District Council of Mount Barker

Mount Barker Flood Mapping Study

STUDY REPORT

District Council of Mount Barker

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Attachment 5 to Item 12.8

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Executive Summary

Mount Barker is located in the Adelaide Hills approximately 28 km southeast of Adelaide CBD. There are a number of watercourses that drain into and through Mount Barker Township including Western Flat Creek, Littlehampton Creek, Mount Barker Creek, Railway Creek and several other smaller tributaries. Mount Barker Creek begins at the junction of Littlehampton Creek and Western Flat Creek, just a short distance upstream of the railway bridge crossing. Mount Barker Creek itself is a major tributary of Bremer River which discharges to Lake Alexandrina. The topography in Mount Barker is undulating and watercourses are generally contained within well defined gullies. The hydrology of Mount Barker is complex with large rural catchments providing significant inflows. However, the increasing urbanisation of Mount Barker is resulting in an increase in runoff potential from within the township itself.

Mount Barker Creek has experienced only minor flooding over the last 30 years with significant flow events recorded in 1987, 1992 and 1996 resulting in minimal damage. These were the highest peak flows recorded at gauging station (A4260557) located downstream of Mount Barker (approximately 2 km downstream of the most downstream channel crossing of Springs Road) which was commissioned in 1979.

In 1986, a Flood Study was undertaken by B.C. Tonkin and Associates to review the existing flood risk within the Mount Barker and Littlehampton Townships. This assessment included a flood frequency analysis of the six (6) years of available streamflow data and also included potential mitigation options and cost assessment. There have been a number of more recent studies commissioned by the District Council of Mount Barker into local flooding in Littlehampton and Mount Barker. Since the earlier Flood Study in 1986, the District Council of Mount Barker has progressively completed several flood mitigation projects to alleviate the flood risk in known higher priority locations.

Whilst there have been a number of recent studies investigating local flooding issues, the 1986 Flood Study was the last comprehensive assessment of regional flooding for the whole township. Due to the dynamic nature of the watercourse with ongoing mitigation works, the hydraulic impact of these modifications may not be fully represented in these recent assessments. This project was able to fully utilise the additional streamflow and rainfall data that has become available since the 1986 Flood Study as well as current catchment development extents and mitigation works. Increased computational power has also allowed for a more complex floodplain modelling methodology to be adopted.

Significant growth is expected around Mount Barker over the next 30 years. Floodplain mapping included the 30 year growth extent as current at the inception of the project with the intent that this information could then be used as a guide for future decision making relating to development within this region.

The catchment hydrology was determined using RORB, which is an industry standard flood hydrology package. Smaller urbanised catchments not suited to this approach were modelled using DRAINS which is more widely used for urban drainage design. The outcomes from the two approaches were used to create a composite flood hydrology analysis for the Mount Barker floodplain hydraulic analysis.

Hydraulic analysis of watercourses within the study area was undertaken using MIKE FLOOD, which is an advanced (but industry accepted) hydrodynamic model that enables channel flows and floodplain flows to be simulated. This modelling package allowed for one-dimensional modelling of the main channel system with two-dimensional modelling capacity across the floodplain. This is the first two-dimensional flood modelling undertaken through the Mount Barker Township. This enabled assessment of flood inundation depth, hazard extents and further relevant parameters.

The development of the hydrodynamic model required various data sets to describe both the physical geometry of the creek and floodplain system and the hydrological inputs that drive the model.

The physical characteristics of the channel were described using a combination of field survey data collected during the course of this and previous investigations. This information was supplemented by aerial photography, with soft photogrammetrical data processing, that remotely collected spot height information across the study area (approximately 25 km^2) during December 2008 to a vertical accuracy of+/- 0.13 m (68% c.i., 1σ) and +/- 0.25 m (95% c.i., 2σ).

The hydrological data consisted of a recorded streamflow for the calibration/verification phase of the project and design flood hydrographs produced based on the current development extent.

A key assumption in the adopted approach is that the channel and floodplain characteristics used in the model are relevant into the future and that these characteristics will remain stable during a flood event. The longer term management of the watercourse will be an important consideration for Council to alleviate the flood risk. This will included maintenance of channel vegetation and ensure debris and other potential channel blockages are cleared. Whilst this assumption is consistent with best practice, floodplain and channel geometry may change over time in association with future development and mitigation works. The outcomes from the current floodplain mapping may become less reliable as these changes occur. Progressively updating the hydraulic model and mapping will be necessary in association with major modification works within the channels and/or floodplain. This is equally true for the local hydrology which may alter over time as further development occurs or mitigation options are constructed.

The process also utilises the concept of a design storm that, again whilst being consistent with best practice, is know to be limited by the synthetic nature of the design storm and its assumed uniform spatial distribution and stationarity over the catchment.

Another area where data and judgements are required is in the setting of model boundary conditions. In the case of the Mount Barker Creek, a fixed tailwater level was applied downstream of Springs Road to ensure the assumed boundary condition would not affect flood depths upstream of Springs Road.

The modelling process therefore describes potential flood risk for the adopted flood hydrographs and assumed channel and floodplain configuration.

The hydrodynamic model was verified by comparing the model outputs with the 100 year ARI flood results from the 1986 Flood Study (B.C. Tonkin and Associates). However, the value in this comparison was limited due to the altered catchment hydrology and mitigation works that have subsequently occurred.

Design flood simulations have been undertaken using the design hydrographs and tailwater conditions as described above. The design hydrology is based on the assumption that future development will be required to demonstrate mitigation of peak discharge such that there is no increase in regional flooding associated with future development.

These results show that during the 100 year ARI flood event there are a number of minor channel breakouts that would lead to flooding of a number of residential and commercial allotments. Due to the overall topography these breakouts generally do not diverge a great distance from the main channel. The areas of greatest concern from a flood extent perspective are at:

- Western Flat Creek between Adelaide Road through to junction with Littlehampton Creek (most upstream point of Mount Barker Creek);
- Railway Creek immediately downstream of Hurling Drive and downstream of Fletcher Road;
- Surcharge from the Morphett Street drainage system; and
- Littlehampton Creek just upstream and downstream of the Gawler Street crossing.

Flood hazard mapping for the 100 year ARI flood event identified that many of these areas that were inundated would be subject to only 'Low' to 'Medium' flood hazard and that the areas affected contained development suitable to that level of flood hazard. Emergency services including the Police Station, CFS and Hospital were all outside the flood extent for the Probable Maximum Flood (PMF).

Review of flood maps for the 20 and 50 year ARI flood events compared with the 100 year ARI event indicated that many of the developed areas subject to flooding during the 100 year ARI event also had potential flooding issues during the higher frequency events. Therefore, many of these areas such as Railway Creek both immediately downstream of Hurling Drive and downstream of Fletcher Road may require mitigation measures to be adopted such as further channel widening to increase capacity.

This report comprises a full set of A3 sized maps that cover the study area. Inundation maps are provided for the 20, 50, 100, 500 year ARI and Probable Maximum Flood (PMF) events. These flood depth maps include the peak flow and time to peak at four (4) locations. These locations and results are included in the table below.

ARI	Littlehampton Creek at Gawler Street			Railway Creek at Wellington Road			Western Flat Creek at Adelaide Road			Mount Barker Creek at Bald Hills Road		
	Critical duration (hr)	Peak flow (m3/s)	Time to peak (hrs)	Critical duration (hr)	Peak flow (m3/s)	Time to peak (hrs)	Critical duration (hr)	Peak flow (m3/s)	Time to peak (hrs)	Critical duration (hr)	Peak flow (m3/s)	Time to peak (hrs)
20	6	17.3	5.5	6	13.4	5.3	6	19.5	6.2	6	53.4	6.5
50	9	22.5	4.8	9	18.4	4.7	9	28.5	5.2	9	69.7	6.5
100	9	31.6	4.2	9	28.2	4.3	9	42.1	4.3	9	107.3	5.3
500	9	69	3.8	9	63.4	3.7	9	106	4	9	252.1	4.7
PMF	2	647	2.3	2	474	2	3	1058	2.5	3	2437	2.7

Hazard maps are provided for the 100 and 500 year ARI flood events. These maps also include flood contours. All maps need to be interpreted in conjunction with this document (including the appendices) and with the mapping disclaimer.

A separate set of A1 sized maps have also been produced and supplied to the District Council of Mount Barker.

1 Introduction

Mount Barker is located in the Adelaide Hills approximately 28 km southeast of Adelaide CBD. There are a number of watercourses that drain into and through Mount Barker Township including Western Flat Creek, Littlehampton Creek, Mount Barker Creek, Railway Creek and several other smaller tributaries, refer Figure 1). Mount Barker Creek itself is a major tributary of Bremer River which discharges to Lake Alexandrina. The hydrology of Mount Barker is complex with large rural catchments providing significant inflows. However, the increasing urbanisation of Mount Barker is resulting in an increase in runoff potential from within the township itself. Carefully consideration must be given to stormwater management to ensure that does not result in an elevation in flood risk.

As the topography of Mount Barker is generally undulating, the watercourses are generally located in clearly defined gullies. When flood waters overtop the banks they typically do not spread over a large distance. However, Mount Barker is a highly urbanised region and numerous properties would be impacted by minor flooding where the channel capacity is exceeded.

Mount Barker Creek has experienced only minor flooding over the last 30 years with significant flow events recorded in 1987, 1992 and 1996 resulting in minimal damage. These were the highest peak flows recorded at gauging station (A4260557) located downstream of Mount Barker (approximately 2 km downstream of the most downstream channel crossing of Springs Road) which was commissioned in 1979. The combined catchment to the downstream gauging station is approximately 86 km^2.

In 1986, a Flood Study was undertaken by B.C. Tonkin and Associates to review the existing flood risk within the Mount Barker and Littlehampton Townships. This assessment also included potential mitigation options and cost assessment. There have been a number of more recent studies commissioned by the District Council of Mount Barker into local flooding in Littlehampton and Mount Barker. Since the earlier report in 1986, the District Council of Mount Barker has progressively implemented several flood mitigation projects to alleviate the flood risk in known higher priority locations.

Whilst there have been a number of recent studies investigating local flooding issues, the 1986 Flood Study was the last comprehensive assessment of regional flooding for the whole township. This project was able to fully utilise the additional streamflow and rainfall data that has become available since the 1986 Flood Study as well as current catchment development extents and mitigation works.

This report describes the collation of background data and the development and application of a hydrodynamic floodplain model that has been used to assess flood inundation and flood hazard within the study area.

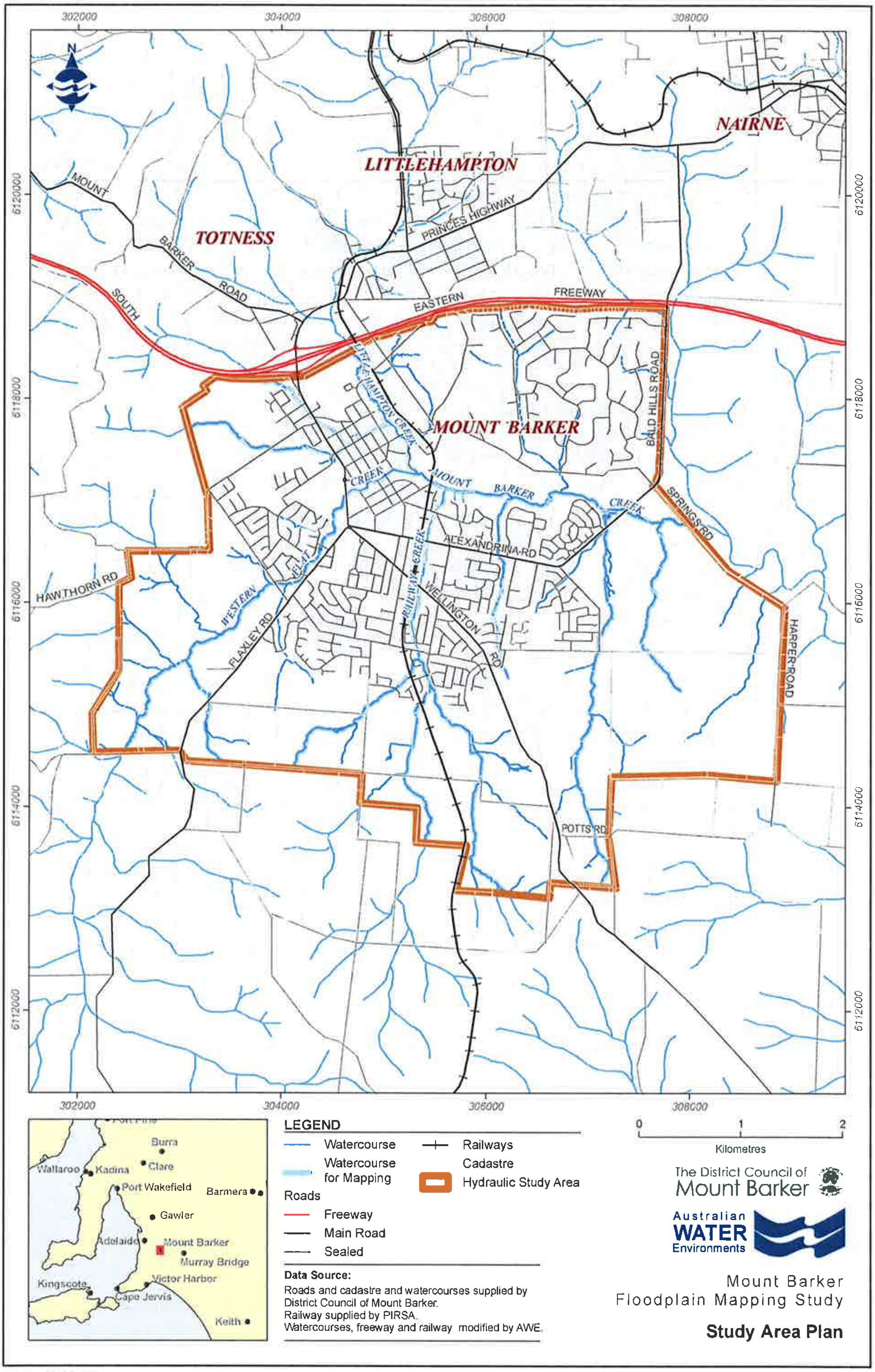

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Figure 1.1

2 Digital Terrain Model (DTM) and Field Survey

The development of the hydraulic model requires various data sets to describe both the physical geometry of the river and floodplain system including any watercourse crossings that may impact on the hydraulic regime. The following sections describe the data sets utilised in this study.

The existing survey data utilised in the study consisted of the following:

- Several bridge design plans (Department for Transport, Energy and Infrastructure);
- 0.15 m GSD digital aerial photography by Aerometrex that was collected during December 2008. DTM generation by soft photogrammetry processing approach.
- GIS data on various structures as collected by the District Council of Mount Barker.

The primary data-set underpinning the development of the floodplain hydraulic model was the 0.15 m GSD digital aerial photography data processed using soft photogrammetry techniques. This terrain capture technique has been used extensively in recent years for flood studies across Australia.

In order to verify the accuracy of the Digital Terrain Model (DTM) generated from the soft photogrammetry processing, the surface was ground-truthed by collecting a series of ground control points. This additional survey along with the airborne GPS data and IMU readings recorded on board the aircraft during the aerial survey ensured the accuracies as listed in Table 2.1.

TABLE 2.1: DTM ACCURACIES

Accuracy	15 cm Pixel Resolution
Horizontal	+/- 0.30 m RMSE
Vertical	+/- 0.13 m (68% c.i., 1σ) +/- 0.25 m (95% c.i., 2σ) Suitable for 0.5 m contours with ground survey control

The only exception to this was in parts of the main channels where there was difficulty with thick vegetation surrounding the area.

The floodplain mapping study area covered a number of watercourses and smaller tributaries which flowed through urbanised areas. It was important to collect relevant detail of these structures to determine if they may potentially affect the hydraulic capacity of the watercourse. Field survey was undertaken between 17-21 December 2009, to obtain dimensions and inverts for a number of watercourse structures. Furthermore, cross sections were surveyed a short distance away from both the upstream and downstream end of the structures. The equipment utilised was the GPS RTK Topcon Hiper GA system. This was supplemented by staff and level for locations where the GPS signal was obstructed. A plan showing the structures that were picked up in the field survey is provided in Figure 2.1.

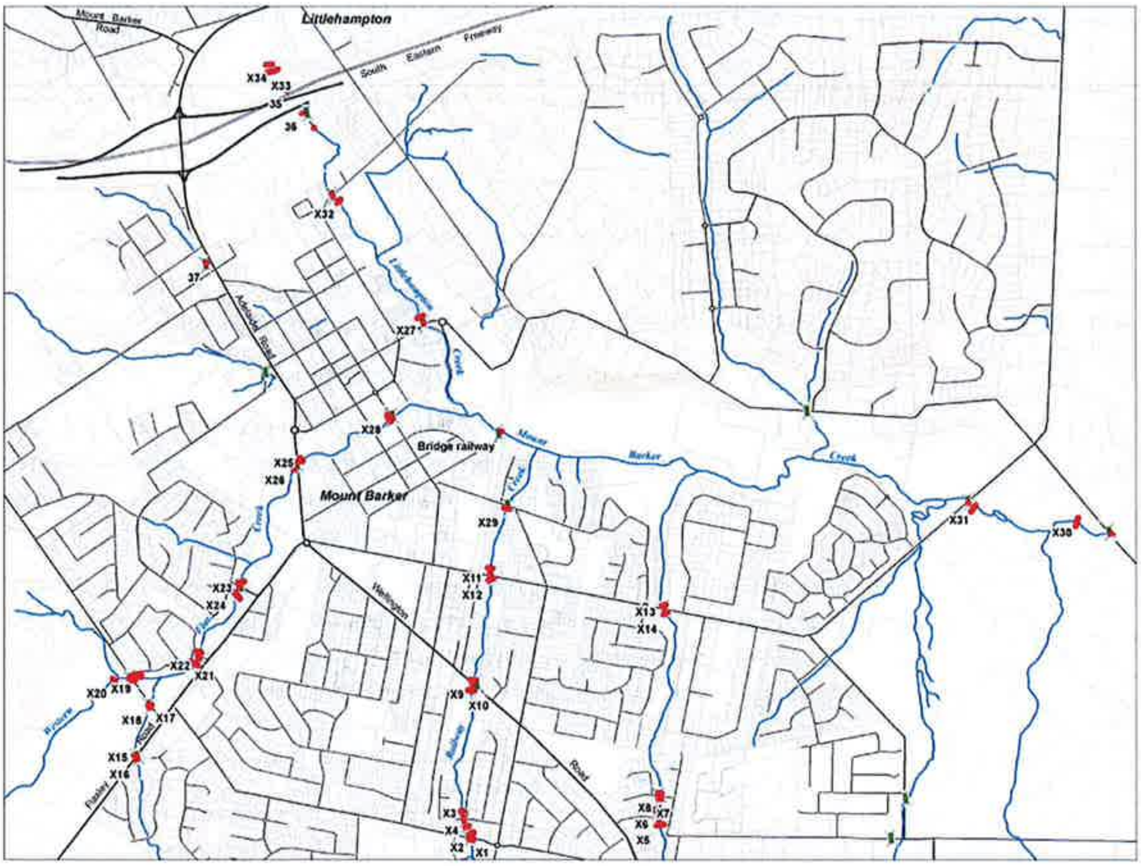

FIGURE 2.1: LOCATION OF BRIDGE/CULVERT STRUCTURES SURVEYED

A full review of the field survey, including details of the structures is provided in "Mount Barker Floodplain Mapping Survey Report" (AWE 2010) which is included as Appendix A.

3 Hydrological Assessment

3.1 Introduction

Development of design hydrographs to be routed through the hydraulic study area was a key component of the project development. The most recent hydrological assessment of the entire catchment contributing to a point downstream of Mount Barker was completed by B.C. Tonkin and Associates (1986). At the time of that investigation, the gauging station (A4260557) downstream of Mount Barker had been operational for a period of just six (6) years. As a consequence, the reliability of the flood frequency analysis extrapolated out to the average recurrence intervals to be investigated as part of this study would have been poor. However, this flow data was the best information available at that time.

The design input hydrographs for this study include the 20, 50, 100, 500 and Probable Maximum Flood (PMF) events.

3.2 Model Establishment

RORB was utilised as the primary hydrological model to develop the design hydrographs. The catchment was delineated into 28 catchments of approximately equal size (see Figure 3.1). As the study area took up a moderate proportion of the overall catchment area, a moderate number of RORB inflow points were necessary within the study area. The study area encompassed several watercourses and numerous smaller tributaries. Only specific watercourse lengths were identified for inclusion in the assessment. The configuration of the catchment geometry was based on the location of the watercourses to be included in the hydraulic assessment.

