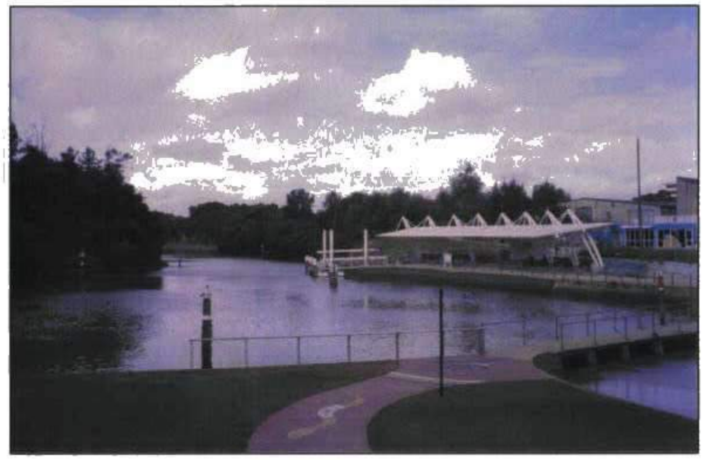
SINCLAIR KNIGHT MERZ

SKM

Lower Parramatta River Floodplain Risk Management Study



FLOOD STUDY REVIEW

Final

March 2005

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1. Introduction and Background

Parramatta City Council (PCC) commissioned Sinclair Knight Merz (SKM) in October 2001 to undertake a study entitled "Lower Parramatta River Floodplain Risk Management Study" (LPR-FRMS). The study encompassed the first three steps in the process set out by the NSW Government's Floodplain Management Manual (2001), namely Data Collection, Flood Study and Floodplain Risk Management Study.

This report describes the Data Collection and Flood Study aspects of the LPR-FRMS. The outcome of the Floodplain Risk Management Study component of the LPR-FRMS is produced in a separate report.

1.1 Reasons for This Study

In March 1999 PCC undertook a review of flood information held by Council, the methodology utilised in mapping flood inundation extents, and the way in which this information is utilised while implementing Council's existing Flood Prone Land Policy. The review focussed on those parts of the Parramatta River and its tributaries that lie downstream of the Charles Street weir.

The principal flood study used in Council's flood inundation extents mapping and for the application of its relevant policy referred to above, for lands downstream of the Charles Street weir is the *"Lower Parramatta River Flood Study"*. This document was prepared in 1986 by Willing and Partners for the NSW Public Works Department. Numerous other flood studies for the major tributaries rely on the results of the 1986 study.

The PCC review identified that the results predicted in the 1986 study would now be subject to variability due to changes in the catchment (such as urbanisation, flood mitigation in the upper catchment areas of the Parramatta River, etc). This would have led to changes in a range of significant hydrologic and hydraulic elements utilised in the 1986 flood modelling processes. Because of the issues identified, Council's information relating to flooding used for S149(2) and (5) certificates, the assessment of development applications and the potential rezoning of land, needed to be revised.

It was also recognised that the existing flood extents mapping was based on the best information available to staff, but was of varying levels of reliability and that Council's mapping reflected predicted inundation *(ie flood depths only)*. Modern Floodplain Management requires a floodplain to be assessed and mapped in terms of flood hazard, that is: a function of flow depth, flow velocity and other factors such as evacuation routes.

As a result of this investigation PCC initiated the preparation of the Lower Parramatta River Floodplain Risk Management Study, that included a complete review of existing flood studies for the Parramatta River and its tributaries.

1.2 Study Area

The Lower Parramatta River is located within the broader catchment area of Sydney Harbour. The Study Area comprises the waterways, tributaries, foreshores and adjacent low lying lands of the Lower Parramatta River from the Charles Street weir to Ryde Bridge.

The catchment is highly urbanised with some development extending into the floodplain. Some development within the study area is prone to flooding with potentially high hazard and damage. Within the broad Study Area the *LPR-FRMS* has studied the following areas:

- Lower Parramatta River from the Charles Street weir to Ryde Bridge;
- The entire drainage system associated with Clay Cliff Creek
- Vineyard Creek to estuarine limit;
- Subiaco Creek to estuarine limit;
- A'Becketts Creek to estuarine limit;
- Duck Creek[1] to estuarine limit;
- Duck River to estuarine limit; and
- Other trunk drainage mains that outfall to the Lower Parramatta River or its tributaries between Charles St weir and Ryde Bridge.

The study area is shown in **Figure 1-1** and the major creeks are shown in **Figure 1-2**.

[1] During the course of this study, a separate study has been undertaken for the whole of the Duck Creek catchment and so it was decided to exclude the estuary of Duck Creek from this study. Flood level and other information in Duck Creek can be found in the Duck Creek Sub-catchment Management Study, 2004.

■ **Figure 1-1 Lower Parramatta River Study Area**

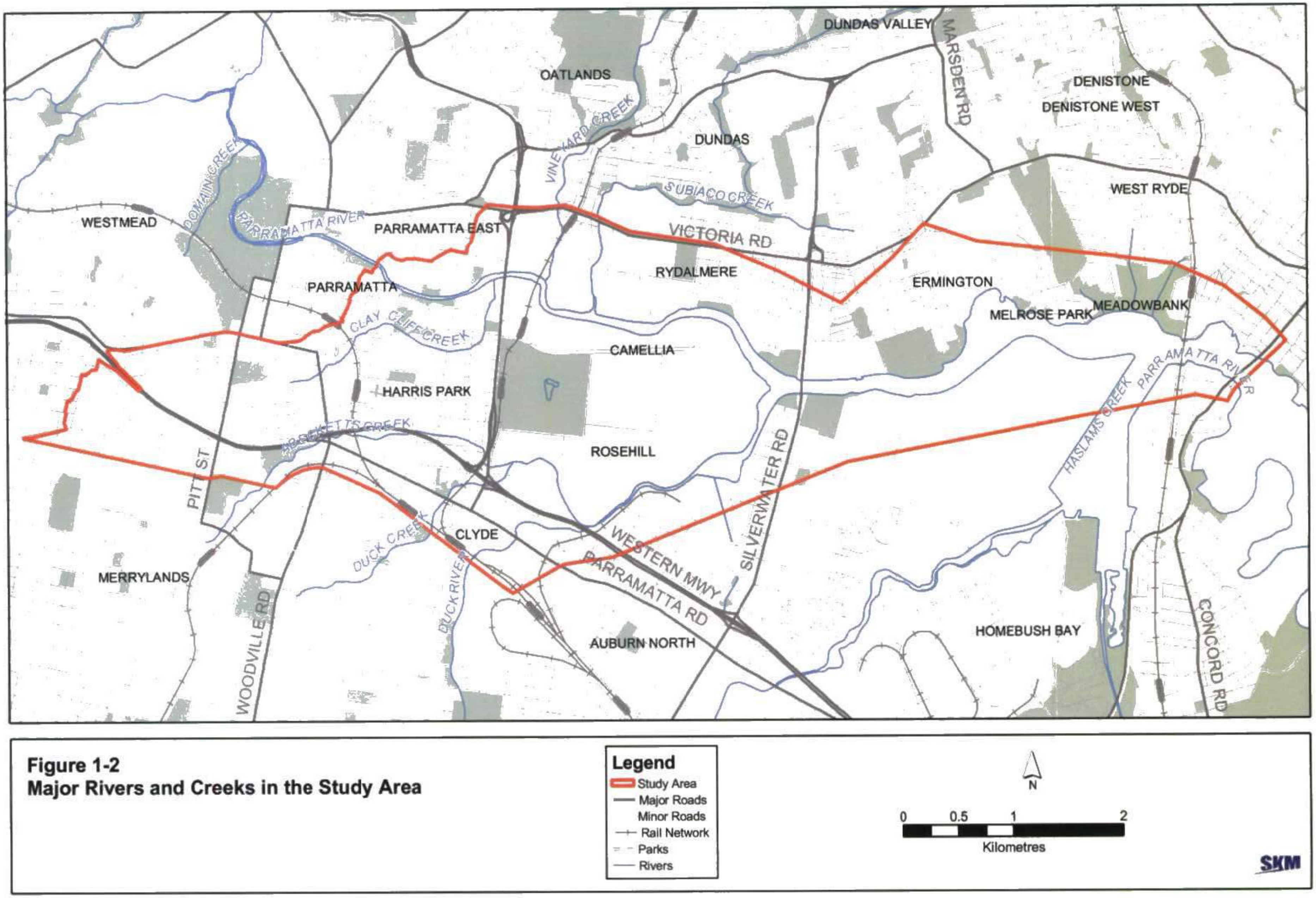

Figure 1-2
Major Rivers and Creeks in the Study Area

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2. Data Available

2.1 Previous Studies

Reports from a number of previous studies were reviewed as part of the current study. Also available were a number of computer models developed in previous studies. The following reports and computer models were available:

- Willing and Partners Pty Ltd (1986) *Lower Parramatta River Flood Study* for the Public Works Department;
- Bewsher Consulting (1990) *A'Becketts Creek SWC No. 46 Catchment Management Study* for the Water Board – computer model was available;
- Bewsher Consulting *Haslams Creek Floodplain Management Study* for Auburn Council –computer model was available;
- Bewsher Consulting (1998) *Boundary Creek Floodplain Management Study and Plan* for Strathfield Municipal Council; computer model was available;
- Brian O'Mara and Associates (1992) *Duck River Flood Study;*
- Brian O'Mara and Associates (1994) *Duck River Study* for Parramatta Council;
- Dalland and Lucas (1992) *Clay Cliff Creek Catchment Flood Study* for Parramatta City Council;
- Dalland and Lucas (1993) *Addendum No. 1 to Clay Cliff Creek Catchment Flood Study* for Parramatta City Council; computer models were available;
- Sinclair Knight and Partners (1991) *Subiaco Creek Flood Study* for Parramatta City Council; all computer models were available;
- Sinclair Knight and Partners (1991) *Duck Creek SWC No. 35 Catchment Management Study* for the Water Board; all computer models were available;
- Sinclair Knight and Partners (1992) *Subiaco Creek Flood Mitigation Study* for Parramatta City Council; all computer models were available;
- Sinclair Knight and Partners (1992) *Vineyard Creek Flood Study* for Parramatta SCity Council - all computer models were available;and
- Webb, McKeown and Associates Pty Ltd (1998) *Powells Creek and Saleyards Creek Flood Study* for Strathfield Municipal Council.

2.2 Streamflow Data

Our discussions with the NSW Department of Infrastructure, Planning & Natural Resources (DIPNR), formerly known as NSW Department of Land and Water Conservation (DLWC), Upper Parramatta River Catchment Trust (UPRCT), PCC and Sydney Water Corporation reveal that there is no streamflow gauging station within the study area.

2.3 Topographic Data

Topographic data to be used in the hydraulic model was available from the following sources:

- Airborne Laser Survey (ALS) carried out in December 2001;
- Waterways Authority bathymetric data;
- Survey of waterway crossings carried out specifically for this study;
- Roads and Traffic Authority (RTA) and State Rail Authority (SRA) data on structures; and
- Previous Studies.

The topographic data obtained from each of these sources is described below.

2.3.1 Airborne Laser Survey

Airborne Laser Survey (ALS) was undertaken over the entire study area in December 2001. This provided elevations at discrete locations, with spot levels at approximately 2.5m intervals. This data was converted to contours with a 0.5m contour interval. PCC supplied ALS data and 0.5m contour data to SKM for use in this study. A sample of the spot level data is included in **Appendix A**.

2.3.2 Bathymetric Data

Bathymetric data was obtained from the Waterways Authority. This included approximately 22,000 soundings covering the following areas:

- Parramatta River between Charles Street weir and Ryde Bridge;
- A 1.8 km reach at the downstream end of Duck River; and
- Homebush Bay.

The soundings were taken over a period of time, with data obtained on many different occasions making up the complete data set.

In addition to the soundings, the Waterways Authority provided 20 cross-sections through the Parramatta River. These were surveyed for a recent study in the Parramatta River. These cross-sections covered a 4.5km reach of the Parramatta River; the most upstream cross-section was close to Charles Street weir and the most downstream cross-section was at the Duck River confluence. The locations of these cross-sections are shown in **Appendix A**.

The Waterways Authority also provided information detailing the location of all seawalls within the study area.

2.3.3 Field Survey

Field survey was undertaken in April 2002 specifically for this study. A total of approximately 70 cross-sections were surveyed to gather details of existing creek bed and floodplain levels and structures such as bridges and culverts. Some photographs of the cross-section locations are included in **Appendix A**.

2.3.4 RTA and SRA

Some details of road and railway bridges in the study area were obtained from the Roads and Traffic Authority (RTA) and State Rail Authority (SRA) respectively.

2.3.5 Previous Studies

Cross-section data was available in some of the previous studies (listed in **Section 2.1**) for the following creeks:

- Clay Cliff Creek;
- Vineyard Creek; and
- Subiaco Creek.

2.4 Tide Level Data

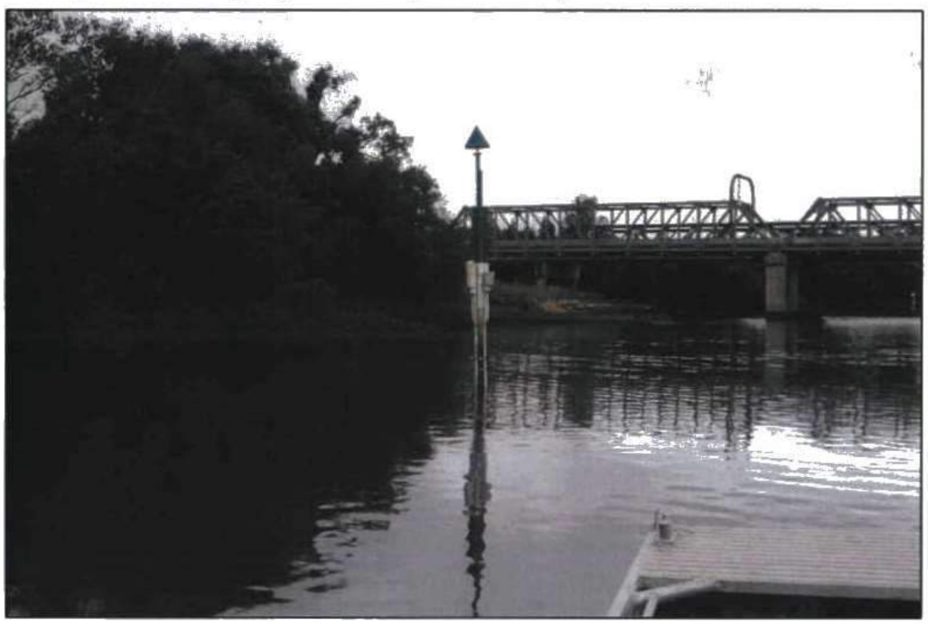
Manly Hydraulics Laboratory, Waterways Authority and Sydney Ports Corporation were contacted to check the availability of historic tide level information within the study area. The authorities did not have any detailed information on tides in the Lower Parramatta River within the study area and PCC commissioned Sydney Ports Corporation to monitor tide level data for the period from 8 March 2002 to 10 April 2002 at the following locations:

- Charles Street weir;
- Carlingford Railway;
- Silverwater Bridge; and
- John Whittons Bridge.

Photos of each of the tide gauges are included in **Figure 2-1** to **Figure 2-4**. The observed tide levels at each of these locations have been plotted in **Appendix A**.

- **Figure 2-1 Tide gauge at Charles Street weir**

- **Figure 2-2 Tide gauge at Carlingford Railway**



- **Figure 2-3 Tide gauge at Silverwater Bridge**

- **Figure 2-4 Tide gauge at John Whitton Bridge**

2.5 Flood Levels

Flood level data was available both from previous studies (see **Section 2.1**) and from community consultation (see **Section 2.6**). Available data on flood levels is summarised in **Appendix D**. One of the questions asked of the community in a questionnaire (see **Appendix A** for the full questionnaire) was to provide information on past flooding events, including depths where possible. However most of the data provided related to either flood levels upstream of the project area or to local flooding from local rainfall. Data from previous reports and community consultation formed the baseline against which results from this current study were compared.

2.6 Community Consultation

2.6.1 Reasons for Community Consultation

The local community can provide useful advice on historical flood problems and perceived solutions. It was also useful to gauge the community's views on various floodplain management issues. Community involvement at this stage of the floodplain management process is likely to lead to greater acceptance of the floodplain management plan when it is implemented.

2.6.2 Community Newsletter and Questionnaire

A questionnaire was distributed to residents and businesses within the study area, in order to understand the community's experience of flooding, identify areas that are flood-prone and to gauge the community's priorities regarding floodplain management. The questionnaire is included in **Appendix A**.

It was found that 22% of people who responded to the survey had some experience of flooding either at home or at work. These respondents were asked to identify the location where they had experienced flooding, and the following flood-affected streets were identified:

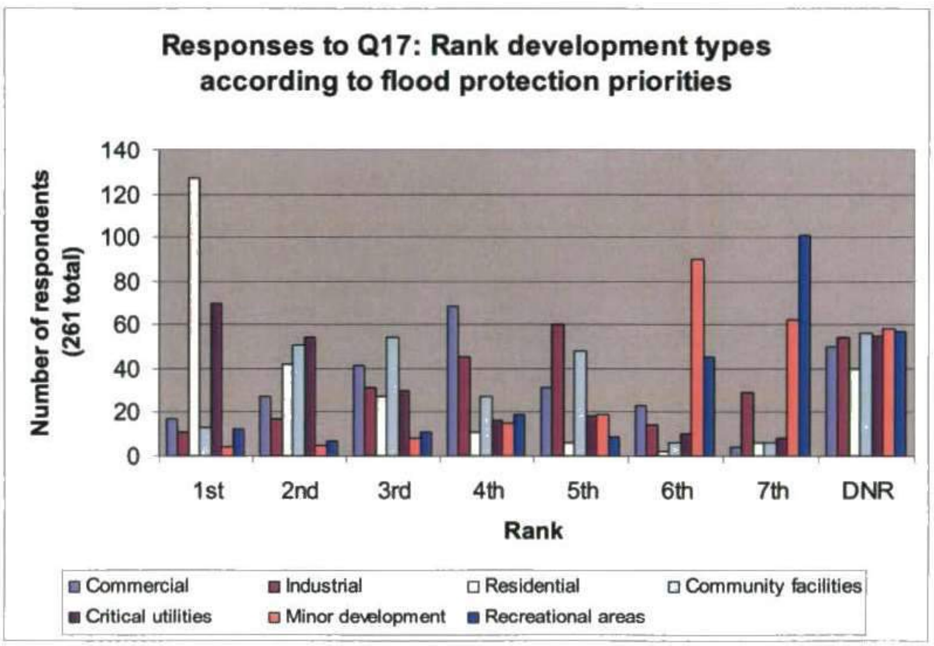
- Noller Parade;
- Arthur Street (north and south end);
- Oak Street;
- Bridge Street;
- Kay Street;
- Alfred Street;
- Brodie Street;
- James Ruse Drive/Hassall Street;
- A'Beckett Street; and
- Grand Ave.

