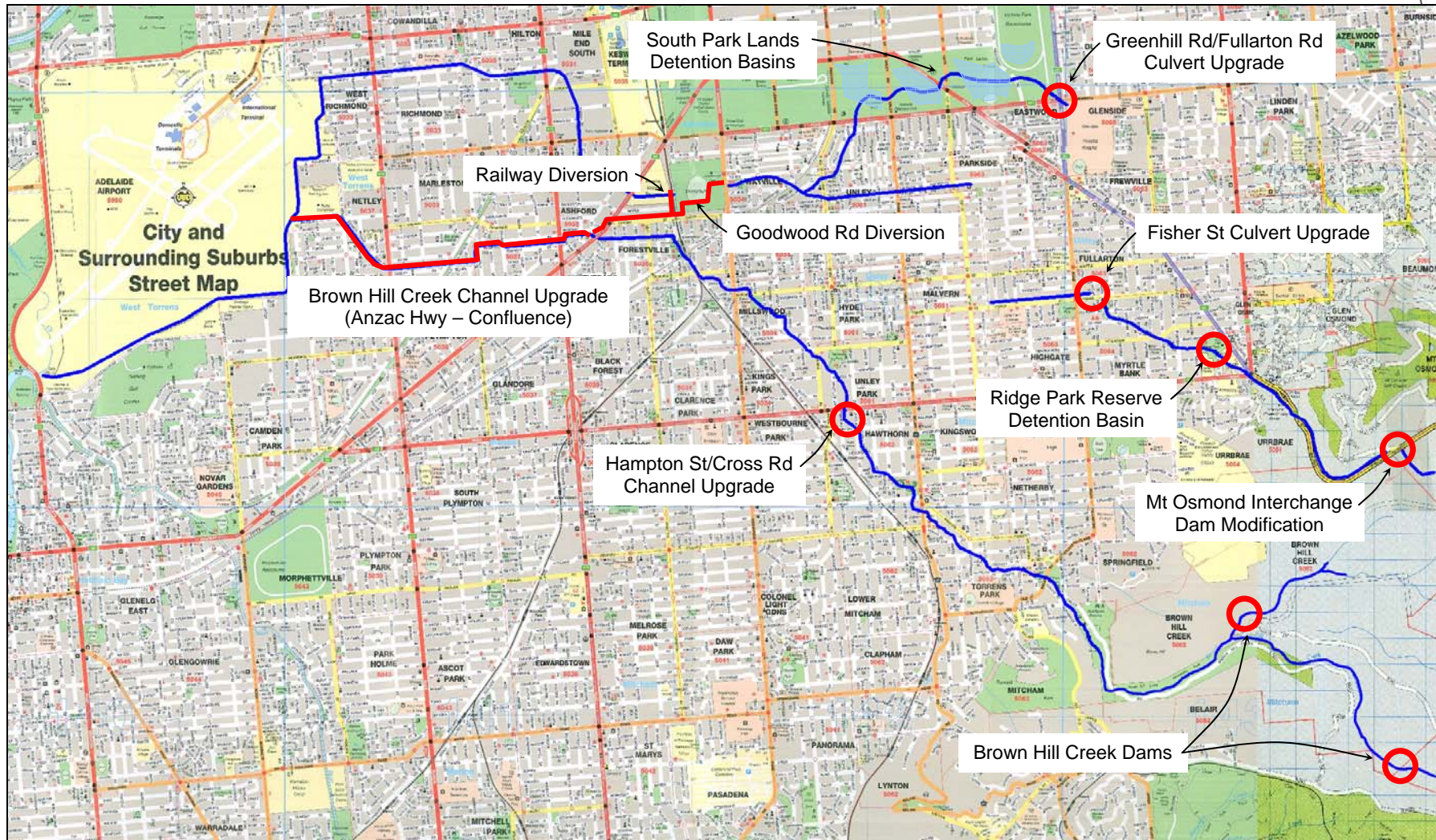


Figure 5-2 Map showing locations of priority works components.

## **Park Lands Creek**

### **Upgrade Fullarton Road/Greenhill Road culvert**

Presently the flows in Parklands Creek from Burnside enter the Glenside Hospital grounds and then are attenuated by the existing Glenside Detention Basin before flowing through the Fullarton Road/Greenhill Road culvert. This area is subject to inundation when the flooding exceeds approximately the 1:10 AEP event. In order to increase protection to approximately the 1:100 AEP and reduce the high damages attributed to the commercial and residential properties that border Greenhill Road it is necessary to increase the capacity of the culvert.

The following information concerning this mitigation option should be adopted:

- 1:100 AEP (90 minute) hydrological modelling assumes a peak flow of 23.6 m<sup>3</sup>/s is required to be passed to reduce inundation.
- The existing Glenside Basin is required to be operational during flood events.
- The existing box culvert is a 3050 mm x 1370 mm RCBC. It has an approximate capacity of 17.4 m<sup>3</sup>/s and is 115 m long.
- An additional 3600 mm x 1200 mm RCBC has been sized to take the additional flow.
- The concrete channel upstream of culvert inlet (approximately 3.1 m wide) needs to be widened to a minimum of seven metres in width to contain flow within the double culvert arrangement.
- When excavating the new approach channel the detention basin levee will need to be offset, but maintain the same levels to ensure no detrimental effect on the basin detention characteristics are experienced.
- Minor 0.7 m raising of the headwall and right hand bank will be required to contain flow.
- Services should be unaffected as the capacity increase will occur parallel to the existing culvert and at the same level. The new culvert alignment should be located on the southern side of the existing culvert to minimise potential service relocation issues and space restrictions on the right bank.
- Will require extensive traffic control allowance due to disruption of a major intersection.

- Provides 1:100 AEP protection to properties within the vicinity of the mitigation option, that were previously inundated as a result of the under capacity culvert.
- Detailed survey will be required to confirm levels during the detailed design.
- Capital cost estimate is \$2.7 million.

A concept drawing is provided in Appendix B.

This component is implemented in conjunction with the South Park Lands detention basins to reduce the costly commercial building flooding that would occur if not implemented in Fullarton, and flooding of residential properties along Greenhill Road in Dulwich.

#### Series of detention basins in the South Park Lands

Park Lands Creek flows east to west through a number of parks within the South Park Lands. A series of levees is proposed to form six detention basins located throughout the Park Lands, connected by the natural creek alignment and larger culverts under existing roads. This will potentially inundate the proposed detention basins during the 1:100 AEP flood event and result in spillway and overland flows to substantially reduce the outlet flows further down Park Lands Creek.

The South Parklands is held in high esteem by many sections of the community and there exists a public fear that construction of the detention basins may result in loss of native grasslands and clearance of significant trees. However, most native grassland areas occur as understorey vegetation to wooded areas, which are unlikely to be cleared. Open turfed playing fields, which are likely to be used, rarely have native grasses due to their high mowing frequency. Similarly, significant trees are aimed to be retained and incorporated into landscaping plans.

The opportunity exists to completely revitalise the watercourse through the South Park Land through the reintroduction of a range of aquatic macrophytes and riparian species. It is assumed that the floor of detention basins will be turfed for continued use as playing fields. However, the perimeters of the basins may be planted with species consistent with the pre-European vegetation.

The following is assumed:

- Six detention basins located throughout Park Lands and connected by the natural creek alignment, feeder culverts and culverts under existing roads.



- The detention basins have a combined storage volume of approximately 254 ML. Assuming the detention basins sizes are the maximum proposed, there will be some spillway flow with the present detention basin configuration. The total storage capacity of the basins is greater than the critical duration flood volume. As the flood fills the individual basins, the peak flow through Park Lands is reduced, so by the time the flood has reached the most downstream basin (Basin 5), the peak flow is significantly less than when the flow enters Park Lands.
- Peak flow through Park Lands assuming no upstream detention (other than the existing Glenside Basin) from the hydrologic modelling is 23.6 m<sup>3</sup>/s (base case + infill flow).
- Revised peak from the critical 6 hour duration storm for the 1:100 AEP event is 7.6 m<sup>3</sup>/s downstream of Roberts Street, which is approximately equal to the Greenhill Road culvert capacity of approximately 8 m<sup>3</sup>/s. Minor flooding along Greenhill Road may therefore still occur.
- Inflow culverts range in size from 750 mm for Basin 1 to 250 mm for Basin 6.
- Proposed spillway widths to promote overland flow when the capacity of the detention levees are exceeded are assumed to be located centrally over the outlet pipes on the creek alignment.
- Some sculpting of the existing banks downstream of Detention Basin 5 may be required to transfer the flow back towards the channel to ensure no floodwaters overflow Greenhill Rd.
- Detailed survey will be required to confirm levels during the detailed design.
- Capital cost estimate is \$10 million.

This component provides a substantial reduction in downstream damages due to high detention capabilities of the proposed basins. Where possible the construction of the basins will preserve the existing flora and maintain the dual use for sporting pursuits. It has the added benefit of not affecting any existing properties due to the open area of the Park Lands. This component is supported by upgrading the culvert at Fullarton Road/Greenhill Road.

A concept drawing is provided in Appendix B.

## **Glen Osmond Creek**

### **Modify the Mt Osmond Interchange Dam to reduce flows**

A review of the hydrology of the existing Mt Osmond Interchange Dam by DTEI found that the original flood control dam was over-designed for the 1:100 AEP event. The hydrological model was rerun with the existing storage level–discharge curve and resulted in a potential 60% reduction of the flow before overtopping of the dam crest occurred for the 1:100 AEP critical flood duration. To further reduce downstream flows without compromising the safety and stability of the Mt Osmond Interchange Dam the following was adopted as a mitigation option:

- Total storage capacity of the Mt Osmond Interchange Dam at the dam crest level SL 165 m is approximately 51 ML.
- Based on the hydrologic model results using the existing storage curve, it is possible to reduce the flow at dam crest level from 3.2 m<sup>3</sup>/s to 1.9 m<sup>3</sup>/s without overtopping.
- The existing orifice plate on the culvert inlet will need to be reduced from 610 mm to 475 mm to achieve required flow reduction.
- Existing peak outflow in downstream channel is 9.3 m<sup>3</sup>/s for the 36 hour critical duration event.
- Revised peak flow downstream with orifice reduction in place is approximately 8.9 m<sup>3</sup>/s.
- Capital cost estimate is \$100,000.

This component can be implemented immediately for a low capital cost. It has the benefit of reducing the downstream flow by a moderate amount in the Glen Osmond creek system with little affect on the environment or community.

A concept drawing is provided in Appendix B.

### **Develop an inline flood detention system in Ridge Park Reserve and rehabilitate stream**

An opportunity exists to rehabilitate the watercourse through Ridge Park and provide an inline flood detention system involving one or more or low level weirs. The concept design adopted incorporates a single embankment.

Due to the steep and confined nature of this reach of the creek the channel has well defined low and high flow sections. Within the high flow channel is a narrow,

sinuous low-flow channel spanned by a number of footbridges. Rehabilitation of this low flow water channel is recommended.