RORB is ideally suited to large scale hydrological assessments. However, as part of this study area there are a number of smaller tributaries that have a relatively small catchment area which is either currently developed or earmarked for future urbanisation. For these situations the local hydrology was assessed using the DRAINS modelling package. DRAINS is an industry standard hydrological and hydraulic program that utilises the ILSAX hydrological procedure. This approach is ideally suited to urban drainage modelling.

3.3 Model Calibration

There was only one (1) stream flow gauge with sufficient data record to allow for a meaningful calibration. This was located a short distance downstream of Mount Barker on Mount Barker Creek and has 30 years of flow record.

Within that flow record there were three (3) dominant flow events. These occurred in June 1987, August 1992 and September 1996 with corresponding peak flows at the gauging station downstream of Mount Barker of 52.3 m^3/s, 50.3 m^3/s and 56.3 m^3/s, respectively.

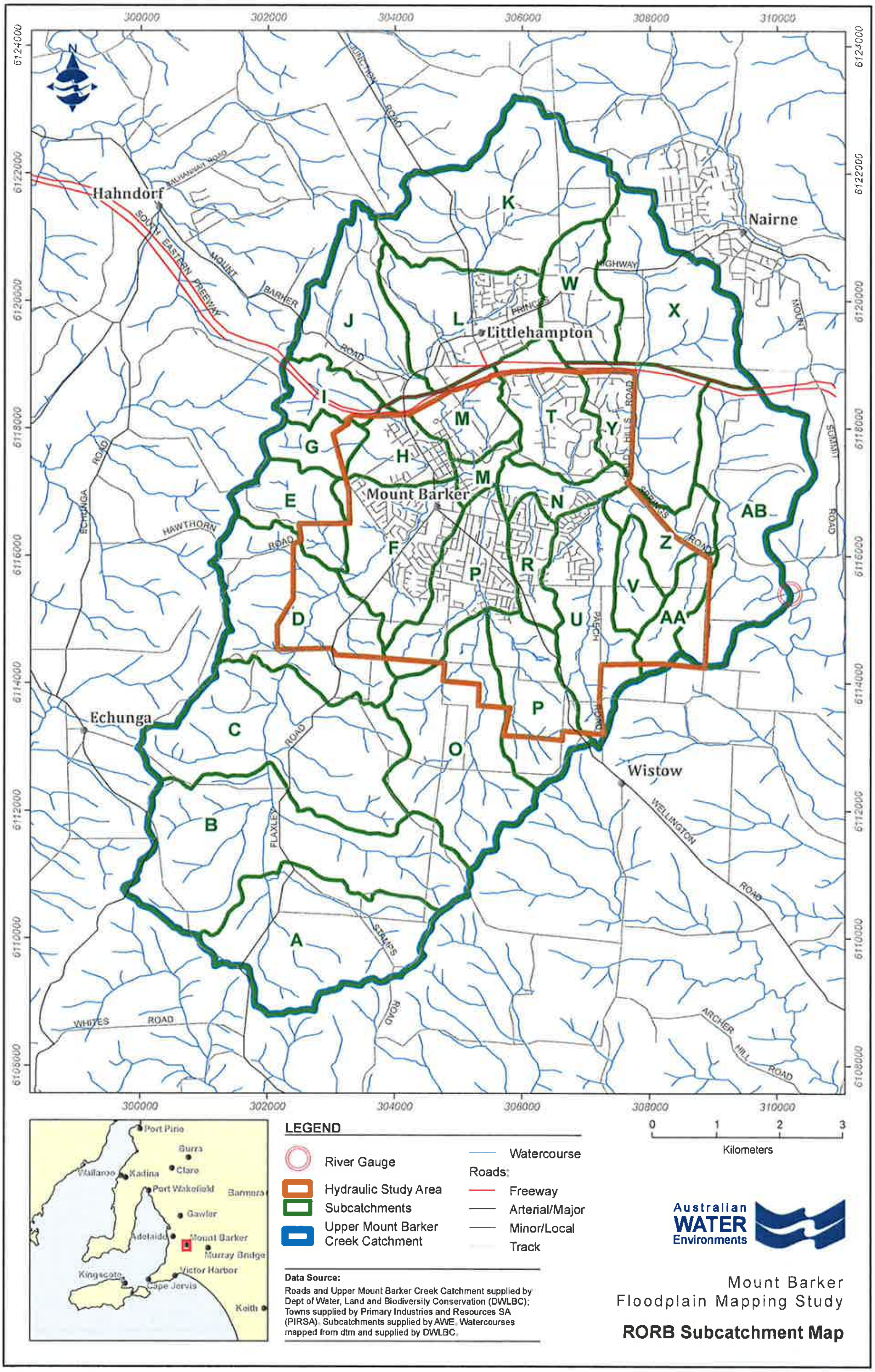

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Figure 3.1

Pluviometer and rainfall gauging stations in the surrounding areas that were operational during the above mentioned calibration events were used to assign a rainfall pattern and depth to each of the defined catchments. This calibration process was used to define the RORB parameters k_c, m and continuing loss. The parameter k_c is an empirical coefficient which is the primary value to modify the shape of the hydrograph to achieve a good match with the gauged hydrograph. Continuing loss represents the depth of rainfall required before surface runoff will occur. The value 'm' is a dimensionless parameter which represents the non-linearity of the catchment and was maintained at 0.8 which is a standard approach.

Over the past 30 years there has been significant development within the catchment, particularly Mount Barker Township. To account for the change in urbanisation within the catchment over that time the development extent associated with the 1992 development scenario was adopted.

A flood frequency analysis using the full gauged data record was undertaken. It was determined that the Generalised Extreme Value approach provided the most realistic peak flow estimate extrapolated out to lower frequency flow events. A summary of the flood frequency analysis is provided in Table 3.1. These represent the peak flow for a range of ARI events at the existing gauging station downstream of Mount Barker.

TABLE 3.1: PEAK FLOW AT GAUGING STATION VS ARI EVENT

ARI	Peak Flow (m^3/s)
2	17.9
5	32.7
10	44.0
20	56.1
50	73.8
100	88.9
500	130.3

These values were compared to previous hydrological study outcomes from the Mount Lofty Ranges and found to be within the bounds of expectation.

From the calibration to the three (3) largest flow events the RORB parameters k_c and continuing loss were defined. The flood frequency analysis allowed for the determination of the appropriate initial loss to be applied to each of the design rainfall events. Given the increased urbanisation of the catchment it was decided to adopt the 1992 development scenario as the base case for the initial loss calculation. This scenario is assumed an average development condition over that period. Based on this assessment, the design parameters for each design storm event are indicated in Table 3.2.

TABLE 3.2: RORB DESIGN PARAMETERS

ARI	k_c	m	Initial Loss (mm)	Continuing Loss (mm/hr)
20	10.3	0.8	29.8	1.54
50	10.3	0.8	38.1	1.54
100	10.3	0.8	39.5	1.54
500	10.3	0.8	45	1.54
PMF	10.3	0.8	0	1.54

3.4 Design Hydrographs

The design hydrographs for the specified ARI events were calculated based on the current catchment configuration. Within RORB this was managed by calculation the current impervious fraction for each of the 28 subcatchments. The estimated peak flow, flow volume and time to peak at the existing downstream gauging station are indicated in Table 3.3.

TABLE 3.3: DESIGN STORM EVENT PEAK FLOW AT DOWNSTREAM GAUGING STATION

ARI	Peak Flow (m^3/s)	Flow Volume (m^3)	Time to Peak (hrs)
20	58.6	1710	8.5
50	77.6	2140	7.5
100	117.8	3020	7
500	246.5	5740	6
PMF	2674	33700	3.5

3.5 Discussion

Hydrological analysis of the Mount Barker catchment has been developed based on the RORB modelling platform and utilising the available data from pluviometers, daily rainfall gauges and the streamflow gauge downstream of Mount Barker. The hydrological model best represents the catchment characteristics with the key parameters modified based on calibration to the available rainfall and stream flow records.

It is important to identify that rainfall data applied to many of the subcatchments through the calibration phase were derived from gauges outside of the overall catchment and may have been daily data only. Whilst rainfall patterns from the most appropriate pluviometers were applied there remains uncertainty regarding the true pattern for these events which would significantly impact the flow output and ultimately, the calibrated RORB parameters to be used in the design.

Model calibration was also based on a flood frequency analysis of data from the existing streamflow gauge. However, throughout the recorded period the development extent within Mount Barker has continued to increase. It is likely that the peak flow associated with a particular rainfall event at the beginning of the gauging period would be less than based on current development conditions. A sensitivity analysis was undertaken that compared the peak flow at the gauging station based on the current development condition against that for the future development scenario (30 year growth plan extent without large scale detention measures). This indicated that further development in the catchment would result in significantly higher flows through Mount Barker Township and may exacerbate existing flooding problems.

Other factors that may impact on the reliability of the hydrological assessment into the future include climate change and future mitigation works such as the creation of large scale detention structures. However, for the purposes of the current hydrological assessment best practice has been followed to provide the most reasonable hydrographs for routing through the hydraulic model of the Mount Barker floodplain.

For full details of the hydrological investigation refer to Appendix B for the "Mount Barker Floodplain Mapping Hydrological Study Report" (AWE 2010).

4 Floodplain Hydraulic Analysis

4.1 Introduction

Water Technology was commissioned by Australian Water Environments (AWE) to undertake the floodplain hydraulic modelling component of the project.

The following scope of work was undertaken to complete the hydraulic modelling:

- Review background information (e.g. previous flood studies) and available topographic and discharge flow data in order to identify any information gaps and possible model constraints;
- Obtain any further information identified as required to develop sound models such as field survey;
- Develop calibrated hydraulic models for the study area; and
- Undertake design flood simulations for the 20, 50, 100, 500 year ARI and PMF events.

4.2 Data Assessment

4.2.1 Previous Study Reports

The following reports were reviewed as part of the data assessment:

- Mount Barker – Littlehampton Township Flood Study (1986), B.C. Tonkin & Associates
- Littlehampton Flood Study (2005), Tonkin Consulting
- Mount Barker Creeks Flood Study (2003), Tonkin Consulting
- Mount Barker Water Resources Management Plan (2004)
- Morphett Street Stormwater Infrastructure Project (2008)
- Hurling Drive Development Flood Study (2009), Tonkin Consulting

4.2.2 Topographic Data

A review of the topographic data provided for this study was undertaken and the results of this review have been detailed in "Flood Mapping Study of Mount Barker - Hydraulic Capacity Analysis" (Water Technology, 2010). This is attached as Appendix C of this report. Figure 4.1 shows the digital terrain model for the Mount Barker floodplain mapping study area.

4.3 Hydraulic Modelling Framework

4.3.1 Overview

This section discusses the philosophy underpinning the hydraulic modelling framework employed for this study.

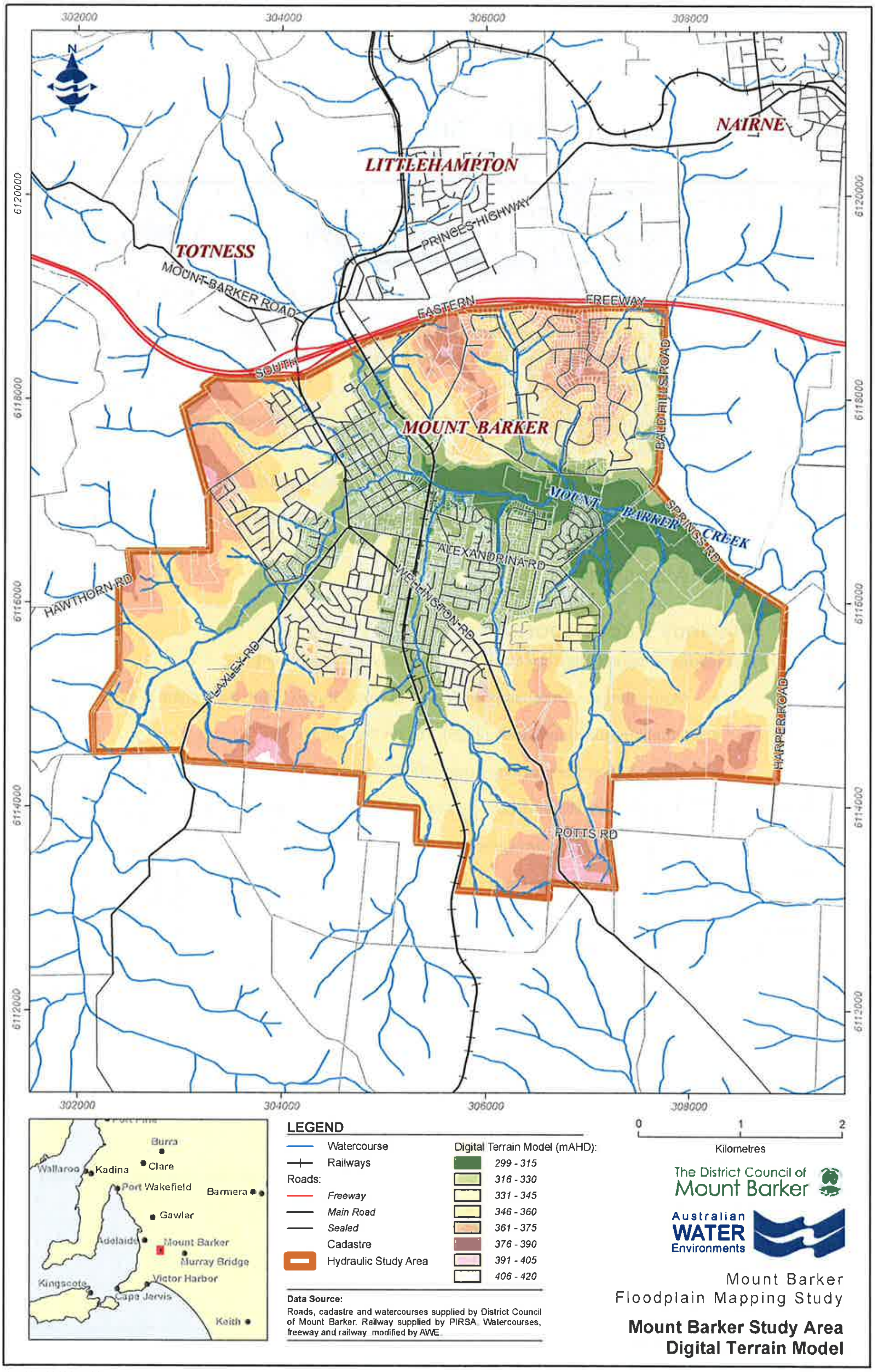

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Figure 4.1

The complexity of the flow and flood behaviour required a flexible hydraulic modelling framework. The adopted framework simulated the flow behaviour focusing on floodplain inundation. The key hydraulic modelling elements are discussed in Section 4.3.1.1.

A comprehensive hydraulic modelling framework has been employed in this study. However, the outcomes of the hydraulic modelling must be viewed in the light of the hydraulic models' capabilities, limitations and uncertainties. These aspects are discussed in Section 4.3.1.2.

4.3.1.1 Hydraulic Model Elements

The framework was required to simulate the flow behaviour across the Mount Barker floodplain balancing excessive model simulation times and topographic resolution. The final hydraulic modelling framework comprised a two – dimensional (2D) hydraulic model which is aimed at picking up broad scale floodplain features for large flood events, coupled with one - dimensional representations of structures such as bridges and culverts and also the Morphett Street drainage network.

The hydraulic modelling suite, MIKE 11, MIKE 21 and MIKE FLOOD, developed by the Danish Hydraulic Institute (DHI) has been applied in this study. MIKE FLOOD is a state-of-the-art tool for floodplain modelling that combines the dynamic coupling of the one-dimensional MIKE 11 river model and MIKE 21 fully two-dimensional model systems. Further details on the capabilities of the MIKE modelling system can be found at **http://www.dhisoftware.com**.

4.3.1.2 Hydraulic Model Capabilities and Uncertainties

There are numerous contributing factors to the ultimate output uncertainty in a complex hydraulic modelling exercise such as that undertaken for this study. Some of the uncertainties relate to the data inputs, whilst others are dependent on the numerical modelling processes itself. Sources of output uncertainty related to the input data for the hydraulic modelling include:

- Photogrammetric data;
- Bathymetry and cross section survey;
- Definition of hydraulic controls/structures;
- Observed flows for model input; and
- Observed flows and water levels for model calibration.

Sources of uncertainty related to the hydraulic modelling process include:

- Model numerical and computational schemes – these relate to the ability of the model to replicate the physics of free-surface flow in channels and over land;
- Floating point accuracy of computing resources (truncation error);
- Model schematisation and set-up (location and spacing of cross-sections, grid resolution); and
- Model parameters such as computational time-steps, surface-friction and other energy-loss parameters (expansion/contraction coefficients and eddy viscosity for example).

There is a wide variation in the magnitude of the impact associated with each source of uncertainty. In order to identify the most significant sources of uncertainty it is possible to consider items as either first or second order magnitude, where second order items are of a significantly smaller magnitude compared to first order items and can generally be ignored. A listing of the main sources of the modelling uncertainty and their approximate magnitudes is provided in Table 4.1.

Due to the complexity of the relationships between the input data and modelling outputs, there is no direct correlation between input and output data accuracy. Further, the error bounds on the data inputs are generally not cumulative. For example, inaccuracies in survey data inputs may be compensated for through adjustment of calibration parameters to achieve output hydraulic results that are nominally more accurate than the sum of the errors in the input data. Hence there are inferred relationships between model inputs and output accuracy that are typically developed through hydraulic modelling project experience.

The model development process can only address uncertainties arising from the following aspects:

- Definition of hydraulic controls/structures;
- Model schematisation and set-up (location/spacing of cross-sections, grid resolution); and
- Model parameters such as computational time-steps, surface-friction and other energy-loss parameters.

Section 4.4 discusses the consideration of these three (3) aspects in the model development. The remaining aspects from Table 4.1 are constrained by the available data sources.

TABLE 4.1: COMPARISONS OF SOURCES OF UNCERTAINTY

Scenario/Data/Process	Order of Accuracy	Approximate Impact on Results
Photogrammetry data and DTM	First	Change in floodplain levels/depths 0.1 m
Cross-section survey	First	Minimal direct impact, location and spacing of sections is more critical to model outputs. Cross-section survey not included in model terrain, instead used to as check on photogrammetry.
Definition of hydraulic controls/structures	First	Change in floodplain levels/depths 0.1 to 0.2 m
Observed flows for model input	First	N/A in this model. In general, it depends on available data, aim for observed/calibration accuracy +/- 10 % for flows
Observed flows and water levels for model calibration	First	N/A in this model, In general it depends on available data, +/- 10 % for flows & +/- 0.15 m for observed flood levels.
Model numerical and computational schemes – these relate to the ability of the model to replicate the physics of free-surface flow in channels, wetlands and over land.	Second	N/A
Floating point accuracy of computing resources (truncation error)	Second	N/A
Model schematisation and set-up (location and spacing of cross-sections, grid resolution)	First	Difficult to quantify, aim for overall accuracy of +/- 0.1 m for levels and +/- 10 % for flows
Model parameters such as computational time-steps, surface-friction and other energy-loss parameters	First	Change in floodplain levels/depths +/- 0.1 m
Level/accuracy of model calibration	First	N/A in this model. In general it depends on availability of calibration data, aim for +/- 0.1 m for levels and +/- 10 % for flows

4.4 Hydraulic Model Construction and Calibration

4.4.1 Overview

The study brief required the determination of design flood levels and extents for the 20, 50, 100 and 500 year event plus the Probable Maximum Flood (PMF) event. The principal tool for the determination of the design flood levels and extents was a robust and calibrated hydraulic model. However, due to ongoing development of the study area and lack of available historic data, no event specific calibration of the model was undertaken.

The principal input to the model construction was the available topographic data. The representation of the significant topographic features underpinned a robust hydraulic model. The topographic data was required to define watercourse form and floodplain features. The 2D hydraulic model required a regular grid of spot heights to define the floodplain terrain.

Details of the hydraulic structures (pipes/culverts/bridges) throughout the study area were used to develop the 1D model elements.

The hydraulic model construction also required the specification of boundary conditions, i.e. flows/water levels at the upstream and downstream limits of the hydraulic models. These boundary conditions were sourced from observed data and/or estimated values from hydrologic models.

Channel form, riparian vegetation and floodplain land use influences the hydraulic roughness. The hydraulic roughness reflects the resistance against flow, due to friction, along a channel or over a floodplain. Defining the hydraulic roughness was based on hydraulic modelling experience after review of the surface type and potential obstructions. There was insufficient data to perform a calibration.