In order to gauge the community's priorities regarding floodplain management, respondents were asked to respond to the following:

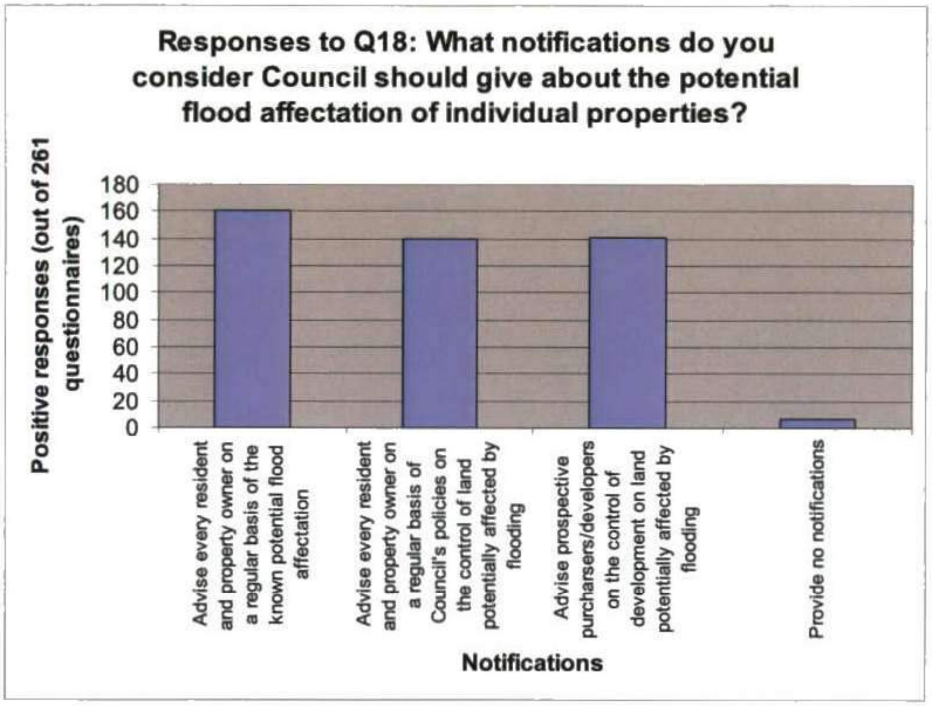
- To rank various development types according to what they considered should be assigned greatest priority in protecting from flooding;
- What notifications they consider Council should give about the potential flood affectation of individual properties;
- To rank various flood protection measures;
- To rank various catchment management measures; and
- To rate their level of satisfaction with Council's service in drainage and flooding areas.

Responses to these questions are summarised in **Figure 2-5** to **Figure 2-9**.

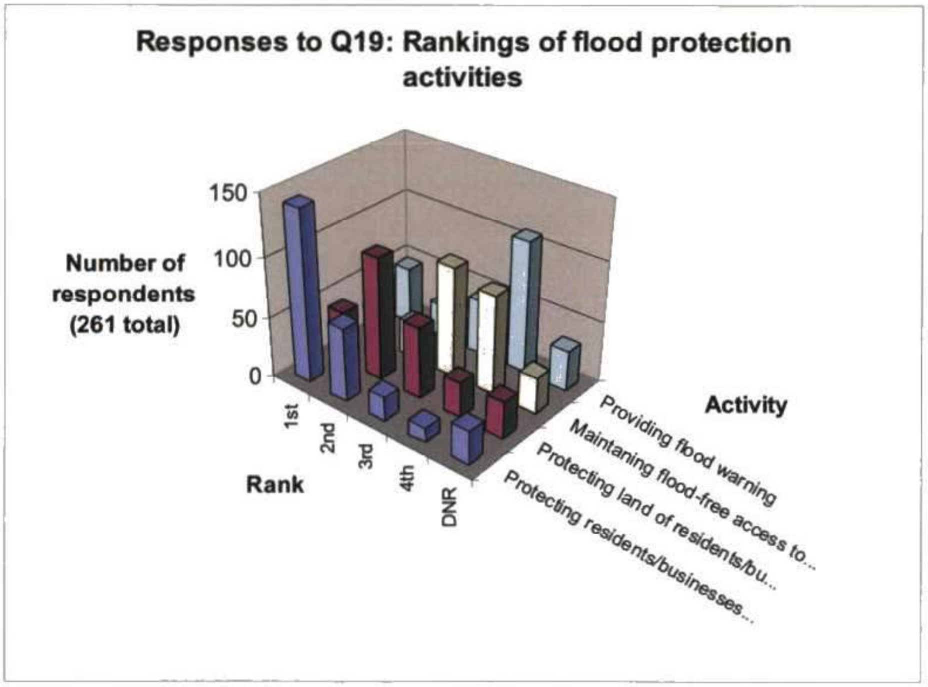
- **Figure 2-5: Rank development types according to flood protection priorities**



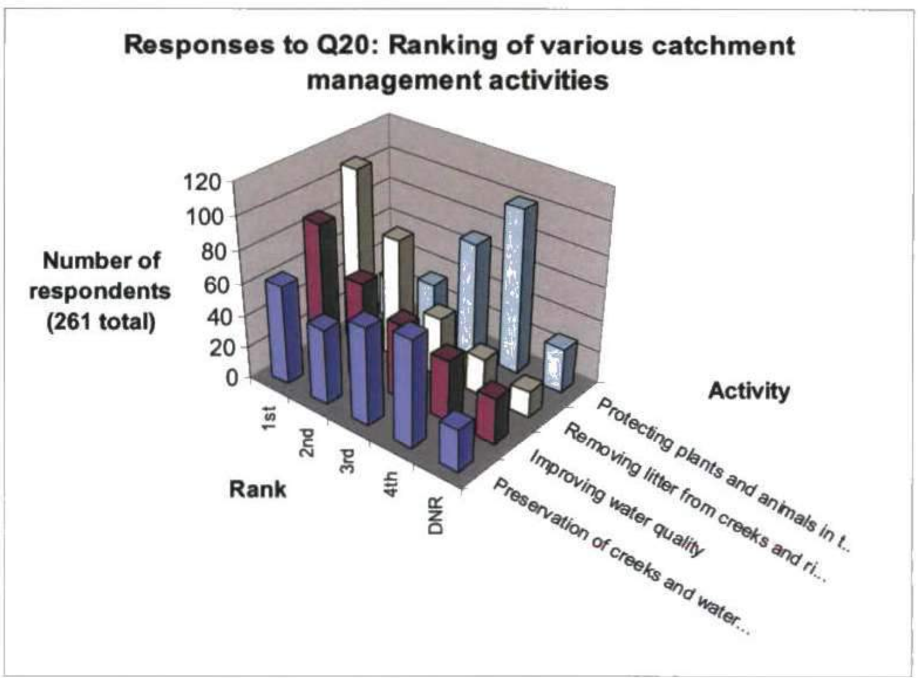
- **Figure 2-6: Council notifications**



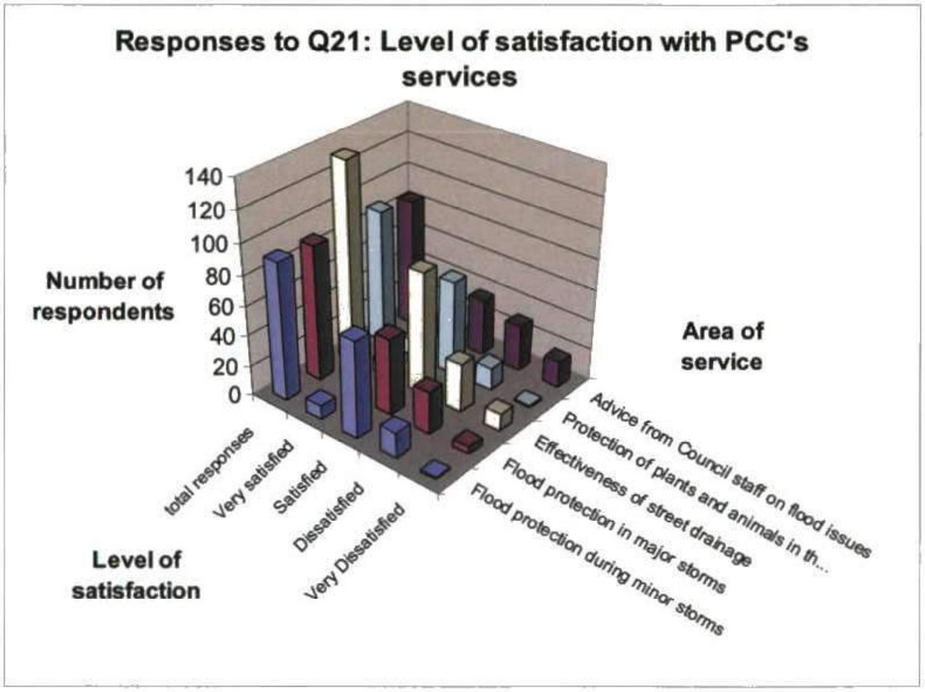
■ **Figure 2-7 Rankings of flood protection activities**



■ **Figure 2-8 Rankings of catchment management activities**



- **Figure 2-9 Satisfaction with level of service**



The results indicate that the community places high importance on protecting residential areas and critical utilities from flooding, and low importance on protection of minor development and recreational areas from flooding.

In terms of notifications, most respondents agreed that Council should:

- Advise every resident and property owner on a regular basis of the known potential flood affectation;
- Advise every resident and property owner on a regular basis of Council's policies on the control of land potentially affected by flooding; and
- Advise prospective purchasers/developers on the control or development on land potentially affected by flooding.

Only a few respondents indicated that Council should provide no notifications.

In terms of flood protection and catchment management activities, respondents ranked the following activities of highest importance:

- Protecting residents/businesses from flooding; and
- Removing litter from creeks and rivers.

Also highly ranked were the following activities:

- Protecting land of residents/businesses from flooding;

- Improving water quality; and
- Preservation of creeks and waterways in a natural state.

Respondents tended to rank the following activities as being of lower importance:

- Maintaining flood-free access to property;
- Providing flood warning; and
- Protecting plants and animals in the study area.

In terms of satisfaction with Council's service, the majority of respondents indicated that they were satisfied with each of the areas listed. Respondents were particularly satisfied with flood protection during minor storms, the effectiveness of street drainage and protection of plants and animals in the study area. Respondents were somewhat dissatisfied with flood protection in major storms and advice from Council staff on flood issues.

2.6.3 Community Workshops

Two community workshops were held as part of LPR-FRMS process. The first was held in May 2002 to discuss the following:

- Introduction, reason for Floodplain Risk Management Study, linkages between flooding, engineering and planning and desired outcomes;
- Description of process for Lower Parramatta River Flood Study Review and Floodplain Risk Management Study;
- Hydrology, flooding and flood modelling;
- Presentation of results of questionnaire;
- Discussion of participants' flood experience; and
- Discussion of what could be done to reduce the impact of flooding.

A second community workshop was held in December 2002 to discuss the following:

- Progress report on flood modelling, environment, hazard mapping and flood damage assessment;
- Overview of the planning framework including land use planning and planning instruments;
- Overview of the flood management process including risk, reducing flood impacts, structural and non-structural flood management measures and assessment of the impact of blockage; and
- Update on the flood planning process including flood planning levels, flood risk precincts and potential for rezoning.

3. Hydrology

The catchment area draining the Upper Parramatta River at Charles Street weir is approximately 108 km^2 and the total catchment area upstream of Ryde Bridge is approximately 212 km^2. Hence, between Ryde Bridge and Charles Street weir, rainfall runoff from 104 km^2 joins the Lower Parramatta River. The Upper and Lower Parramatta River catchments are shown in **Figure 3-1**.

There are many previous studies that have been undertaken on the major tributaries in the Lower Parramatta River catchment, and many of these included models that were available for use in the current study. A list of major tributaries of the Lower Parramatta River and available models is presented in **Table 3-1**.

- **Table 3-1 Major tributaries and existing hydrological models**

Catchment	Area (km^2)	Modelling program	Source or model	Catchment outlet
Upper Parramatta River	108	XP-RAFTS and MIKE-11	Upper Parramatta River Catchment Trust maintain up-to-date hydrological and hydraulic models of the Upper Parramatta River Catchment. Their MIKE-11 model was available for use in this study	Charles Street weir
Clay Cliff Creek	3.1	XP-RAFTS	Dalland and Lucas (1993) *Addendum No. 1 to Clay Cliff Creek Catchment Flood Study* for Parramatta City Council. This model was updated for use in the current study; see details in **Section 3.2.1**	Parramatta River confluence
Vineyard Creek	5.0	RORB	Sinclair Knight and Partners (1992) *Vineyard Creek Flood Study* for Parramatta City Council. This model was updated for use in the current study; see details in **Section 3.2.2**	Parramatta River confluence
Subiaco Creek	8.4	RORB	Sinclair Knight and Partners (1991) *Subiaco Creek Flood Study* Sinclair Knight and Partners (1992) *Subiaco Creek Flood Mitigation Study*	Parramatta River confluence
Duck Creek	9.2	Design Hydrographs creek outlet	Flood Modelling undertaken by Cardno-Willing as part of Duck Creek Sub-catchment Management Plan (2003)	Duck River
Duck River	18.7	N/A	No model was available from the previous study by Brian O'Mara and Associates (1994) A new model was set up using XP-RAFTS (see **Section 3.2**)	Parramatta – Strathfield railway line
Haslams Creek	17.1	XP-RAFTS	Bewsher Consulting *Haslams Creek Floodplain Management Study* for Auburn Council	Upstream side of Bennelong Road (just upstream of the point where Haslams Creek flows into Homebush Bay)
Boundary Creek	0.7	ILSAX	Bewsher Consulting (1998) *Boundary Creek Floodplain Management Study and Plan* for Strathfield Municipal Council	Upstream side of Parramatta Road
Powells Creek	8.4	ILSAX	Powells Creek and Saleyards Creek Flood Study (Webb, McKeown and Associates, 1998) from Strathfield City Council	Where Powells Creek passes under Homebush Bay Drive
Archers, Denistone and Charity Creeks	7.8	N/A	No previous study or model available. A new model was set up using XP-RAFTS (see **Section 3.2**)	Parramatta River confluence

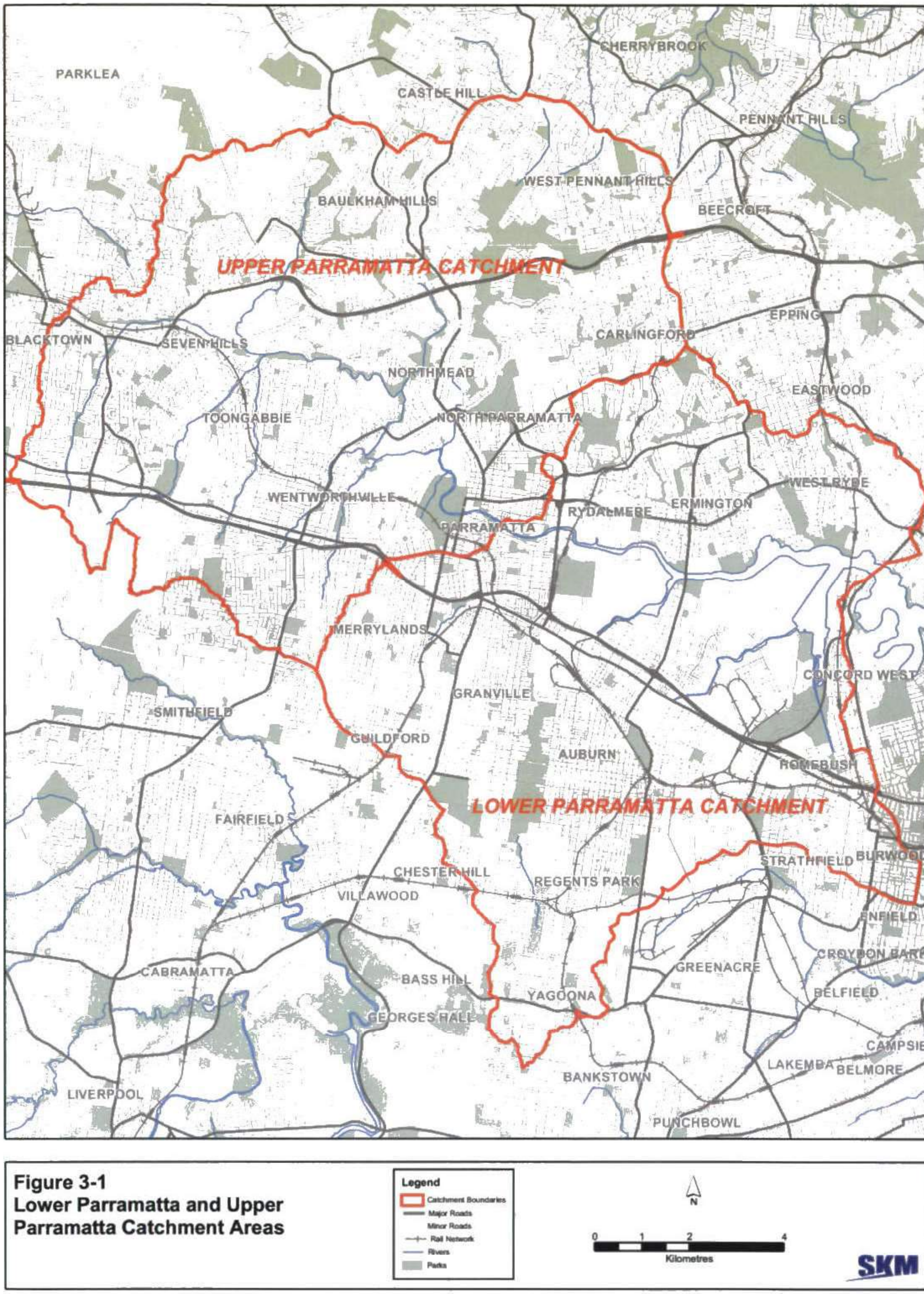


Figure 3-1
Lower Parramatta and Upper Parramatta Catchment Areas

3.1 Hydrological Approach

The approach adopted for this study was to use rainfall-runoff routing models to obtain flow hydrographs, which were then used as the input to the hydraulic model.

Where possible, an existing hydrological model was used for each of the major catchments. **Table 3-1** listed available hydrological models for the major tributaries.

For most of the sub-catchments, existing hydrological models were available. These models had been developed and calibrated against known data and so it would not have been appropriate for this study to develop new models or to change the overall parameters of the model. These models were checked for consistency in terms of impervious fraction and only adjusted where there had been substantial change in the catchment since the model was developed.