Opportunity exists to reinstate a range of aquatic macrophyte species and replace the exotic trees present along this low flow channel with appropriate native riparian shrub species. All species selected for this watercourse should be shade tolerant to cope with growing beneath the significant River Red Gum population.

The following information concerning the mitigation option should be adopted:

- A three metre high levee has been assumed with side slopes of 1V:3H, spanning the creek at the bottom of Ridge Park, with a crest length of 40 m and width of four metres.
- Taking existing topography into account it is expected that the actual detention basin capacity for a levee of three metre height is in the order of five megalitres.
- Peak flow in the upstream channel is approximately 8.9 m<sup>3</sup>/s assuming reductions are made to the Mt Osmond Interchange Dam outflow as described above.
- The detention storage when subjected to major floods would back up through the existing channel close to the Cross Road culvert outlet, resulting in an approximately 200 m long by 25 m wide tapered temporary flood storage.
- The 1200 mm diameter outlet pipe would be sized to pass 8.0 m<sup>3</sup>/s and the detention basin would store flows above this flow.
- An overflow spillway has not been allowed for in the concept design as the culvert located under Cross Road has a maximum capacity of approximately 10 m<sup>3</sup>/s. Thus any excess flow that backs up upstream of the culvert inlet would flow down Cross Road and towards the Brown Hill Creek catchment.
- Significant trees (River Red Gums) and appropriate infrastructure offset distances and existing structures would be kept because the duration of inundation during a 1:100 AEP event would only be four hours.
- The levee would be wide enough to allow a bike track to traverse the crest and the remaining basin may be sculptured to further enhance multipurpose benefits for public use as a recreation reserve.
- It is expected that no services will be encountered during construction as the majority of the work is above ground.

- Detailed survey will be required to confirm levels during the detailed design.
- Capital cost estimate is \$600,000.

This component provides a range of multipurpose community benefits (recreation and biodiversity enhancement), as well as being relatively low cost and effective in reducing the peak flow of shorter duration storm events from the Mt Osmond Interchange dam.

A concept drawing is provided in Appendix B.

This component may also provide an opportunity to construct a wetland, and if the hydrogeology of the area proves suitable, a water reuse scheme could be established to water the adjoining playing fields. The viability of reuse should be investigated during the detailed design of the mitigation option.

#### Upgrade culverts under Fisher Street

This is a known major breakout location for small flood events due to the constriction caused by the culvert and downstream control effects. Upgrading this culvert substantially reduces flooding damages further downstream in the Fullarton area.

- The existing culvert has a diameter of 1.5 m with a capacity of approximately 3.5 m<sup>3</sup>/s.
- Hydrological modelling shows that the maximum flow that the culvert is required to pass for a 100 AEP flood is approximately 8.1 m<sup>3</sup>/s, assuming that the Mt Osmond Interchange Dam modification and Ridge Park Reserve detention system are both implemented.
- 2 x 1.5 m diameter culverts be utilised to pass the required flow with widening of the upstream and downstream channel by two metres to accommodate the headwalls for the two culverts.
- Align the new culvert through the Fisher Street Reserve (along existing alignment), along the road reserve, and into the downstream channel. It will be necessary to acquire one property on Wycliff Street and the rear portion on two Fisher Street properties for construction, larger outlet works, and for maintenance and access.
- During construction the condition of the existing culvert will need to be assessed. It has been assumed that the existing culvert will be replaced, however it may be possible to reuse the existing culvert if found to be in a suitable condition.

- There are services currently in the area in which the additional culvert will need to traverse, however the new alignment will run parallel to the existing pipe where possible and be maintained at the same level. This should result in no major clashes with critical services.
- Detailed survey will be required to confirm these levels during the detailed design.
- Capital cost estimate is \$4.0 million.

This component in association with the Mt Osmond Interchange Dam modification and Ridge Park Reserve detention system reduce the downstream flood damages considerably by passing the total floodwater through the upgraded culverts. The new culvert will reduce the existing flooding flow path through the suburbs of Fullarton and Parkside. It requires the acquisition of one property and partial acquisition of a further two properties to be implemented.

A concept drawing is provided in Appendix B.

## **Keswick Creek**

### *Diversion culvert at Goodwood Road to divert water through the Showgrounds and under Anzac Highway into Brown Hill Creek*

The existing culvert through the Showgrounds has a capacity of approximately 25 m<sup>3</sup>/s. At higher flows it forms a constriction and subsequently floods areas through the Showgrounds and down into Keswick. Hydrological modelling predicts a flow of approximately 36 m<sup>3</sup>/s at this point. Diverting water upstream of the Showgrounds culvert allows the flow to be contained within the culvert with a subsequent reduction in flood damages occur through the Showgrounds.

This option diverts water (approximately 14 m<sup>3</sup>/s) at Goodwood Road, just upstream of the entrance to the Showgrounds culvert, and diverts it through the Showgrounds to Leader Street, continuing along Leader Street to Anzac Highway, and then down Anzac Highway to discharge into Brown Hill Creek downstream of the present Anzac Highway Bridge culvert.

There is the potential to reduce construction costs if the Goodwood Road diversion is laid parallel with the railway line diversion (discussed below). Furthermore there are capacity issues in Keswick Creek further downstream of the Showgrounds and Keswick Army Barracks. If more flows are diverted into Brown Hill Creek at the

Showgrounds then flooding issues further downstream can also be addressed at that point.

The new Goodwood Road culvert alignment would join with the railway line diversion half way along Leader Street and then follow the same alignment along Anzac Highway and into Brown Hill Creek. The combined diversion to Brown Hill Creek of 25 m<sup>3</sup>/s leaves a base flow in Keswick Creek of 11 m<sup>3</sup>/s.

From available service location information there appears to be sufficient room within the road reserve corridor for the proposed culverts to be constructed. However, it will be necessary during detailed design, to negotiate with the relevant service providers as to what services can potentially be moved to allow easier construction of the culvert and what form of protection is required for other services if the minimum spacing distances can not be met. (650 mm water mains will need particular attention to avoid clashing with the culvert at Goodwood Road and Anzac Highway.)

Key technical information for the Goodwood Road diversion is detailed below:

- Existing Keswick Creek channel flow is approximately 36 m<sup>3</sup>/s at the entrance to the Showgrounds culvert.
- The existing twin culverts are 1520 mm high by 2320 mm wide for a total capacity of approximately 25 m<sup>3</sup>/s.
- The diversion inlet is just upstream of the Showgrounds culvert and seeks to divert approximately 14 m<sup>3</sup>/s to minimise flooding in the Showgrounds and downstream Keswick area.
- A diversion of 14 m<sup>3</sup>/s requires a 3.0 m x 1.8 m RCBC to be located on the southern side of existing culvert, and a minor 0.85 m raising of the headwall to contain flow. The culvert length is approximately 1525 m.
- The proposed inlet is a four metre wide by 30 m long side sloping collector trough (inlet SL 29.1m) with weir crest level SL 31.0 m. The final optimal inlet arrangement and the maximum amount of flow diverted will need to be confirmed during detailed design.
- Diversion flow occurs at approximately 15 m<sup>3</sup>/s.
- Property acquisition will be required on the southern side at inlet and northern side at outlet.

- Detailed survey will be required to confirm levels during the detailed design.
- Capital cost estimate is \$16 million (based on implementation in isolation from the railway line diversion discussed below).

This component significantly reduces downstream flooding in the high flood damage area of the Showgrounds and suburb of Keswick. It provides an additional benefit for the further downstream Suburb of Mile End, as the effect of transferring flows to the Brown Hill Creek catchment reduces the requirement for channel upgrades downstream in the Keswick Creek. The capacity of diversion is dependent on upgrading Brown Hill creek and the temporary storages being implemented.

A concept drawing is provided in Appendix B.

#### *Diversion Culvert at railway line to divert water under Anzac Highway into Brown Hill Creek*

The existing culvert under Anzac Highway has a capacity of approximately 20 m<sup>3</sup>/s. At higher flows it forms a constriction and subsequently floods areas through the suburbs of Ashford, Keswick and Mile End. The capacity of the Keswick Creek channel further downstream varies between 20 m<sup>3</sup>/s and 30 m<sup>3</sup>/s and is also subject to inflows. This causes substantial flooding in the commercial area of Mile End and surrounding suburbs.

Diverting water upstream of the Anzac Highway culvert into Brown Hill Creek allows the flow to be reduced to below the existing channel capacity downstream. This provides substantial reductions in flood damages in the commercial district of Mile End.

This option diverts water (approximately 11 m<sup>3</sup>/s) from the railway line reserve south to Leader Street, along Leader Street to Anzac Highway and then down Anzac Highway to discharge into Brown Hill Creek downstream of the present Anzac Highway Bridge culvert.

From available service location information there appears to be sufficient room within the road reserve corridor for the proposed culverts to be constructed. However, it will be necessary during detailed design, to negotiate with the relevant service providers as to what services can potentially be moved to allow easier construction of the culvert and what form of protection is required for other services if the minimum spacing distances can not be met. (650 mm water mains will need particular attention to avoid clashing with the culvert at Anzac Highway.)

Key technical information for the diversion is detailed below:

- The diversion inlet is just downstream of showground culverts/railway line and seeks to divert approximately 11 m<sup>3</sup>/s to minimise the base flow and substantially reduce flood damages and inundation further downstream in Keswick Creek.
- Existing Keswick Creek channel flow is reduced to approximately 22 m<sup>3</sup>/s downstream of the existing Showgrounds culvert, due to the Goodwood Road diversion transferring 14 m<sup>3</sup>/s to Brown Hill Creek.
- A diversion of 11 m<sup>3</sup>/s requires two 2100 mm x 1800 mm RCBC.
- Culvert length is approximately 930 m.
- Keswick Creek channel to be widened from four to eight metres over a 30 m section and transitioned over 15 m upstream and downstream. A small weir (0.25 m high) is located downstream to initiate diversion. The final optimal inlet arrangement and the amount of flow diverted will be determined during detailed design.
- Property acquisition will be required on the northern side at the outlet.
- Detailed survey will be required to confirm levels during the detailed design.
- Capital cost estimate is \$16 million (based on implementation in isolation from the Goodwood Road diversion discussed above).

This component significantly reduces downstream flooding in the high flood damage area of Mile End. It provides an additional benefit as the effect of transferring flows to the Brown Hill Creek catchment reduces the requirement for channel upgrades downstream in the Keswick Creek. The capacity of diversion is dependent on upgrading Brown Hill Creek capacity and implementing temporary flood storages.

A concept drawing is provided in Appendix B.

### **Brown Hill Creek**

#### **Two Flood Control Dams Upstream of Brown Hill Recreation Park**

Flood control dam options investigated previously range from a single large dam to a series of cascading storages. Following assessment of the potential locations, storage volumes and technical constraints two storage locations were selected within the gorges in the Brown Hill Creek catchment.



The first location (Dam 2) lays several hundred metres upstream of the junction of Brown Hill Creek Road and Tilley's Hill Road. The second location (Dam 4) is on the southern arm of Brown Hill Creek towards the upstream boundary of the Mitcham and Adelaide Hills Councils (refer locality plan in Appendix B).