4.4.2 One Dimension Model Components (MIKE 11)

This study applied the 1D model components to simulate flow behaviour through hydraulic structures such as bridges and culverts and also through the piped sections of channel associated with Morphett Street Drains 1 and 2.

4.4.2.1 Structure Details

Each of the structures detailed in Appendix C were incorporated as MIKE 11 structures within the MIKE FLOOD simulation program. Each structure was checked to ensure the structure capacities matched those provided in the report.

Details of the piped channel sections of the Morphett Street Drain 1 and 2 were used to construct the pipe network within MIKE 11. The model is linked to the 2D model grid at the upstream and downstream of the network.

The location of the modelled structures is shown in Figure 4.2.

4.4.2.2 Boundaries

As all the 1D model components are linked within the 2D model grid structure specific boundaries for each component are not required. As flow on the 2D grid surface enters a grid cell linked to a 1D structure that structure becomes active. Flow then passes through the structure and re-enters the 2D grid downstream.

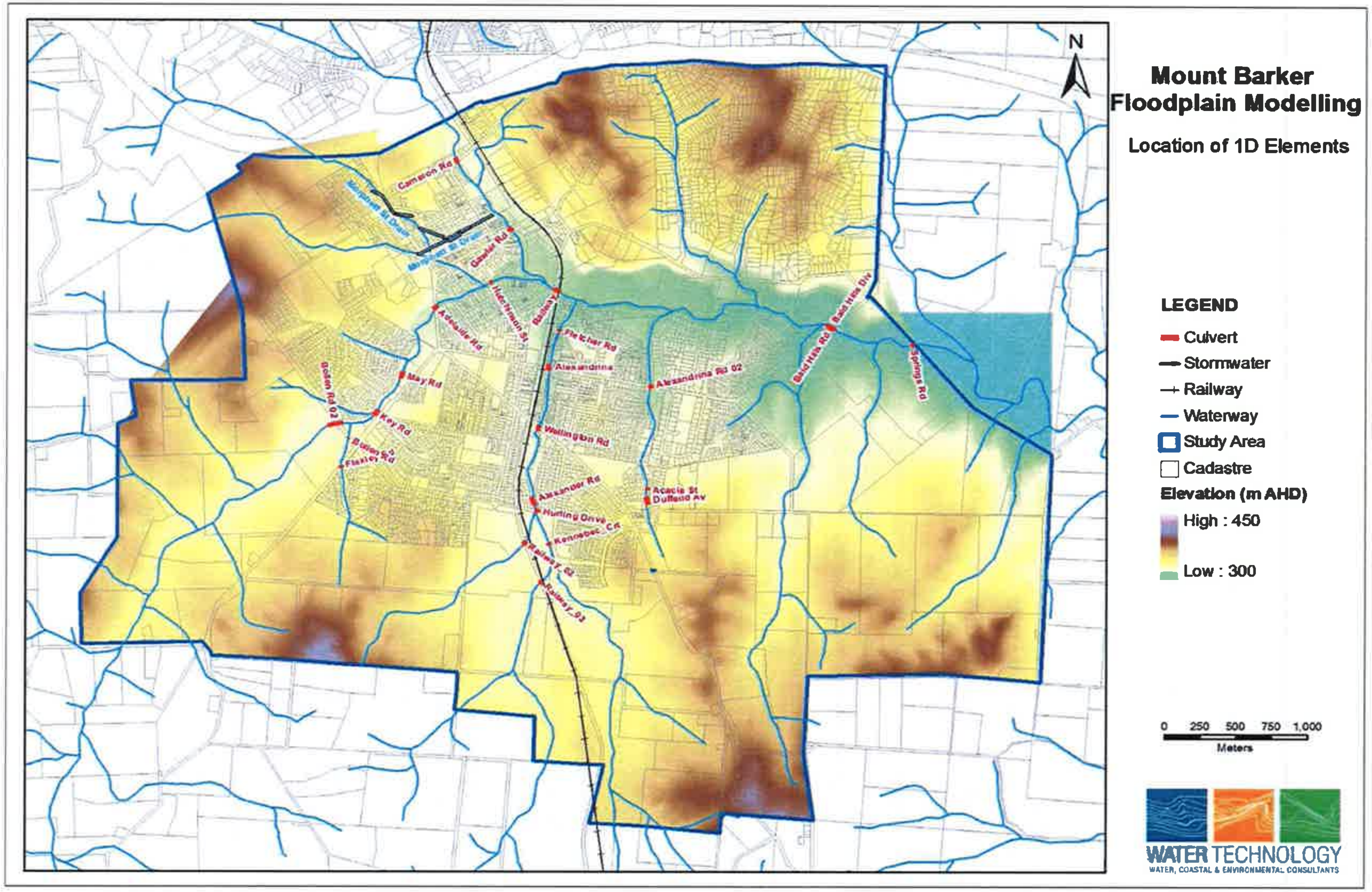

FIGURE 4.2: LOCATION OF 1D MODEL ELEMENTS

4.4.2.3 Roughness

Hydraulic roughness was expressed as Manning's n values. Manning's n values were applied based on structure material (i.e. concrete, steel) for the 1D components.

4.4.3 Two Dimensional Model Components (MIKE 21)

This study applied the 2D model components to simulate flow behaviour where there was overbank (floodplain) flooding. The 2D models consisted of the following elements:

- Grid extent and resolution.
  - The study area was converted from the raw ALS points into a coarser grid resolution (6m) for the 2D model to be constructed and run in a reasonable timeframe.
- Key topographic features, such as road and channel embankments, were stamped into the model grids. This stamping ensures these key features are reflected in the 2D model topography.
- A section of terrain associated with the Hurling Drive development was incorporated into the model grid to replace the existing topography with revised surface data.
- Boundaries - the boundaries at the edge of the hydraulic study area are:
  - Littlehampton Creek inflow boundary:
    - The Littlehampton Creek inflow was applied just downstream of the South Eastern Freeway.
  - Additional inflow boundaries:
    - Boundaries were applied at four (4) other tributaries at the study area boundary. Two of these were upstream of the Morphett Street drain system, one was an inflow to the Railway Creek system and one was a tributary of Western Flat Creek.
  - Mount Barker Creek outflow boundary:
    - A fixed water level boundary was applied at the downstream section of Mount Barker Creek. The tailwater was applied downstream of Springs Road. Water levels were chosen to ensure the boundary conditions did not affect water levels upstream of Springs Road.

Flows from catchment areas upstream of the hydraulic study area were inputted to the model at the boundary. Flows from within the hydraulic study area were incorporated as source points located along any given channel, their locations reflecting the centroid of the area contributing flow to that location.

Two different sets of boundaries and source points were used for the long duration (RORB) and short duration (DRAINS) flows. The location of all boundaries and source points for the two sets of flows is shown in Figure 4.3 and Figure 4.4.

For the long duration events, the location of source points along Railway Creek at Hurling Drive and Western Flat Creek at Bollen Road were adjusted during the modelling process due to their initial proximity to culvert structures. The local area inflow along Western Flat Creek immediately upstream and downstream of Bollen Road was also split into two components to better represent the distributed nature of the inflows and indicate the effectiveness of the bunding on the upstream side of Bollen Road.

Hydraulic roughness within the 2D model was expressed as Manning's n. For the estimation of the floodplain Manning's n, this study assessed land use and vegetation cover.

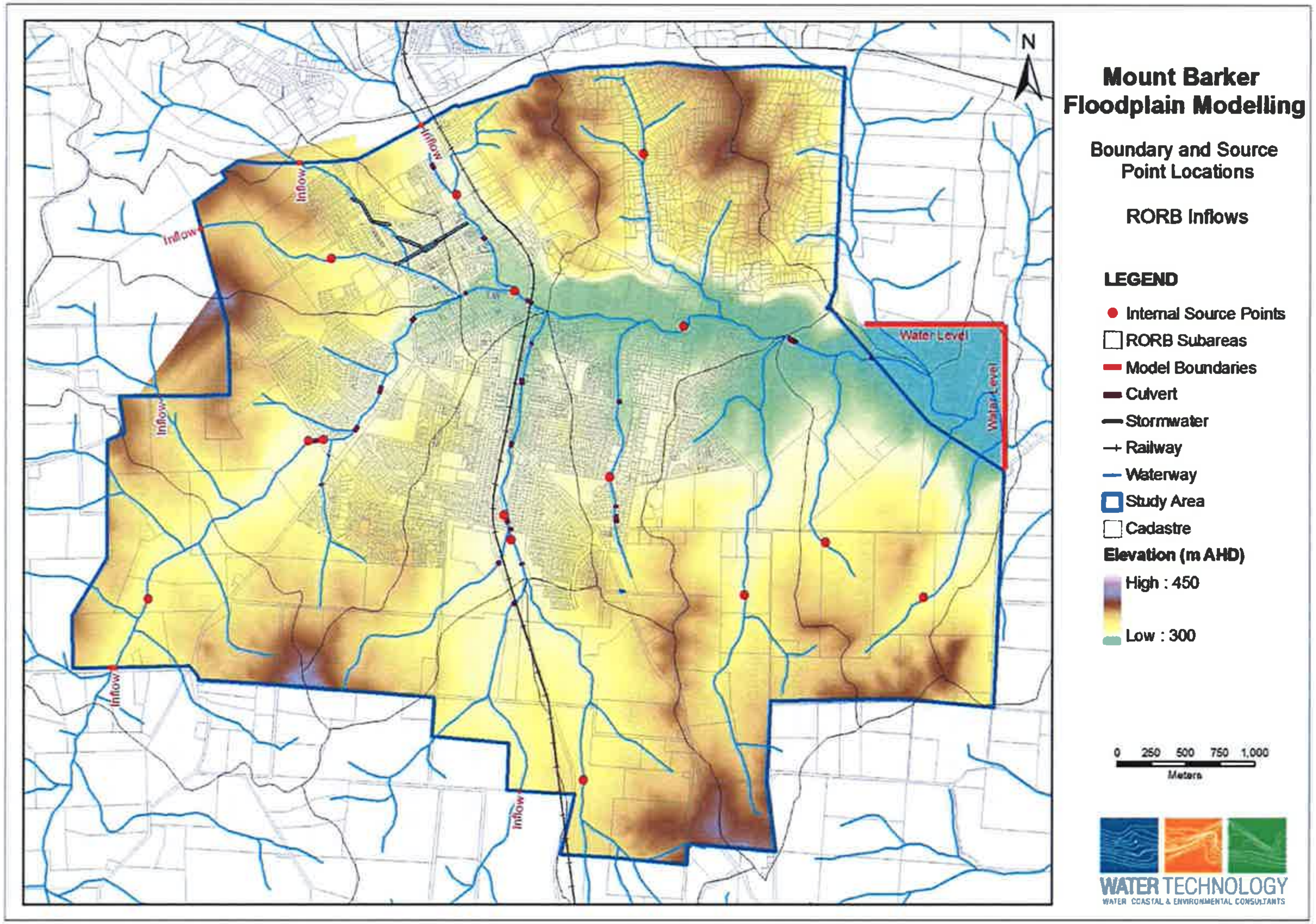

FIGURE 4.3: LONG DURATION (RORB) FLOW BOUNDARY AND SOURCE POINT LOCATIONS

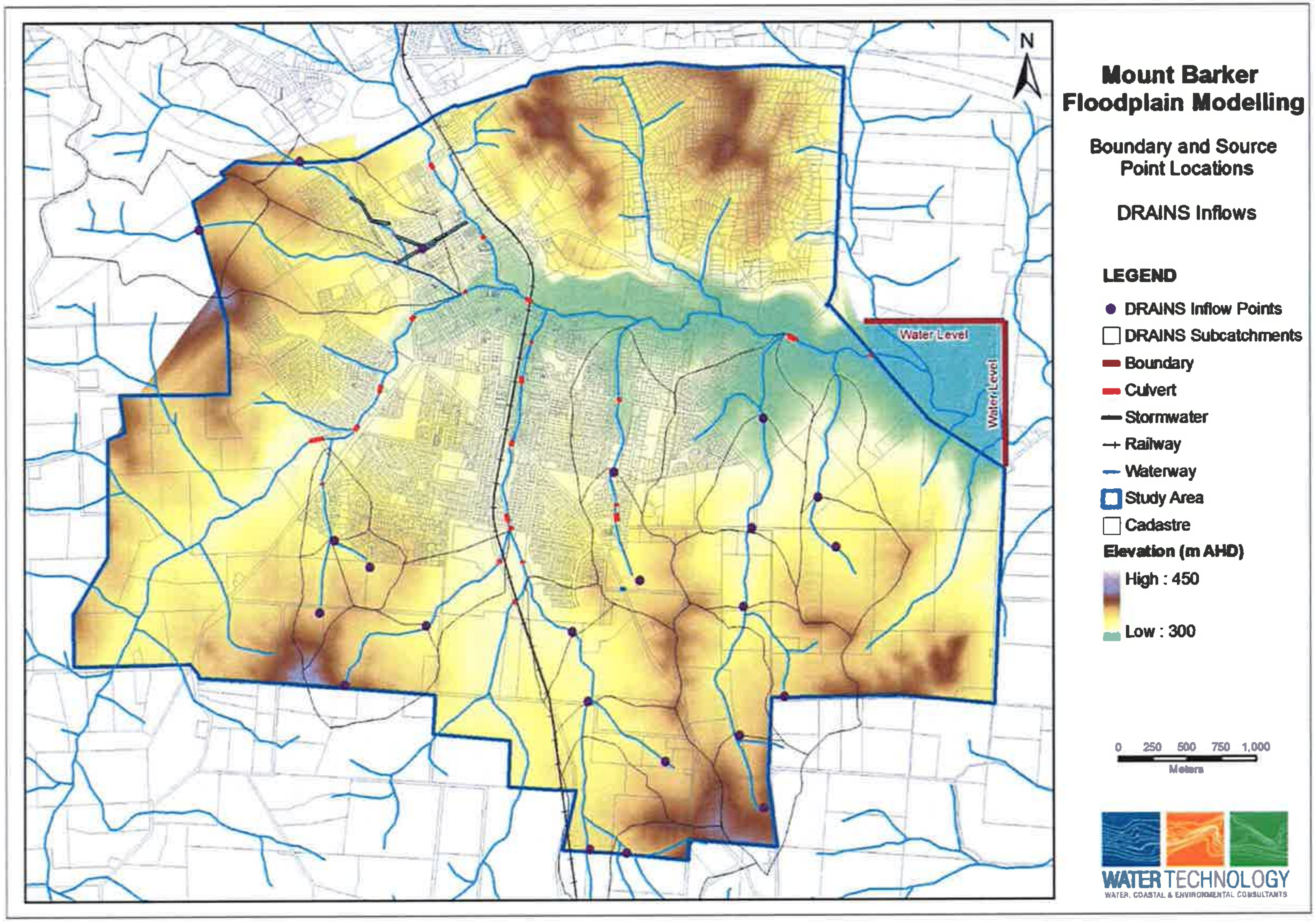

FIGURE 4.4: SHORT DURATION (DRAINS) FLOW BOUNDARY AND SOURCE POINT LOCATIONS

Hydraulic roughness values adopted for the 2D hydraulic model are summarised in Table 4.2, which shows the different values adopted for each land use of ground cover.

TABLE 4.2: MANNING'S ROUGHNESS VALUES

Land Use / Topographic Description	Manning's "n"
Heavily vegetated river channel	0.125
Less vegetated river channel	0.07
Lightly vegetated river channel	0.04
Horticulture	0.07 - 0.08
General rural land	0.045
Urban housing	0.15
Commercial areas	0.20

The assumed Manning's n value for various channel reaches is defined in the "Flood Mapping Study of Mount Barker - Hydraulic Capacity Analysis" (Water Technology, 2010) which is attached as Appendix C. As a reference, the Brisbane City Council Natural Channel Design Guidelines (November 2003) contains visual representations of a range of Manning's roughness values. This may be downloaded from the Brisbane City Council website (http://www.brisbane.qld.gov.au/planning-building/common-building-projects/residential-projects/subdivision/subdivision-development-guidelines/technical-documents/index.htm).

4.4.4 Hydraulic Model Calibration

4.4.4.1 Overview

This section discusses the refinement of the hydraulic models' parameters through calibration. The calibration process consisted of a comparison of modelled results to calibrated RORB model outputs.

4.4.4.2 Calibration Data and Approach

Usually historical flow/flood events are used to calibrate the models. The calibration events are chosen on the basis of available flow and corresponding flood extent information. Unfortunately no suitable calibration data was available for the hydraulic study area. As an alternative calibration approach, the hydraulic model outputs at the model boundary were compared to the calibrated RORB model design event outputs at the same location.

4.4.4.3 Calibration Results

Table 4.3 displays the peak flow for both the RORB and hydraulic model for each ARI event at the existing gauging station downstream of Mount Barker.

TABLE 4.3: 2D MODEL CALIBRATION EVENTS – PEAK FLOWS FOR ARI EVENTS

Event	Peak flow (m^3/s)		
	RORB	Hydraulic Model	Error
20 year	54.4	54.1	-0.5%
50 year	68.6	70.7	+3.0%
100 year	106.5	108.3	+1.9%
500 year	227.9	254.6	+11.7%
PMF	2478.4	2478.0	0.0%

A comparison of hydrograph shapes for each ARI event is given in the Figure 4.5 below

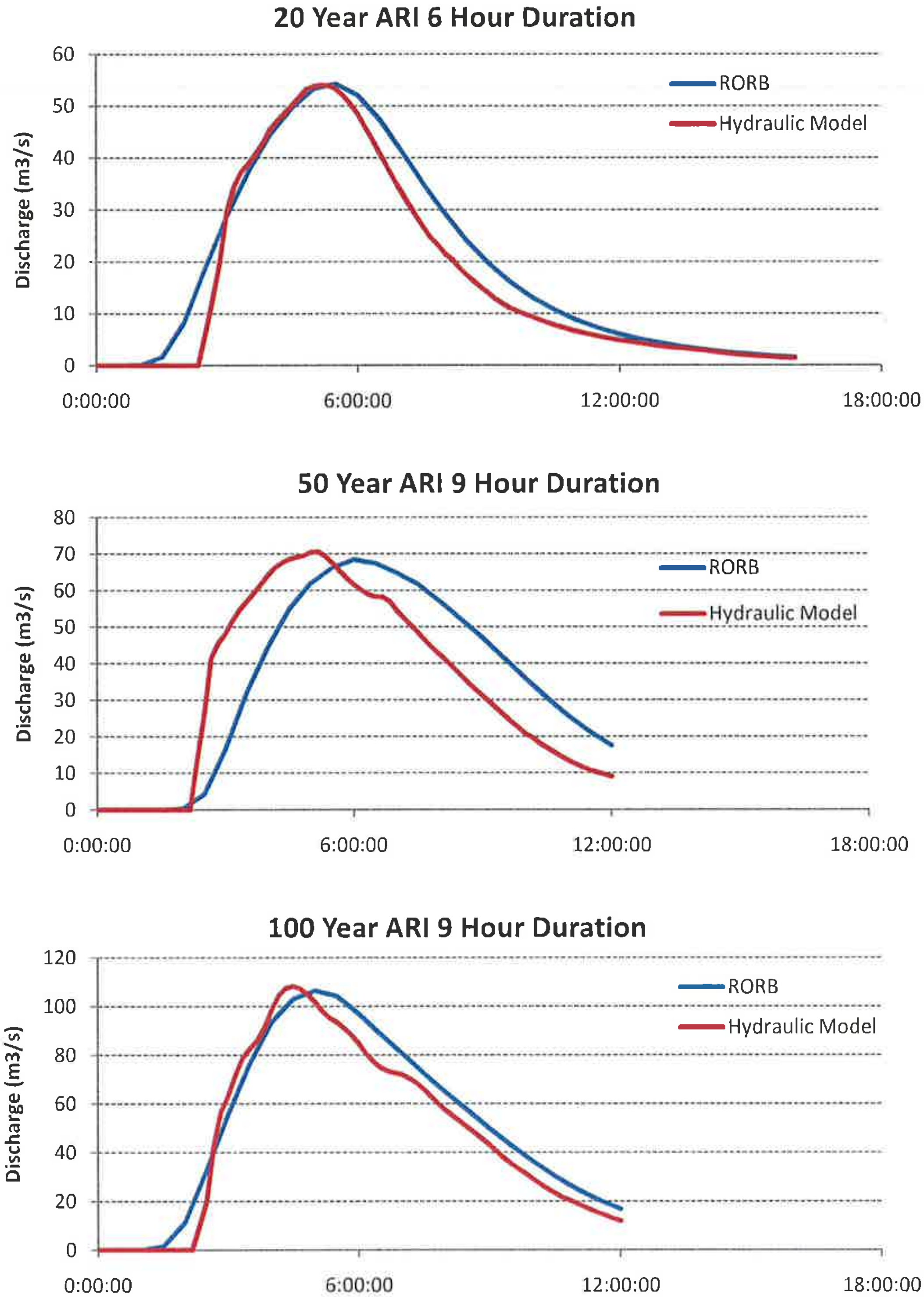

FIGURE 4.5: COMPARISON OF RORB AND HYDRAULIC MODEL HYDROGRAPHS AT MODEL OUTLET

Table 4.4 displays the hydrograph volume for both the RORB and hydraulic model for each ARI event at the gauging station downstream of Mount Barker.