In some flood models, the whole of the catchment is modelled as a single catchment in order to provide a 'simpler' model for assessment of flows for a variety of duration floods. However for this study, it was considered more important to use the existing calibrated models and the difficulty of storm durations was overcome by running each sub-catchment for a variety of flow durations until the critical overall flood levels were obtained.

Rainfall patterns (Intensity/frequency/duration (IFD) relationships) were developed using AR&R for Clay Cliff Creek, Vineyard Creek, Subiaco Creek and Duck River. These IFD curves were checked against the IFD curves available from Parramatta, Ryde and Auburn Councils. The modelling did not simply adopt a single IFD curve.

Parramatta City Council plans to update a number of their flood studies and at that time it may be appropriate to modify the models to provide a consistent set of parameters such as percentage impervious, loss rates, etc.

In a few cases, the models were updated for this study, where necessary and run for the relevant design events. The Upper Parramatta River is discussed in **Section 3.1.1**. **Sections 3.1.2** and **3.1.3** discuss the approach in the remainder of the Lower Parramatta River catchment.

For each of the eleven hydrological models shown in **Table 3-1**, hydrographs at the interface of hydrological model and the MIKE-11 model were generated for five different probabilities from 20% AEP to PMF for ten different durations of storm. This provided over 500 flood hydrographs that became the flow input in the MIKE-11 model.

The following design events were modelled:

- 20% AEP;
- 5% AEP;
- 2% AEP;
- 1% AEP; and
- Probable Maximum Flood (PMF).

For the 1%, 2%, 5% and 20% AEP events, durations from 30 minutes to 12 hours were modelled (30 minutes, 45 minutes, 60 minutes, 90 minutes, 2 hours, 3 hours, 4.5 hours, 6 hours, 9 hours and 12 hours). For the PMF, durations from 30 minutes to 150 minutes (30 minutes, 45 minutes, 60 minutes, 90 minutes, 2 hours and 150 minutes) were modelled.

3.1.1 Upper Parramatta River Catchment

The Upper Parramatta River catchment extends from Baulkham Hills in the north to Greystanes in the south and from Seven Hills and Prospect in the west to Parramatta town centre at the catchment outlet in the east. Major tributaries in the Upper Parramatta River Catchment include Toongabbie Creek and Darling Mills Creek.

The Upper Parramatta River Catchment, to its outlet at the Charles Street weir, has been modelled by the Upper Parramatta River Catchment Trust (UPRCT). The UPRCT used XP-RAFTS for the hydrology and MIKE-11 for the hydraulics. The MIKE-11 hydraulic model of the Upper Parramatta River Catchment was obtained from UPRCT and run for the 1%, 2%, 5% and 20% AEP events, for a range of storm durations from 30 minutes to 12 hours. Hydrographs were extracted at the catchment outlet at Charles Street weir. These hydrographs formed inputs into the Lower Parramatta River hydraulic model created for this study.

The first model used in the Upper Parramatta River was EXTRAN which was calibrated to the 1988 and 1991 floods. Later the MIKE 11 model was calibrated to the EXTRAN model. However there has been substantial changes in the catchment with a number of basins constructed. These basins have been included in the model but as there has not been any major flood since 1991, the calibration of the current model cannot be verified.

3.1.2 Existing Hydrologic Models

Existing models were obtained for most of the major tributaries of the Lower Parramatta River. Existing models were listed in **Table 3-1**. These models were updated where necessary and run for the relevant design events. This is discussed further in **Section 3.2**.

3.1.3 New Hydrologic Models

There were some areas of the Lower Parramatta River catchment that were not available in any existing hydrological model. These areas included Duck River, Homebush Bay, Archers, Denistone and Charity Creeks and areas on the banks of the Parramatta River. For these areas, an XP-RAFTS model was established and run for the relevant design events. This is discussed further in **Section 3.3**.

3.2 Updating of Available Hydrologic Models

Hydrological models were available for the following tributaries in the Lower Parramatta River catchment:

- Clay Cliff Creek;
- Vineyard Creek;
- Subiaco Creek;

- Haslams Creek;
- Boundary Creek; and
- Powells Creek.

A summary of the available existing models was presented in **Table 3-1**. Most of these models did not require updating, therefore were run with the parameters unchanged. The exceptions were Clay Cliff Creek and Vineyard Creek, which are discussed in **Sections 3.2.1** and **3.2.2**.

3.2.1 Clay Cliff Creek Catchment

Clay Cliff Creek flows to the east and into the Parramatta River at the James Ruse Drive Bridge. It has a catchment area of 310 ha extending from Merrylands in the west to Harris Park in the east.

An XP-RAFTS model of Clay Cliff Creek was reproduced from Dalland and Lucas (1992) report that described the details of an existing RAFTS model. The results of the model were compared to the results obtained from the new model. The major difference between the original model and the new model was that the original model used a single subcatchment at each node to represent the pervious and impervious areas; whereas the new model was improved by using two subcatchments at each node, one representing pervious areas and the other representing impervious areas.

In order to provide consistency, instead of reproducing design rainfall from Dalland and Lucas (1992) rainfall data in the new model, rainfall data from the UPRCT's Upper Parramatta River XP-RAFTS model was used. The intensities were compared and the differences were found to be insignificant.

The XP-RAFTS model was calibrated by running the model for the rural land use and comparing the results to Probabilistic Rational Method estimates.

The Clay Cliff Creek XP-RAFTS model was attached to the XP-RAFTS model that contained Duck River and the remainder of the subcatchments not included in an existing hydrological model.

3.2.2 Vineyard Creek Catchment

Vineyard Creek drains the Rydalmere area and flows to the south into the Parramatta River just downstream of the point where the Carlingford railway line crosses the River.

Sinclair Knight completed a Flood Study of Vineyard Creek in 1992. As part of this study, a RORB model of Vineyard Creek was established. Before running this RORB model, a review of the pervious and impervious fractions in the catchment was undertaken, and the model parameters were updated with revised impervious fractions.

Vineyard Creek receives flow from a catchment of 0.84 km^2 that is diverted from the adjacent Brickfield Creek catchment and piped into the Vineyard Creek catchment. Flow from the diverted catchment was represented by adjusting the outflow from Vineyard Creek catchment.

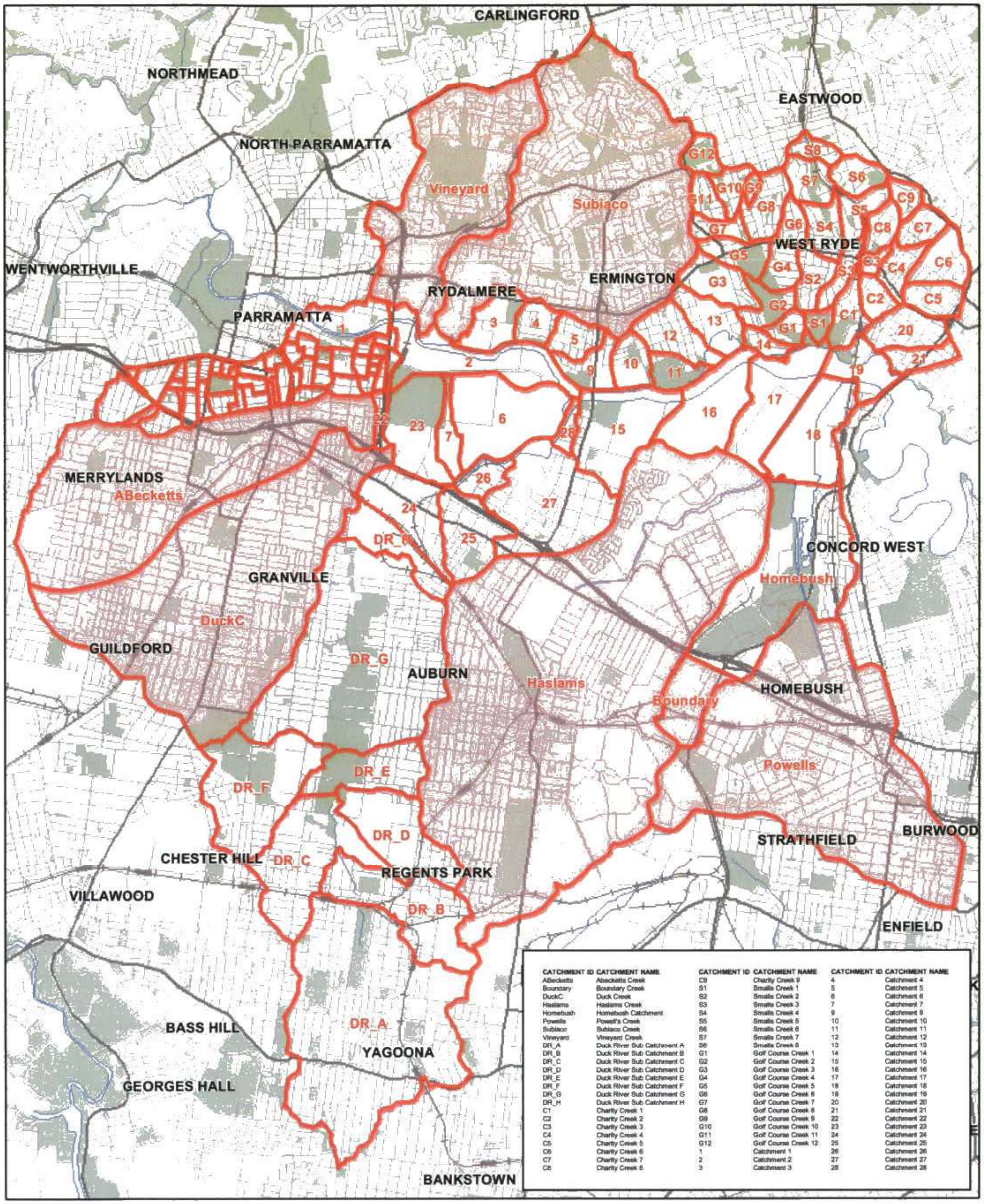
3.3 Development of New Hydrologic Models

3.3.1 Modelling Software

XP-RAFTS version 5.1 was used to establish a hydrological model for the areas in the Lower Parramatta River catchment where an existing model was not available. This version of XP-RAFTS was chosen in preference to XP-RAFTS 2000, because of the forms of output available. Version 5.1 allows hydrographs to be exported from each subcatchment in a format that can be directly converted into a MIKE-11 input file. This form of output was extremely valuable as the model included 80 subcatchments where results were extracted for input into MIKE-11.

3.3.2 Model Set Up

Modelled sub-catchments are shown in **Figure 3-2** and **Figure 3-3.**



CATCHMENT ID	CATCHMENT NAME	CATCHMENT ID	CATCHMENT NAME	CATCHMENT ID	CATCHMENT NAME
ABecketts	Abecketts Creek	C9	Charity Creek 9	4	Catchment 4
Boundary	Boundary Creek	S1	Smalls Creek 1	5	Catchment 5
DuckC	Duck Creek	S2	Smalls Creek 2	6	Catchment 6
Haslams	Haslams Creek	S3	Smalls Creek 3	7	Catchment 7
Homebush	Homebush Catchment	S4	Smalls Creek 4	9	Catchment 9
Powells	Powell's Creek	S5	Smalls Creek 5	10	Catchment 10
Subiaco	Subiaco Creek	S6	Smalls Creek 6	11	Catchment 11
Vineyard	Vineyard Creek	S7	Smalls Creek 7	12	Catchment 12
DR_A	Duck River Sub Catchment A	S8	Smalls Creek 8	13	Catchment 13
DR_B	Duck River Sub Catchment B	G1	Golf Course Creek 1	14	Catchment 14
DR_C	Duck River Sub Catchment C	G2	Golf Course Creek 2	15	Catchment 15
DR_D	Duck River Sub Catchment D	G3	Golf Course Creek 3	16	Catchment 16
DR_E	Duck River Sub Catchment E	G4	Golf Course Creek 4	17	Catchment 17
DR_F	Duck River Sub Catchment F	G5	Golf Course Creek 5	18	Catchment 18
DR_G	Duck River Sub Catchment G	G6	Golf Course Creek 6	19	Catchment 19
DR_H	Duck River Sub Catchment H	G7	Golf Course Creek 7	20	Catchment 20
C1	Charity Creek 1	G8	Golf Course Creek 8	21	Catchment 21
C2	Charity Creek 2	G9	Golf Course Creek 9	22	Catchment 22
C3	Charity Creek 3	G10	Golf Course Creek 10	23	Catchment 23
C4	Charity Creek 4	G11	Golf Course Creek 11	24	Catchment 24
C5	Charity Creek 5	G12	Golf Course Creek 12	25	Catchment 25
C6	Charity Creek 6	1	Catchment 1	26	Catchment 26
C7	Charity Creek 7	2	Catchment 2	27	Catchment 27
C8	Charity Creek 8	3	Catchment 3	28	Catchment 28

Figure 3-2
Lower Parramatta Sub-Catchments

(see Figure 3-3 for Clay Cliff Creek Sub Catchment Labels)

Legend
- Catchment Boundaries
- Existing Models Used
- Major Roads
- Minor Roads
- Rail Network
- Rivers
- Parks

N

0 0.5 1 2
Kilometres

SKM

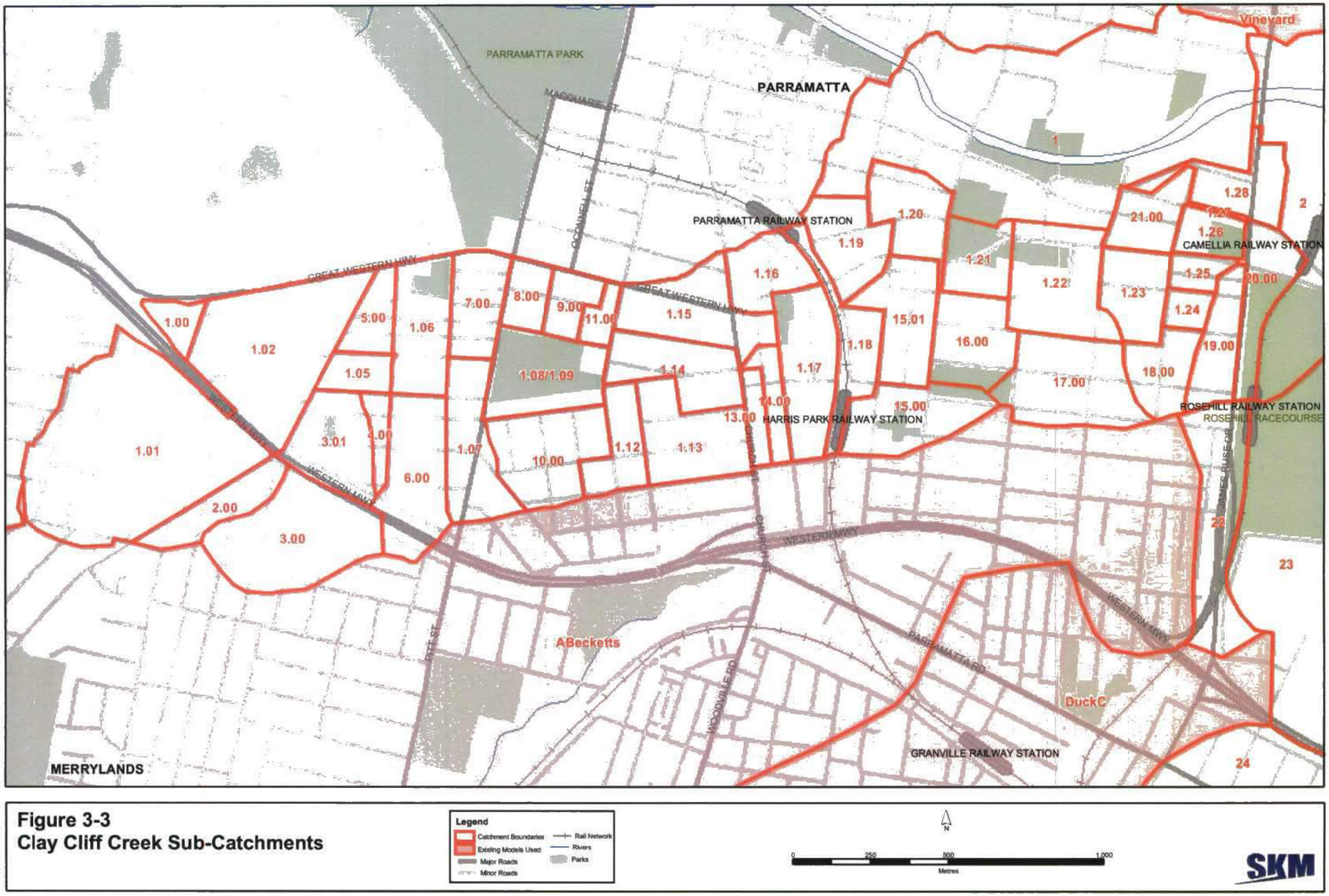


Figure 3-3
Clay Cliff Creek Sub-Catchments

3.3.2.1 Catchment Areas

Subcatchments were delineated using the ALS topographic data (0.5 m contours) where available, and outside the range of this data, ortho-photographic maps with 2-m contours were used. These subcatchments were then digitised using ArcMap, and the catchment areas obtained from the GIS.

3.3.2.2 Pervious and Impervious Fractions

Pervious and impervious fractions for each subcatchment were estimated from AusImage™ (SKM's in-house aerial photography of the Sydney basin) aerial photography. For each subcatchment, the major landuses were identified and the area of each landuse estimated. The following impervious fractions were used for different landuse types:

- Residential – impervious fraction = 45%;
- Industrial/commercial – impervious fraction = 90%; and
- Open space – impervious fraction = 5%.

3.3.2.3 Vectored Slopes

Vectored slopes were calculated for each subcatchment by measuring the length of the flowpath from the highest point in the subcatchment to the subcatchment outlet. The height difference between these two points was divided by the flowpath length.

3.3.2.4 Lag Times

Where necessary, lag times were estimated based on the properties of the flowpath including the nature of the flowpath (for example concrete, natural or overland flowpath), length of the flowpath and the slope of the flowpath. An average flow velocity was assumed based on the nature of the flowpath and the slope. Assumed velocities ranged from 0.8 to 3.5 m/s.