The Brown Hill Creek Gorges form steep sided valleys cut by a narrow creek. Much of the native vegetation was cleared in the past for crops and sheep grazing with little remnant native vegetation remaining intact.

It is assumed that during normal flow events (i.e. less than 1:5 AEP flood), water may be backed up behind any one of the potential flood control dam sites to a depth of one metre for two to three hours. Such an event is likely to be contained within the existing channel thereby having minimal effect on fauna upstream of the dam. During a 1:100 AEP event however, the water level is likely to rise to a depth of 19 metres at either of the dam sites for up to 12 hours, temporarily inundating large areas upstream of the dam.

It is expected that the dams would be potentially classified as High C under the current ANCOLD Guidelines on Assessment of the Consequences of Dam Failure (2003), and consequently would have to satisfy certain level of technical design, minimum spillway capacities and ongoing surveillance requirements. During detailed design a comprehensive assessment will need to be undertaken to confirm the correct classification and corresponding design parameters.

Key technical information for the flood control dams is detailed below:

- The preferred option is for two embankment dams located to limit their intrusiveness on the environment and existing properties: Dam 2 of 19.6 m in height and 335 ML capacity located on the northern tributary, and Dam 4 of 18.9 m in height and 60 ML capacity located on the southern tributary. Storage volume and inundation footprints are based on preliminary assessment only. Further survey will be required to confirm levels during detailed design.
- An embankment dam was chosen as a conservative and robust lower cost dam that is ideal for a range of differing foundation conditions. Geotechnical conditions are assumed to be one metre of excavatable soil overlying rock and further survey and geotechnical investigation are essential to properly assess the foundation conditions. Refinement of dam type and design and associated

construction cost will be achieved based on more accurate survey and known foundation conditions.

- The peak flow of 27.2 m<sup>3</sup>/s in the upper catchment is reduced to a flow downstream at Scotch College of approximately 13.1 m<sup>3</sup>/s if both dams are implemented.
- Spillways are assumed to pass the Probable Maximum Flood (PMF) as the dams would be classified as high hazard (ANCOLD 2000). Spillway lengths for Dam 2 and Dam 4 are assumed to be 25 m and 20 m respectively and will need confirmation during detailed design.
- Outlet pipe sizes are approximately 1200 mm RCP.
- Permanent access roads will need to be constructed for both dams to assist in construction, and to provide access during a 1:100 AEP flood event.
- Construction of Dams 2 and 4 would require property acquisition for placement of the dam embankments only. The inundation footprint would not inundate any houses or buildings.
- Extensive environmental studies will need to be undertaken prior to detailed design to ensure that relevant Commonwealth and State approvals are granted for any action that has, will have, or is likely to have a significant impact on any threatened species of fauna.
- Capital cost estimate (Dam 2 and Dam 4) is \$17 million.

This component is very cost effective and provides a substantial reduction in downstream flood damages. The Dams provide significant benefits for flooding and hazard reduction upstream of Cross Road, with effects diminishing downstream of Cross Road due to the urban runoff component of flow dominating. The two dams are located in an area of some community sensitivity, attributable to its environmental and recreation values, and extensive environmental assessment and community consultation will be required. It is highly recommended that this component is implemented.

A concept drawing is provided in Appendix B.

### **Increase channel capacity between Hampton Street and Cross Road**

This location is a known breakout point for flows coming down Brown Hill Creek. The channel upstream of Cross Road is deficient and spills when the capacity is exceeded (for approximately 1:10 AEP). Spill extends to both the east and west of

Cross Road resulting in flood damages through downstream suburbs. By upgrading this section of channel will allow the full capacities of Hampton Street and Cross Road bridges to be achieved.

- With construction of the Brown Hill Creek Flood Control Dams the maximum 1:100 AEP flow (36 hours) is approximately 17.8 m<sup>3</sup>/s.
- Existing Hampton Street bridge capacity is approximately 30 m<sup>3</sup>/s.
- Existing Cross Road capacity is approximately 30 m<sup>3</sup>/s.
- The replacement concrete lined channel is approximately 250 m long and has been designed for a capacity of 25 m<sup>3</sup>/s.
- Concrete channel dimensions are a four metre wide invert with two metre high vertical walls approximately 200 mm thick. Upstream of Cross Road, transitioned over a 50 m length, the training walls will need to be raised to three metres.
- Detailed survey will be required to confirm levels during the detailed design.
- Capital cost estimate is \$2.0 million.

This component is reliant on the Brown Hill Creek Flood Control Dams being constructed to reduce channel flows to an acceptable level and minimise the degree of channel upgrade required. This component should be adopted to reduce the extensive flooding caused by the deficient channel capacity at this location.

A concept drawing is provided in Appendix B.

### **Brown Hill Creek Channel Capacity increase and concrete lining from Anzac Highway to the confluence with Keswick Creek**

For much of its length the Brown Hill Creek channel downstream of Anzac Highway consists of a concrete channel and narrow drainage reserve. In areas where the stream remains unlined, it typically consists of an incised earth channel devoid of native vegetation. Over its length capacity varies considerably from 25 m<sup>3</sup>/s to 70 m<sup>3</sup>/s due to numerous obstructions and under-capacity cross sections.

To substantially reduce inundation and flood damages in both Keswick Creek and Brown Hill Creek west of Anzac Highway, the proposed Goodwood Road and Railway Diversions need to be complemented by an upgrade of the Brown Hill Creek channel. The proposed diversion rate of 25 m<sup>3</sup>/s (Goodwood Rd Diversion – 14m<sup>3</sup>/s and Railway Diversion – 11m<sup>3</sup>/s), in addition to the existing peak flow of

approximately 35 m<sup>3</sup>/s in the Brown Hill Creek channel, requires the channel to be upgraded to a capacity of approximately 60 m<sup>3</sup>/s. This flow rate is dependent on all upstream components being adopted.

The following information has been adopted:

- Design flow is approximately 60 m<sup>3</sup>/s, which is made up of the reduced flow contributed from the Brown Hill Creek channel (35 m<sup>3</sup>/s) and diversions from Keswick Creek (25 m<sup>3</sup>/s).
- The channel will be concrete lined the entire length and will have vertical walls which are, on average, two metres deep with an invert width of eight metres. Dimensions will vary locally dependent on specific drainage corridor and depth constraints.
- Channel widening will not be effective if carried out in isolation. Structure upgrades of each of the bridges and pedestrian walkways will be required as well as the removal of specific downstream flow restrictions. Structure upgrades assumed are:
  - Farnham Road
  - South Road
  - Daly Street
  - Birdwood Terrace
  - Marion Road
  - Harvey Street
  - Beare/Watson Street
  - Pedestrian bridges (Beauchamp Street, Warwick Street, Packard Street and Gray Street)
- Vertical walls are proposed to facilitate easier construction and give a wider invert to work from.
- Any existing drops in invert have been smoothed out to minimise hydraulic inefficiencies.
- An allowance for property acquisition has been made in the following locations due to insufficient drainage corridor width:
  - Acquire a ten metre strip of land from approximately nine private residences downstream of Daly Street for the concrete channel.

- Acquire approximately a two metre strip of land from potentially seven private residences between Marion Road and Beare/Watson Street bridges. The preferred properties for acquisition need to be confirmed during detailed design.
- Existing trash racks, floating litter booms and silt basins will be kept at existing locations to aid rubbish removal and reduce maintenance costs.
- Detailed survey will be required to confirm levels during the detailed design.
- Capital cost estimate (concrete lined option) is \$37 million.

### **5.3 Summary of the Residual Flood Risk in the Catchment**

The following sections describe anticipated flooding in the catchment for the 1:100 AEP flood event if the priority works components are implemented. Post mitigation flood inundation and flood hazard maps for the 1:100 AEP (including future infill effects) are provided in Appendix C.

#### **5.3.1 Park Lands Creek**

- With no mitigation upstream of the Glenside detention basin, the flooding in the vicinity of the Glenside Hospital is the same as is experienced currently and still extends westwards into the suburb of Eastwood towards Glen Osmond Road.
- The upgrade of the Fullarton Road culvert reduces the flooding north along Fullarton Road and west along the fringes of the Greenhill Road commercial district, and passes the entire flow through to the South Parklands.
- Temporary storage in the South Park Lands controls the flow of water through the Park Lands and reduces the area of inundation mainly to the leveed areas. The flow out of the Park Lands detention scheme is significantly reduced (to 7.6 m<sup>3</sup>/s), however there is expected to be some spill from the channel downstream of Greenhill Road to the confluence.
- There is some spill downstream of Detention Basin 5 shown on the post mitigation inundation map, this causes further damage downstream of Greenhill Rd. However, this damage can be easily avoided during the detailed design phase if the floodwaters from the spillway are guided back into the creek channel prior to Greenhill Rd. No damages have therefore been assumed for this specific area.

### 5.3.2 Glen Osmond Creek

- Detention in the upper reaches of Glen Osmond Creek provided by a reduction in outflow from the Mount Osmond Interchange Dam and the Ridge Park Reserve detention basin marginally reduces flow in the channel downstream and minimises spill from the channel in that section.
- Upgrading the Fisher Street culvert to pass 8.5 m<sup>3</sup>/s prevents overtopping of the culvert, which previously caused significant flooding northwards through Fullarton and into Parkside.
- Downstream of the culvert, a higher flow is experienced in the channel. This causes the capacity of the channel to be exceeded. The inundated area downstream of Fisher Street is therefore expected to be approximately the same as under present conditions. The flooding would consist of generally minor, low level flooding through the southern area of Fullarton and Unley. Most of this water makes it way back into the creek system upstream of the confluence of Glen Osmond and Park Lands Creeks.
- Downstream of the Windsor Street culvert, the inundated area is expected to be similar to the 1:100 AEP inundation area under present conditions, which overtops the channel along Culvert Road and heads towards and back into Park Lands Creek downstream of Greenhill Road.

### 5.3.3 Keswick Creek

- Downstream of the confluence of Park Lands and Glen Osmond Creeks, Keswick Creek has a 100 AEP inundation area equivalent to the existing 1:20 AEP flood inundation area (ie: much reduced) until it reaches the offtake at Goodwood Road, which diverts water through the Showgrounds, down Leader Street and Anzac Highway to Brown Hill Creek. No flooding is experienced through the Showgrounds.
- Downstream of the Goodwood Road diversion, the flow in the channel is reduced to approximately 22 m<sup>3</sup>/s, which is contained within the capacity of the Showgrounds culvert (capacity 25 m<sup>3</sup>/s) and main channel.
- The railway line diversion (approximately 11 m<sup>3</sup>/s) reduces the channel flow even further to approximately 11 m<sup>3</sup>/s so that the flow in the Keswick Creek is contained within the channel.
- Due to inflows further downstream, breakouts occur at Manchester Street and Scotland Road. Flow that exits west of the channel returns to the channel further downstream. Flows that exit the channel to the east head north-west

and eventually fill up the low lying sections of Cowandilla. The area affected for 1:100 AEP would be between the current 1:20 and 1:50 AEP levels. Flood waters would then make their way into Adelaide Airport.