TABLE 4.4: 2D MODEL CALIBRATION EVENTS – HYDROGRAPH VOLUME

Event	Hydrograph Volume (ML)		
	RORB	Hydraulic Model	Error
20 year	1139	982	-13.8%
50 year	1556	1493	-4.0%
100 year	2266	2066	-8.8%
500 year	4600	4605	+0.1%
PMF	26800	17617	-34.3%

4.4.4.4 Discussion

The peak flows at the hydraulic model outlet corresponded well with RORB flow estimates at the same location. The peaks from the hydraulic model were generally within 3% of the RORB peak flows over the range of design events. The hydrograph shape at the hydraulic model outlet was also found to be consistent with the RORB hydrograph. Hydrograph volumes tended to be slightly less in the model compared to the RORB outputs.

The Mount Barker catchment is steep with little flood storage capacity, and floods tend to be flashy as a result of this. Peak flow is usually more important than hydrograph volume for determining flood inundation, depth and hazard under this sort of regime. The close correspondence between the modelled peak flow and the RORB peak flow at the outlet indicates that the model will provide a good estimate of peak flood depth and hazard.

4.5 Floodplain Inundation and Hazard Mapping

4.5.1 Floodplain Inundation Maps

A series of flood inundation maps for the 20, 50, 100, 500 and PMF events are presented in Appendix D. These maps provide the outcome of the hydraulic analysis across the study area. The primary information presented relates to maximum flood inundation depth for each grid cell. These are presented as a set of graduated intervals with corresponding colour scheme provided in the legend. Peak flow and travel time of peak are also presented at representative locations.

4.5.2 Flood Hazard Maps

The discussion of design flood results thus far has focussed on the extent and depth of flooding. The velocity of water also has an important role in the impact of flooding. Deep flowing water can be expected to have a larger impact than if it were shallow.

Furthermore, hazard to people, animals and property will be increased if water is flowing fast rather than slow. Research has determined safety thresholds for movement of small children through flowing waters which is considered a key aspect of hazard definition in terms of safe evacuation from flood effected areas. Flood hazard mapping introduces the effects of velocity and effectively links the combined threats poised by depth of water and flow velocity. Figure 4.6 below illustrates the adopted flood hazard rating system (based on SCARM, 2000).

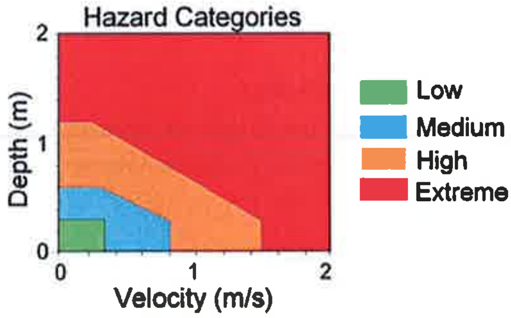

FIGURE 4.6: FLOOD HAZARD RATINGS (ADAPTED FROM SCARM 2000)

As illustrated by Figure 4.6 if floodwater is deep it may create a serious hazard. Similarly, water flowing with high velocity, even at a shallow depth, may present a similar hazard.

Hazard mapping is particularly important for emergency services and for planning urban developments. Some developments in low hazard areas may be appropriate because economic losses may be low and/or managed and human life is less likely to be put at risk, whereas it would be unwise to allow new development in high hazard areas. In high hazard areas both property and people's well being could be put at risk during a flood.

The Australian Government (SCARM 2000) has also published information on the types of development that could be considered appropriate for various hazard zones. This information in presented in Table 4.5.

TABLE 4.5: LAND USE IN RELATION TO FLOOD HAZARD (ADAPTED FROM SCARM 2000)

Land Use	Low	Medium	High	Extreme
Open Space / Recreation	✓	✓	✓	✓
Residential	✓	✓		
Commercial / Industrial	✓	✓	✓*	
Public Institutions	✓	✓		
Hospitals	✓			
Aged Care Homes	✓			
Caravan Parks	✓	✓		
Museums / Libraries	✓			
Clubs	✓	✓	✓	✓
Schools	✓	✓		
Police	✓			
Council	✓	✓		
Telephone Exchange	✓			
Emergency Services	✓			

* Only if insured. Most properties in South Australia are unable to get flood insurance.

Appendix E contains flood hazard maps for the 100 and 500 year flood events.

4.6 Floodplain Mapping Results

4.6.1.1 20 Year ARI Flood Inundation Map

Flood inundation associated with the 20 year ARI storm event appears generally to be confined within the main watercourse channels. There are however a couple of locations where breakouts occur.

Upstream of Bollen Road floodwaters from Western Flat Creek expand out beyond the channel to cover a significant proportion of the valley. This is primarily driven by the bund to the south west of Bollen Road which allows this area to perform as a detention basin.

There appears to be a number of locations between Bollen Road and Adelaide Road where Western Flat Creek channel capacity is exceeded. There is a linear park along this watercourse that acts as a floodway and no private property appears to be affected. One more significant breakout is just downstream of May Road where a breakout to the north east runs along the rear of properties accessed from Peake Court.

Further downstream along Western Flat Creek the channel capacity appears to be exceeded in the reach between Stephens Street and McLaren Street. Just downstream of Hutchinson Street a breakout from the channel travels towards the southeast. This breakout concentrates within Victoria Crescent and continues to flow southeast to Hampden Road and ultimately back to Mount Barker Creek just upstream of the railway bridge. Flood depth appears to be relatively shallow.

Railway Creek appears to have a number of potential problematic flood locations during a 20 year ARI flood event. The capacity of the Hurling Drive culverts appears to be of concern adjudged by the ponding observed on the upstream side of the structure. Between Hurling Drive through to just downstream of Wellington Road there appears to be a moderate proportion of flow not contained within the channel. Predominately this area of inundation is contained within open space but between Hurling Drive and Faehrmann Avenue there are several properties that may be subject to minor inundation. There is insufficient capacity in this reach and hence floodwaters will divert along Whittaker Street to the northern termination before re-entering Railway Creek main channel. Flood waters will also be conveyed within the Separation Avenue road reserve. Further downstream, just beyond Fletcher Drive, there is a further channel breakout to the north. This breakout may cause floodwaters of a minor depth to cross a number of properties accessing from Bernhardt Court.

A minor tributary to Littlehampton Creek enters the study area beneath the South Eastern Freeway adjacent to the Mount Barker turnoff approaching from Adelaide. This catchment is referred to Morphett Street Drain 1 from the "Mount Barker Creeks Flood Study" (Tonkin 2003). Flows from this catchment have been throttled down by the installation of an orifice plate (800 mm diameter opening) on the existing culvert which has a diameter of 1500 mm. Downstream of the South Eastern Freeway, this catchment drains through an established residential area. There are a series of open channels and piped sections to convey runoff. Ultimately this approaches the Morphett Street Drain. Floodplain mapping indicates that there may be some surface flows commencing between Pridmore Terrace and Druids Avenue. These generally flow in an easterly direction towards Cameron Street. Minor ponding appears to occur to the southwest of Cameron Street and negligible flows progress beyond this location. Flooding in this area may be particularly problematic given the high density commercial nature development in this area.

Littlehampton Creek enters the study area beneath the South Eastern Freeway. It appears there would be some minor breakouts directly downstream of the culvert opening. Further downstream the channel capacity exceeds the flow with the next breakout observed just upstream of Gawler Street. A short distance downstream of Gawler Street there is a junction between Western Flat

Creek and Littlehampton Creek. Downstream of the Gawler Street bridge there is a more apparent breakout along both the south-western bank and a further breakout following Dutton Road before ultimately veering south just prior to the left turn heading out of Mount Barker. Flow then progress through the recently developed shopping complex to the railway embankment and rejoins the main channel at the railway bridge. Flows along Dutton Road that may restrict traffic movement may be of importance given the number of residences that access Mount Barker from recent development north east of the town centre.

Downstream of the railway bridge, flood waters appear to back up behind the waste water treatment lagoons just south of Springs Road. Another tributary entering around this location appears to exceed channel capacity near the junction with Mount Barker Creek but this area is generally contained within park or open space areas.

Bald Hills Road appears to be overtopped at both the Mount Barker Creek crossing and further southwest at the creek discharging from the golf course. Downstream of the structure, floodwaters also appear to exceed the channel capacity through to Springs Road. There are few houses and other structures along this reach and these seem to be well clear of the inundation extent.

4.6.1.2 50 Year ARI Flood Inundation Map

Review of the 1 in 50 year ARI flood inundation map indicates that the locations of breakouts from the main channels are predominately the same as for the 1 in 20 year ARI flood with few additional areas of concern. The actual extent of and depth of these breakouts, however, has increased and may potentially lead to a higher risk of property damage and safety concern.

One area of increased flood extent compared to the 20 year event is the small watercourse approaching Adelaide Road from the west adjacent to Morphett Street (referred to as Morphett Street Drain 2 in "Mount Barker Creeks Flood Study" (Tonkin 2003)). The 50 year event appears to exceed the capacity of the piped drainage system resulting in floodwaters travelling east of Adelaide Road, through commercial properties just south of Morphett Street, before merging with floodwaters associated with the breakout from Morphett Street Drain 1. The overall extent of flooding in this region is increased and it appears that overland flow continues east of Cameron Street and discharges to the main channel of Littlehampton Creek.

A further new breakout when compared to the 20 year event occurs along Western Flat Creek just downstream of Adelaide Road. The extent and depth is relatively minor but may impact upon existing residential properties.

At the wastewater treatment plant adjacent to Mount Barker Creek, it would appear that floodwaters will breach the embankment of the western most treatment lagoon which may potentially be of concern for water quality management.

4.6.1.3 100 Year ARI Flood Inundation and Hazard Map

When compared with the 50 year event, several new areas of flooding are observed in the floodplain mapping of the 100 year ARI event. Downstream of Bollen Road it appears the channel capacity is insufficient and floodwaters would extend along Memorial Drive and also impact private property along Wuttke Road and Maurice Road.

Along Western Flat Creek, downstream of Adelaide Road, the channel capacity is exceeded generally with flooding extending south of the main channel to Albert Place. Floodwaters also extend along Victoria Crescent before entering Mount Barker Creek. There is a further breakout from Albert Place which conveys flow southeast along Hutchinson Street before turning northeast along Knott Street and rejoining Victoria Crescent. This area of flooding is of particular concern given the significant number of private properties that may be impacted.

The floodwaters associated with the Morphett Street Drainage system are again apparent but do not appear to be significantly more severe than for the 20 and 50 year flood events.

Upstream of the Gawler Street crossing of Littlehampton Creek the floodwaters extend well beyond the channel banks. This may be attributed to both the overland flow from Morphett Street Drain and backwater associated with insufficient capacity of the crossing structure. This impacts on a number of commercial buildings and would need to be reviewed.

Flooding across Bald Hills Road would be more severe in the 100 year ARI flood event and may restrict vehicle movements.

Flood hazard mapping identifies that all main channel flows are Extreme hazard rating, which is mainly driven by the depth. For the areas identified in the above sections as being of concern from a flood inundation perspective, the majority of these are subject to only Low flood hazard with some isolated areas of Medium hazard. The exception to this observation is along Railway Creek downstream of Fletcher Road. At these locations the flood risk is typically classified as medium with some small locations of high risk. Victoria Crescent is also an exception with areas of Extreme flood hazard along much of the road. There may be issues with safe access and egress from these allotments during a 100 year ARI flood event. Based on Table 4.5, the hazard risk at these locations is generally compatible with the current land use.

4.6.1.4 500 Year ARI Flood Inundation and Hazard Map

During the 500 year ARI event the majority of road crossings are significantly under capacity leading to overtopping of the road or railway.

The flood extent along Western Flat Creek between Bollen Road and Adelaide Road has increased and a number of private properties, particularly north of the channel, will be subject to inundation. Downstream of Adelaide Road, the flood extent widens further and would affect properties south of the channel through to Knott Street. Downstream of Hutchinson Street the flood depth within the urban area increases, particularly along Victoria Crescent where depths may exceed one (1) metre.

Along Railway Creek there are similar issues with a large number of residential allotments being inundated. As for previous recurrence intervals, the area of most concern is downstream of Fletcher Road where flood depths within allotments may exceed one (1) metre.

Flooding through the region associated with the Morphett Street Drain is worse in extent and depth but generally remains below one (1) metre in depth.

Developed areas of extensive High hazard flooding would include:

- Many of the properties along Western Flat Creek between Kay Road and Bollen.
- South of Western Flat Creek between Adelaide Road and Gawler Street, with Extreme rating along Victoria Crescent.
- Littlehampton Creek just upstream of the Gawler Street crossing.
- Adjacent to Morphett Street associated with surcharge from the drainage system.
- Between Pridmore Terrace, Druids Avenue and Adelaide Road.
- Railway Creek along Whittaker Street and particularly downstream of Fletcher Road.

4.6.1.5 Probable Maximum Flood Inundation Map

The PMF event for the Mount Barker catchment is equivalent to a 1 in 10 million year recurrence interval in accordance with procedures in Australian Rainfall and Runoff. Although flood events of this magnitude may not be particular relevant for development planning purposes, this can provide information for emergency management in catastrophic flood conditions.

It is observed that a significant area within Mount Barker Township would be inundated to a depth of greater than one (1) metre with some allotments being inundated by greater than 2.5 metres. Emergency services including Police Station, CFS Station and the Hospital are located outside of this flood envelope. It is important to note that this map represents the PMF associated with regional flooding. A higher frequency event over a smaller extent may result in greater inundation depths related to failure of local stormwater drainage infrastructure.

4.6.1.6 Key Location Flood Summary

A detailed description of the flood extent and hazard has been provided above. Further to this, additional details including peak flow and time to peak from the start of the rainfall event has been collated at four (4) critical locations. These locations included:

- Littlehampton Creek at Gawler Street;
- Western Flat Creek at Adelaide Road;
- Railway Creek at Wellington Road; and
- Mount Barker Creek at Bald Hills Road.

The peak flows and time to peak are summarised in Table 4.6.

TABLE 4.6: PEAK FLOW AND TIME TO PEAK AT KEY LOCATIONS

ARI	Gawler Street			Wellington Road			Adelaide Road			Bald Hills Road		
	Critical duration (hr)	Peak flow (m3/s)	Time to peak (hrs)	Critical duration (hr)	Peak flow (m3/s)	Time to peak (hrs)	Critical duration (hr)	Peak flow (m3/s)	Time to peak (hrs)	Critical duration (hr)	Peak flow (m3/s)	Time to peak (hrs)
20	6	17.3	5.5	6	13.4	5.3	6	19.5	6.2	6	53.4	6.5
50	9	22.5	4.8	9	18.4	4.7	9	28.5	5.2	9	69.7	6.5
100	9	31.6	4.2	9	28.2	4.3	9	42.1	4.3	9	107.3	5.3
500	9	69	3.8	9	63.4	3.7	9	106	4	9	252.1	4.7
PMF	2	647	2.3	2	474	2	3	1058	2.5	3	2437	2.7

A review of flood hazard was completed for the railway bridge pedestrian crossing at Mount Barker Creek. This identified that in the 20 year flood event the flow depth would exceed 0.7 metres which correlates to a high/extreme flood hazard. For the 100 year flood event the depth would be greater than 1.2 metres. This would be classified as an extreme flood hazard.

5 Conclusions

A detailed hydrodynamic model of the Mount Barker floodplain has been developed. Design flood simulations, based on updated topography and hydrological inputs, have been modelled and results presented in detailed flood inundation and flood hazard maps.

Whilst the overall accuracy and reliability of the model results are considered appropriate for the purposes of the study, it is important to recognise the inherent uncertainties in the overall floodplain mapping process. Therefore, the flood information produced in this study represents a risk profile across the floodplain that can be used to guide land use planning and emergency response measures. The flood extents presented are not likely to be exactly reproduced during an actual flood event.

The model may be improved or updated in the future as new information becomes available such as additional streamflow records and potential calibration events. It may also be updated to consider changes to development extent over time. In this way the model can be used as an ongoing tool for floodplain management. Possible applications could be the investigation of floodplain development options or flood warning procedures.

The Mount Barker floodplain model is considered an appropriate tool for the assessment of flood mitigation options at a later stage.

Appendix A : Mount Barker Floodplain Mapping Survey Report

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Australian WATER Environments

Mount Barker Floodplain Mapping Survey Report

Introduction

A digital terrain model (DTM) was required for floodplain mapping of Mount Barker Creek and its main tributaries. The model required data relating to ground elevations over the floodplain and main channels. Aerometrex were commissioned to develop a DTM covering the overall hydraulic study area. The DTM was produced using aerial photography survey methodology. The aerial survey of the hydraulic study area was completed during December 2008. The main watercourses through Mount Barker are vegetated with deciduous trees which typically have a full canopy during the summer period. This canopy restricted vision of the ground thus limited the accuracy of the DTM in these areas. The outcome was that only low quality data of ground elevation was available for the larger proportion of the main channel. This survey was suitable to create ground contours of 0.5m intervals. The area of this DTM survey is approximately 26 km^2. The metadata for the DTM is in Appendix 1. Figure 1 provides an overview of the extent of the DTM.

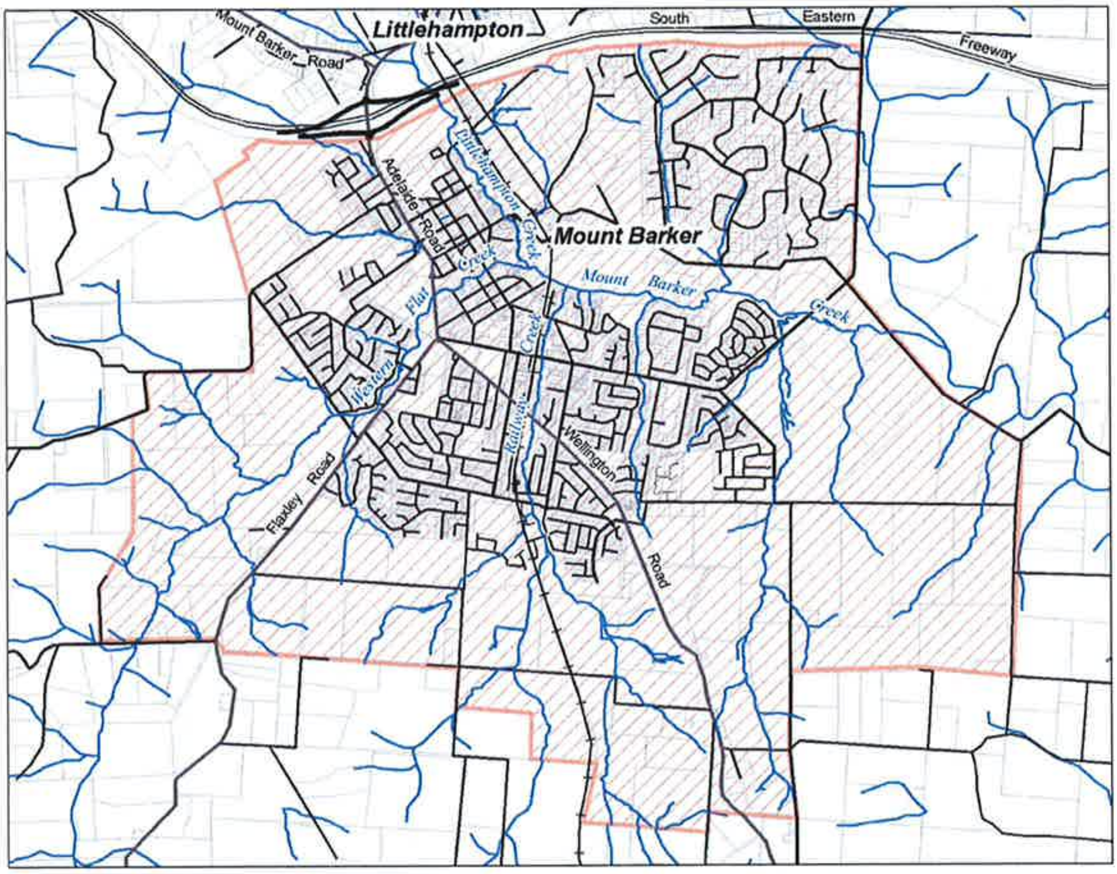

Figure 1: Hydraulic Study Area

Field surveying was undertaken to supplement the DTM by providing typical channel cross sections along the main watercourses and details of critical structure.