3.3.3 Input for Design Flood Estimation

3.3.3.1 Design Rainfall

Because of the large size of the Lower Parramatta catchment area, it was necessary to vary the modelled rainfall across the catchment area. Simulated time series rainfall data was used to define rainfall in each of the subcatchments. Intensity-Frequency-Duration (IFD) curves and standard intensity patterns from Australian Rainfall and Runoff were used to simulate the time-series data. The following sources of rainfall data were used:

- Upper Parramatta River Catchment Trust: time series rainfall data was obtained from the UPRCT, as used in their model of the Upper Parramatta River Catchment. The UPRCT rainfall data was used for subcatchments at the upstream end of the Lower Parramatta River. Time series rainfall data for the remainder of the Lower Parramatta River catchment was simulated using the same start times as the UPRCT data so that the rainfall data for the Upper and Lower Parramatta River catchments would be compatible;

- Ryde City Council: for Archers, Denistone and Charity Creeks, and nearby subcatchments, an IFD curve provided by Ryde City Council was used to define the rainfall;
- Powells Creek and Saleyards Creek Flood Study (Webb, McKeown and Associates Pty Ltd 1998): some IFD data was obtained from this study, comprising an incomplete set of recurrence intervals and durations. An IFD curve was therefore developed separately to fill in the recurrence intervals and durations where IFD data was not provided in the report. The IFD curve developed was compared to that used in the study and the differences were minimal. This IFD data was used in the area near Powells Creek (Homebush Bay);
- Duck River Study (Brian O'Mara and Associates 1994): IFD parameters were obtained from this Study (presented in Exhibit 5) and used to develop an IFD curve including the relevant recurrence intervals and storm durations. This data was used for the subcatchments of Duck River;
- Auburn City Council: IFD parameters were obtained from Auburn City Council and an IFD curve was developed including the relevant recurrence intervals and storm durations. This IFD data was used in the vicinity of Haslams Creek catchment, on the banks of the Parramatta River;
- Developed from AR&R: for the area on the north bank of the Parramatta River, near Vineyard and Subiaco Creeks, an IFD curve was developed using the parameters presented in Australian Rainfall and Runoff, Volume II.

IFD data was compared across the Lower Parramatta River catchment to ensure that the rainfall intensities were comparable and consistent with a gradual increase in intensity towards the coast.

3.3.3.2 Loss Rates

For all new models only, the following loss rates were adopted for major storm events:

- Pervious areas: initial losses = 15 mm, continuing losses = 1.5 mm/hr; and
- Impervious areas: initial losses = 1.5 mm, continuing losses = 0 mm/hr.

For the PMF, lower loss rates were adopted, see **Section 3.4.2.2**.

3.3.4 Model Calibration

Generally within the study area there is very little data on recorded flood levels. This may be due to the infrequency of major floods and that there are often not many houses in the vicinity of the creeks and river.

All available data on flooding has been summarised in **Appendix D**.

3.3.4.1 Duck River

In the absence of recorded streamflow data, it was not possible to calibrate hydrologic models for tributary catchments. The Duck River section of the model was therefore calibrated against the following results:

- The natural (rural) hydrological model was calibrated against a Probabilistic Rational Method Assessment undertaken as part of the current study as described in AR&R ;
- In the Duck River Flood Study (1992) Brian O'Mara and Associates quote the peak flow obtained from a RAFTS model as well as results from a synthetic unit hydrograph assessment, a Rational Method assessment and an RSWM model (Willing and Partners 1986); and
- In the Parramatta Council Duck River Study (1994), Brian O'Mara and Associates quote the peak flows for the upper and lower parts of the catchment, as well as comparing these to the results presented by Willing and Partners (1986) and to those of a Rational Method assessment.

It was found that the peak flow results obtained for Duck River in this study were higher than most of the peak flows estimated in earlier studies. However, earlier studies only provided very brief details and the results of earlier studies could not be verified. The critical storm remained at 2 hours for the upper part of the catchment (not including Duck Creek and A'Becketts Creek). The natural (rural model) case agreed well with the rural Probabilistic Rational Method estimates, and the existing case showed that flows have significantly increased over the natural case, to a degree consistent with the level of urbanisation.

3.3.4.2 Denistone and Charity Creeks

Ryde Council have a policy of not releasing their computer models to consultants and so SKM had to develop a new hydrological model for Denistone and Charity Creeks. However to ensure consistency with their models, Denistone and Charity Creeks were calibrated to results provided by Ryde City Council. Ryde City council advised the following:

- Archers Creek catchment area is 331 ha but the peak discharges for design events are unknown;
- Denistone Creek catchment area is 215 ha and the peak discharge is 71.3 m^3/s for the 2 hour 100 year ARI storm; and
- Charity Creek catchment area is 237 ha and the peak discharge is 88.6 m^3/s for the 2 hour 100 year ARI storm.

The digitised catchment areas were checked against those provided by Ryde City Council and the lag times and impervious fractions were checked and reviewed until the results from the Lower Parramatta model were consistent to those provided by Ryde City Council. The results from the model are summarised in **Table 3-2**.

Table 3-2 Modelled RAFTS results for Archers, Denistone and Charity Creeks

Creek	Catchment Area (ha)	Critical duration (100 year ARI event)	Peak flow (m^3/s)
Archers	318	90 mins	86.8
Denistone	219	2 hours	69.8
Charity	235	2 hours	88.6

3.4 Derivation of Inflow Hydrographs

The following design flood events were modelled:

- Large flood events: 1%, 2%, 5% and 20% AEP; and
- Extreme flood events: PMP.

3.4.1 Large Flood Events

All hydrologic models were run to generate inflow hydrographs for the selected design flood events between 20% AEP to 1% AEP and for a range of storm durations for the catchment area of the Lower Parramatta River between Charles Street Weir and Ryde Bridge. In the case of RORB models for Vineyard Creek, different runoff coefficients were used in the previous studies for different AEPs. Runoff coefficients used in the previous studies were plotted on log-probability graphs and straight lines were drawn to estimate runoff coefficients for the remaining design flood events.

Inflow hydrographs generated by models were converted into inflow time series for use in the hydraulic model for the Lower Parramatta River.

3.4.2 Extreme Flood Events

3.4.2.1 Lower Parramatta River

SKM undertook a detailed study on the PMF for the Upper Parramatta River Catchment for the UPRCT in November 2001. The methodology recommended in the amended version of the Bulletin 53 (BoM, 1996) was used to estimate depths, temporal and spatial distribution of the Probable Maximum Precipitation (PMP). Details on the PMP were used in the XP-RAFTS model to generate inflow hydrographs for a range of storm duration up to and including the 6 hour storm. Inflow hydrographs generated by XP-RAFTS model were routed through channels and floodplains using the MIKE-11 model for the Upper Parramatta River. The 4 hour PMP event resulted in a peak flow of approximately 2,600 m^3/s upstream of Charles Street Weir.

The methodology recommended in the amended version of Bulletin 53 maximises the rainfall on the study catchment and thereby results in maximising the flow at the catchment outlet. Ryde Bridge is the downstream boundary for this study. If the PMP is maximised for the entire catchment upstream of Ryde Bridge, the peak flow estimated at Charles Street Weir would be reduced from that obtained by maximising PMP for the catchment upstream of Charles Street Weir. This would cause inconsistency with PMF levels derived by UPRCT for the Charles St Weir. Thus in order to satisfy the following objectives, the following method was used to estimate PMF for the Lower Parramatta River:

The method involved using the inflow hydrograph for the 4 hour PMP event for the Upper Parramatta River catchment and applying a suitable multiplier to the 4.5 hour-1% AEP inflow hydrographs from sub-catchments located between Charles Street Weir and Ryde Bridge to maximise (within reasonable limit) outflow at Ryde Bridge. In view of the low probability of the PMF (in the order of a once in a million year event), this method is considered adequate to determine the PMF to be used in the MIKE-11 model.

The regression equation presented in Hydrological Recipes (CRC for Catchment Hydrology, 1996) for the estimation of peak flow from a catchment located in South Eastern Australia provides an estimated peak flow of 2300 m^3/s for the PMF event at Charles Street Weir. The PMF flow at Charles Street Weir estimated using the regression equation is approximately 88% of magnitude of the PMF flow obtained in from the detailed assessment of the PMF in SKM's 2001 study. The regression equation estimates the magnitude of the PMF at Ryde Bridge at 3500 m^3/s. Hence, the PMF flow at Ryde Bridge should be approximately 4,000 m^3/s.(3500/0.88).

By trial and error, the flows for the downstream catchments, were increased in multiples of the 1% AEP, to provide the required flow of about 4,000 m^3/s at Ryde Bridge. The trials showed that a multiplier of three times the 1% AEP flow in the sub-catchments, produced a flow of 3,847 m^3/s, which correlates well to the estimate above.

The MIKE 11 hydraulic model for the Lower Parramatta River was then used to simulate flood levels, flows and velocities for the PMF event. Details on the methodology and results are discussed in **Section 4.5.2.1**.

3.4.2.2 Clay Cliff Creek

A requirement for this study was to estimate PMF for Clay Cliff Creek. The amended version of Bulletin 53 (BoM 1996) indicates that the Generalised Short Duration Method would be applicable in the estimation of PMP up to storm duration of 6 hours for Clay Cliff Creek catchment. The following procedures were adopted for estimating depths, spatial and temporal distribution of PMP for Clay Cliff Creek catchment:

- PMP depths for a range of storm durations up to 6 hour storms were estimated using the procedure of Bulletin 53 (BoM 1996);
- The Generalised Short Duration Method (BoM, 1996) was used to define spatial distribution of PMP over Clay Creek Catchment; and
- The temporal pattern for the Generalised Short Duration Method of Bulletin 53 was used.

The above inputs were used in the XP-RAFTS model for Clay Cliff Creek. The following rainfall losses were adopted in the XP-RAFTS model for simulation of catchment runoff for the PMP events:

- Pervious areas: initial losses = 0 mm, continuing losses = 1 mm/hr; and
- Impervious areas: initial losses = 0 mm, continuing losses = 0 mm/hr.

Inflow hydrographs generated by XP-RAFTS were routed through the creek and its floodplain to estimate flood levels, flows and velocities. Inputs used and results obtained from the hydraulic model are discussed in **Section 4.5.2.2**.

3.4.2.3 Other Tributaries

The extreme flood for the other tributaries was determined as outlined **in Section 3.4.2.1**.

3.5 Verification of Design Flood Estimation

For Duck River, Denistone Creek and Charity Creek, peak flows from XP-RAFTS were validated against other sources of data:

- For Duck River, peak flows for the rural land use were compared to the Probabilistic Rational Method estimates and peak flows for the existing case were compared to those obtained in previous studies; and
- For Denistone and Charity Creeks, peak flows for the existing case were compared to flows for the 100-year event provided by Ryde City Council.

The estimated 1% AEP design flood for Duck River was also compared with 1% design flood for two sub-catchments located within Parramatta River Catchment. The two sub-catchments are similar in size to Duck River sub-catchment at the railway. Land use in the two sub-catchments is generally comparable to Duck River sub-catchment.

- **Table 3-3 Comparison of 1% AEP Design Flow in Duck River**

Catchment	Location	Model	Catchment Area (ha)			% Impervious	No. of Detention Basins	Peak Flow	Runoff/-sq km	Critical Storm Duration	Design Rainfall
			Per-vious	Imper-vious	Total			m^3/s	$m^3/s/$ sq km	minutes	mm
Duck River	U/S of Railway	XP-RAFTS	963.49	942.70	1,906	49.45	Nil	352.70	18.50	90	86.10
Haslams Creek	Homebush Bay	XP-RAFTS	903.90	706.70	1,611	43.88	2	254.70	15.81	120	97.00
							all removed	286.00	17.76	60	83.10
Blacktown Creek	Node 8.037J	XP-RAFTS	923.13	960.50	1,884	50.99	13	253.94	13.48	120	Note 1
							all removed	332.00	17.63	90	Note 2

Note 1
Seven Hills 92.09 mm
Blacktown 89.18 mm
Kings Langley 95.84 mm

Note 2
Seven Hills 81.65 mm
Blacktown 79.4 mm
Kings Langley 84.80 mm

Table 3-3 shows details on land use and flow characteristics for the sub-catchments. The data in **Table 3-3** for Halsams Creek is based on the latest XP-RAFTS model used for the Haslams Creek Flood Study (Aug 1999) carried out by Bewsher Consulting. This shows a very similar peak flow rate per square kilometre for the 1% AEP event in Haslams Creek (with basins removed) for a similar size catchment Duck River. However it should be noted that Haslams Creek has a slightly lower percentage impervious (44% for Haslams Creek compared to 49% for Duck River). If the percent impervious for Haslams Creek was increased to that for used for Duck River, the runoff rate per square kilometre would be virtually identical. Also in **Table 3-3**, note Blacktown Creek flow, for the situation without the basins has a very similar flow rate to that adopted for Duck River. This demonstrates that the 1% AEP design flood estimated in this study for Duck River is consistent with two other sub-catchments within Parramatta River Catchment.

3.6 Frequency Analysis of High Tides

A time series of annual maximum (1914 to 2000) peak tide levels at Fort Denison gauge was collected from Sydney Ports Corporation. A General Extreme Value (GEV) probability distribution was fitted to the annual maxima. Parameter values for GEV were estimated using LH-moments. The time series data and the probability distribution fitted to the data are shown in **Figure 3-4**. Results of the high tide frequency analysis are given in **Table 3-4**.

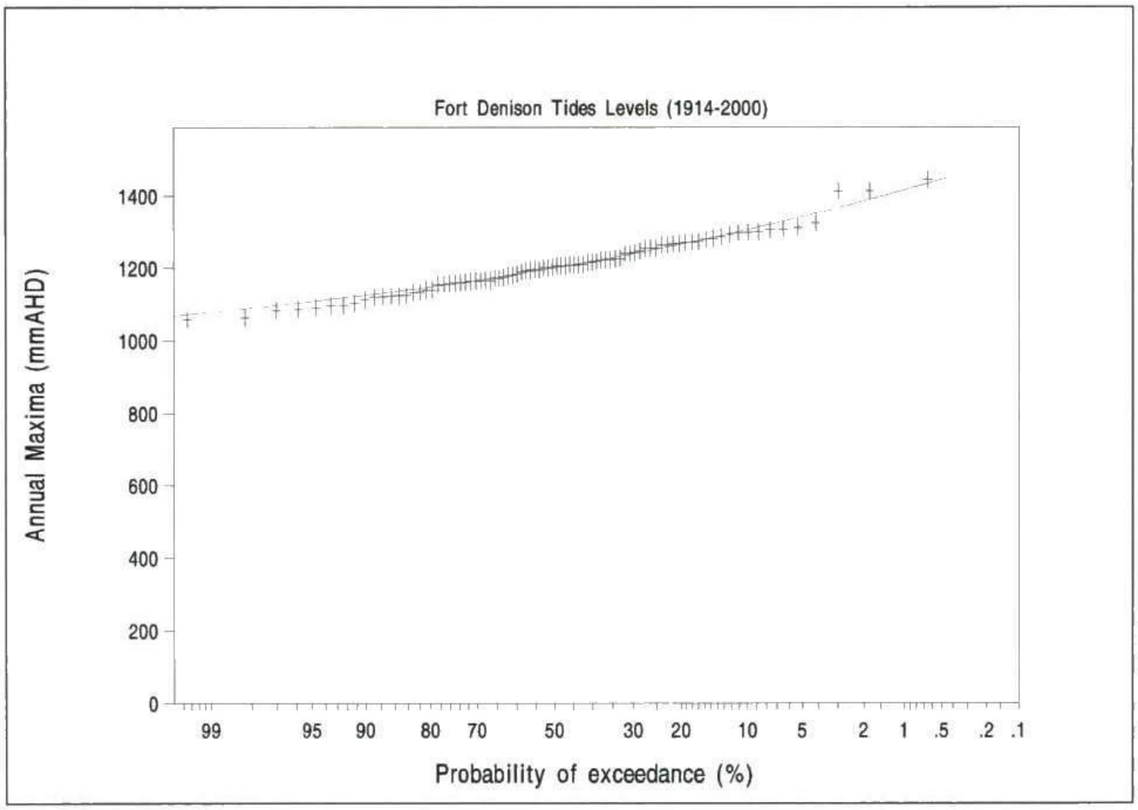
- **Table 3-4 Frequency and Magnitude of High Tides at Fort Denison**

Exceedance Probability	Tide Level (mAHD)
20% AEP	1.27
5% AEP	1.34
2% AEP	1.39
1% AEP	1.42

The 1% AEP tide level at Fort Denison estimated in this study is slightly lower than that used in the 1986 study by Willing & Partners. It is to be noted that high tide data for the period 1916 to 1945 were used in the 1986 study and the magnitude of 1% AEP high tide at Ford Denison was estimated at 1.50 mAHD.

The 1% AEP tide level of 1.42 m AHD was used as the downstream flood level in determining peak flood levels for the Lower Parramatta River.

- **Figure 3-4 Frequency Curve of High Tides at Fort Denison**



4. Hydraulics

Two of the objectives of the LPR-FRMS are:

- To review flood behaviour within the study area; and
- To investigate alternative floodplain management options for the Floodplain Risk Management Study.
- Outcomes from investigations on alternative floodplain management will be included in the report on the Floodplain Risk Management Study. Outcomes of the review of flood behaviour are presented here.

4.1 Approach

Both steady state (FLOWBD) and unsteady state (USTFLO) hydraulic models were used in the 1986 Lower Parramatta River Flood Study (Willing and Partners) for the main stem of the Lower Parramatta River. A steady state hydraulic model for the main stem of Duck River was also developed in that study using FLOWBD. With the advancement of computer technology, both FLOWBD and USTFLO models are now practically obsolete.

A steady state hydraulic model using HEC-2 modelling software was used in the 1992 and 1993 flood study for Clay Cliff Creek. A single flow path was represented in the HEC-2 model for Clay Cliff Creek and its associated floodplain but as significant overland flooding occurs on the floodplain of Clay Cliff Creek the HEC-2 model would tend to overestimate flood levels. The HEC-2 model being a steady state model does not account for the volume of floodwater stored on the floodplain. Hence, HEC-2 does not account for the attenuation of the flow hydrograph due to floodplain storage. Moreover, the representation of a single flow path to define the flooding conditions in the creek and on the floodplain is considered a very coarse representation of the two-dimensional flood behaviour.

Steady state hydraulic models using HEC-2 were developed for the reaches of Vineyard Creek, Subiaco Creek and A'Becketts Creek as part of previous flood studies for the respective creeks.

As part of this study, it was considered appropriate to develop one single hydraulic computer model to define flood behaviour in the channels and on the floodplain within the study area. It was also considered appropriate to route the inflow hydrographs for the selected flood events and for a range of storm events using the hydraulic model rather than relying on the results obtained from the hydrologic model.

The consultant reviewed existing flood level and flow data and information obtained is described in **Appendix D**. However, due to the paucity of historic inflow data and historic flood level information for major floods, the hydraulic model was mainly calibrated against observed tide data.

The calibrated model was used to simulate flooding conditions for the selected flood events. Sensitivity of model results to adopted bed resistance values and tailwater conditions were assessed.