#### **5.3.4 Brown Hill Creek**

- The dams in the upper reaches of Brown Hill Creek reduce 1:100 AEP flows in the channel down to Cross Road to approximately the same as the existing 1:10 AEP flood. Minor flooding near the creek channel in Torrens Park is still experienced; however the extensive flooding near Hampton Street is eliminated due to the channel upgrade.
- Upstream of Tabor Christian College near Avenue Street spill occurs from the channel due to the channel being under capacity for the various inflows further upstream. The spill flows north through the road network in Goodwood and water spreads out north of Mitchell Street, then towards the Showgrounds, and pools behind the tramway.
- A significant amount of spill still occurs between First Street, Forestville and Anzac Highway, Everard Park. Spill occurs from both the north and south banks of the channel. Spill from the south bank flows west and south-west inundating large areas between Anzac Highway and Brown Hill Creek. Spill from the north bank flows west and north-west inundating large areas between Brown Hill and Keswick Creeks.
- Flow is kept mainly within the channel downstream of Daly Street due to the upgraded channel capacity. However, the overflow from upstream of Anzac Highway makes its way towards this section of channel and produces low level inundation to the south of the channel.

#### **5.4 Summary of Indicative Floodplain Protection**

The level of protection provided varies across the catchment due to the range of channel capacities and differing flow paths for each creek system. It is not possible to be definitive with statistics for individual areas, and subsequently properties, without undertaking detailed flood plain mapping for all of the AEP events of interest. However, assessments on a sub-catchment scale have been made and results are presented in Table 5.2 below. The catchment has been subdivided into readily discernable sections and the level of protection described in the table refers to the flood magnitude at which inundation of properties would occur (be that below or above floor heights). If a section of the catchment would begin to be inundated by a 1:50 AEP flood but not below it is assigned a 1:50 AEP flood protection level.

**Table 5-2 Indicative level of flood protection with all priority works components in place.**

Reach	Level of Protection (AEP) <sup>1,2</sup>	
	Do Nothing	Priority Works Components
Park Lands Creek	1:10	1:50
Glen Osmond Creek	1:10	1:50 <sup>3</sup>
Keswick Creek Anzac Hwy to Richmond Rd	1:10	1:100
Keswick Creek downstream Richmond Rd	1:10	1:50 <sup>3</sup>
Brown Hill Creek upstream Cross Rd	1:10	1:100
Brown Hill Creek between Cross Rd & Anzac Hwy	1:10	1:50 <sup>4</sup>
Brown Hill Creek downstream Anzac Hwy	1:10	1:100

**Notes:**

1. Level of protection is flood when one or more properties may experience flooding. Flood preparedness by owners and occupiers would prevent damage in most of these cases.
2. This table makes allowance for the plus future infill flow scenarios are modelled.
3. Some nuisance flooding is expected for the 1:50 AEP flood event with minor damage to infrastructure.
4. A small proportion of properties could experience flooding from the 1:20 AEP, but the vast majority would not.

The information presented herewith illustrates the following points:

- the likelihood of flooding somewhere along Brown Hill, Keswick, Park Lands, and Glen Osmond Creeks is presently very high with all creeks having a 10% chance of flooding somewhere along their length each year; and
- irrespective of what structural components are implemented there is a need for a community awareness and flood preparedness program because flooding can still be expected in some parts of the catchment.

Even with the implementation of engineering works, flooding is still expected in some limited areas from 1:20 or 1:50 AEP flood event. While it would be technically possible to provide higher levels of flood protection everywhere, the social impacts and capital costs would far outweigh the benefits. The components here have been developed with a view to minimising social impacts and ensuring the costs of works are outweighed by the benefits.

In the case of Glen Osmond Creek and some parts of Brown Hill Creek between Cross Road and Anzac Highway, there is a significant contribution of runoff from the urban areas which exceeds the existing channel capacity.

Whilst flood detention measures can be placed further upstream, the effectiveness of these measures diminishes the further down the catchment due to the inflows from neighbouring urban areas in shorter duration storms. To reduce the likelihood



of flooding any further in these areas would require the acquisition of land to either increase the capacity of the channel or to provide enough open space to provide adequate flood storage. Such an approach cannot be justified economically nor is it considered likely to be socially acceptable. Nevertheless, whilst there are very real limits to the ability to reduce the likelihood of flooding any further than that indicated in, community awareness and flood preparedness measures can help ensure that physical and emotional damages are minimised. Hence non-structural components have a key role to play even if all the structural components are implemented.

## **5.5 Summary of additional multi-purpose outcomes from the preferred components**

As indicated in Section 4.3, each potential flood mitigation measure was assessed for its potential to provide additional benefits. The priority works components that have been selected are listed in Table 5.3 along with additional benefits that could be achieved from their implementation.

In developing the scope of work associated with each component the full range of potential benefits were considered but in a number of cases it was impractical to incorporate additional benefits. For example:

- Upgrading Brown Hill Creek potentially provides an opportunity to incorporate a linear park. This alternate was assessed but found to be very costly and uneconomic even once allowance had been made for the values from the multipurpose outcomes (eg increases in property values, recreational benefits etc).
- The creation of flood control dams in Brown Hill Creek potentially provides opportunity for also storing water. However, the available space for the dams is very limited and any loss of temporary flood storage will compromise the primary functionality of the dams. Opportunities may exist for summer storage of water but further investigations are required to ascertain the feasibility of such an approach.
- Recent investigations into ASR at the Victoria Park Racecourse indicates that this is unlikely to be cost effective. The proposed temporary storage arrangements included within this Flood Management Master Plan have therefore been developed recognising that this other work is ongoing. The concept design ensures that the development of an ASR scheme in the future could take place whilst recognising that this is unlikely in the near term (i.e. the design does not forego future ASR opportunities).

**Table 5-3 Additional multiple benefits from the priority works components.**

Mitigation Component	Multipurpose benefits in addition to reducing flood risk
Planning Measures	<p>Water Sensitive Urban Design techniques provide a range of potential means by which water can be retained on site provided these techniques are requirements for new developments. On-site retention of runoff is a simple means by which new development can be accommodated without having undue adverse impacts on water quality or runoff volumes (at least for smaller floods). It is also a means by which water savings can be achieved on a property scale and soil moisture levels returned to more natural levels.</p> <p>Embracing effective neighbourhood Master Planning through council development plans can provide precinct scale works so that amenity, recreation, water reuse and water quality improvements can be effectively achieved and managed within redeveloped areas.</p>
Upgrade Fullarton Rd/Greenhill Rd culvert	Glenside Hospital buildings and grounds are retained in present form.
Series of detention basins in the South Park Lands	<p>Opportunities to re-create the "natural" ephemeral creek through the south Park Lands system as well as replenish soil moisture stores for terrestrial plants over a large area in the South Park Lands. This could improve biodiversity and water quality as well as provide opportunities to reuse of stormwater through ASR for irrigating watered areas of South Park Lands. Council is presently investigation ASR opportunities in partnership with state government.</p>
Modify Mt Osmond Interchange Dam outlet.	Flood mitigation only.
Develop an inline flood detention system in Ridge Park Reserve and rehabilitate stream	Stream rehabilitation and biodiversity improvements. Potential future opportunities to incorporate water reuse through ASR for Ridge Reserve.
Upgrade culverts under Fisher St	Reduces social impact in extreme hazard flood zone
Goodwood Road Diversion from Keswick Creek to Brown Hill Creek (approximate capacity 14 m <sup>3</sup> /s)	Reduces social impact in high hazard flood zone
Diversion from Keswick Creek to Brown Hill Creek near the railway line	Reduces social impact in high hazard flood zone
Flood Control Dams upstream of the Brown Hill Recreation Park	<p>The creation of a flood control dam or series of dams in the rural portions of Brown Hill Creek provides the opportunity to incorporate measures to improve water quality and undertake riparian rehabilitation activities.</p> <p>Reduces social impact in extreme hazard flood zone</p>
Increase channel capacity between Hampton Rd & Cross Rd	Reduces social impact of extreme hazard flood zone
Upgrade Brown Hill Creek channel from downstream of Anzac Hwy to confluence	Reduce stream bed and bank erosion and transport of sediments into the lower sections of Brown Hill Creek and potentially the gulf.

## 6. SUMMARY OF THE CONSULTATION PROCESS

A summary of the consultation process is provided in the sections that follow. A detailed report on the consultation process and outcomes is provided in a separate report (QED, 2005).

### 6.1 Key Consultation Values

The consultative approach taken in developing this Master Plan was based on the following key values:

- It is important to understand and respect local issues, opportunities, concerns and fears and work to fully understand them early in the process.
- The Flood Management Group and Technical Steering Committee and the organisations they represent have an important role in guiding the development of the Master Plan. It was critical to fully involve them in the design and development of the process so as to generate a wider commitment to the outcomes.
- The aim of the process is not to maintain the status quo, but to move towards change in managing the catchment.
- The process must allow all interested parties the opportunity to debate the difficult issues.
- Clear objectives for the consultative process must be set, and boundaries of discussion clearly defined to be clear about what is negotiable and what is not.

These values were used to guide the consultation process associated with the Master Plan.

### 6.2 Consultation Process

The project was undertaken in three main stages and the focus for the consultation process varied across these stages.

In Stage 1 the consultation process focussed on liaison and engagement between the key stakeholders – the five main Councils, the Patawalonga Catchment Water Management Board and relevant State Government agencies, mainly through the Flood Management Group and the Technical Steering Committee.

In Stage 2 consultation focussed on residents, interested groups and the general public.

In Stage 3 the consultation process focussed again on engagement between the key stakeholders five main Councils, the Patawalonga Catchment Water Management Board and relevant State Government agencies primarily through the Flood Management Group to reach agreement on the final set of priority works components.

## **6.3 Key Stakeholder Discussions and Engagement**

### **6.3.1 Flood Management Group**

The Flood Management Group was initiated by the Patawalonga Catchment Water Management Board to assist with the development the flood plain mapping conducted in 2003 by Hydro Tasmania. This Group then assisted in the development of the Project Brief for the Flood Mitigation Study which has lead to the development of this Master Plan. The Group consists of the Chief Executive Officers of each Council as well as representatives from the Adelaide and Mount Lofty Ranges Natural Resource Management Board (which subsumed the Patawalonga Catchment Water Management Board) and relevant state government agencies.

The Flood Management Group's role was to manage the Study, with input from staff members on the Technical Steering Committee. The Flood Management Group met on five occasions during Stage 1. The purpose of those meetings was to brief members of the Group on with progress of the technical aspects of the Study as well as the wider consultation process.

The Flood Management Group played an important role in ensuring that both State and Local Government perspectives were included as the study progressed.

The Flood Management Group a further two times during Stage 3 of developing the master Plan to firstly review the outcomes from Stage 2 and to agree on the final range of priority works components. The Group meet a second time to discuss the draft Master Plan.