Structure details and typical cross sections adjacent each site

There are a relatively large number of small culvert/bridge structures crossing the main channels of the local creeks within the Mount Barker hydraulic study area. Generally, a cross drainage structure exists at any road or rail crossing. An initial site inspection identified key structures that may lead to a reduction of the channel capacity during high flow events. Details of these structures were obtained for the purposes of hydraulic capacity assessment for the floodplain model and inclusion in Council GIS data systems. Available information on existing structures was obtained from DTEI and the District Council of Mount Barker.

Flow capacity of culverts and bridges can be influenced by the upstream and downstream channel geometry. A series of cross sections were taken by field survey for the purposes of:

- Gaining detailed survey information upstream and downstream of the crossings;
- Providing typical sections to be applied to reaches where DTM is of low quality;
- Identifying the dimensions of structures; and
- Providing upstream and downstream invert elevations.

Australian Water Environments (AWE) and Water Technology (WT) collated and reviewed additional details of bridge/culvert structures across the main channels of the local creek network and floodplain that had the potential to impact on the channel capacity. A total of 21 structures were selected and these included road and rail crossings.

Figure 2 provides an overview of the distribution of structures surveyed through Mount Barker.

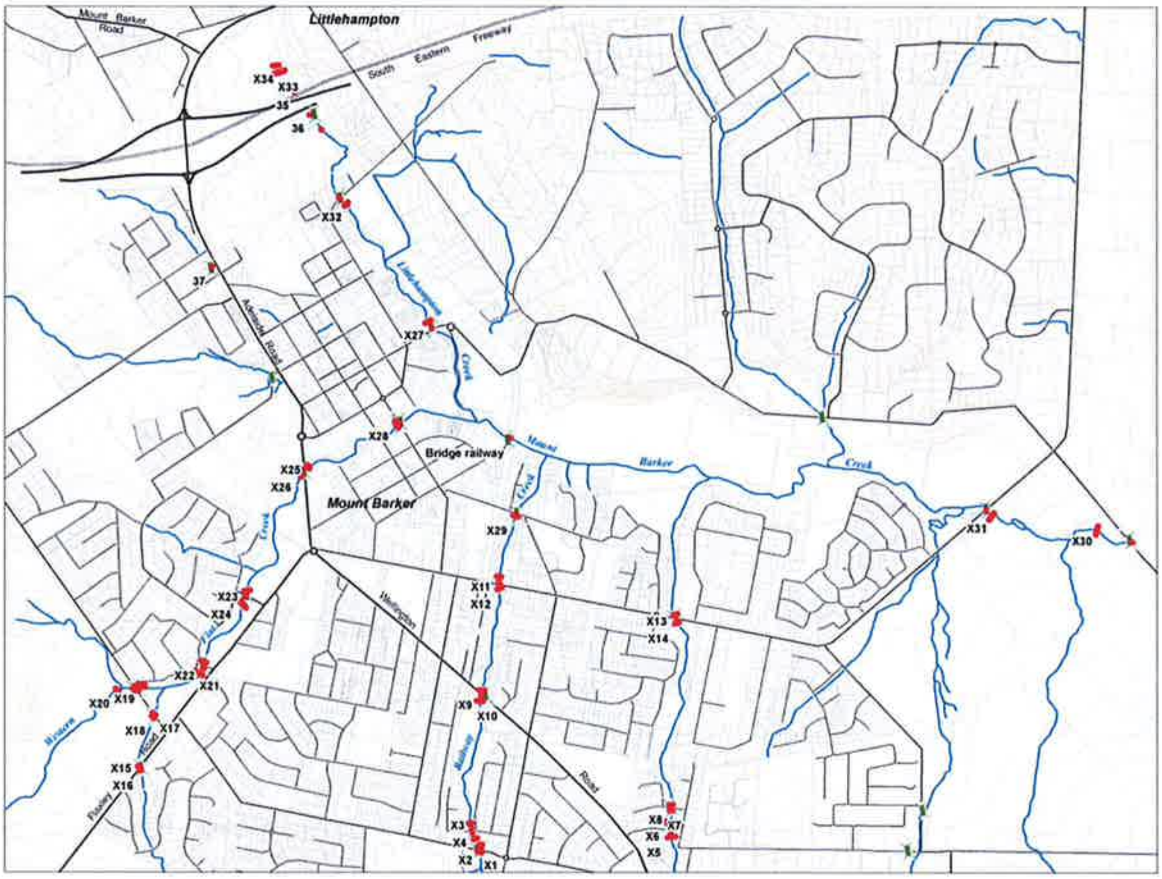

Figure 2: Survey Location Map

The cross-section and structure survey was conducted by AWE from 17-21 December. The equipment used was the GPS RTK Topcon Hiper GA system. Alternately, staff and level techniques were used when satellite signals were not accessible due to tree canopy and bridge deck restrictions. The equipment was a Pentax AP 128 Automatic Compensator Level with a five (5) metre staff. Survey Quality Management checks were applied to all field processes. The datum for the survey was:- Horizontal GDA 94 MGA54, Vertical mAHD.

The channel geometry and a summary of the structures (if applicable) at the surveyed sites is detailed in the following sections.

Site X1 and X2 - Hurling Drive

Railway Creek enters the current urban extent of Mount Barker through culverts beneath Hurling Drive (see Figure 3). The watercourse approaching this culvert structure is described as an earthen natural channel. The structure comprises of twin concrete box culverts with dimensions 1800mm wide and 1200mm high. An invert elevation of 323.49m was recorded on the concrete apron at the upstream end of the structure. invert elevation of 323.95m was recorded on the downstream apron. This elevation rise was due to an accumulation of silt.

A cross section (X1) was surveyed 2m upstream of the structure. Downstream, a cross section (X2) was surveyed 16m from the culvert. The surveyed cross sections for X1 and X2 are shown in Figure 4 and Figure 5 respectively.

Figure 3: Cross section X1 and X2; Hurling Drive

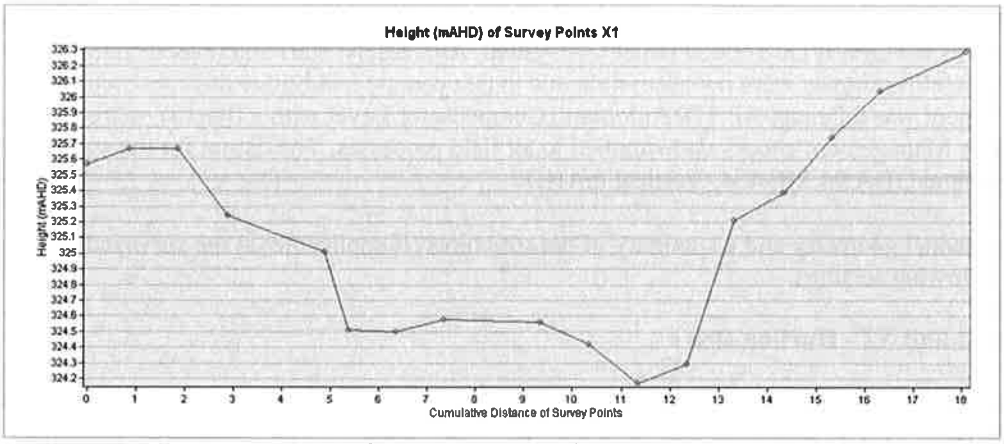

Figure 4: Cross section X1

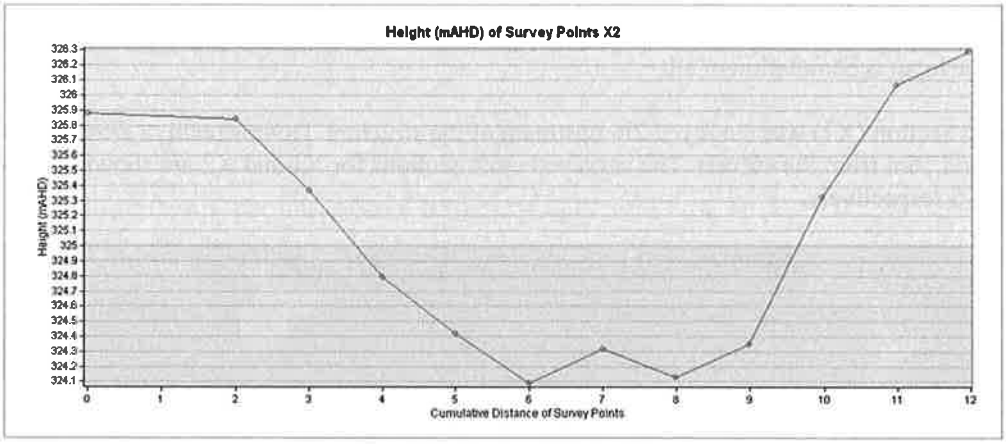

Figure 5: Cross section X2

Site X3 and X4 – Alexander Drive

The second survey location was directly downstream of X2 at the intersection with Alexander Drive (see Figure 6). Upstream of this crossing the watercourse is an open channel constrained by residential allotment on each side. The structure beneath Alexander Drive is twin concrete box culverts each with dimensions of 2700mm wide and 1500mm high. The invert elevation of the structure at the upstream end is 319.6m. On the downstream side of the structure the invert elevation is 319.42m.

A cross section (X3) was surveyed downstream of the Alexander Drive culvert while a further cross section (X4) was surveyed 27m upstream of the culvert. The surveyed cross sections for X3 and X4 are shown in Figure 7 and Figure 8 respectively.

Figure 6: Cross section X3 and X4; Alexander Drive

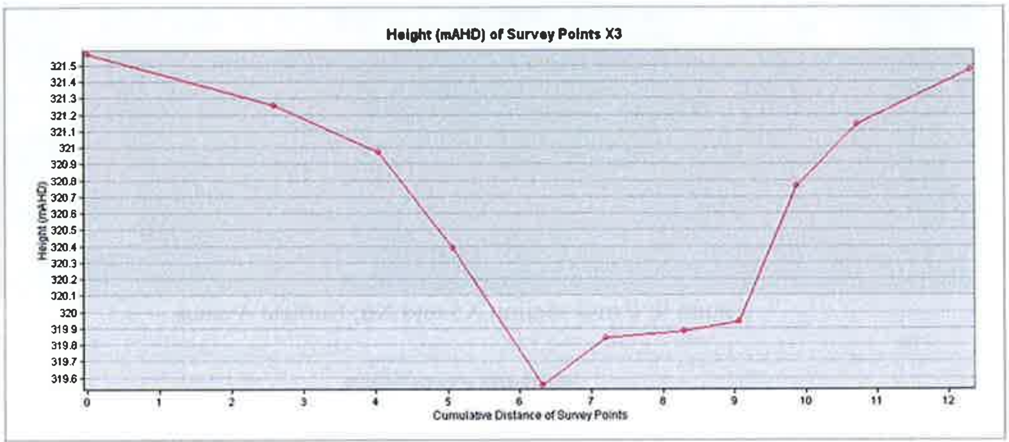

Figure 7: Cross section X3

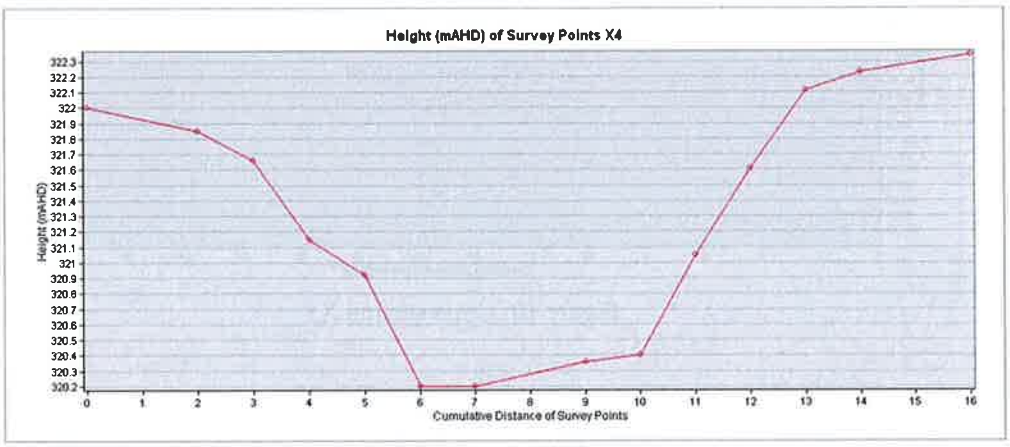

Figure 8: Cross section X4

Site X5 and X6 – Duffield Avenue

An unnamed tributary to Mount Barker Creek enters the township from the south (see Figure 9). Survey has been undertaken where this tributary crosses Duffield Avenue. The main channel is described as an earthen natural channel. The structure is twin concrete pipes of 650mm diameter. Invert elevation at the upstream end of the culvert is 331.28m. At the downstream end the invert elevation is 331.06m.

A cross section (X5) was surveyed 19m upstream of Duffield Avenue while a further cross section (X6) was surveyed 25m downstream of the culvert. The surveyed cross sections for X5 and X6 are shown in Figure 10 and Figure 11 respectively.

Figure 9: Cross section X5 and X6; Duffield Avenue

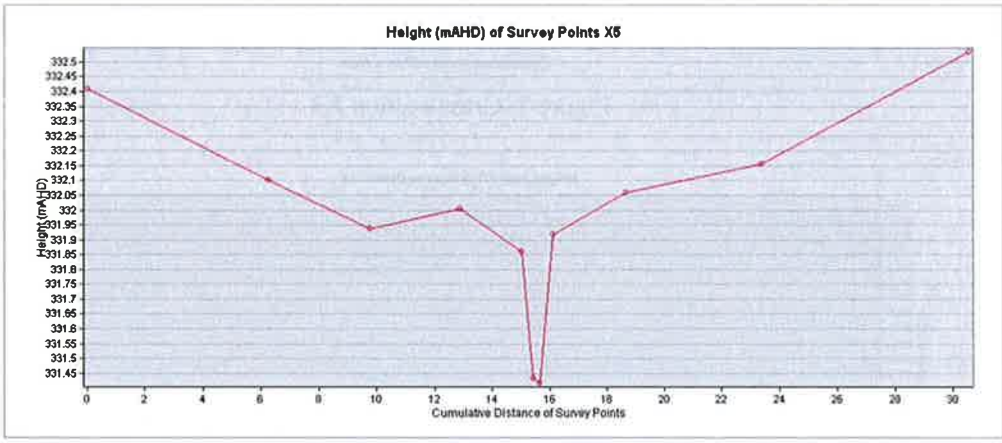

Figure 10: Cross section X5

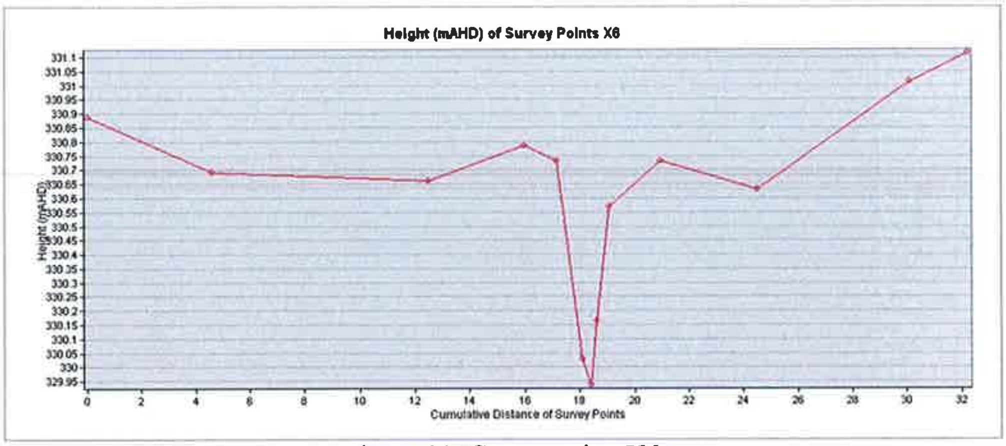

Figure 11: Cross section X6

Site X7 and X8 – Acacia Street

The Acacia Street culvert is a short distance downstream of Duffield Avenue and the watercourse remains an earthen natural channel (see Figure 12). The structure is twin concrete pipes (650mm diameter). Invert elevation at the upstream end of the culvert is 328.65m and 328.39m at the downstream end.

A cross section (X7) was surveyed 4m upstream of Acacia Street while a further cross section (X8) was surveyed 2m downstream of the culvert. The surveyed cross sections for X7 and X8 are shown in Figure 13 and Figure 14 respectively.

Figure 12: Cross section X7 and X8; Acacia Street

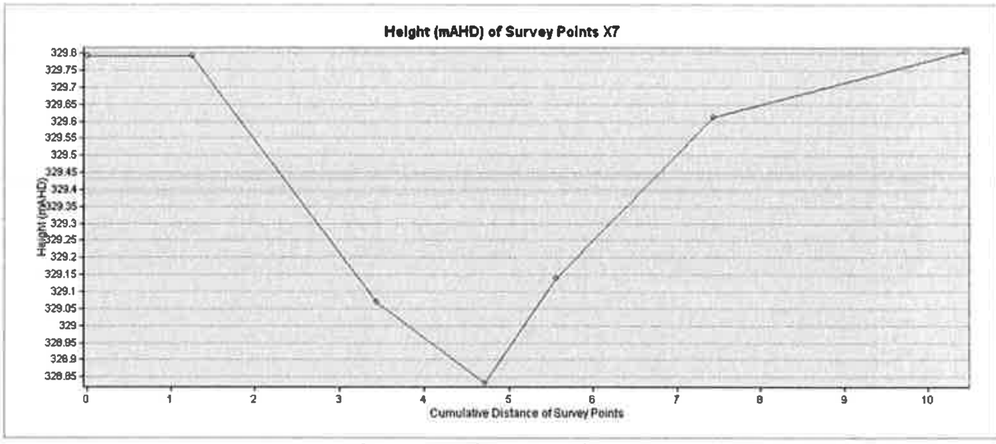

Figure 13: Cross section X7

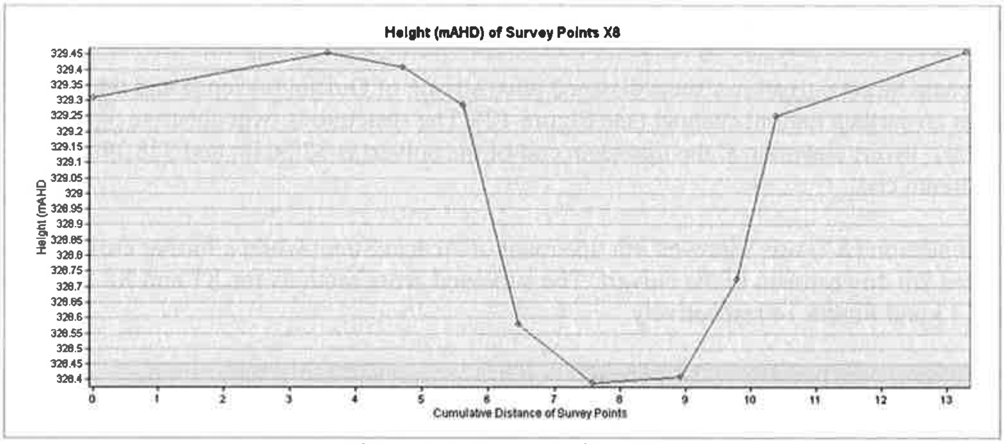

Figure 14: Cross section X8

Site X9 and X10 – Wellington Road

Downstream of the Alexander Drive culverts, Railway Creek continues as an open earthen channel flowing towards the north. The next major crossing of this channel is at Wellington Road (see Figure 15). This is one of the major arterial roads radiating out from Mount Barker Township. At this location there is a culvert structure consisting of three (3) concrete box culverts each having dimensions of 3000mm wide and 2000mm high. Invert elevation at the upstream end of the culvert was recorded as 316.55m. At the downstream end the invert elevation was 316.56m.

A cross section (X9) was surveyed 8m downstream of Wellington Road while a further cross section (X10) was surveyed 24m upstream of the culvert. The surveyed cross sections for X9 and X10 are shown in Figure 16 and Figure 17 respectively.