4.2 The Hydrodynamic Modelling Software

In the context of this study the need for the development of a hydraulic computer model arises from the following considerations:

- Different modelling systems used in previous studies to model the Lower Parramatta River and its tributaries within the study area;
- Attenuation of floods by floodplain storage;
- Complex over bank flooding particularly in Clay Cliff Creek floodplain;
- Marked changes in land use on the floodplain; and
- Flood impact assessment.

The hydrodynamic model selected for use in this study is the Danish Hydraulic Institute's MIKE-11 (version 1999b) modelling system. MIKE-11 is a one-dimensional, finite difference modelling system for rivers and floodplains using the full Saint Venant Equations of momentum and continuity for unsteady flow. The modelling system allows flow to occur in one-dimensional flowpaths which can be linked in a network to represent quasi two-dimensional flow behaviour experienced on floodplains. It has the ability to model structures, weirs and floodplain storages. The model has been extensively used in flood studies in Australia for the last 15 years.

MIKE-11 was set using the following data:

- Topographic data: as channel and floodplain cross sections;
- Obstructions to flow: details of structures such as levees, culverts, bridges and weirs;
- Inflows to the model at appropriate locations; and
- Downstream boundary conditions in the form of water levels or rating curves.

The first step in developing a model involves schematising the floodplain into discrete topological elements. Important topological elements are stream channels, floodplains and hydraulic structures including bridges, culverts, weirs, levees, causeways, etc. These elements are usually represented by cross sections orthogonal to the direction of flow.

The second step in constructing a model is to designate links between each of the topologic elements. The links indicate the direction of flow assigned in the model and show the inter-connected network of flow paths.

The third step involves transforming the topologic data into hydraulic parameters for use in the solution of the momentum and continuity equations. This includes vertical integration of cross sectional area, hydraulic radius, width and bed resistance.

In the fourth step, hydrologic inputs such as inflows and outflows to the model are defined. Generally, inflows are defined by inflow hydrographs, whereas outflows are defined by water level hydrographs or stage-discharge rating curves (a curve that shows relationship between flood flows and flood levels at a specified location in a stream channel).

In the fifth step, the model is run to simulate selected historic flooding conditions and comparisons are made between recorded and simulated results to gain confidence in the model and its results. In this process refinement is made to the model schematic and assigned bed resistance values until the model satisfactorily reproduces the recorded flood behaviour.

Once the model is calibrated, the model is used to simulate flooding conditions for different floods and floodplain conditions.

4.3 Model Formulation

4.3.1 Identification of Major Flow Paths

Major flowpaths within the study area were identified from the following sources:

- Aerial photographs;
- Available topographic information;
- Previous reports; and
- Site visits.

Major flowpaths included the following watercourses within the study area:

- Lower Parramatta River;
- Clay Cliff Creek and overland flowpaths;
- Vineyard Creek;
- Subiaco Creek;
- Duck River; and
- Homebush Bay.

4.3.2 Sources of Topographic Data

Details on the topographic data available for this study were discussed in **Section 2.3.** Information on mean high water marks and location of seawalls received from the Waterways Authority was utilised to identify channel geometry in plan form. Topographic data obtained from the ALS for the channel was substituted (as ALS provided water surface levels on water bodies) with sounding data and data from surveyed cross sections. A digital terrain model (DTM) was created using the ALS data, sounding data and surveyed cross section data. The DTM was used to extract cross sections at specified locations to define flow paths within the area of interest. Flow paths and cross-sections are shown in **Figure 4-1**.

Further details of the locations of cross-sections and cross-section names can be seen in **Appendix C**.

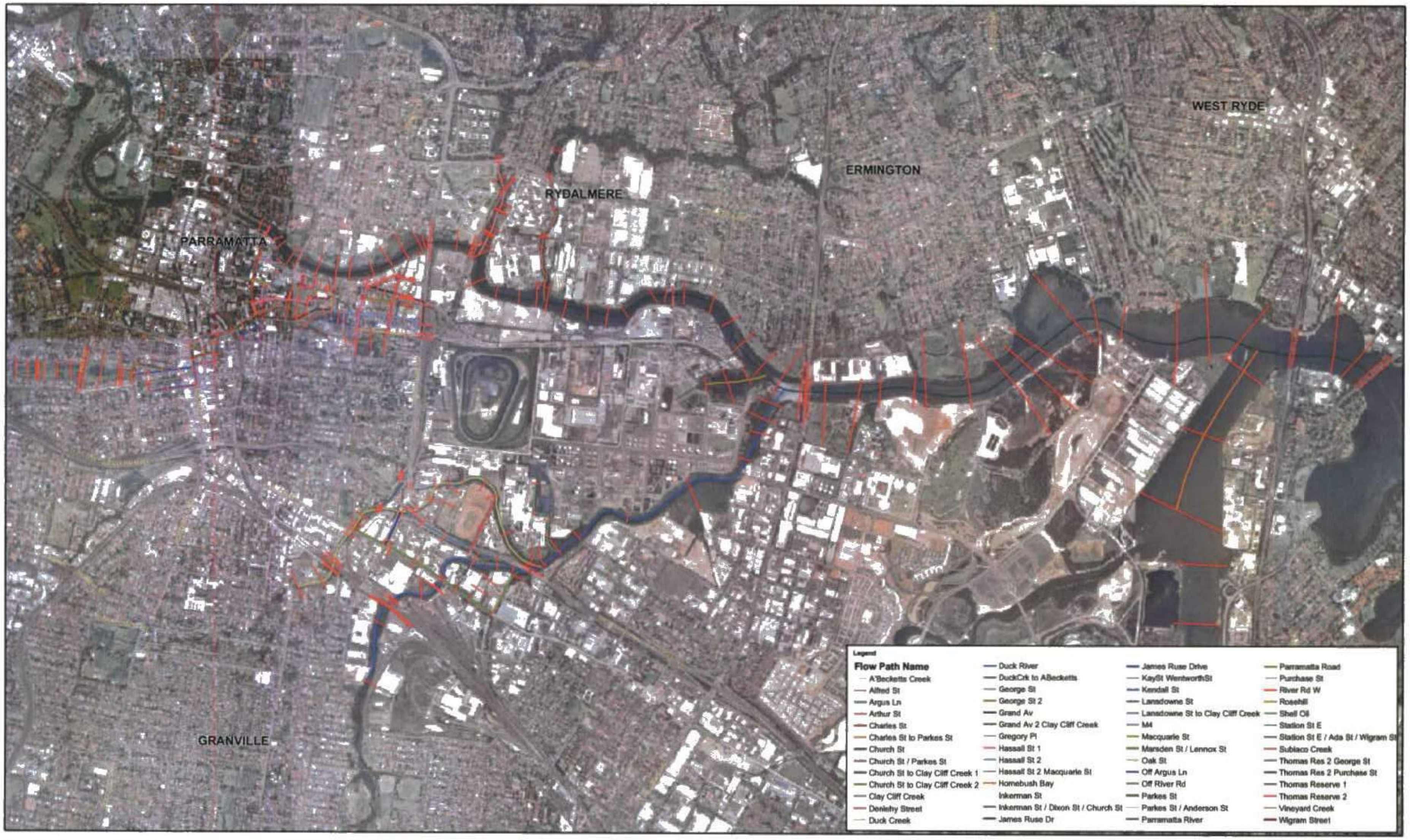


Figure 4-1
Lower Parramatta Model
Cross Sections and Flow Paths

More than 400 cross sections were extracted from the DTM for use in the MIKE-11 model to represent the identified flowpaths. Plots of cross sections used in the MIKE-11 model are presented in a separate volume of the report.

4.3.3 Manning's 'n'

Bed resistance in the model was defined in terms of Manning's 'n'. Typical Manning's 'n' values used for the channels in different parts of the model are summarised in **Table 4-1**.

- **Table 4-1 Manning's 'n' values for Main Channels**

Lower Parramatta River	Duck River	Clay Cliff Creek
0.025 to 0.035	0.035	0.020

Manning's n values used in this study for the Lower Parramatta River, Duck River and Clay Cliff Creek are consistent with those used in the previous flood studies. The lower roughness for Lower Parramatta River reflects that the channel is generally 'smoother' than Subiaco Creek, while the smoothness of Clay Cliff Creek reflects that it is generally a concrete lined channel. Manning's n values used for Vineyard Creek and Subiaco Creek were generally consistent with those used in previous flood studies for the respective creeks.

Relative resistances were used in the MIKE-11 model to vary Manning's n values for the floodplain. **Table 4-2** shows the Manning's 'n' range of values used for the various parts of the model for overland (floodplain) areas.

- **Table 4-2 Manning's 'n' values for Floodplain**

Location	Lowest (smoothest) 'n' value	Highest (roughest) 'n'value
Parramatta River	0.025	0.05
Duck River	0.035	0.035
Vineyard Creek	0.018	0.09
Subiaco Creek	0.09	0.10
Clay Cliff Creek	0.035	0.02
Overland flow along roads and properties	0.018	0.04

4.3.4 Obstruction to Flow

Waterway crossings that were most likely to obstruct flood flows in the watercourses as well as on the floodplain were represented in the MIKE-11 model set up. More than forty waterway crossings of various sizes were represented in the MIKE-11 model set up.

In this study all openings were assumed to be completely open. Effects of blockages on flooding conditions will be assessed at the floodplain management stage of this study.

4.3.5 Boundary Conditions

4.3.5.1 Inflow Boundaries

Inflow hydrographs were extracted from the MIKE-11 model results for the Upper Parramatta River at the catchment outlet upstream of Charles Street weir for the selected design flood events and a range of storm durations. These hydrographs were used to define catchment runoff from the 108 km^2 catchment at Charles Street weir and became the upstream inflow boundary conditions.

Inflow hydrographs generated by hydrologic models for the following creeks were used as direct inflows to the MIKE-11 model for the Lower Parramatta River:

- Vineyard Creek;
- Subiaco Creek;
- Duck Creek[2];
- Haslams Creek;
- Boundary Creek; and
- Powells Creek.

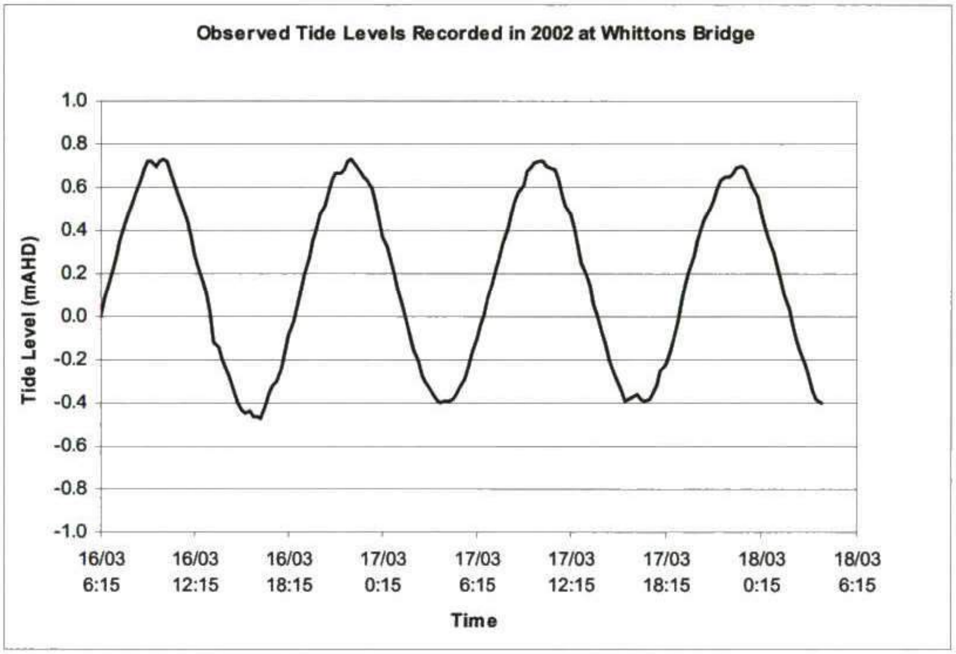
Inflow hydrographs generated by XP-RAFTS model for the sub-catchments were used in the MIKE-11 model to define inflows from the remaining catchment. The remaining catchment is defined as the catchment area downstream of Charles Street weir and also downstream of outlets of Vineyard, Subiaco, Duck, Haslams, Boundary and Powells Creeks draining into the Lower Parramatta River within the study area. The remaining catchment area includes catchment areas of Clay Cliff Creek, Duck River (excluding Duck Creek catchment), Archers Creek, Denistone Creek, Charity Creeks and other areas draining directly into the main channel.

4.3.5.2 Downstream Boundary (Tide levels)

The downstream boundary of the MIKE-11 model was defined by observed tides shown in **Figure 4-2**. It is to be noted that in the 1986 Lower Parramatta River Flood Study (Willing and Partners), a sinusoidal curve was fitted to a high spring tide with an amplitude of 0.66m. The amplitude of the tide used in this study is about 0.6 m. A higher amplitude tide was not used as it would have resulted in a joint probability that would have exceeded the probability of the flood flow being considered.

[2] Design flow hydrographs supplied by PCC

■ **Figure 4-2 Observed Tides at John Whittons Bridge**



However, in the downstream part of Parramatta River, the peak flood levels are controlled by the extreme flood level and not the flood flow level. To allow for this, the longitudinal profile of flood levels, from Charles St Weir to Ryde Bridge, was truncated when the flood level dropped to 1.42 m AHD, about three kilometres upstream of Ryde Bridge. The level of 1.42, was assessed as the 1% AEP using a frequency analysis, see **Table 3-4.**

4.4 Model Calibration

4.4.1 General

Ideally, in order to use the hydraulic model to investigate effects of constructed and natural obstructions on flooding, as well to assess alternative floodplain management options, it is desirable for the model to satisfactorily reproduce observed flood events. However the degree that this can be achieved is very much dependent on the quantity and quality of information available to verify the performance of the model.

In this study there was limited data to calibrate the model against observed flood events, due to the poor availability of:

- Recorded flood levels in the Lower Parramatta River;
- Historic inflow data at Charles Street weir; and
- Historic tidal records.

Available flood level data is detailed in **Appendix D**.

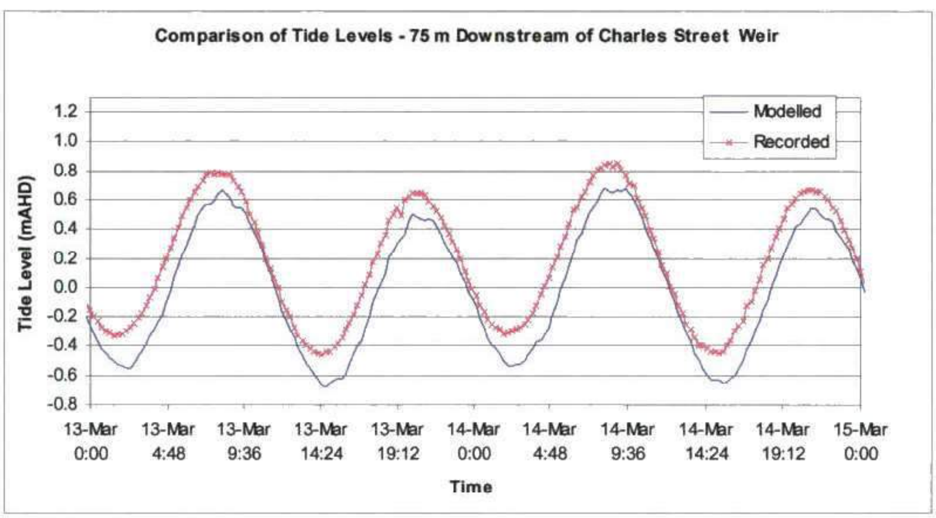
It should be noted the previous study, undertaken in 1986 had the same problem and no model calibration was undertaken due to the limited availability of calibration data.

In the absence of good historical flood level and flow data, the consultant decided that it would be desirable to at least calibrate the model against tide data, which could be considered to be the equivalent of a small flood. While this approach, does not provide calibration data for the floodplain, it does provide data against which to calibrate the main channel and therefore provides a valuable additional degree of confidence in the model. The tide data collection process was described in **Section 2.4.**

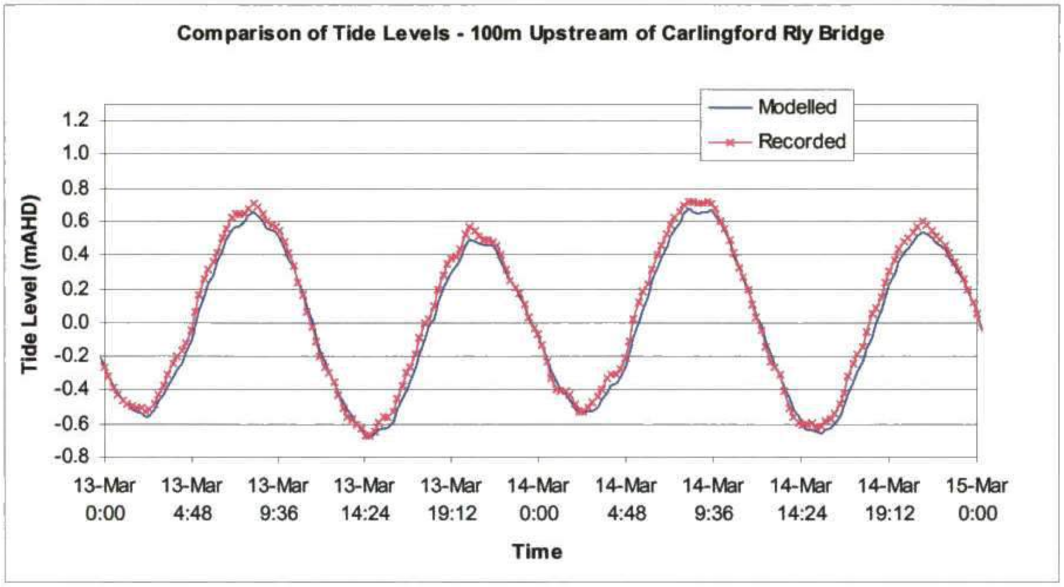
4.4.2 Calibration Results

The charts in **Figure 4-3** to **Figure 4-6** show the results of this calibration. Generally, acceptable results were achieved in terms of tidal phase and amplitude with limited adjustment of Manning's n. However, in the vicinity of Charles Street weir, as shown in **Figure 4-3** the model slightly underestimated tide levels. However, it is now understood that Sydney Ports Corporation thinks that there might be a clock and datum error with the Charles St Weir tide data.