### **6.3.2 Technical Steering Committee**

The Technical Steering Committee was appointed in February 2005 to provide a broad skill based input to the Study and to help ensure that all feasible social, economic and environmental perspectives were covered. The Committee consisted of State Government representatives and staff from all catchment Councils, including staff with social and environmental perspectives as well as engineering. The multi-disciplinary background of the members was important, given that this

was much more than a study about engineering options, but needed to consider the social, environmental and economic aspects of implementation as well.

The Technical Steering Committee played an important role in building commitment to the Study process. It was important to keep the Committee motivated in their involvement and to maintain the early momentum of the Study throughout, particularly when delays in the wider consultation process occurred.

The Technical Steering Committee's role in the Study was defined early on as to:

- review and contribute to development of flood mitigation strategies;
- have active involvement in feedback of emerging issues to project team;
- keep their organisations informed – in particular their CEO's;
- maintain the 'big picture' perspective; and,
- facilitate the flow of information.

The Committee provided input into the identification of opportunities and barriers, identifying other key stakeholders, development of assessment criteria for different flood mitigation options and to provide an information conduit to their respective Council.

The Technical Steering Committee acted as a key reference point which the project team utilised for the testing of flood mitigation options for the technical aspects of the study.

The short listing of flood mitigation options, the development of assessment criteria for the options and the analysis of the options against the assessment criteria all took place at the Technical Steering Committee meetings.

### **6.3.3 Agency meetings to collate technical data and information during Stage 1**

Technical members of the project consultancy team met with technical staff of each of the five councils, as well as staff from the Department of Transport Energy and Infrastructure, and the Bureau of Meteorology for the purpose of informing them about the scope of the project and to identify data sets and information held by Councils and agencies that might be of assistance to the project. Information on known flooding issues and hot spots, drainage system upgrades recently undertaken by councils, planning initiatives, current and potential future uses and

management plans for open space areas, and staff perceptions of community concerns and council priorities were the main topics of discussions.

#### **6.3.4 Briefing of Members of Parliament**

It was recognised as being important that Members of Parliament whose electorates fell within the catchment of the study or adjoined it, or who generally had a strong interest in the topic, be briefed prior to the first Technical Steering Committee which would engage the Councils. The briefing was held on 23 February 2005 and facilitated by the consultants. It covered an outline of the study, its objectives, methodology and timing. It was attended by approximately 12 State and Federal members and staff from their offices.

#### **6.3.5 Project information updates**

Project Information Updates (in the form of a one to two page summary of progress) were prepared after key Technical Steering Committee meetings to provide State Agency and Council's Chief Executive Officers and relevant staff with the progress of the project. This ensured that the same briefing material and messages were distributed to all the key organisations involved.

The first information update was distributed in April 2005 and the second was distributed in June 2005.

#### **6.3.6 Briefings of Councils**

A presentation was made to each Council about the methodology, timing, and the various components being considered as part of the Study as well as the proposed community consultation process. This provided a useful opportunity for Elected Members to gain some understanding of the complexities of the study and to introduce the concept of the trade offs that might need to be made. It also enabled the proposed consultation process to be tested and developed. As a result of the feedback from these briefings the location of the Brown Hill Creek dams was reviewed, the presentation and description of various other components was reviewed and changed and an additional Community Information Day was held.

#### **6.3.7 State Agency briefing**

A briefing of around twenty members of various State Government Agencies was held in August 2005. The purpose of this briefing was to introduce a wider range of government players to the detailed components that had been developed for three catchment wide scenarios that were proposed for consultation. The consultation process was also outlined in detail. The draft Community Information Brochure was

introduced as the primary consultation tool. Subsequently the brochure was redrafted to reflect a set of priority works.

## **6.4 Community Consultation**

The community consultation process that formed Stage 2 of the Master Plan development was based around two community information days and a range of written material that was designed to inform people so that they could participate in either information day or make a separate written submission.

Information on the priority works components and the means for members of the public to make comment on them was distributed in the following ways.

### **6.4.1 Media release and advertising**

Media releases were issued by the Patawalonga Catchment Water Management Board to announce commencement of the study to develop the Master Plan and the community information days.

Advertisements to announce the consultation process and the Community Information Days were placed in four Messenger Press newspapers.

### **6.4.2 Patawalonga and Torrens Catchment Water Management Board and Council newsletters**

Articles were written for these news letters and distributed to residents.

### **6.4.3 Technical reports**

A set of three documents were prepared. The outcomes from Stage 1 were described in the Stage 1 Technical Report. This was report was of a highly detailed technical nature and so a shorter summary report was prepared to make the information more accessible to the public. Both of these reports were available by Council and Patawalonga Catchment Water Management Board web sites, as well as having hard copies available for perusal at Council and Board offices.

The third document was a summary brochure the "Community Information Update Brochure". The brochure was a full colour, six page A4 brochure that was distributed widely throughout the catchment (over 18,500 copies) to residents and community interest groups. It was also available via the web and Council and Board offices. It included a brief history of flooding within the Brown Hill and Keswick Creek catchments, the purpose of the Flood Mitigation Study and the parties involved. It was written in clear community language. The main purpose of the document was to provide the community with an overview of the need for a

catchment wide approach and an outline of priority structural and non-structural components which could be combined in a catchment wide scenario to reduce flood risk.

A floodplain mapping fact sheet produced in 2003 for the Patawalonga Catchment Water Management Board was made available at Council offices and the Patawalonga Catchment Water Management Board.

#### **6.4.4 Response sheets**

Response sheets were developed and made available at the Community Information Days to assist the community in responding to the Study. The response sheets provided space for comments on the catchment wide approach, priority works components and any other comments or issues. The response sheets were filled out at the Information Days and placed into a response box, or mailed, faxed or emailed to a central returning office (QED Pty Ltd).

#### **6.4.5 Telephone information line**

A telephone information line was established and enquiries were received by a staff member assigned to the task. The majority of calls received were requests for further information regarding the Community Information Days, or for a copy of the Technical Summary Report or a floodplain mapping fact sheet. Where necessary, calls were referred to the Board's or the Consultant Team's Project Manager.

#### **6.4.6 Community information days**

Members of the community were invited to attend one of two Community Information Days held during November 2005 to find out more about the Study and how it might affect them. The Information Days were held at the West Torrens City Council office and the Unley Citizens Centre and were designed to be an informal occasion where members of the public were able to have direct access to the consultants and to take their time looking at a series of posters that described the Flood Mitigation Study and the priority works components. The West Torrens Information Day was held in the afternoon and evening on a Wednesday and the Unley one was held on a Saturday in order to provide a choice of times and days.

The Project Team, Council and Patawalonga Catchment Water Management Board staff were present at the Days in order to answer any questions that members of the public might raise. This format gave people the opportunity to talk with experts in their own time in a non threatening environment and leave feeling satisfied that they were able to have their say. Most people stayed for well over an hour, with some staying for two or three hours.



The Community Information Days enabled Council staff to generate discussion with local residents on a catchment wide scale, explaining the importance of working together to move towards reducing flood risk and providing detail on different components at a more localised scale. Staff from all Councils attended the Information Days, as did Bureau of Meteorology staff.

## **6.5 Outcomes from the consultation process**

The results from the consultation process indicated that:

- There was support across the catchment for progressing with physical works, in particular temporary storage at the South Park Lands and Flood Control Dams in Brown Hill Creek.
- If the flood control dams in Brown Hill Creek were to proceed there would be a range of ecological issues that would need to be addressed. Support from some community groups is unlikely unless these issues are identified and addressed.
- There would be strong objections to a dam in the Brown Hill Creek Recreation Park.
- Many respondents were frustrated that no action has taken place as yet.
- People who were flooded in November 2005 wanted more warning and more help with the cleanup.
- Some respondents thought the flood preparedness component was being done in lieu of capital works and there should be more capital works to achieve a higher level of flood protection.
- Managers of the Royal Adelaide Showgrounds identified an extensive range of issues that would need to be addressed for the temporary storage to be acceptable to them. Whilst these could be addressed it is possible that they could become cost prohibitive.
- There was some support for a more coordinated approach between landholders and government on the maintenance of channel capacity.
- Some people thought that the Goodwood Orphanage should have been included as a temporary flood storage.

A final set of priority works components were recommended to the Flood Management Group in October 2006. The final set excludes the Wayville Showgrounds Arena Temporary Storage in favour of a diversion between Keswick and Brown Hill Creeks. The Goodwood Orphanage storage had previously been investigated but found to be cost neutral. It was therefore not included.

## 7. COSTS, BENEFITS AND FUNDING ARRANGEMENTS

### 7.1 Predicted Flood Damage Costs

#### 7.1.1 Introduction

An important aspect of preparing the Flood Management Master Plan for the Brown Hill and Keswick Creek Catchments involves the assessment of flood damage costs.

The Bureau of Transport Economics (2001) has conducted a detailed examination of the costs of natural disasters. Chapter Four of their report provides the recommended framework for estimation of costs arising from natural disasters (including floods). Damage costs are divided into three main categories;

- direct tangible losses;
- indirect tangible losses; and,
- intangible losses.

A brief description of each of these categories and typical items that should be included is detailed below.

#### **Direct tangible losses**

Direct tangible losses are the most straightforward and obvious. They are the losses that arise from the destruction of or damage to a man-made physical asset. This includes losses as a result of damage to buildings, be they residential, commercial or industrial. They can be:

- private or public buildings and the contents of buildings (e.g. furniture and fittings, retail stock, machinery and goods used for production of a commercial product);
- private or public infrastructure such as roads, railway lines, telecommunications, pipelines, electricity generation and distribution systems; and,
- vehicles and plant.

#### **Indirect tangible losses**

Indirect tangible losses are those incurred as a consequence of the event occurring, but are not related directly to the physical damage that has occurred. These costs include such things as the:

- marginal cost incurred by emergency service organisations in responding to the flood;
- equivalent cost of volunteers' time in assisting with the response effort;
- costs incurred by landholders in cleaning up after the flood, including their time;
- emergency assistance grants given to people to help them deal with urgent issues (e.g. alternative temporary accommodation, replacing a fridge, fixing damaged windows); and,
- disruption to business.

Of the above list the following indirect tangible costs that have not been included in the model are as follows:

- marginal cost incurred by emergency service organisations in responding to the flood; and,
- equivalent cost of volunteers' time in assisting with the response effort.

### **Intangible costs**

This category includes all those items that cannot be categorised as a direct or indirect tangible cost. These costs include:

- loss of life;
- costs associated with personal injury;
- increased medical costs/reduced life expectancy associated with increases in levels of sickness in a community following a disaster including stress related illnesses;
- disruption to households;
- loss of private memorabilia;
- loss of heritage values; and,
- loss of items/features of cultural significance.

Intangible costs are those for which no market exists and hence there is no agreed method in place to quantify them. In regard to this item the Bureau of Transport Economics has this to say:

*“The largest gap in the estimation of disaster costs is the inability to adequately estimate intangible costs. Evidence suggests that they are at least comparable with direct costs and possibly much larger. Research is needed to develop reliable methods to overcome this gap”.*

These costs have not been included in the damage estimates.