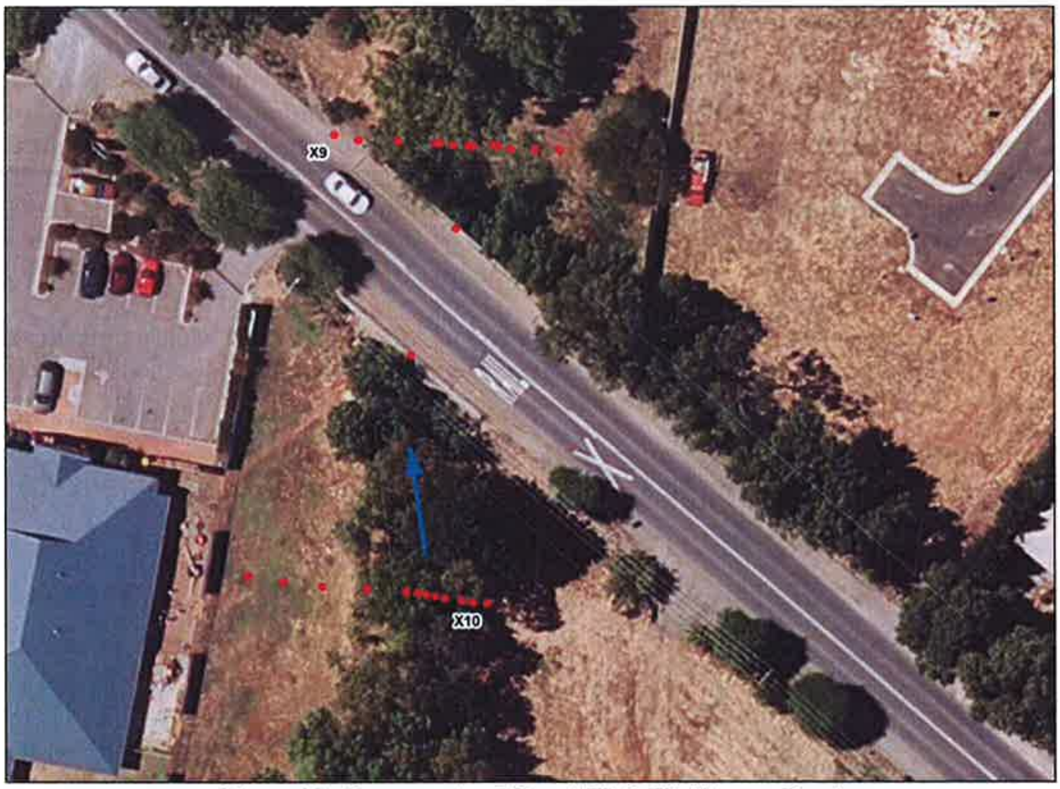

Figure 15: Cross section X9 and X10; Wellington Road

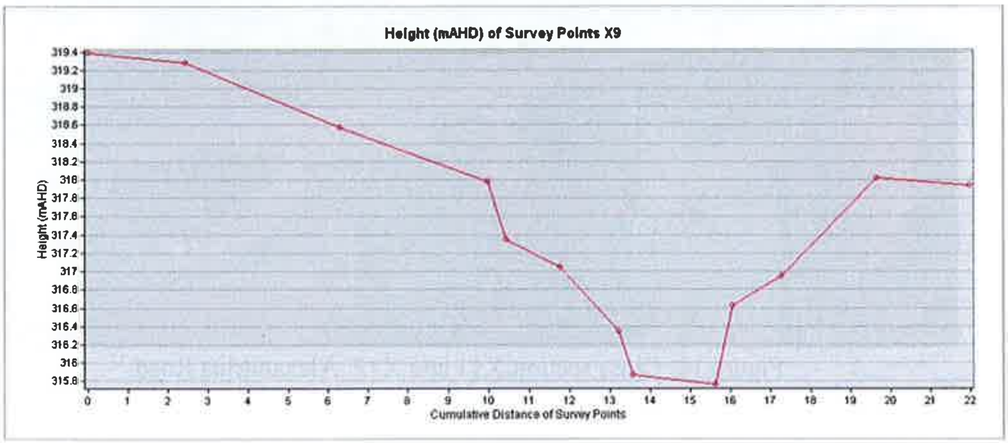

Figure 16: Cross section X9

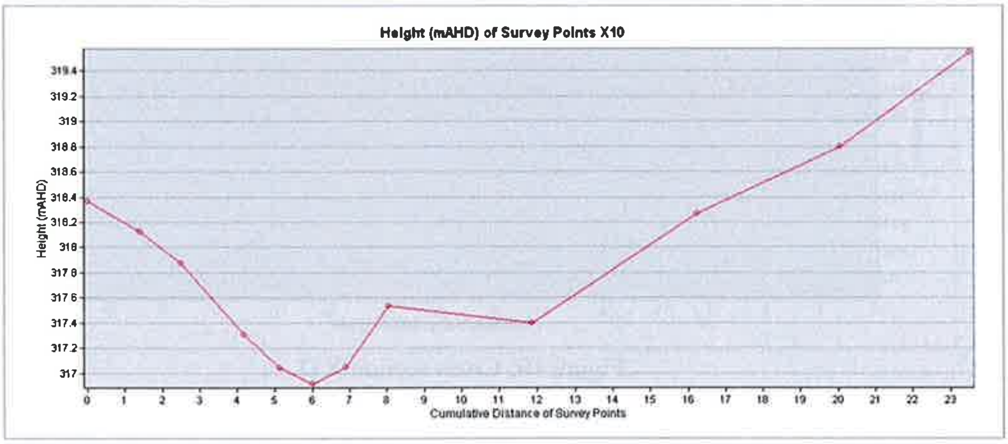

Figure 17: Cross section X10

Site X11 and X12 – Alexandrina Road

Further downstream of the Wellington Road culverts, Railway Creek continues as an open earthen channel flowing towards the north. This channel is more heavily constrained by surrounding residential properties and over recent years the channel has been modified to increase capacity and reduce the frequency of flooding. This crossing is at Alexandrina Road (see Figure 18). This is another of the major arterial roads radiating out from Mount Barker Township. At this location there is a 1900mm high by 6000mm wide box culvert. Invert elevation at the upstream end of the culvert was recorded as 312.68m. At the downstream end the invert elevation was 312.61m.

A cross section (X11) was surveyed 23m downstream of Alexandrina Road while a further cross section (X12) was surveyed 11m upstream of the culvert. The surveyed cross sections for X11 and X12 are shown in Figure 19 and Figure 20 respectively.

Figure 18: Cross section X11 and X12; Alexandrina Road

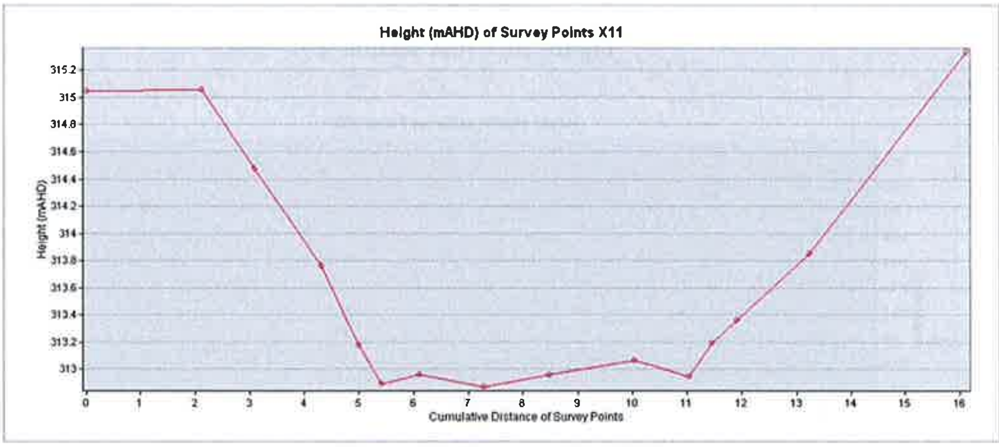

Figure 19: Cross section X11

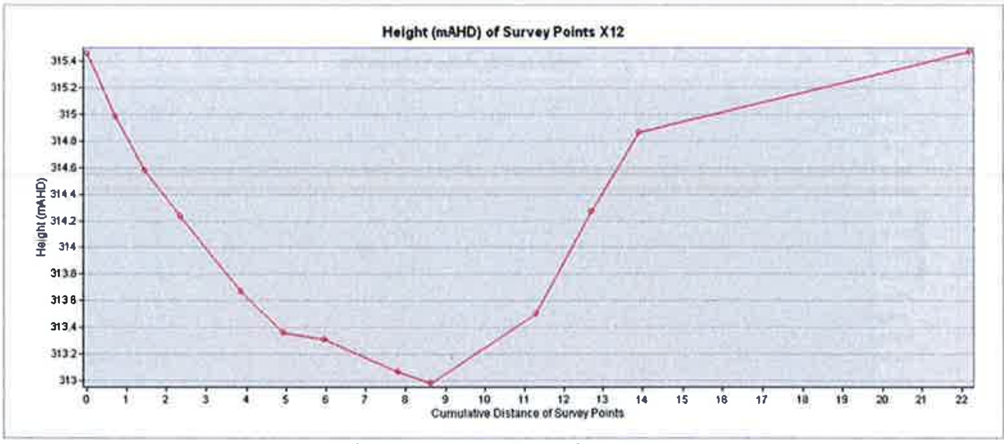

Figure 20: Cross section X12

Site X13 and X14 – Alexandrina Road

A short distance east of where Railway Creek crosses Alexandrina Road there is another crossing where the adjacent unnamed tributary flows towards the north (see Figure 21). This is on the same watercourse as cross sections X5-X8 but further downstream. The channel is bounded by residential allotments on both sides of the creek upstream and downstream of Alexandrina Road. The channel is an earthen open channel that has been modified in recent years to alleviate the flooding potential of surrounding properties. This structure is the last prior to this tributary discharging into Mount Barker Creek downstream of the township (see Figure 2). This crossing comprises of twin box culverts each with dimensions 1200mm wide and 1200mm high. Invert elevation of the culvert was recorded as 314.05m at the upstream end and 314.09m at the downstream end of the culvert.

A cross section (X13) was surveyed 5m downstream of Alexandrina Road while a further cross section (X14) was surveyed 8m upstream of the culvert. The surveyed cross sections for X13 and X14 are shown in Figure 22 and Figure 23 respectively.

Figure 21: Cross section X13 and X14; Alexandrina Road

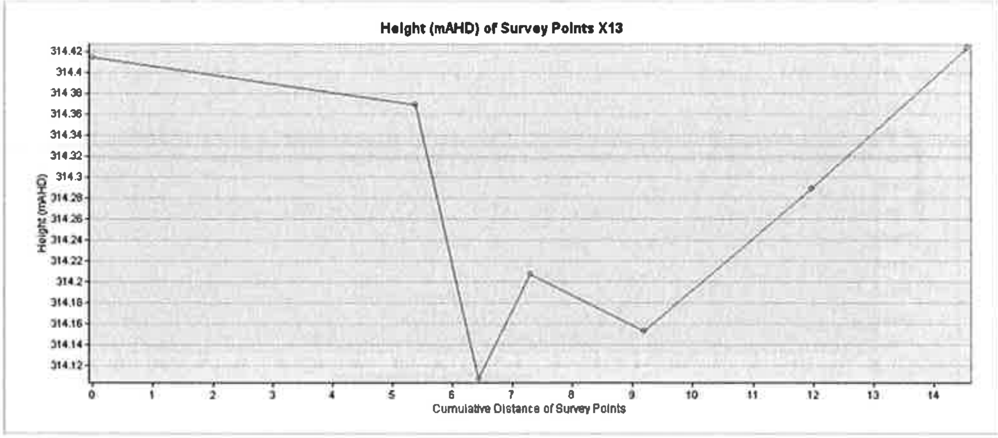

Figure 22: Cross section X13

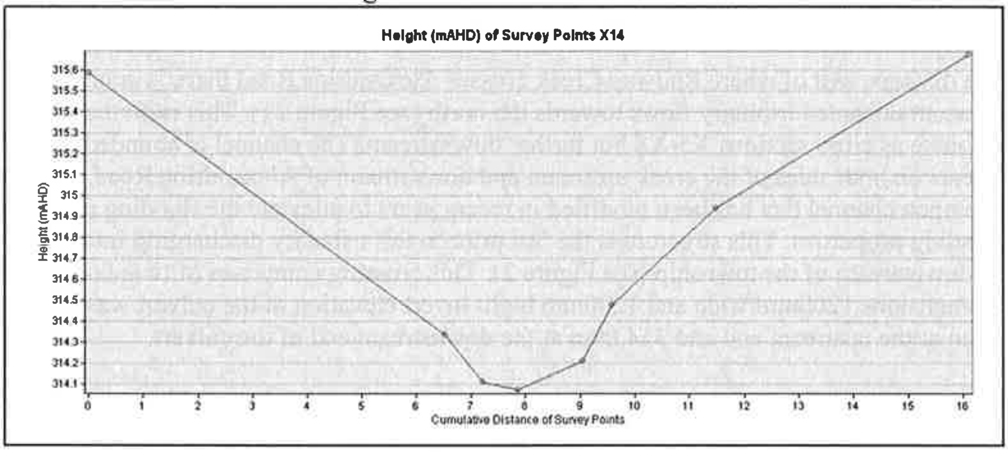

Figure 23: Cross section X14

Site X15 and X16 – Flaxley Road

Western Flat Creek is one of the major tributaries to Mount Barker Creek and approached Mount Barker from the southwest. Several smaller tributaries discharge to Western Flat Creek. One of these tributaries discharges across Flaxley Road and continues to flow in a northerly direction (see Figure 24). The channel is bounded by residential allotments just upstream of Flaxley Road and is an earthen open channel that has been modified with the recent subdivision of the surrounding area. Beneath Flaxley Road is a single 900mm diameter culvert. Invert elevation of the culvert was recorded as 330.25m at the upstream end and 329.25m at the downstream end of the culvert.

A cross section (X15) was surveyed 2m downstream of Flaxley Road while a further cross section (X16) was surveyed 2m upstream of the culvert. The surveyed cross sections for X15 and X16 are shown in Figure 25 and Figure 26 respectively.

Figure 24: Cross section X15 and X16; Flaxley Road

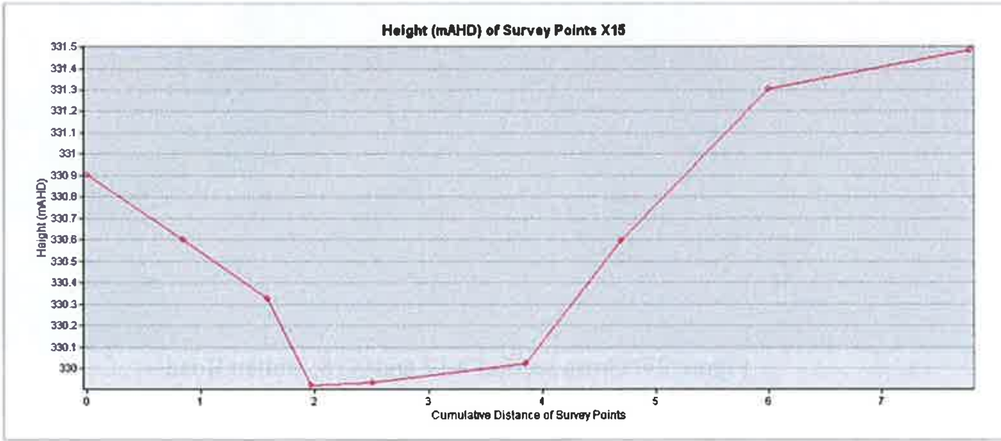

Figure 25: Cross section X15

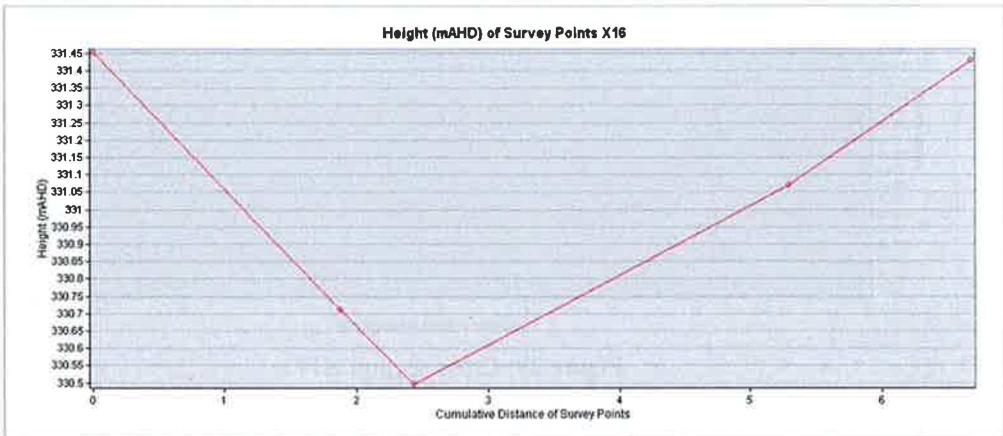

Figure 26: Cross section X16

Site X17 and X18 – Bollen Road

Within a short distance downstream of X15 the tributary reaches Bollen Road (see Figure 27). The channel is an earthen open channel that could generally be described as natural although discharging through rural land. The culvert structure is a single 900mm diameter culvert. Invert elevation of the culvert was recorded as 325.1m at the upstream end and 324.95m at the downstream end of the culvert.

A cross section (X17) was surveyed 0.5m downstream of Bollen Road while a further cross section (X18) was surveyed 0.5m upstream of the culvert. The surveyed cross sections for X15 and X16 are shown in Figure 28 and Figure 29 respectively.