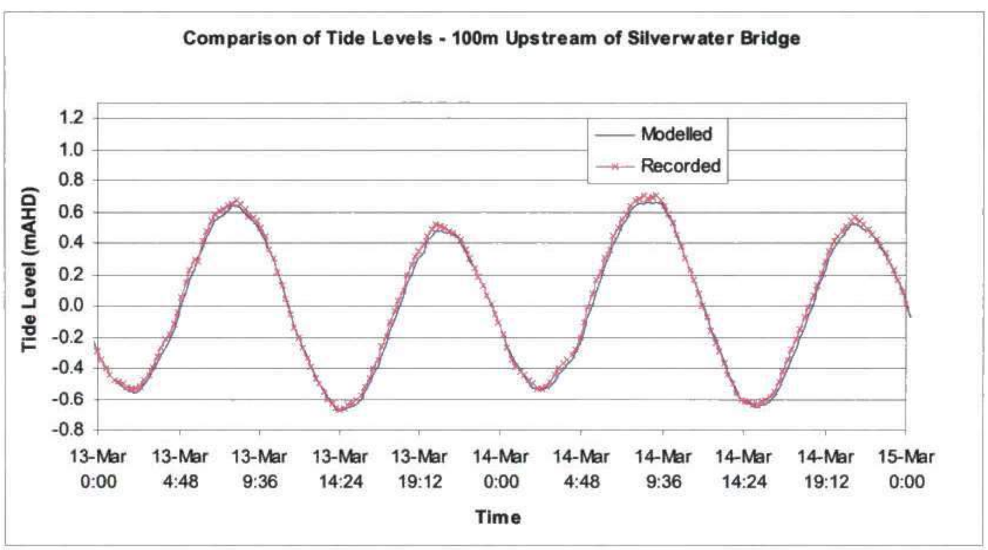
- **Figure 4-3 Model calibration against tide: 75 m downstream of Charles Street Weir**



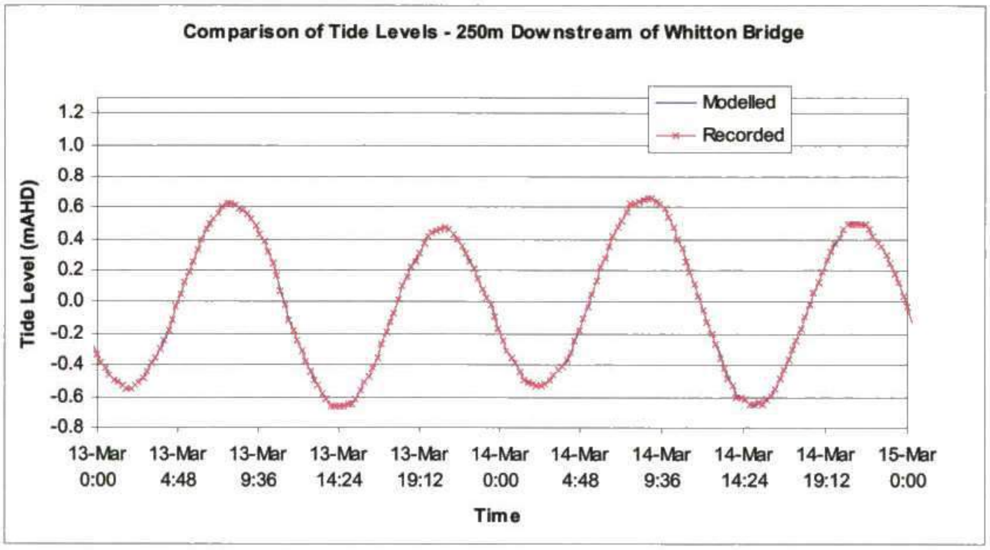
- **Figure 4-4 Model calibration against tide: 100 m upstream of Carlingford Railway bridge**



- **Figure 4-5 Model calibration against tide: 100 m upstream of Silverwater Bridge**



- **Figure 4-6 - Model calibration against tide – 250 m downstream of John Whitton Bridge**[3]



A comparison of observed tide data at the four monitoring stations is shown in **Figure 4-7.** The following observations can be made from **Figure 4-7:**

- The tide arrived at the most upstream station (ie. Charles Street weir) prior to arriving at the most downstream monitoring station (ie. John Whittons Bridge) – indicating possible error in synchronisation of clocks[4];
- Tides recorded at Charles Street weir were consistently higher than those monitored farther downstream. Possible reasons for this could be due to
  - Error in gauge datum[4] connection;
  - Near shore effects; and
  - Vertical stratification within the water column.

The slight difference between modelled and observed levels is not considered significant when it is considered that even the 20% AEP flood has a peak flood level some 3 metres above the tide level.

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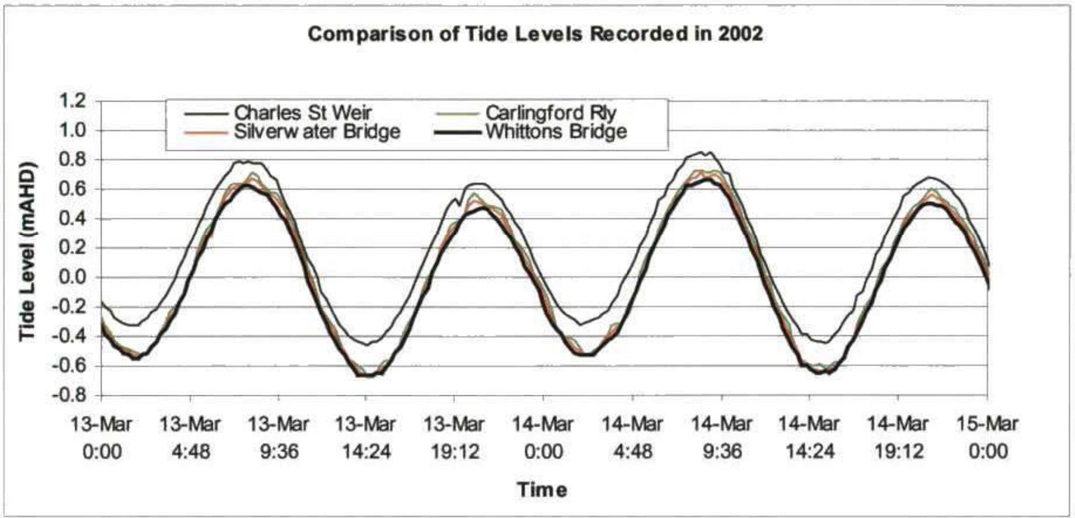
[3] Modelled elevation lies underneath the recorded levels (because this was used as the downstream boundary to the model)

[4] It is understood that Sydney Ports Corporation now admit that there might be a clock and datum error with the Charles St Weir tide data

- **Figure 4-7 Comparison of Observed Tides**



4.5 Model Simulations for Design Floods

4.5.1 Large Flood Events

Large flood events, in this study, are defined by those design flood events up to and including the 1% AEP event. The MIKE-11 model for the Lower Parramatta River was run for the 20% AEP, 5% AEP, 2% AEP and 1% AEP design flood events for storm durations of 30 minutes, 45 minutes, 60 minutes, 90 minutes, 2 hours, 3 hours, 4.5 hours, 6 hours, 9 hours and 12 hours. In each model run the downstream boundary shown in **Figure 4-2** was used. The MIKE-11 model generated flood levels, flows and velocity time series at modelled cross sections. The range of flood levels, flows and velocities simulated by the model for the selected storm durations for each design flood event were analysed to obtain peak flood levels, flows and velocities for each model cross section.

The procedure in more detail, is as follows:

1. Say the model is being run for a 9 hour-1% AEP event storm. For each of the hydrologic models used, a 9 hour storm with a 1% rainfall was run and output hydrographs[5] obtained. As discussed in Section 3.3.3.1, the rainfall was obtained from local area IFD curves, a single IFD curve was not used.
2. The generated hydrographs are then used as inputs to the MIKE-11 model and the hydraulic model run
3. The water levels, flows velocities for all cross sections in the model are extracted to an output file
4. The process is then repeated for all other storm durations from 30 minutes to 12 hours for the 1% AEP event
5. The flood levels for each of the durations at each cross section is then inspected and the highest flood level, velocity, flow etc extracted.

[5] Output is a graph of flow in cubic metres per second against time

6. The procedure is then repeated for all other AEPs and the PMF.

The results of these runs are peak flood levels at each cross section for each AEP considered. Using this approach, peak flood levels are obtained at all locations without the complexity and uncertainty of having to decide about the joint probability of say a Duck River flood and a Parramatta River flood. Conceptually, the method assumes that a storm of the same duration and AEP will occur over the whole catchment at the same time. This approach is the same as has been used by UPRCT and therefore flows and water levels at Charles Street Weir are consistent with those predicted by the Trust.

Section 4.3.5.2 describes the design procedure adopted at the downstream end of the Lower Parramatta River model where peak tide levels produce higher flood levels than a flood in Parramatta River. Due to the limited availability of historic streamflow data, a joint probability analysis of storm tide and upstream inflow was not undertaken as part of this study. However, in order to represent flooding from storm tides, peak flood levels in the downstream reaches of the Lower Parramatta River and its tributaries simulated by the MIKE-11 model were adjusted to represent peak storm tide levels of appropriate probability. This was achieved by adopting results of tide frequency analysis instead of lower peak flood levels simulated by the MIKE-11 model.

It was noted in the 1986 Lower Parramatta River Flood Study (Willing and Partners) that flood levels in the downstream reaches of the Lower Parramatta River and its tributaries may be produced by a storm tide. The probability of a coincidental peak storm tide and the selected design flood event was considered to have a probability rarer than the probability of the selected design flood event.

Peak flood levels, flows and velocities for the selected design flood events are included in **Appendix B**.

4.5.2 Extreme Flood Event

4.5.2.1 Lower Parramatta River

A detailed PMF study for the Upper Parramatta River Catchment was undertaken by SKM for the UPRCT. Results from the PMF study for the Upper Parramatta River catchment were available for this study. The results indicate that the 4 hour PMP event produced the peak flow in the Parramatta River upstream of Charles Street weir. This inflow hydrograph was used to define inflow from the 108 km^2 catchment upstream of Charles Street weir. Downstream of Charles Street weir, inflow hydrographs equivalent to three times the 1%AEP inflows for the 4.5 hours storm were used in the model to check the magnitude of the peak outflow at Ryde Bridge. The model simulated a peak flow of 3740 m^3/s at Ryde Bridge that was considered to be in good agreement with the peak flow estimate obtained by using an alternative technique as discussed in **Section 3.4.2.1**.

Detailed results on peak flood levels, flows and velocities for this flood event for all modelled channels and floodplains are shown in **Appendix B**.

4.5.2.2 Clay Cliff Creek

PMP inflow hydrographs for selected storm events were simulated using the XP-RAFTS model. The 1% AEP storm was assumed to occur concurrently on the remaining catchment area of the Lower Parramatta River. In the lower reaches of Clay Cliff Creek, flood levels in Clay Cliff Creek are influenced by flood level in the Lower Parramatta River. Hence, in the lower reaches of Clay Cliff Creek flooding conditions would be governed by the PMF in the Lower Parramatta River.

Results shown in Appendix B for Clay Cliff Creek refer to the worst flooding resulting from the following two events:

- PMP events occurring on Clay Cliff Creek with 1% AEP downstream flooding; and
- PMF for the Lower Parramatta River.

4.6 Sensitivity Analysis

A sensitivity analysis was performed to assess the effects of:

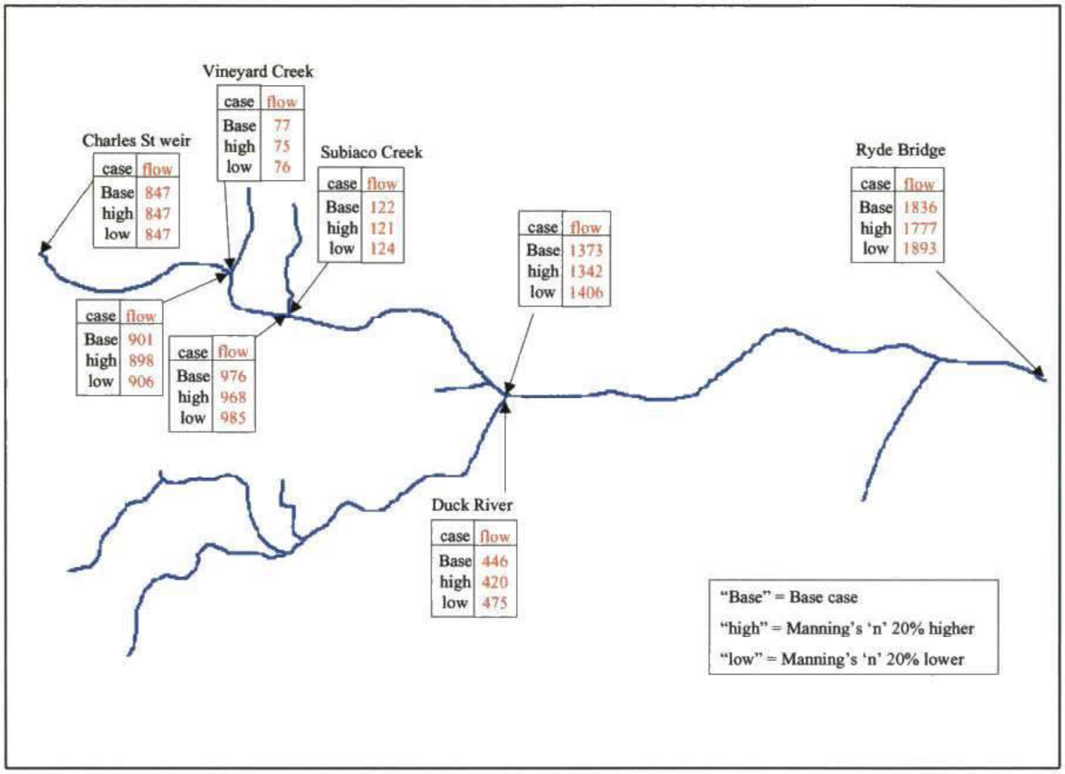
- Varying Manning's 'n'; and
- Changing the timing of the tide with respect to the timing of the storm events.

4.6.1 Manning's 'n'

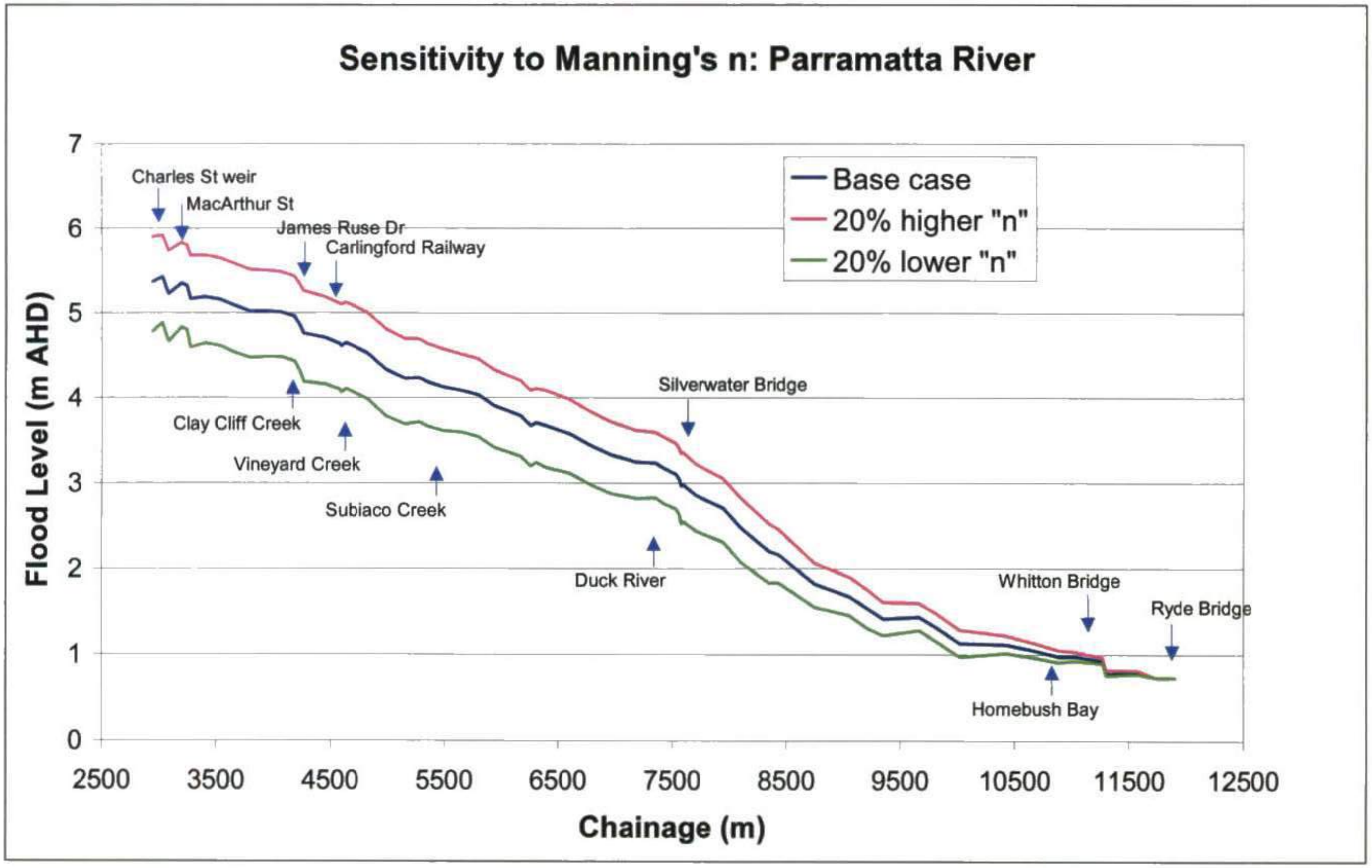
Sensitivity to Manning's 'n' was tested by making Manning's 'n' 20% higher and 20% lower throughout the model in each of two sensitivity analysis model runs. Sensitivity to Manning's 'n' of both flow rates and flood levels was tested.

Results of this sensitivity testing are summarised in **Figure 4-8** and **Figure 4-9**. **Figure 4-8** indicates modelled peak flows were almost insensitive to the variation of Manning's n.