### **7.1.2 Structure of damage estimating model**

Hydro Tasmania developed a GIS-based flood damage estimating model in 2003 that automates the damage estimating process in accordance with the categories outlined above. The model allows the user to select any area or land use type in the catchment and obtain an estimate for the likely damage for the following flood events:

- 1:10 AEP flood;
- 1:20 AEP flood;
- 1:50 AEP flood;
- 1:100 AEP flood;
- 1 :500 AEP flood; and,
- The Probable Maximum Flood (PMF).

These Consequence Assessments are broken down into the following separate categories:

- residential;
- commercial office;
- commercial retail;
- industrial;
- institution;
- public utilities;
- recreation; and,
- vacant land.

The model calculates these consequence assessments by using the Digital Terrain Model (DTM) for the catchment, survey of all floor levels and the inundation model

to define a depth classification<sup>1</sup> “above floor” and “below floor”<sup>2</sup> (“below floor” means floodwaters have encroached on the property, but have not reached the floor level). These depth classifications are defined according to the following ranges:

- 0 - 0.1 m
- 0.1 - 0.25 m
- 0.25 - 0.5 m
- 0.5 - 1.0 m
- 1.0 - 1.5 m
- 1.5 - 2.5 m
- 2.5 - 5.0 m

This means that there are the following numbers of variables for each property under each flood event scenario:

- eight types of property;
- two types of inundation; and,
- seven ranges of inundation.

This results in 112 variables per property. The Consequence Assessments are calculated by assigning a multiplier to each of these variables, which when applied to the property’s value, provides a “virtual” estimate on the cost of damage that applies to a particular property under a certain level of inundation and flow velocity. The word “virtual” is used here to indicate that this value incorporates a portion of the damage costs to public utilities throughout the catchment, not just the property itself.

The multipliers were determined from a number of sources and refined in the model by trial and error, as follows:

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<sup>1</sup> Although flood velocity is a contributing factor, high velocities were only recorded in the channels, with floodplain velocities generally less than 1 m/s. Therefore, velocity was deemed an insignificant factor in the calculation of consequences. However, velocity was used for the hazard mapping.

<sup>2</sup> Some properties affected by the 1:500 AEP flood were not surveyed as part of this project (1,588 properties). Although their floor levels would not be exceeded, they do represent consequences that remain unquantified for the 1:500 AEP flood.

- Chris Wright (2001) completed a comprehensive review of the impact of a flood in the Mile End/Keswick industrial/commercial zone. This study was an analysis of approximately 130 businesses in the area and determined the impact of a 1:100 AEP flood on their operations. It was a very comprehensive study and was used as a “seed” for the determination of the multipliers for commercial and industrial properties.
- The Insurance Council of SA was approached to gain an insight into flood damages on residential and commercial properties. It was here that the non-linear damages curve was developed for the multipliers.
- Councils provided improvement values for each property and these were correlated with Valuation/Planning SA data. The property values were based on the 2000 valuation records.
- Real estate agents and valuers provided assistance and knowledge with respect to the value of residential land institutional properties.
- Interviews with stakeholders in the areas affected by recent floods (residential, commercial, industrial and government). These sources are considered to have generally over-estimated the value of damages.
- Airport damages were determined by interviews with airport owners discussions with West Torrens City Council, the Patawalonga Catchment Water Management Board.

From these meetings/interviews/communications, probable damages for properties were determined at various flood levels and these were applied to the model. Subsequent adjustments to the various land uses and depths were made by empirical trials until a reasonable match was achieved.

The model was firstly used to estimate damages associated with the base case or do nothing case. The floodplain inundation model was then rerun with mitigation measures in place and the flood damages model used to re-estimate damages post mitigation works.

### **7.1.3 Flood damages – No Works Scenario**

This section provides a brief commentary on the flood damages experienced in the catchment for a 1:100 AEP event. A detailed description of the flooding expected can be found in Section 4.1, and a copy of the flood inundation map is provided in Appendix A.

### **Park Lands Creek**

- The overflow from Conygham Street creates flooding through the Glenside Hospital, local residential retirement areas, and minor flooding to predominantly residential properties between Fullarton Road and Glen Osmond Road. The water is generally less than 0.1 m deep with additional water flooding the Greenhill Road road network into the business precinct. Total damages of \$5.5 million are experienced.
- Flooding through the South Park Lands is mainly the recreation fields, however some properties along South Terrace are inundated giving a total damage value of \$1.8 million.
- Downstream of Greenhill Road some areas of floodwaters are quite deep (up to 2.5 m), but are contained mainly within the proximity of the main channel, inundating most properties that border the channel. This combined with the overland flow path through Wayville originating from Greenhill Road produces most of the expected \$8 million damage.
- The total pre-mitigation flood damage estimate for Park Lands Creek is expected to be in the order of \$15.3 million. This substantial flood damage is mainly due to the insufficient capacity of the Fullarton Road Culvert near Glenside and the Green Hill Road culvert in Wayville, and corresponding overland flow into residential and business properties.

### **Glen Osmond Creek**

- Flow is generally contained within the Glen Osmond Creek channel, until Fisher Street, where water spills out of both banks of the channel. Spill from the south bank is contained within approximately 50 m of the channel with water up to 0.25 m deep. Spill from the north bank flows in a north-west direction inundating large residential areas in Fullarton and Unley, with water up to 0.25 m deep. Isolated areas within the flooded extent experience depths of up to 0.5 m deep. Total damages of \$2.2 million are experienced in this area.
- Downstream of the long Windsor Street culvert spill occurs between George Street and Porter Street. This spill flows with depths of generally less than 0.2 m north-west towards Park Lands Creek. Similarly, water spills from the channel between Unley Road and Little Charles Street. This water also flows with depths generally less than 0.1 m towards Park Lands Creek. Flooding in this area generally affects residential properties only. There is also

considerable upstream flooding which is attributed from the overland outflow from Fisher Street. Total damages of \$2.7 million are experienced for flooding downstream of Windsor Street culvert.

- The total pre-mitigation flood damages for Glen Osmond Creek is expected to be in the order of \$4.9 million. This minor flood damage is mainly due to the insufficient capacity of the Fisher Street culvert and the corresponding low level overland flow through Fullarton and Unley.

### **Keswick Creek**

- Upstream of the Showgrounds, flow is generally contained close to the banks of Keswick Creek. There is some minor flooding of small, low-lying residential areas adjacent to the creek channel, which are flooded with water up to 1.5 m deep. This flooding affects very few properties and therefore this reach has flood damages in the order of \$3.7 million.
- Flow reaching the Showgrounds culvert exceeds the capacity of the culvert. Floodwaters inundate the Showgrounds and associated buildings and the progress westerly and north-westerly along the railway line, causing an expected \$9.1 million worth of flood damages. Some residential housing south of the Showgrounds is affected also.
- Channel capacities and the Anzac Highway culvert are exceeded and flood the Keswick Military Barracks and residential houses around the Forestville, causing approximately \$6.0 million of flood damages.
- Overflow from upstream outbreaks combined with insufficient channel capacity between Anzac Highway down to Railway Terrace leads to large amounts of Mile End being inundated, this is further exacerbated by the inflows from other urban catchments and the upstream railway line inflow. Major flood damages of \$28.9 million occur due to the commercial business located through Mile End and Mile End South and the mainly residential areas through Keswick, Marleston and Ashford. Minor low level flooding then continues on through Richmond and Netley.
- Downstream of Railway Terrace a significant amount of water still spills from the channel and is fed from upstream flooding due to the area being very flat and low-lying. Areas of Hilton and Cowandilla are expected to have inundation that could be up to 1.0 m. This water then makes its way towards the creek and Adelaide Airport. Substantial flood damages of \$24.2 million are expected.



- Flooding in Adelaide Airport is widespread from the inflows from West Torrens and the low levels near the Keswick Creek bend into the Airport. It inundates areas between runways and much of the industrial/commercial park in the north-east of the precinct. Major infrastructure flooding is assumed to occur here and this has tentatively been assessed as flood damages of \$34.2 million.
- The total pre-mitigation flood damages for Keswick Creek are expected to be in the order of \$106 million. This substantial flood damage is mainly due to the insufficient capacity and obstruction in the existing channels and the effect of the floodwaters on the commercial precinct.

### **Brown Hill Creek**

- Brown Hill Creek is mostly contained within the channel except for a few outbreak locations near the Soldiers Memorial, George Street and in the deficient channel and bridges (Hampton Street) area upstream of Cross Road. Flow is normally contained close to the channel, where it breaks out it travels overland to the north through the road network of Hawthorn. Flood damages of \$1.8 million are expected.
- Between Cross Road and Goodwood Road water spills from the channel through Millswood and overland flow occurs from the Cross Road overbank flow. The majority of this flow heads north towards the Showground through residential areas with flow depths of generally less than 0.25 m. The other low level flood path heads north-west through residential Kings Park. Flood damages are in the order of \$4.5 million.
- Downstream of Goodwood Road the flow is mainly contained within the channel until First Avenue, Forestville. However, between the Forestville Reserve and Anzac Highway a large amount of spill occurs. These floodwaters flow south-west and north-west affecting residential and commercial/industrial properties generally with water less than 0.25 m deep. Minor flood damages of approximately \$1.72 million are expected. Additional low level flooding resulting from this heads further south-west into the Plympton area and westward to Kurralta Park, until it eventually heads back towards Brown Hill Creek.
- Downstream of Anzac Highway, south of the channel, through the mainly residential suburbs of Kurralta Park, Everard Park, Plympton, North Plympton and small areas of Camden Park, low level flooding occurs from the east with

depths up to 0.25 m. This water comes from the outbreak upstream of Anzac Highway and at certain locations along the existing channel. The areas north of the channel are inundated by spill from upstream reaches of Brown Hill and Keswick Creeks and a major breakout at Daly Street in Kurralta Park. Again low level flooding occurs from the east up to 0.25 m. Flood damage in this reach is approximately \$62 million due to the extensive area that the low level flooding encompasses and the commercial areas in Netley precinct.

- The total pre-mitigation flood damages for Brown Hill Creek are expected to be in the order of \$70 million. This substantial flood damage is mainly due to the insufficient capacity and obstruction in the existing channels.

#### **7.1.4 Flood damages –post mitigation works**

This section provides a brief commentary on the reduction in flood damages in the catchment that can be attributed to implementing the preferred mitigation options, for a 1:100 AEP event. A post-mitigation flood inundation map is provided in Appendix C.

##### **Park Lands Creek**

- Conyngham Street Culvert is unchanged following implementation of the flood mitigation options. However, the flooding from the Fullarton Road culvert is eliminated by the upgrade and this results in a substantial flood damage reduction in the commercial, and only minor damage in the residential areas, for this reach. Damages are expected to reduce from \$5.5 million to less than \$0.1 million.
- The detention basins in the South Park Lands control the spread of floodwaters. As a result, no buildings within the Park Lands are expected to be affected by floodwaters. However, the detention basins will cause inundation of several playing fields, which will require a significant clean-up effort once floodwaters have receded. This area is considered fully protected against the 1:100 AEP flood, therefore nil damage has been assumed.
- There is some spill downstream of Detention Basin 5 shown on the post mitigation inundation map, this causes further damage downstream of Greenhill Rd. However, this damage can be easily avoided during the detailed design phase if the floodwaters from the spillway are guided back into the creek channel prior to Greenhill Rd. No damages have therefore been assumed for this specific area.