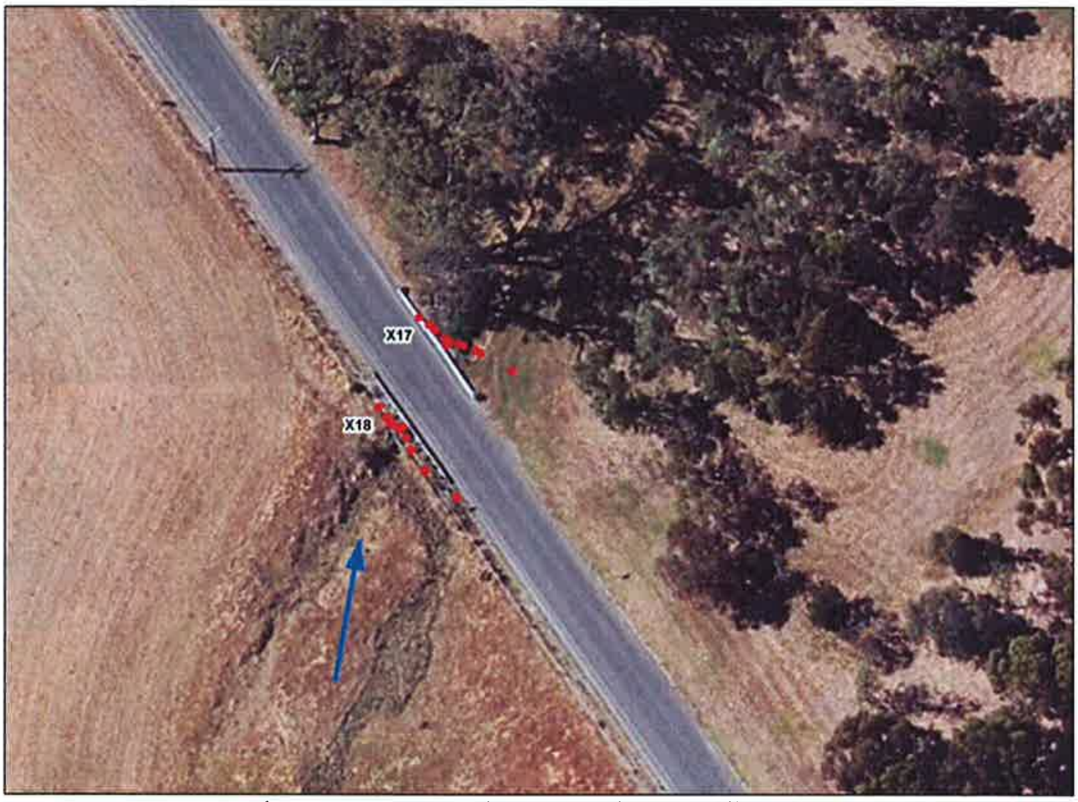

Figure 27: Cross section X17 and X18; Bollen Road

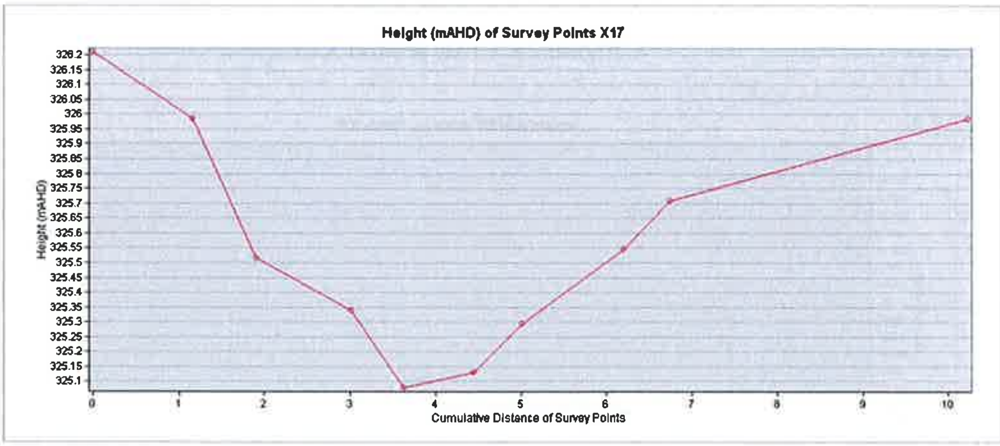

Figure 28: Cross section X17

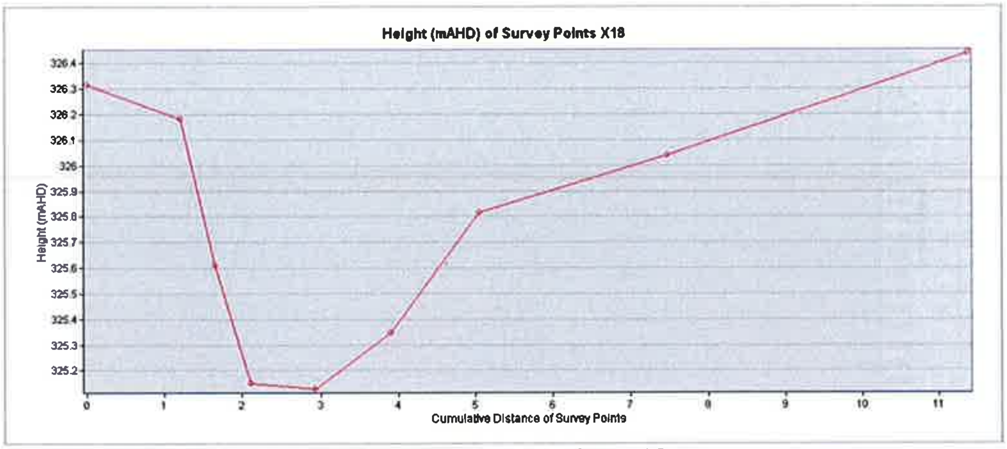

Figure 29: Cross section X18

Site X19 and X20 – Bollen Road

The main channel of Western Flat Creek crosses Bollen Road a short distance northwest of X17-X18 (see Figure 30). The channel is an earthen natural channel flowing through rural land. Beneath Bollen Road the culvert consists of four (4) circular pipes each with an internal diameter of 1800mm. At the crossing there is a solid concrete wall on each side of the road. The wall is approximately one (1) metre high with an elevation of 325.1m on the top. Invert elevation of the culvert was recorded as 322.81m at the upstream end and no elevation was taken at the downstream end of the culvert.

A cross section (X19) was surveyed 14m downstream of Bollen Road while a further cross section (X20) was surveyed 67m upstream of the culvert. The surveyed cross sections for X19 and X20 are shown in Figure 31 and Figure 32 respectively.

Figure 30: Cross section X19 and X20; Bollen Road

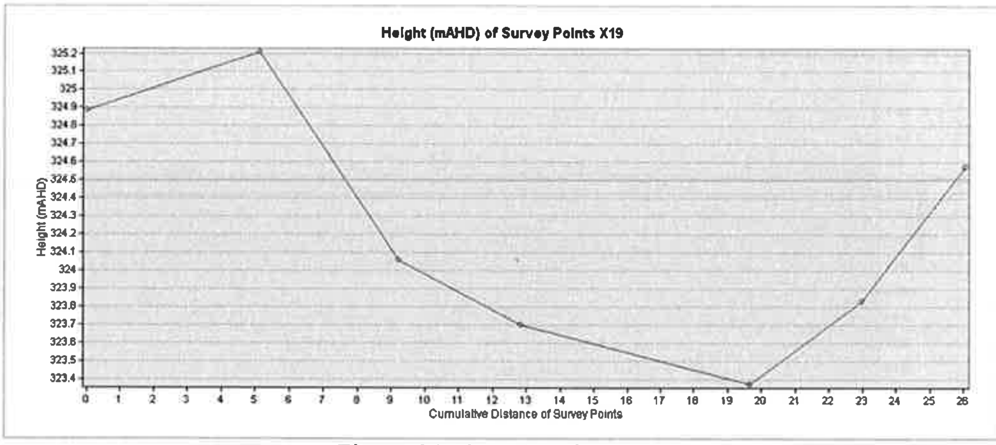

Figure 31: Cross section X19

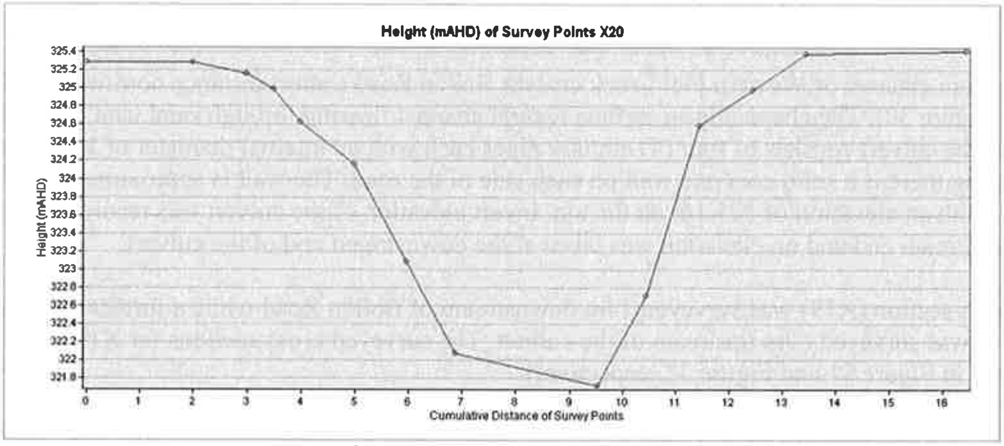

Figure 32: Cross section X20

Site X21 and X22 – Kay Road

Downstream of Bollen Road, Western Flat Creek flows in a north eastern direction towards the town centre. A short distance downstream, Western Flat Creek crosses Kay Road (see Figure 33). The watercourse in this reach was modified and widened to alleviate potential flooding as the north western side of the floodplain has been developed as residential properties over the past few decades. The channel is an earthen channel flowing through rural land. Beneath Kay Road there are three (3) identical culverts with dimension of 2100mm wide and 450mm high. Invert elevation of the culverts was recorded as 321.74m at the upstream end and no elevation was taken at the downstream end.

A cross section (X21) was surveyed 27m upstream of Kay Road while a further cross section (X22) was surveyed 15m downstream of the culvert. The surveyed cross sections for X21 and X22 are shown in Figure 34 and Figure 35 respectively.

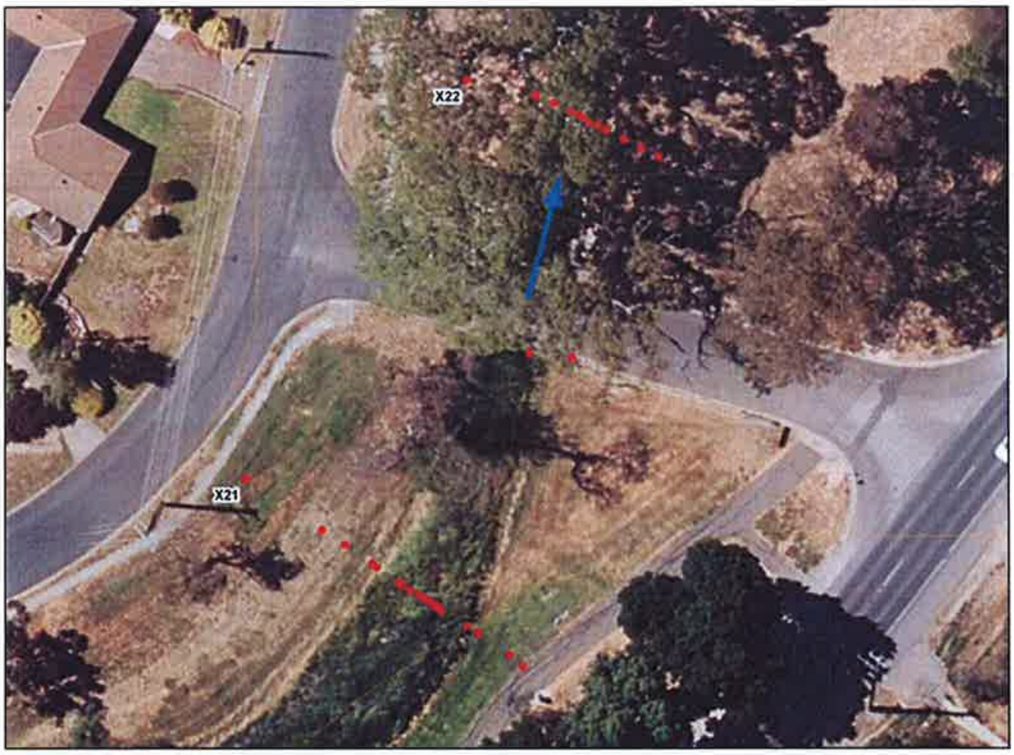

Figure 33: Cross section X21and X22; Kay Road

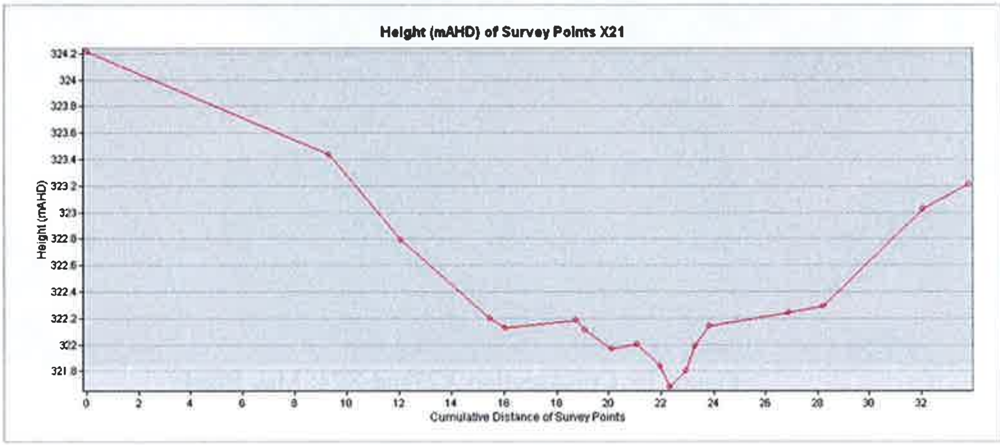

Figure 34: Cross section X21

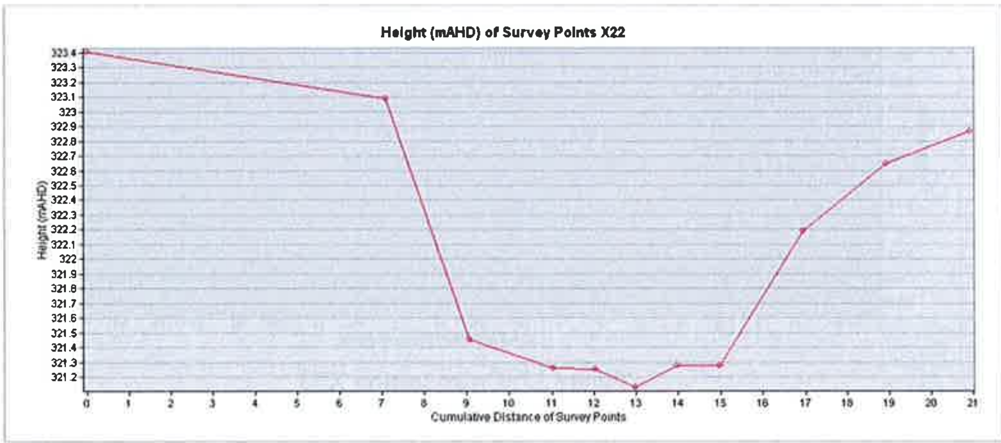

Figure 35: Cross section X22

Site X23 and X24 – May Road

Continuing downstream along Western Flat Creek the main channel is intersected by May Road (see Figure 36). The watercourse in this reach has been modified to alleviate potential flooding of adjacent residential properties. The culvert structure consists of two (2) identical box culverts with dimension of 4450mm wide and 1850mm high. Invert elevation of the culverts was recorded as 318.84m at the upstream end and 318.7m at the downstream end of the culvert.

A cross section (X23) was surveyed 15m downstream of May Road while a further cross section (X24) was surveyed 30m upstream of the culvert. The surveyed cross sections for X23 and X24 are shown in Figure 37and Figure 38 respectively.

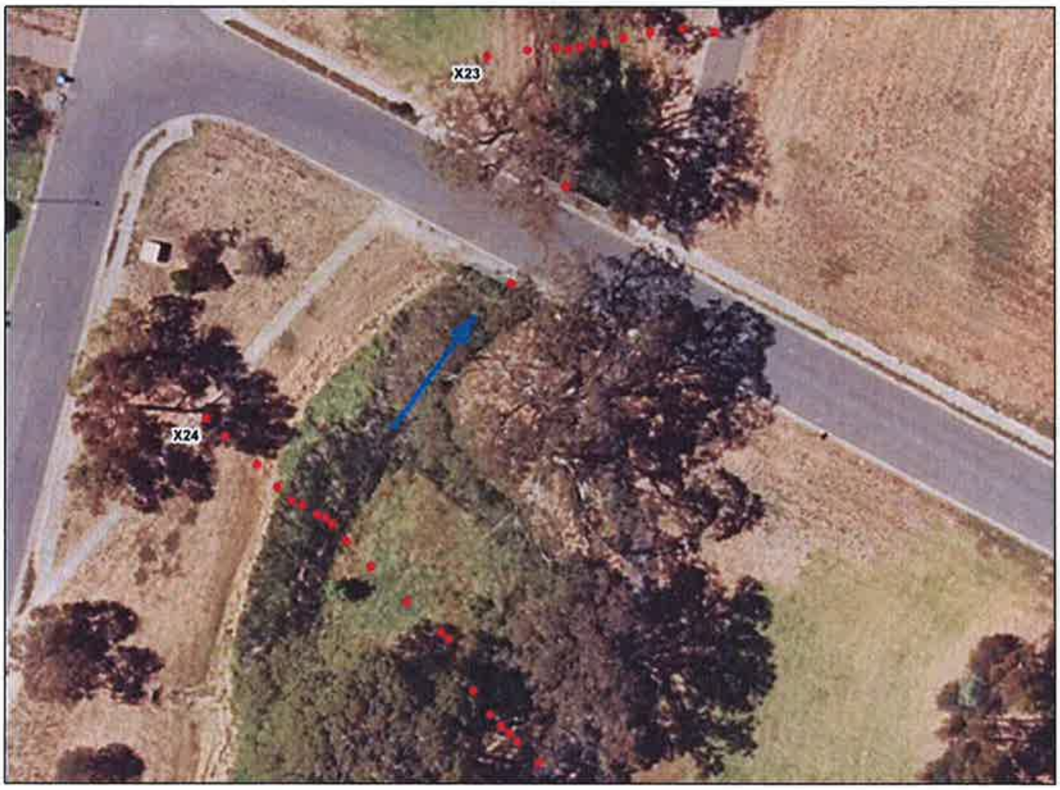

Figure 36: Cross section X23and X24; May Road

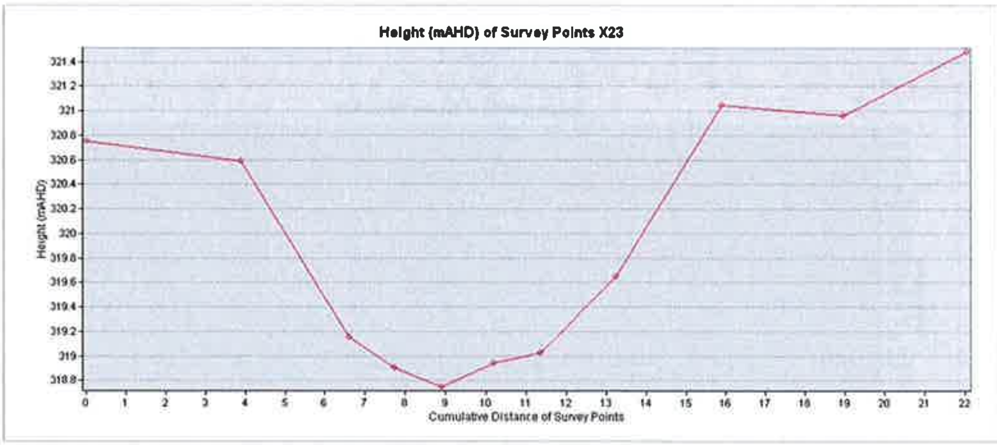

Figure 37: Cross section X23

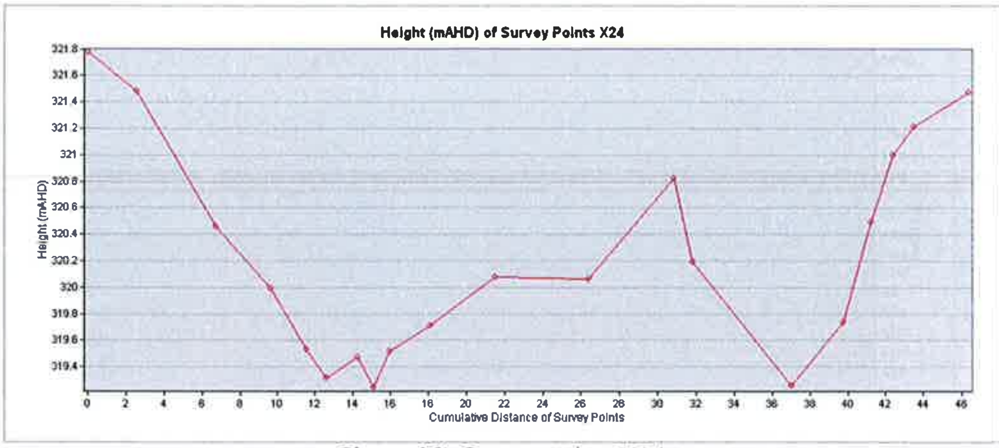

Figure 38: Cross section X24

Site X25 and X26 – Adelaide Road

Western Flat Creek enters the town centre area as it crosses beneath Adelaide Road (see Figure 39). The culvert consists of two (2) different types of channel. One side has a concrete floor and provides a pedestrian link under Adelaide Road. The other side is an earthen channel. A one (1) metre high concrete wall separates the two channel types. The culvert structure consists of three (3) identical box culverts with dimension of 2900mm wide and 2300mm high. Invert elevation (earthen channel) of the culverts was recorded as 315.18m at the upstream end and 315.23m at the downstream end of the culvert.

A cross section (X25) was surveyed 11m downstream of Adelaide Road while a further cross section (X26) was surveyed 15m upstream of the culvert. The surveyed cross sections for X25 and X26 are shown in Figure 40 and Figure 41 respectively.