- **Figure 4-8 Sensitivity of flows to Manning's 'n' (results for 1% AEP)**



- **Figure 4-9 Sensitivity of flood levels to Manning's 'n' (results for 1% AEP)**



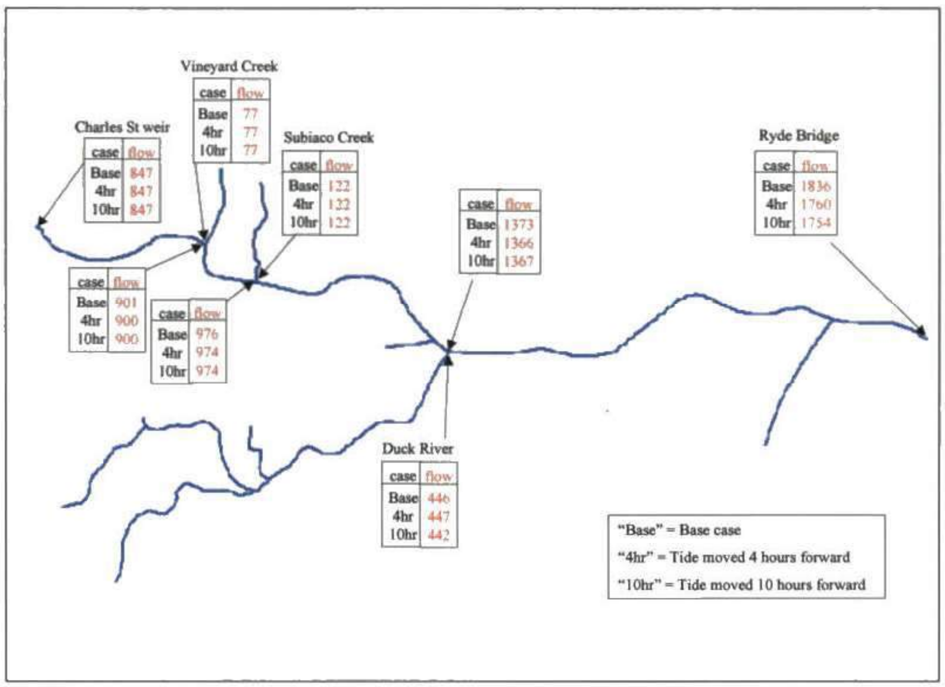
Peak flood levels in the Lower Parramatta River for the 1% AEP event can vary by 0.5m due to a 20% variation in the adopted Manning's n. Effects of Manning's n on peak flood levels are more pronounced in the upper reach of the river and less pronounced in the lower reach downstream of Homebush Bay as shown in **Figure 4-9**.

4.6.2 Tide

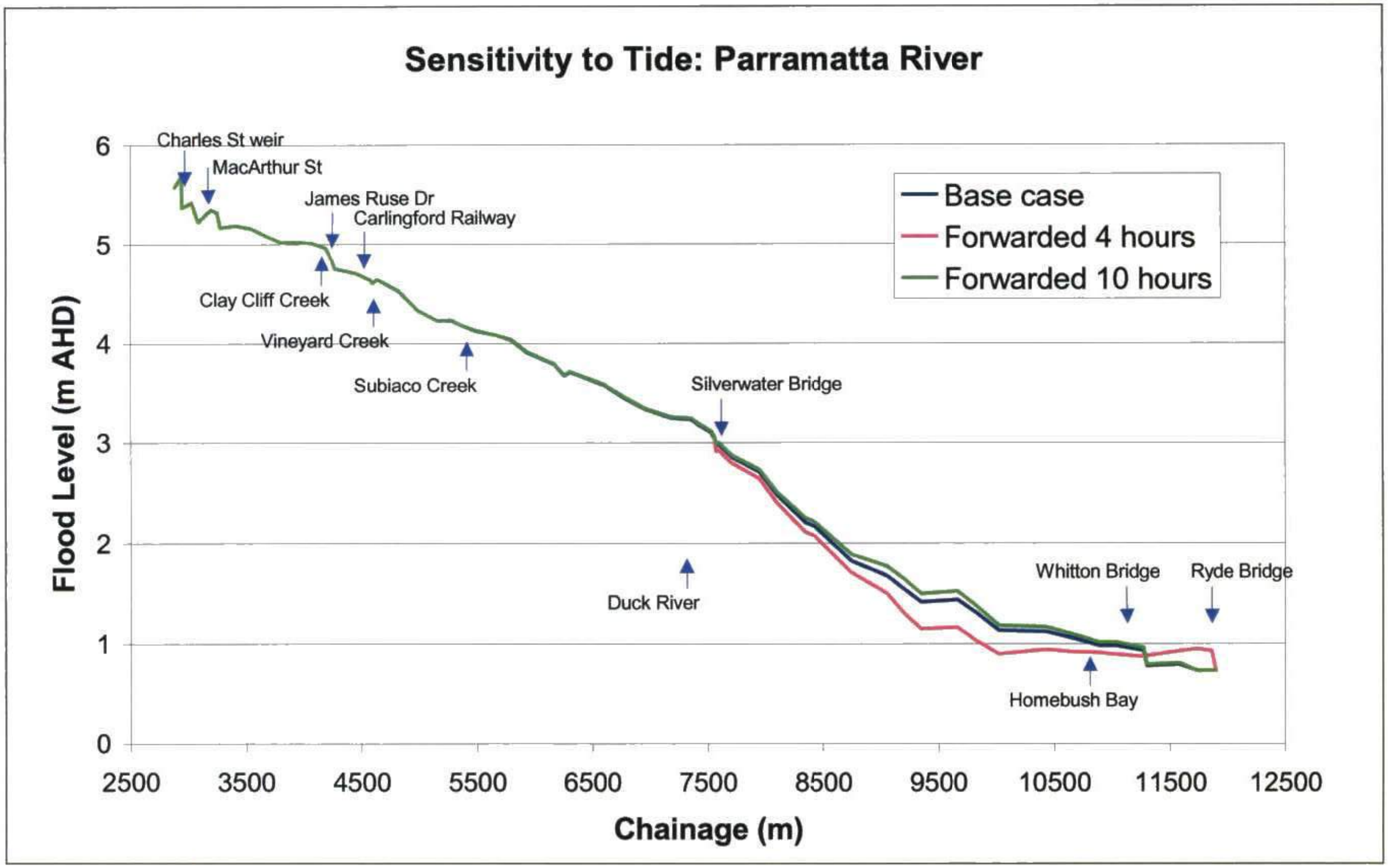
Sensitivity to the tide was tested by changing the phase of the tide. This meant that the timing of the high tide was varied relative to the timing of the storm events. The phase of the tide was moved 4 hours forward and 10 hours forward in each of two sensitivity analysis model runs. Sensitivity to the tide of both flow rates and flood levels was tested.

Results of this sensitivity testing are shown in **Figure 4-10** and **Figure 4-11**.

- **Figure 4-10 Sensitivity of flows to phase of tide (results for 1% AEP)**



- **Figure 4-11 Sensitivity of flood levels to phase of tide (Results for 1% AEP)**



It can be seen in **Figure 4-10** and **Figure 4-11** that the phase of the tide has only a small effect on flow rates and flood levels at the downstream end of the model. The effect is further reduced when it is considered that the 1% tide level is 1.42m AHD and so the section of flood levels derived in the MIKE 11 model, `from about Chainage 9 500 will be replaced by a horizontal line with a flood level of 1.42 m AHD. At the upstream end, the model results for the 1% AEP are not influenced by the phase of the tide.

4.7 Validation of Model Results

Model results for peak flows and flood levels were compared to results of previous studies, in particular the *Lower Parramatta River Flood Study* (Willing and Partners 1986).

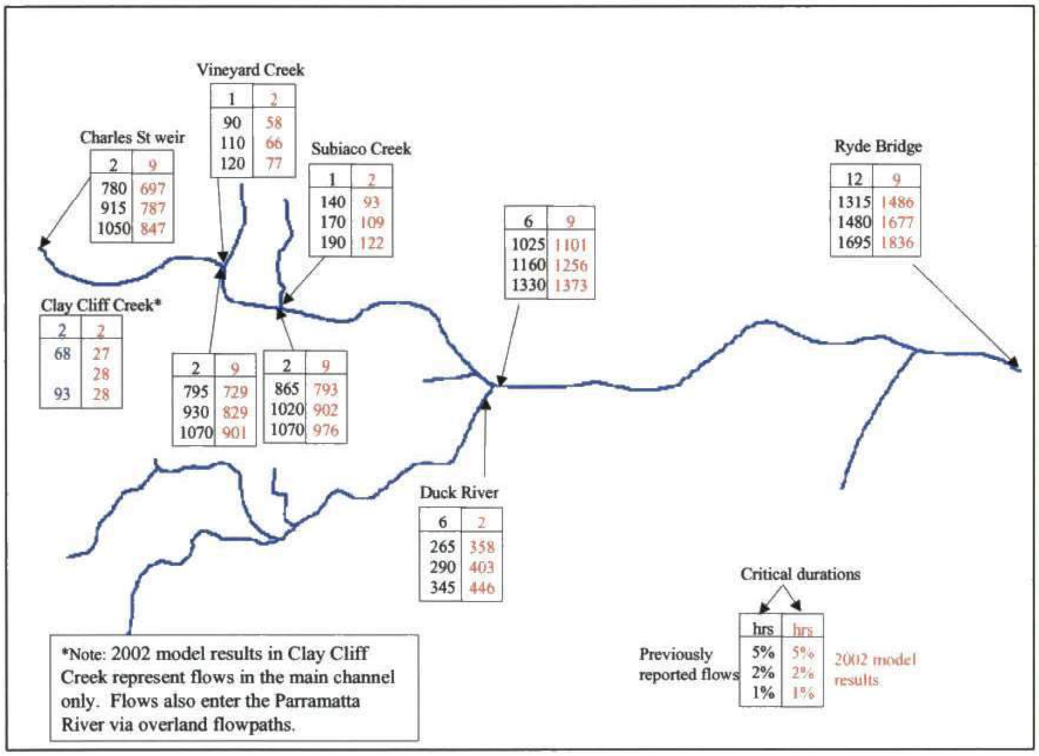
4.7.1 Peak Flows

Flows in the Parramatta River, Duck River, Vineyard Creek and Subiaco Creek were compared to flows presented by Willing and Partners (1986) in the *Lower Parramatta River Flood Study*. Flows in Clay Cliff Creek were compared to flows presented by Dalland and Lucas (1992/1993) in the *Clay Cliff Creek Catchment Flood Study*. A comparison of peak flows is presented in **Figure 4-12.**

The figures in the left hand column are results from the *Lower Parramatta River Flood Study* (Willing and Partners, 1986) (except for Clay Cliff Creek where the data comes from *Clay Cliff Creek Catchment Flood Study* (Dalland and Lucas 1992/ 1993)). The figures in the right hand column are the results of the current study.

Figure 4-12 indicates significant variations in the magnitudes of peak flows obtained in this study and in the 1986 Willing & Partners Study. There are also significant differences in the design storm events producing peak flows. The 9 hour design storm was found to generate peak flows in the Lower Parramatta River between Charles Street Weir and Ryde Bridge in this study. In the 1986 study the 2 hour storm generated peak flows at Charles Street Weir and the 12 hour storm generated peak flows at Ryde Bridge. Except Duck River, critical design storm durations for tributary catchments in the 1986 study were lower than those obtained in this study. However, for Duck River the critical design storm duration obtained in the 1986 study was significantly longer (6 hours as opposed to 2 hours) than that obtained in this study.

■ **Figure 4-12 Comparison of peak flow results (1% AEP) from this study and previous studies**



It is to be noted that peak flows in this study were obtained by running the MIKE-11 model for a range of design storm events for each of the selected design flood events. In the 1986 study peak flows were obtained from results of the hydrologic model.

In the case of Clay Cliff Creek, Dalland & Lucas (1992/1993) estimated peak flows in from the catchment using results from RAFTS (a former version of XP-RAFTS) model. In this study, peak flows at the creek outlet were estimated using the MIKE-11 model. MIKE-11 model results indicate the capacity of Clay Cliff Creek approximately $30m^3/s$. However, the flow carrying capacity of the creek varies substantially along its length especially at sections of the creek that are covered. Hence, substantial floodplain is inundated when the flood flow in the creek is in excess of its capacity. The complex overland flood behaviour was not modelled in the previous studies and hence, the degree of attenuation of the inflow hydrograph was not properly catered for in the RAFTS model.

4.7.2 Flood Levels

Flood levels were compared in the following rivers and creeks:

- Flood levels in the Parramatta River and in Duck River were compared to results from the *Lower Parramatta River Flood Study* (Willing and Partners 1986); and
- Flood levels in Clay Cliff Creek were compared to results from the *Clay Cliff Creek Catchment Flood Study* (Dalland and Lucas 1992/1993).

4.7.2.1 Parramatta River

Flood level results for Parramatta River are shown in **Figure 4-13**. Generally there is reasonable agreement between the 1986 flood study and this study except for the area downstream of Subiaco Creek.

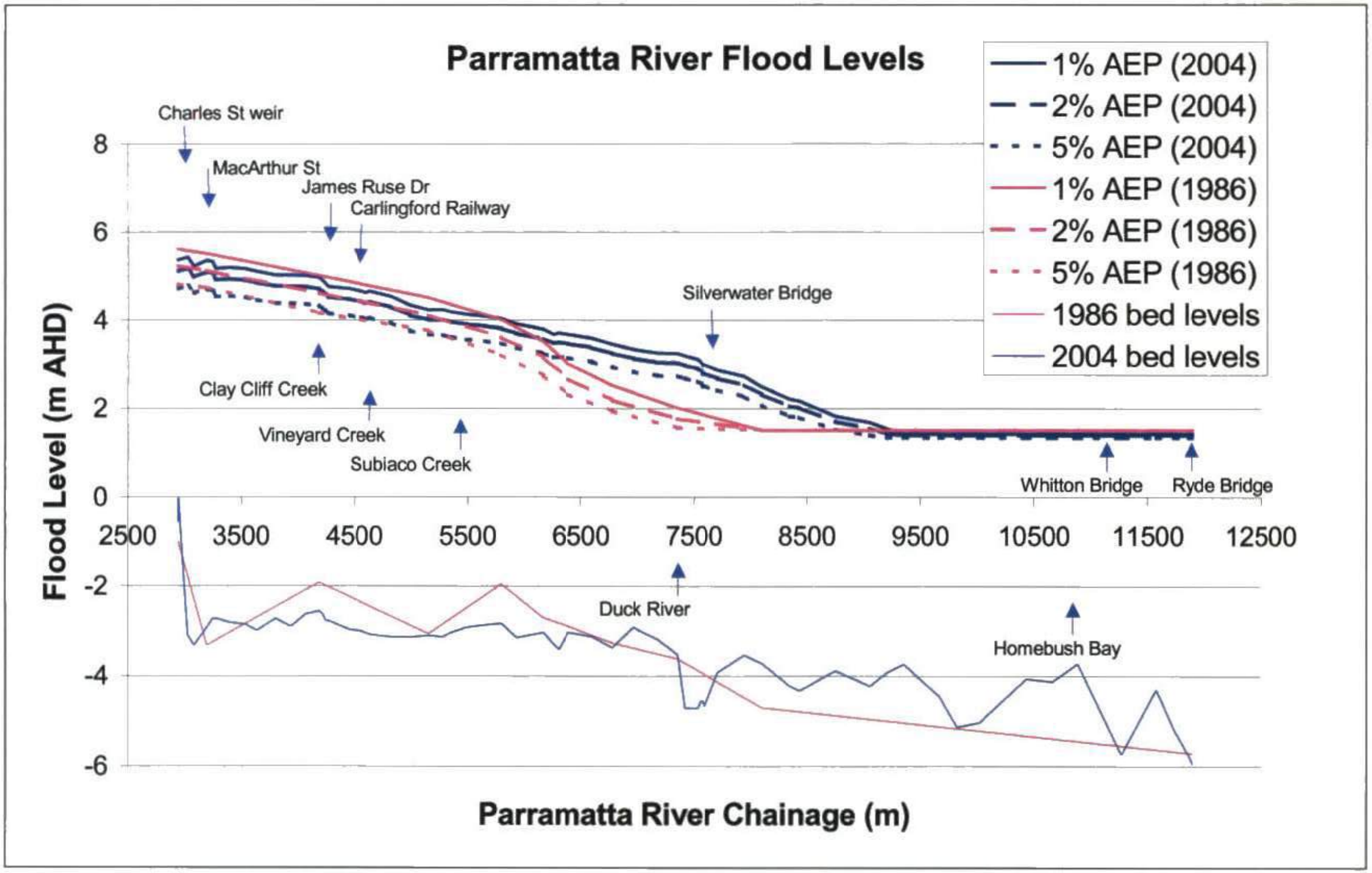
Upstream of Subiaco Creek, flood levels estimated in this study are slightly lower than those estimated in the 1986 study. This could be due the flood mitigation works undertaken within the Upper Parramatta River catchment since the 1986 study. For example, Loyalty Road Flood Retarding Basin, McCoy Park Flood Retarding Basin, Sierra Place Flood Retarding Basin were constructed within the Upper Parramatta River catchment since 1986.

Downstream of Subiaco Creek as far as Duck River, flood levels estimated in the 1986 study are up to 1.2m lower than the present study. Flood profiles from the 1986 study indicate a steep flood surface downstream of Subiaco Creek. However, flood profiles from this study indicates a more gradual change in flood surface slope downstream of Subiaco Creek. Further discussion and possible reasons for this discrepancy is provided in **Appendix D**.

The horizontal flood level from about Chainage 9 500 shown in **Figure 4-13** is at 1.43 m AHD which is assessed as the 1% AEP tide level as calculated and described in **Section 3.6** and **Section 4.3.5.2**.

The supporting modelling data used in the 1986 study was not available for use in this study for making a direct comparison of input data. The 1986 flood study report states that the Lower Parramatta River was modelled by the unsteady state model USTFLO. The report does not indicate whether inflow hydrographs generated by the hydrologic model for a range of storm durations for each of the selected design flood events were routed through USTFLO model.

- **Figure 4-13 Comparison of flood level results (1%, 2% and 5% AEP) in Parramatta River from this study and the previous (1986) study**



The report does indicate that the unsteady state modelling was undertaken using a critical storm duration of 2 hours. It is possible that concurrent flooding from the tributaries of the Lower Parramatta River were not correctly represented in the unsteady model. Hence, the discrepancy in flood level between this study and the 1986 study could arise from the following limitations of the 1986 modelling study:

- Unsteady flow modelling undertaken for the main stem of the Lower Parramatta River;
- Modelling undertaken for the 2 hour design storm event; and
- Inappropriate representation of concurrent flooding from tributary catchments.