- Once Park Lands Creek flows under Greenhill Road, there is very little overbank flow. Any water that does spill from the channel is generally contained within 10 m of the channel and is therefore unlikely to affect many properties. This area is considered fully protected against the 1:100 AEP flood. Nil damage is assumed.

Overall the attributed reduction in flood damages from the mitigation options that directly affect Park Lands Creek have reduced the pre-mitigation flood damages from \$15.3 million to \$0.1 million for the 1:100 AEP flood.

### **Glen Osmond Creek**

- Upstream of Kennilworth Road flow is generally contained within the Glen Osmond Creek channel providing full 1:100 AEP flood protection. At this point water spills out of both banks of the channel. Spill from the south bank is contained within approximately 50 m of the channel with water up to 0.25 m deep. Spill from the north bank flows in a north-west direction inundating large residential areas in Fullarton and Unley with water up to 0.25 m deep. Isolated areas within the flooded extent experience depths of up to 0.5 m deep. The area of inundation is significantly reduced from the No Works Scenario, and is considered to have protection up to the 1:50 AEP flood event. Flood damages are reduced from \$2.2 million to \$0.1 million for the 1:100 AEP flood.
- Downstream of the long Windsor Street culvert a small amount of spill occurs between George Street and Porter Street. This spill flows with depths of generally less than 0.1 m north-west towards Park Lands Creek. Flood damages are reduced from \$1.70 million to \$0.34 million.
- Similarly, water spills from the channel between Unley Road and Little Charles Street. This water also flows with depths generally less than 0.1 m towards Park Lands Creek. Flooding in this area generally affects residential properties only. This area is also considered protected against the 1:50 AEP flood. Flood damage in this area are however similar (\$1.0 million) for the 1:100 AEP flood.

Overall the attributed reduction in flood damages from the mitigation options that directly affect Glen Osmond Creek have reduced the pre-mitigation flood damages from \$4.9 million to \$3.0 million, a relatively small effect due to minimal mitigation options affecting this creek system.

## **Keswick Creek**

- Upstream of the Showgrounds, flow is generally contained within the banks of Keswick Creek due to the upstream mitigation options reducing the flow. There is some minor flooding of small, low-lying residential areas adjacent to the creek channel, which are flooded with water up to 0.5 m deep. This flooding affects very few properties and therefore this reach has close to 1:100 AEP flood protection with flood damages of \$0.5 million.
- Once water reaches the Showgrounds culvert it is generally contained within the Keswick Creek channel until it reaches Richmond Road, Mile End, due to the influence of the Goodwood Road and railway line diversion culverts. Nil flood damage is assumed.
- Downstream of Richmond Road to Railway Terrace, Keswick Creek breaks its banks on both sides in certain locations. Parts of the commercial/industrial area of Mile End are flooded with water of up to 0.25 m deep. Spill from the eastern bank is contained within approximately 50 m of the creek channel and is picked up by the channel before Manchester Street. Spill from the western bank flows north-west towards Richmond Oval with depths of up to 0.25 m. This area has a level of protection equivalent to the 1:50 AEP flood as the flows at this level would just be contained within the existing channel capacities. Flood damage in this area is reduced substantially from \$18.1 million to \$2.8 million for the 1:100 AEP flood.
- Downstream of Railway Tce water spills from the channel due to the large inflows from the city centre. Overflow occurs between London Road and Turner Street, Richmond. Floodwaters inundate commercial/industrial and residential areas in Mile End and Cowandilla with waters up to 0.5 m deep, but the depth of flooding is significantly reduced from the No Works Scenario. The area is considered to have protection up to the 1:50 AEP flood event, however, due to the area being very flat and low-lying, some properties may be affected by the 1:20 AEP flood event. A moderate reduction in flood damages from \$36.5 million to \$21.0 million is achieved.
- Flooding in Adelaide Airport is reduced substantially from the No Works Scenario (\$34.2 million) and this area is considered to have protection from the 1:50 AEP flood event with revised damages of \$3.8 million for the 1:100 AEP flood.

Overall the attributed reduction in flood damages from the mitigation options that directly affect Keswick Creek have reduced the pre-mitigation flood damages from \$106 million to \$28 million. This substantial saving is mainly due to the transfer of flood waters via diversions to the Brown Hill Creek system and the corresponding reduction in flow down the existing channel.

### **Brown Hill Creek**

- Brown Hill Creek has mainly a 1:100 AEP flood event level of protection upstream of Avenue Street, Millswood. Pre-mitigation damage of \$1.8 million compares with post mitigation damages of \$0.3 million.
- Between Avenue Street and Regent Street water spills from the channel and flows north with depths of generally less than 0.1 m. This area has a 1:50 AEP flood event level of protection. Flood damages are reduced from \$4.5 million to \$0.8 million for the 1:100 AEP.
- Downstream of this location the level of protection is 1:100 AEP until First Avenue, Forestville. However, between First Avenue, Forestville and Anzac Highway spill occurs. These floodwaters flow south-west and north-west affecting residential and commercial/industrial properties with water generally less than 0.25 m deep. The areas affected by this flooding are considered to have a level of protection of 1:50 AEP. Minor flood damage reduction is provided for the 1:100 AEP flood (\$1.72 million to \$1.50 million, this includes the additional low level flooding that occurs west of Anzac Highway).
- Downstream of Anzac Highway, the upgrade of the Brown Hill Creek channel contains the 1:100 AEP flood event, so no damage is attributable to this reach. Damages are reduced by \$62 million

Overall the attributed reduction in flood damages from the mitigation options that directly affect Brown Hill Creek have substantially reduced the pre-mitigation flood damages from \$70 million to \$12 million for the 1:100 AEP flood. This saving is the main result of increasing the channel capacity downstream of Anzac Highway.

## **7.2 Benefit–Cost Analysis**

A detailed benefit-cost analysis was undertaken during Stage 1 of the Master Plan development process by the South Australian Centre for Economic Studies (reported in HTC, AWE, QED & SACES, 2005). This earlier work involved sensitivity analyses across various parameters in the benefit cost evaluation. Discount rates were varied, as were implementation time frames, to ascertain the

effect that assumptions in the selection of parameters would have on the selection of components. The analysis determined that whilst the benefit-cost ratio and net present values varied with the above parameters, the economic rankings between components remained the same. Hence the ranking of components was insensitive to the above parameters.

The results of the benefit-cost analysis for the Master Plan are presented below in Table 7-1 for the recommended implementation scenario of a ten year works program. (The works program is described in Section 8).

**Table 7-1 Summary of benefit-cost analysis.**

	No Works	Ten year build program
Average Annual Damages (\$m)	12.7	2.7
Present Value Residual Damage (\$m)	168	74
Present Value Damage Reduction (\$m)	0	94
Present Value Costs (\$m)	-	83
Benefit Cost Ratio	-	1.13
Net Present Value (\$m)	-	11

Note: Calculated over a 30-year life span at a discount rate of 7% per annum. Costs and benefits increase linearly over the ten-year implementation period.

If the works program is accelerated the economic results are more favourable. If the works program were delayed beyond ten years then the economic assessment becomes less attractive, but still has a positive net present value.

For example, if all structural works were in place along with the recommended flood preparedness program over a five year time frame, then the scheme would have a benefit cost ratio of 1.18 with positive net present value of \$17 million. A 15 year implementation program still has a positive net present value (\$6 million). If the work were protracted over a 20 year period the costs would most likely exceed the benefits.

### 7.3 Suggested Cost Sharing Arrangements

The suggested cost sharing framework presented below is based on the following principles:

- The three spheres of government each have interest in reducing flood risk;

- Cost sharing between councils should reflect the benefits that they each receive from any flood management actions and not be related to the specific location where those actions are implemented; and,
- The approach should be as simple and transparent as is reasonably possible.

It is anticipated that implementation of the Master Plan would be eligible for funding under the Commonwealth's Natural Disaster Mitigation Program, whilst funding at a state level would be expected to come from through the Urban Stormwater Initiative.

Precedents have been set (most recently in the Gawler River) that where the three spheres of government have an interest then this should be an equal interest. It has been assumed that basic starting point for cost apportionment between the three spheres of government would be a third share each, but this will be subject to negotiation between the various parties.

The proposed local government cost apportionment is based on the benefits that each council receives from the mitigation works. These benefits are considered in two forms:

1. Benefit from a reduction in flood damages; and,
2. Benefits from urban development that have already or may take place in the future that will increase the risk of flooding downstream.

Consideration of both of these benefits is consistent with the preferred cost sharing approach outlined in by the Urban Stormwater Initiative (2005, 2006), which is based on a study by KBR (2004) and Lipp & Kemp (2002).

It is proposed that equal weighting be given to these two types of benefits.

The benefits from flood damage reductions have been estimated by reviewing flood damages on a council by council basis for both the pre-mitigation and post mitigation scenarios.

The average annual damages have been calculated for floods up to and including the 1 in 500 AEP flood. Damages from 1 in 100 AEP event have been estimated from the 2006 mapping. The damage estimates for the 10, 20, 50 and 500 AEP events have been based on the 2003 flood inundation maps with these damages adjusted in the same proportion as the damages for 2003 and 2006 mapping for the 1 in 100 AEP event. The results are presented in Table 7-2.

**Table 7-2 : Average annual damages by council**

Council	Average Annual Damages (up to the 1 in 500 AEP event)	
	No Priority Works Components	All Priority Works Components
Burnside	\$439,934	\$36,929
Adelaide	\$178,942	\$ -
Unley	\$2,059,425	\$514,522
Mitcham	\$132,449	\$53,059
West Torrens (Including the Airport)	\$7,342,803	\$1,008,095

Note: Damages for floods above the 1 in 500 AEP have not been included in the assessment

The benefits are then calculated as the proportion of damage savings for each council to the total damage savings. The results are presented in Table 7-3.

**Table 7-3 Apportionment of costs based on reduction in flood damages.**

Council	Percentage share of flood damage savings
City of Burnside	4.7%
City of Adelaide	2.1%
City of Unley	18.1%
City of Mitcham	0.9%
City of West Torrens	74.2%
Total	100 %

Note: Saving calculated from reduction in average annual damages within each council area.

The benefits from past and future urban development and their contribution to increased flows have been apportioned based on the impervious areas within each council using the projected infill development case. These areas were estimated in Stage 1 of the Master Plan Development and are primary drivers of the hydrological model on which the various flood scenarios are based (Table 7.4).