Figure 39: Cross section X25and X26; Adelaide Road

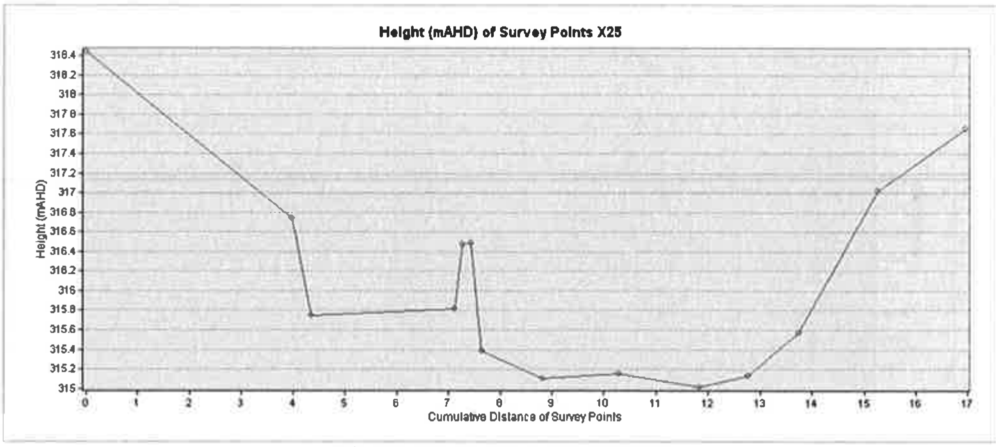

Figure 40: Cross section X25

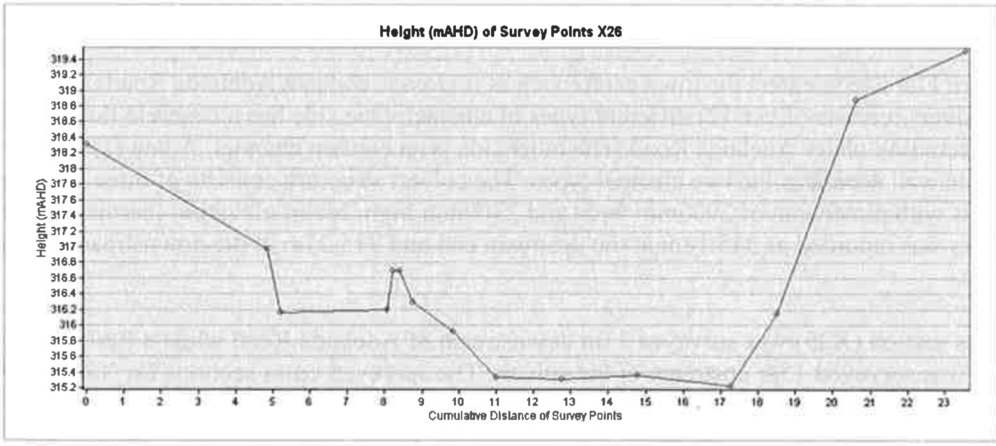

Figure 41: Cross section X26

Site Bridge – Railway

The railway bridge on Mount Barker Creek is located just downstream of the junction with Western Flat Creek (see Figure 42). The watercourse is a natural open channel. The structure is a railway bridge and abutment having the dimensions of 21100mm wide and 4780mm high. Top of the sleepers is 314.59mAHD. The natural surface elevation is 309.81m.

Figure 42: Bridge; Railway

Site X27 –Gawler Street

Gawler Street crosses Littlehampton Creek and provides a link to the more recently developed north eastern region of Mount Barker. The watercourse consists of natural open channel and the structure is a road bridge deck and abutments (see Figure 43). Bridge dimensions are 6000mm wide (between abutments on each side of the watercourse) and 2570mm high form natural surface to bottom of bridge girders. The length from upstream to downstream is 10100mm (on each abutment face). Elevation at the top of the deck is 318.13m. Invert elevation of the watercourse on the upstream side of the bridge is 314.50m. No invert elevation was taken at the downstream side.

The upstream cross section (X27) is 29m from the bridge and shown in Figure 44. Downstream of the bridge the watercourse is densely vegetated with mature trees.

Figure 43: Cross section X27; Gawler Street

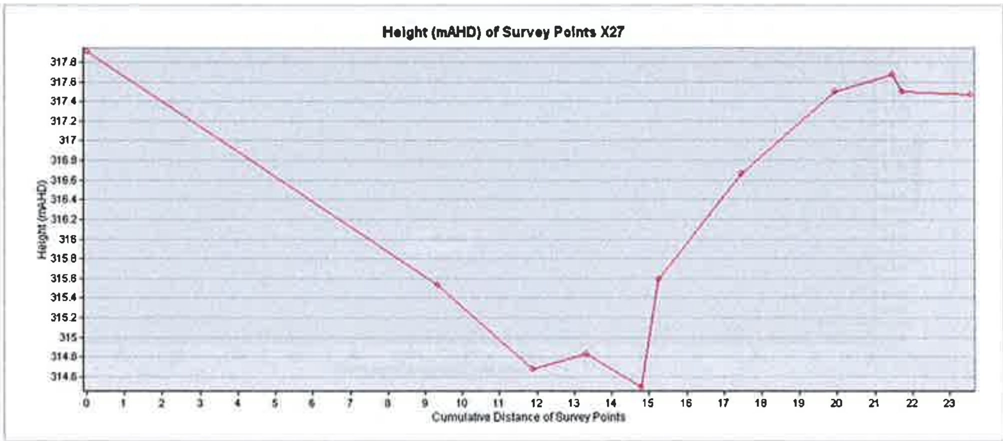

Figure 44: Cross section X27

Site X28 –Hutchinson Street

Hutchinson Street is the last significant road crossing (see Figure 45) before Western Flat Creek discharges to Mount Barker Creek. The watercourse consists of two (2) types of channel; a concrete sealed floor and an open earth channel. The two (2) types of channel are divided by a concrete wall approximately one (1) metre high. The structure is road bridge deck and abutment having a width of 8050mm and height 3550mm. There were no invert elevations taken at the bridge.

The surveyed cross section (X28) was taken 5m upstream of the bridge is shown in Figure 46. The elevations from distance 15 to 30 are approximate. The actual cross-sectional general shape is similar to X25 (see Fig 40).

Figure 45: Cross section X28; Hutchinson Street

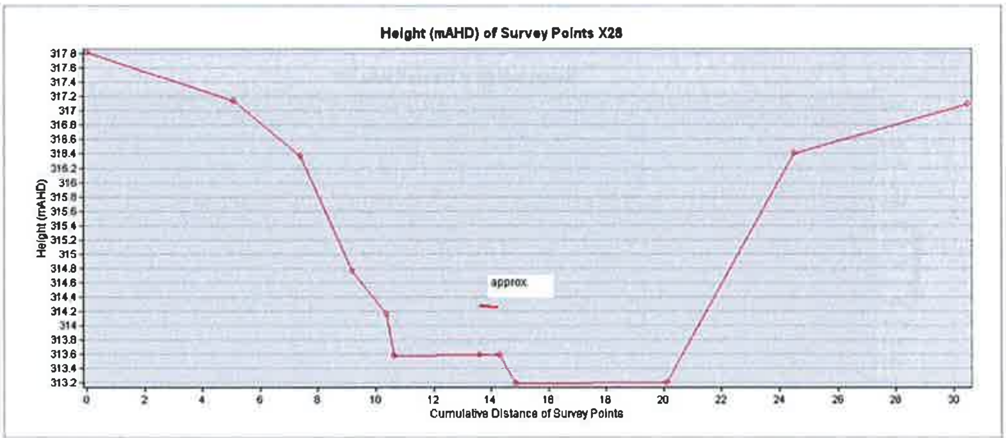

Figure 46: Cross section X28

Site X29 –Fletcher Road

Fletcher Road is the final road crossing (see Figure 47) along Railway Creek prior to discharging to Mount Barker Creek. The watercourse consists of an open earth channel but is somewhat constrained due to the surrounding residential development. The structure consists of one (1) concrete box culvert of dimensions 5850mm wide and 1900mm high. Invert elevation upstream of the structure is 311.06m. There was no elevation recorded at the downstream side. Upstream, the elevation at the top of the headwall is 313.544m and the footpath is at 314.256m.

A cross section (X29) was recorded 6m upstream of the culvert and is shown in Figure 48.

Figure 47: Cross section X29; Fletcher Road

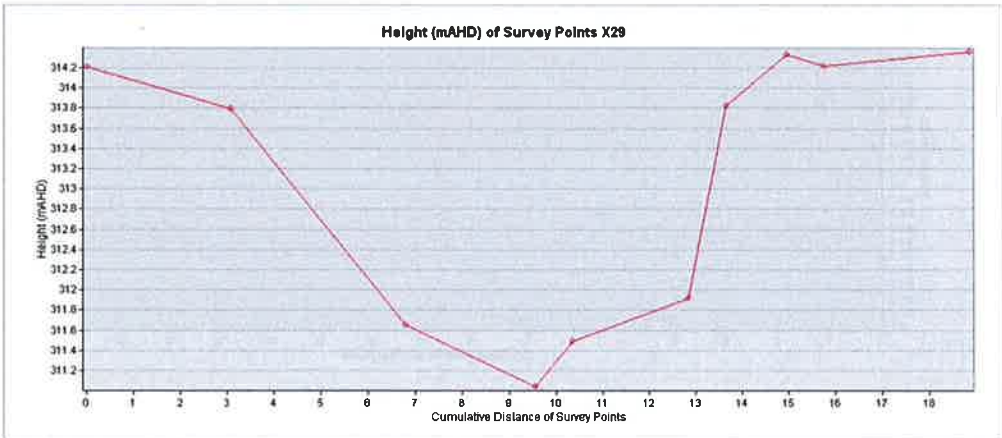

Figure 48: Cross section X29

Site X30 –Springs Road

Springs Road was the most downstream channel crossing that was surveyed (see Figure 49). The watercourse at this location is described as a natural open channel. The structure is a road bridge deck and abutment having the dimension of 23.35m wide and 4.60m high. Elevation of the top of the deck is 304.73m. Invert elevation at the downstream side of the bridge is 299.96m.

A cross section (X30) was surveyed 157m upstream of the bridge and is shown Figure 50.

Figure 49: Cross section X30; Springs Road

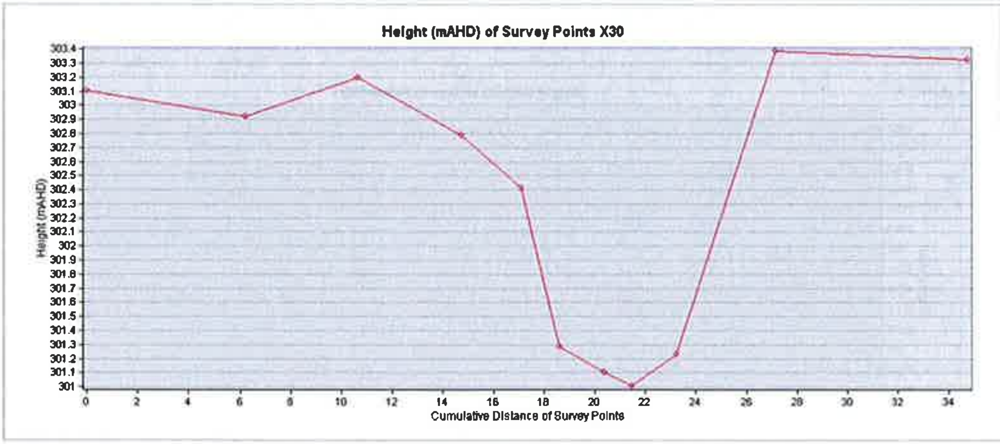

Figure 50: Cross section X30

Site X31 – Bald Hills Road

The crossing of Mount Barker Creek through Bald Hills Road was surveyed (see Figure 51). The watercourse at this location is described as a natural earthen channel. The structure is four (4) culverts above four (4) pipes. The dimensions of the culverts are 1800mm wide and 1200mm high. The pipes are all 500mm diameter. Invert upstream elevations of the pipes is 304.57m and 305.63m at the culverts.

A cross section (X31) was taken 31m upstream of Bald Hills Road and is shown in Figure 52.

Figure 51: Cross section X31; Bald Hills Road

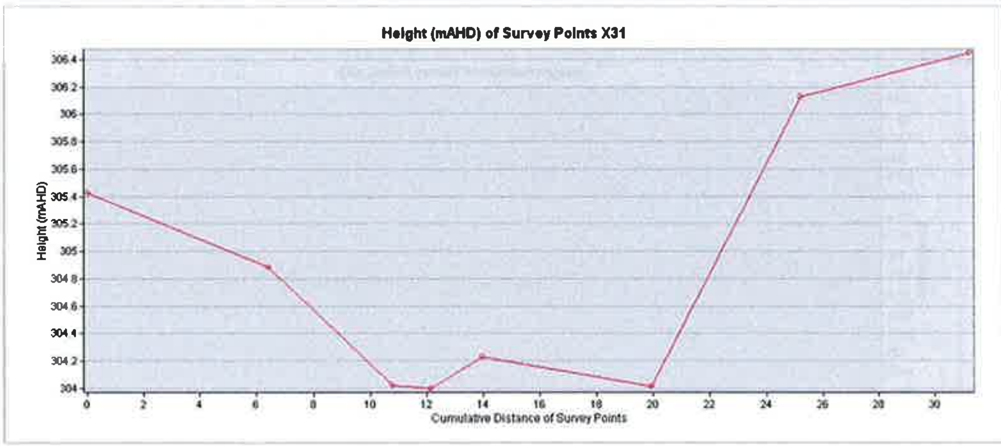

Figure 52: Cross section X31

Site X32 – Cameron Road

Survey was undertaken at the Cameron Road crossing (see Figure 53) which is located on Littlehampton Creek upstream of the township but downstream of the South Eastern Freeway. The watercourse is an open earthen channel but further along becomes constrained by residential and commercial developments adjacent to the banks. The structure is a single culvert with dimensions of 4440mm wide and 2600mm high. Invert elevation at the upstream end of the culvert is 319.34m and 319.33m at the downstream end. The bridge deck has an elevation of elevation 324.03m.

A cross section (X32) was surveyed 33m downstream from the culvert and is shown in Figure 54.

Figure 53: Cross section X32; Cameron Road

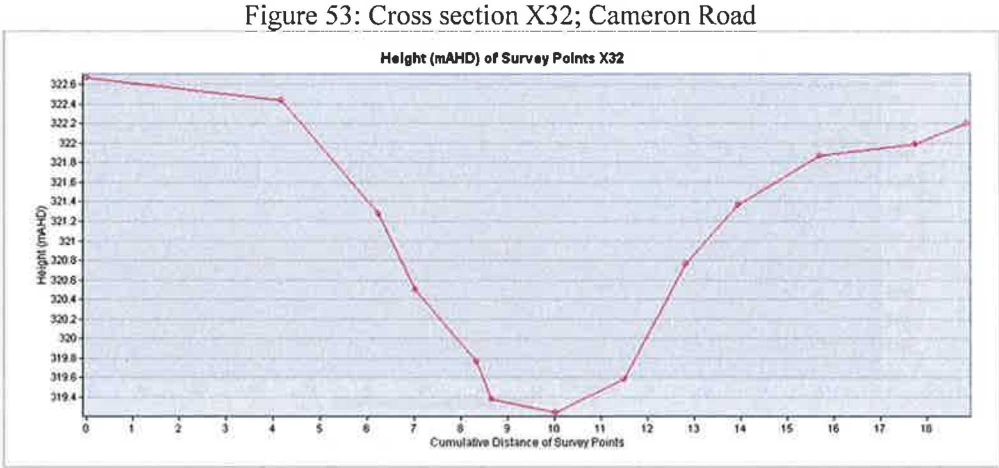

Figure 54: Cross section X32

Site X33 and X34 (35, 36) – S. E. Freeway

Littlehampton Creek flows through the South Eastern Freeway (see Figure 55) and details of this structure have been collected in the survey. Both upstream and downstream of the culvert beneath the South Eastern Freeway the watercourse is described as open earth channel. The structure is single steel corrugated oval shaped culvert. Measured dimensions of the culvert were 3480mm wide by 3800mm high. Invert elevation at the upstream side of the freeway is approximately 325m. The invert elevation at the downstream end is approximately 324.4m. Point number 35 and 36 are approximate locations of each end of the pipe.

Two (2) cross sections (X33 and X34) were surveyed 99m and 130m upstream of the culvert respectively. These cross sections are shown as Figure 56 and Figure 57. At site X34 there is a constructed concrete weir with a rectangular notch.

Figure 55: Cross section X33 and X34 (35, 36); S. E. Freeway

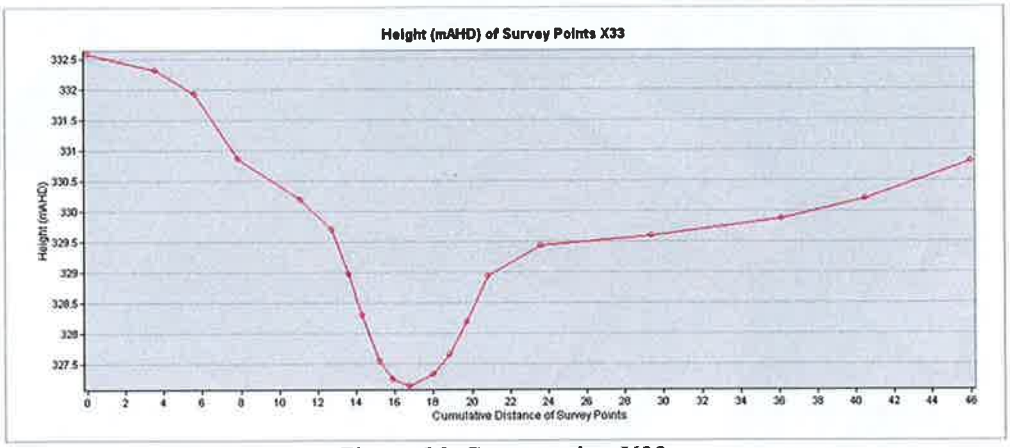

Figure 56: Cross section X33

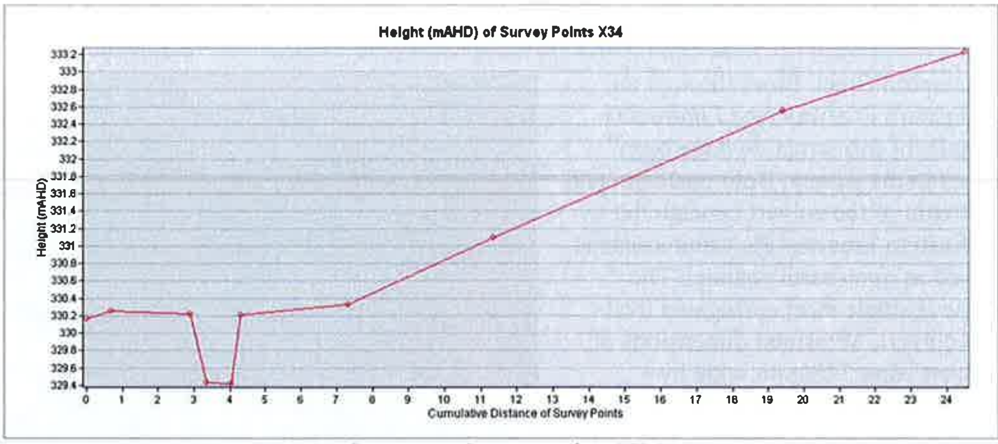

Figure 57: Cross section X34

Site 37 – Adelaide Road

The final survey location was where the local channel is directed into an underground drainage system along Adelaide Road (see Figure 58). The dimensions of the culvert are 2150mm wide and 900mm high. The invert elevation at the upstream end of the pipe is 335.42m. Natural surface elevation at top of inlet is 336.72m.

Figure 58; Inlet 37- Adelaide Road

Appendix 1

Aerometrex DTM Project Specifications

• Generate DTM data from imagery and manually edit in 3D where necessary, concentrating on the actual creek bed and surrounding area in particular. Breaklines and extra spot heights will be captured as part of this process.

• As a guide to the horizontal and vertical accuracy obtainable from this resolution, see the table below:

Horizontal +/- 0.36m RMSE
Vertical +/- 0.10m (68% c.i., 1?)
+/- 0.20m (95% c.i., 2?)
Contours 0.5m

Mt Barker Flood Mapping Study, data output to Australian Water Environments.

Date of 15cm photography: 8th December 2008
Date of 60cm photography: 20th December 2008
Camera: Vexcel Ultracam D
Pixel Size: 15cm and 60cm
Horiz: GDA94, MGA Zone 54
Vert: AHD
Supply Date: 11th January 2010

Data Detail:

DTM\MtBarker_3m_grid.xyz - XYZ ascii DTM file of 3m x 3m grid points.

DTM\MtBarker_3m_grid_&_50cmbreakpoints.xyz - XYZ ascii DTM file of 3m x 3m grid points with breaklines interpolated to points every 50cm.

CONTOURS\MtBarker_contours.dwg - Autocad File Format of 0.5m contours with 2.5m index contours.
CONTOURS\MtBarker_contours.dxf - DXF File Format of 0.5m contours with 2.5m index contours.
CONTOURS\MtBarker_contours.dgn - Microstation File Format of 0.5m contours with 2.5m index contours.

BREAKLINES\MtBarker_breaklines.dwg - Autocad File Format of Breaklines.
BREAKLINES\MtBarker_breaklines.dgn - Microstation File Format of Breaklines.
BREAKLINES\MtBarker_breaklines.dxf - DXF File Format of Breaklines.