**Table 7-4 Impervious areas by sub-catchment and council.**

Sub-catchment	Area (ha)	Infill scenario percentage impervious	Council Area
Goodwood Rd	194	28	Adelaide/Unley
Hutt Street	18	50	Adelaide
Park 23	86	70	Adelaide
Park Lands	123	0	Adelaide
Pulteney / King William	65	50	Adelaide
South Rail Crossing	37	25	Adelaide
Beaumont	380	23	Burnside
Glenside	310	30	Burnside
Belair Road	332	24	Mitcham
Hawthorn	140	28	Mitcham
Kitchener	51	25	Mitcham
Urrbrae	375	14	Mitcham
Anzac	260	27	Unley
Charles	300	25	Unley
Keswick	65	37	Unley
Parkside	40	28	Unley
Windsor	190	25	Unley
Glen Osmond Road	64	31	Unley/Burnside
AW504580	132	33.6	West Torrens
Junction	400	42	West Torrens
Mile End	233	59	West Torrens
Morphett Road	153	30	West Torrens
Tapleys	283	37.4	West Torrens

The impervious area apportionment approach results are presented in Table 7.5.

**Table 7-5 Apportionment of impervious area by council.**

Council	Impervious area within catchment (ha)	Apportionment of impervious area
Adelaide	138	12.4%
Burnside	190	17.1%
Mitcham	184	16.5%
Unley	238	21.3%
West Torrens	364	32.7%

The apportionment by impervious area and by flood damage reduction are combined by taking the average apportionment from both methods (i.e. a 50% weighting is applied to both benefits). Refer Table 7.6.

**Table 7-6 Apportionment of local government costs between Councils**

Council	Percentage share of costs
City of Burnside	10.9%
City of Adelaide	7.2%
City of Unley	19.7%
City of Mitcham	8.7%
City of West Torrens	53.4%

If costs are shared by thirds across the three spheres of government then the proportional cost share between all parties would be as follows in Table 7-7

**Table 7-7 Suggested apportionment of costs between Councils, State and Federal Government.**

Government Body	Percentage share of costs
City of Burnside	3.6%
City of Adelaide	2.4%
City of Unley	6.6%
City of Mitcham	2.9%
City of West Torrens	17.8%
State Government	33.3%
Commonwealth	33.3%

## 7.4 Suggested Responsibilities

This Master Plan is designed to address major catchment wide flooding issues and is not intended to deal with local drainage issues or opportunities. It is therefore envisaged that the management of internal council drainage systems that feed water into the major trunk drains and watercourses that transfer water through the catchment and across council boundaries would remain the responsibility of individual councils.

Implementation, maintenance and ongoing management of the works proposed herein would be best done by a single body that has the specific task of

implementing the works. This would ensure works are funded and managed consistently across administrative boundaries.

In the past when similar issues have arisen, a body has been established in the form of a drainage authority, a regional subsidiary of local government or (for water quality improvements) a state government statutory authority (catchment water management boards).

It is therefore recommended that a “public authority” be established to manage the implementation of the Master Plan.

State Government funding would be managed through the Stormwater Management Authority.

The “public authority” would work with the Stormwater Management Authority to secure the necessary Commonwealth funding and to ensure adequate progress was being made in the implementation of the Master Plan.

The “public authority” could be in a number of forms (as illustrated above). It is understood that a detailed review of the preferred form of public authority is currently underway. In the absence of this detailed review it is recommended that Councils establish a Regional Subsidiary to progress the implementation of the physical works.

The Master Plan also includes a significant investment in flood preparedness. Flood preparedness measures are best implemented at the local level and there is no need for a Regional Subsidiary to be in place to implement these actions (because the benefits are received directly by the people involved). Local councils should therefore be encouraged to implement these actions for their own areas.

The Master Plan also proposes opportunities for Council to improve their approach to managing new development to reduce flood risk and to achieve multiple benefit outcomes. Implementation of these opportunities should be the responsibility of Councils.

## 8. PRIORITIES AND TIMEFRAMES

The priority works components have been developed as a package of works that collectively are required to achieve the outcomes of the Master Plan. With a few exceptions the benefits from each component are minimal unless one or two others are also implemented.

Notwithstanding this, there is a logical progression in which works need to be undertaken. This progression is not always about the effectiveness of the individual works but a requirement to ensure that unwanted third party impacts do not occur as a result of the order in which works are undertaken.

In summary:

- Non-structural works will have immediate positive impacts and hence should be implemented immediately.
- Works involving temporary storage of flood waters can proceed at any time and logically will provide some benefits even if other works are not undertaken.
- Works involving localised channel capacity improvements can also proceed at any time provided the increased capacity does not create a knock on effect. To be sure this is not the case these works should take place after temporary storages and major channel capacity upgrades have been undertaken.
- Works involving transfers between systems must be undertaken after channel capacity improvements have been implemented.
- Major Channel upgrades should progress from downstream to upstream and ideally should (but not must) follow the construction of temporary flood storages.

The following order of works is therefore proposed:

- Stage 1 and Ongoing:
  - Flood preparedness; and,
  - Planning measures.
- Stage 2:
  - Brown Hill Creek Flood Control dams;
  - Ridge Park temporary flood storage;

- Mount Osmond Interchange temporary flood storage; and,
- Temporary flood storages in the South Park Lands.
- Stage 3:
  - Upgrade Brown Hill Creek channel downstream of Anzac Highway; and,
  - Increase capacity of Fullarton Road/Greenhill Road culvert.
- Stage 4:
  - Install diversions between Keswick and Brown Hill Creeks.
- Stage 5:
  - Increase channel capacity at Fisher Street; and,
  - Increase channel capacity at Hampton Street.

A project implementation outline is provided in Figure 8-1. An indicative cash flow to match the work program is provided in Table 8-1.

**Table 8-1 Indicative Master Plan cash flow.**

Expenditure Year	\$ m
Year 1	5
Year 2	13
Year 3	17
Year 4	12
Year 5	15
Year 6	14
Year 7	12
Year 8	11
Year 9	3
Year 10	1

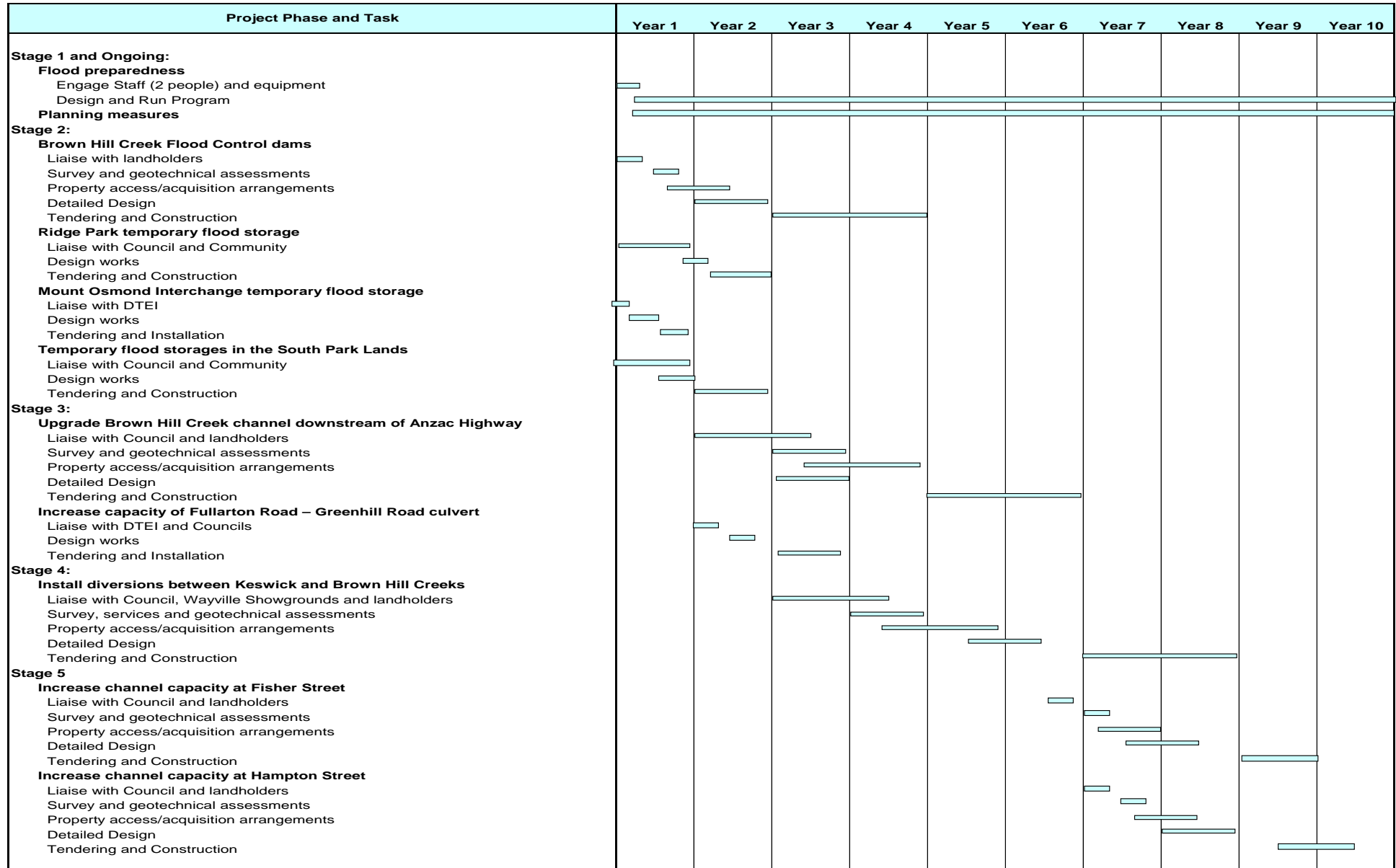


Figure 8-1 Master Plan implementation program.

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## **APPENDIX A PRESENT FLOOD MAPS**



## Pre Mitigation Inundation Map

## Pre Mitigation Hazard Map

## APPENDIX B CONCEPT DRAWINGS

SA-201587-0001	Greenhill & Fullarton Road Proposed Culvert
SA-201587-0002	South Parklands Basins
SA-201587-0003	Mount Osmond Interchange Upgrade Orifice Plate Details
SA-201587-0004	Ridge Park Reserve Detention Basin
SA-201587-0005	Fisher Street Proposed Culvert
SA-201587-0006 (5 sheets)	Brown Hill Creek Diversion
SA-201587-0007	Brown Hill Creek Dams
SA-201587-0008	Cross Road to Hampton Street Channel Upgrade
SA-201587-0009 (2 sheets)	Brown Hill Creek d/s Anzac Hwy Channel Upgrade

SA-201587-0001

SA-201587-0002

SA-201587-0003

SA-201587-0004

SA-201587-0005



SA-201587-0006-01

SA-201587-0006-02

SA-201587-0006-03

SA-201587-0006-04

SA-201587-0006-05

SA-201587-0007

SA-201587-0008

SA-201587-0009-01



SA-201587-0009-02

## **APPENDIX C POST MITIGATION FLOOD MAPS**

## Post Mitigation Inundation Map

## Post Mitigation Hazard Map