4.7.2.2 Duck River

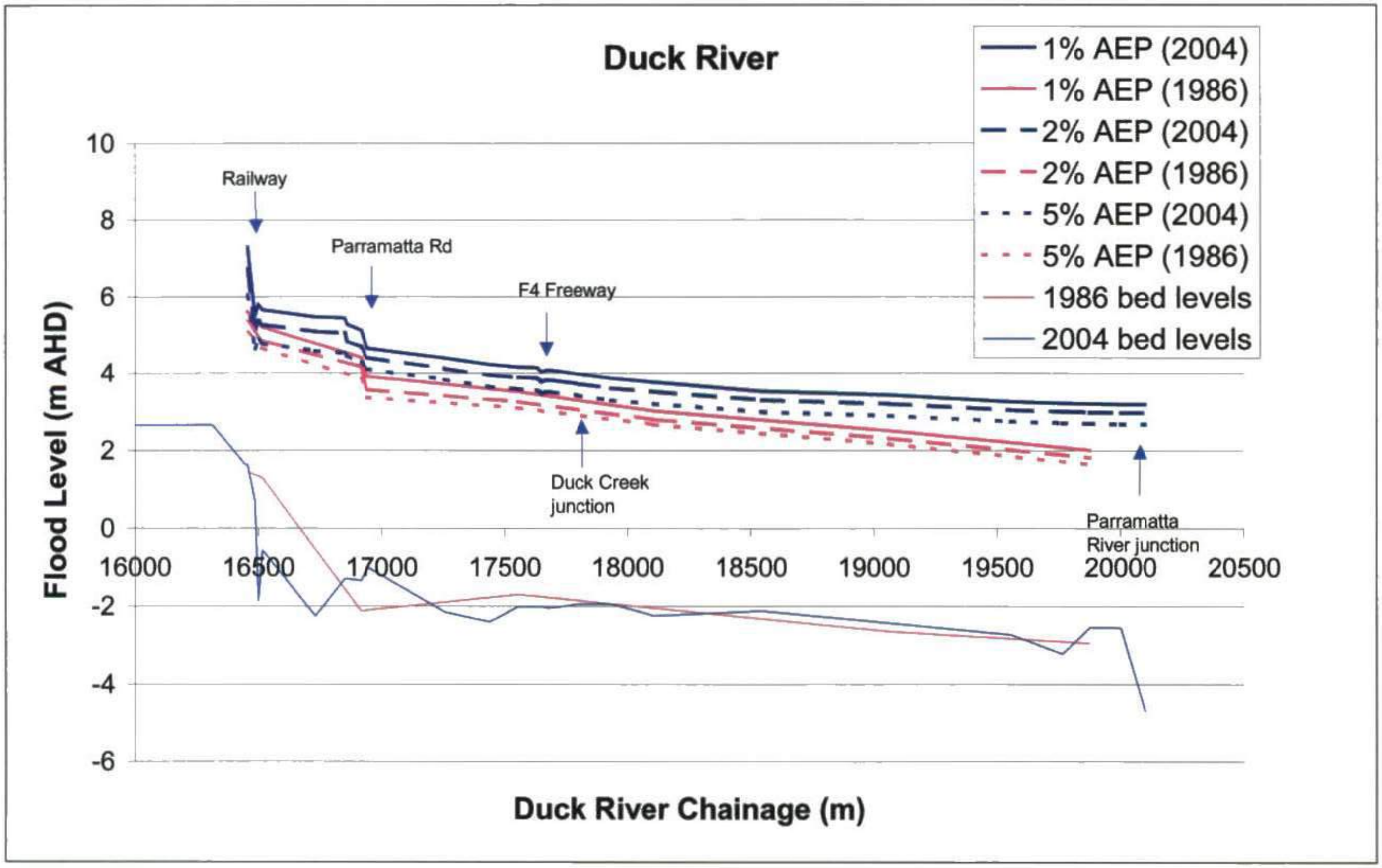
Results for Duck River are shown in **Figure 4-14**. Peak flood levels in Duck River estimated in the 1986 study are generally lower than those estimated in this study. See **Appendix D** for further details of the likely reasons for these differences.

The reasons for this discrepancy are:

- A steady state hydraulic model was used in the 1986 study for Duck River which had the following drawbacks;
  - Unable to assess the attenuation effects on the floodplain
  - Co-incident flooding in tributaries and Parramatta River
  - Not able to model the overland flowpaths that have been included in the MIKE-11 model
- Lower flood level in the Parramatta River adopted in the 1986 study influenced flood levels in Duck River; and
- Peak flows in Duck River estimated in this study are generally greater than those estimated in the 1986 study.

In addition, as detailed in **Appendix D**, there has been a considerable change in riverbed profile since the 1986 flood.

- **Figure 4-14 Comparison of flood level results (1%, 2% and 5% AEP) in Duck River from this study and the previous (1986) study**



4.7.2.3 Clay Cliff Creek

Results for Clay Cliff Creek are shown in **Figure 4-15**. Generally, flood levels estimated in this study are lower than those estimated in previous studies undertaken by Dalland & Lucas in 1992 and 1993. However, for Church Street and Alfred Street flood levels estimated in this study were higher than those estimated in the 1992 and 1993 study. Reasons for variations in flood levels between this study and previous studies on Clay Cliff Creek arise due to the following:

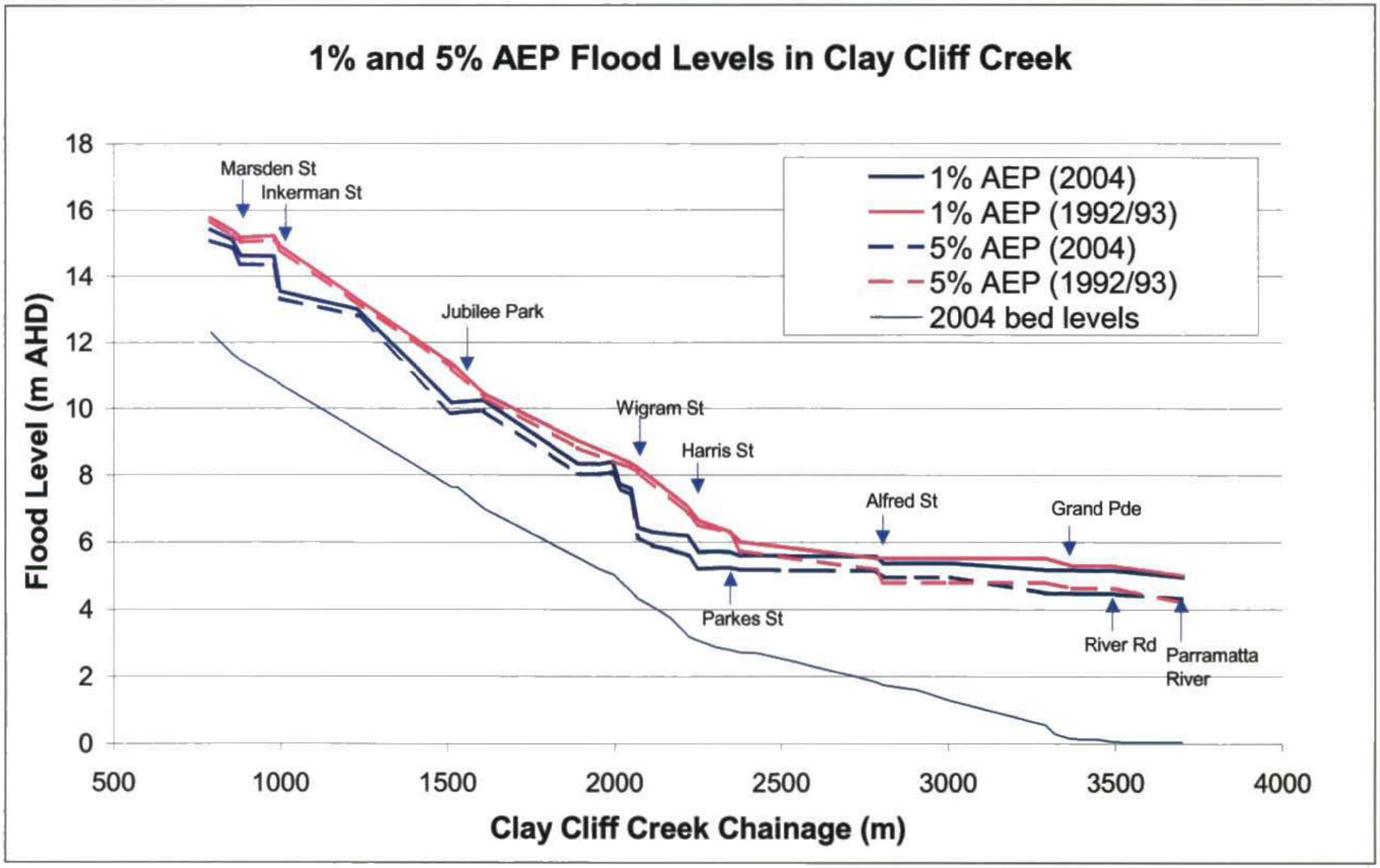
- The split catchment option was not used in the RAFTS model for Clay Cliff Creek in the previous studies. For an urbanised catchment it is a standard practice to split the catchment into pervious and impervious sub-catchment. The standard practice was followed in this study.
- The RAFTS model was used in the previous studies to route the inflow hydrograph through the creek and its floodplain where substantial over bank flooding would occur. In this study, the hydraulic model was used to route the flow through the creek and its floodplains.
- A single thread steady state hydraulic model was used in the previous studies to estimate flood profiles for the selected design flood events. Peak flows estimated by RAFTS were routed through a series of composite cross sections representing both the creek and its floodplain. In this study, separate flow paths were defined to represent the creek and its floodplain using in a quasi two dimensional hydraulic model. This approach fairly closely mimics the flood behaviour in the creek and on the floodplain taking due consideration of floodplain storage.

4.8 Flood Inundation Mapping

Peak flood levels presented in **Appendix B** were utilised to create flood surfaces for each of the selected design flood events. These surfaces were then intersected with the Digital Terrain Model for the study area to generate flood inundation polygons for each of the design flood events. All analysis and mapping were undertaken using ArcMap. Flood inundation maps for the 1% AEP flood event are shown in **Appendix C**.

Full details of flood levels and velocities at each cross-section in the MIKE-11 model can also be found in **Appendix B**.

- Figure 4-15 Comparison of flood level results (1% and 5% AEP) in Clay Cliff Creek from this study and the previous (1992/1993) study



5. Conclusions and Recommendations

A modern approach was adopted in this study to review the flood study for the Lower Parramatta River between Charles Street Weir and Ryde Bridge. The review used:

- Up-to-date catchment hydrology for the Upper Parramatta River Catchment;
- Existing/updated catchment hydrology for the tributaries draining into the Lower Parramatta River within the study area;
- Airborne Laser Survey;
- An additional 70 surveyed cross-sections;
- MIKE-11 computer model;
- Use of GIS to develop digital terrain models;
- Multiple design storms to generate maximum flood levels; and
- Appropriate methodology for estimating concurrent flows in tributaries.

Topographic data used in this study were obtained from a range of sources. The Waterways Authority supplied sounding data and 20 river cross sections for the Lower Parramatta River. Airborne laser survey was undertaken by Parramatta City Council for the study area that provided spot levels with an accuracy of 150 mm and 0.5m contours. Approximately 70 cross sections were surveyed as part of the study. Information on waterway crossings was obtained from the RTA and SRA.

All available topographic data were used to create a digital terrain model for the study area ArcMap. The terrain model was then used to extract cross sections for use in the hydraulic model. In excess of 500 cross sections were extracted from the terrain model to set up a quasi two-dimensional hydraulic model using the MIKE-11 modelling program.

Due to the limited availability of observed streamflow, historic flood levels and tide data, the MIKE-11 model was calibrated against recent observed tides monitored at four locations within the study area. The model satisfactorily reproduced the observed tides at all four locations.

The MIKE-11 model was run for a range of storm durations for the selected design flood events using inflow hydrographs simulated by hydrologic models for the tributaries. Results were then analysed to obtain peak flood levels, flows and velocities at modelled cross sections. Results obtained in this study were compared against those obtained in the 1986 Lower Parramatta River Flood Study and Flood Study Reports for Clay Cliff Creek prepared by Dalland & Lucas in 1992 and 1993 for Parramatta City Council.

Generally, results from this study compared well with previous studies. However, flood levels estimated in the 1986 study in the Lower Parramatta River downstream of Subiaco Creek were up to 1.2 m lower than those obtained in this study. Lower flood levels in the Parramatta River resulted in lower flood levels in Duck River in the 1986 study. Possible reasons for this variation are discussed in **Appendix D**.

Difference in flood levels between this study and the 1986 study results from the following:

- Modelling approach – this study adopted the modern practice in hydrologic and unsteady hydraulic modelling;
- Modelling programs – this study used commercially available modelling programs that have been widely used in flood studies and floodplain management studies both in Australia and overseas;
- Availability of additional topographic data – this study used much more detailed and up-to-date topographic data than those used in the 1986 study;
- Changes to bed level in Parramatta River; and
- Changes in land use - this study used most recent catchment conditions that prevailed at the time of undertaking the airborne laser survey.

Generally, this study simulated lower flood levels in Clay Cliff Creek and its floodplain than those obtained in the 1992 and 1993 study. However, there are a number of locations where flood levels estimated in this study were higher than those estimated in the previous studies. A detailed flood modelling was undertaken for Clay Cliff Creek in this study that properly represents the complexity of over bank flooding in Clay Cliff Creek. In the previous flood studies for Clay Cliff Creek, a simplified approach (steady state hydraulic model representing a single flow path) was adopted for Clay Cliff Creek. The simplified approach did not cater for the attenuation of the inflow hydrograph due to floodplain storage and overland flowpaths.

Results obtained from this study were used to develop flood inundation maps. Sensitivity of model results was checked due to variation in bed resistance and phase of the tide. Results on the variation of model results due to blockages and floodplain management issues are reported in a separate document.

The following recommendations are made in the light of this study:

- This study reviewed the flood behaviour in the Lower Parramatta River between Charles Street Weir and Ryde Bridge using the December 2001 floodplain conditions. The study needs to be updated in due course to estimate flood levels if there are modifications of floodplain conditions.
- Computer models used in this study were not calibrated against observed flood events due to paucity of required data. It is recommended that Parramatta City Council, Sydney Water Corporation and the NSW Department of Infrastructure, Planning and Natural Resources consider how to monitor streamflows in the Parramatta River and its major tributaries in a flood event. This will allow the computer model to be better calibrated against observed flood events in the future.
- Overland flooding resulting from minor drainage systems within the study area was not investigated in this study. Detailed studies will be undertaken in the future to address overland flooding issues.
- Design inflow hydrographs used in this study were obtained after running a number of hydrologic models. It would be prudent for Parramatta City Council

to aim to combine the models, when funds are available, into one hydrologic model for the Lower Parramatta River covering the catchment between Charles Street Weir and Ryde Bridge. This would then link better to the Upper Parramatta River Catchment where there is a single hydrologic model.

- At present, Parramatta City Council has been developing sub-catchment management plans for Vineyard Creek and Subiaco Creek[6]. Detailed hydrologic models (using XP-RAFTS) and detailed hydraulic models (using MIKE-11) are currently being developed for these creeks. The detailed hydraulic models for these creeks could be included into the MIKE-11 model for the Lower Parramatta River. This would eliminate the possibility of future studies using different flood levels in the Parramatta River. There is one MIKE-11 model for the Upper Parramatta River.
- The flood levels from this study are adopted by Parramatta, Auburn and Ryde Councils when they are considering development or planning in the floodplain.

[6] A detailed model became available for Duck Creek during this study and the hydrographs for Duck Creek at the confluence with Duck River, became input to the Lower Parramatta River MIKE 11 flood model.

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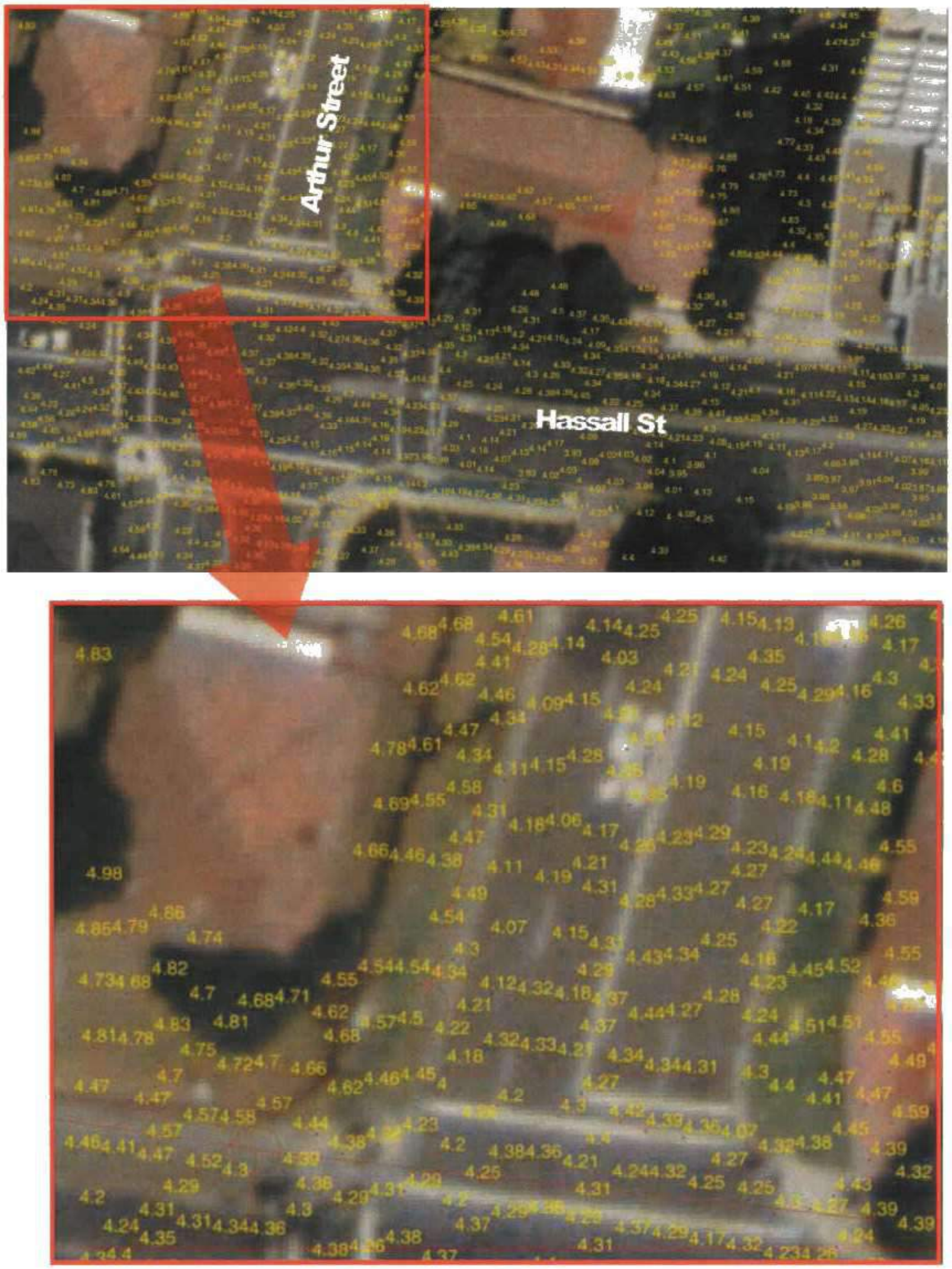
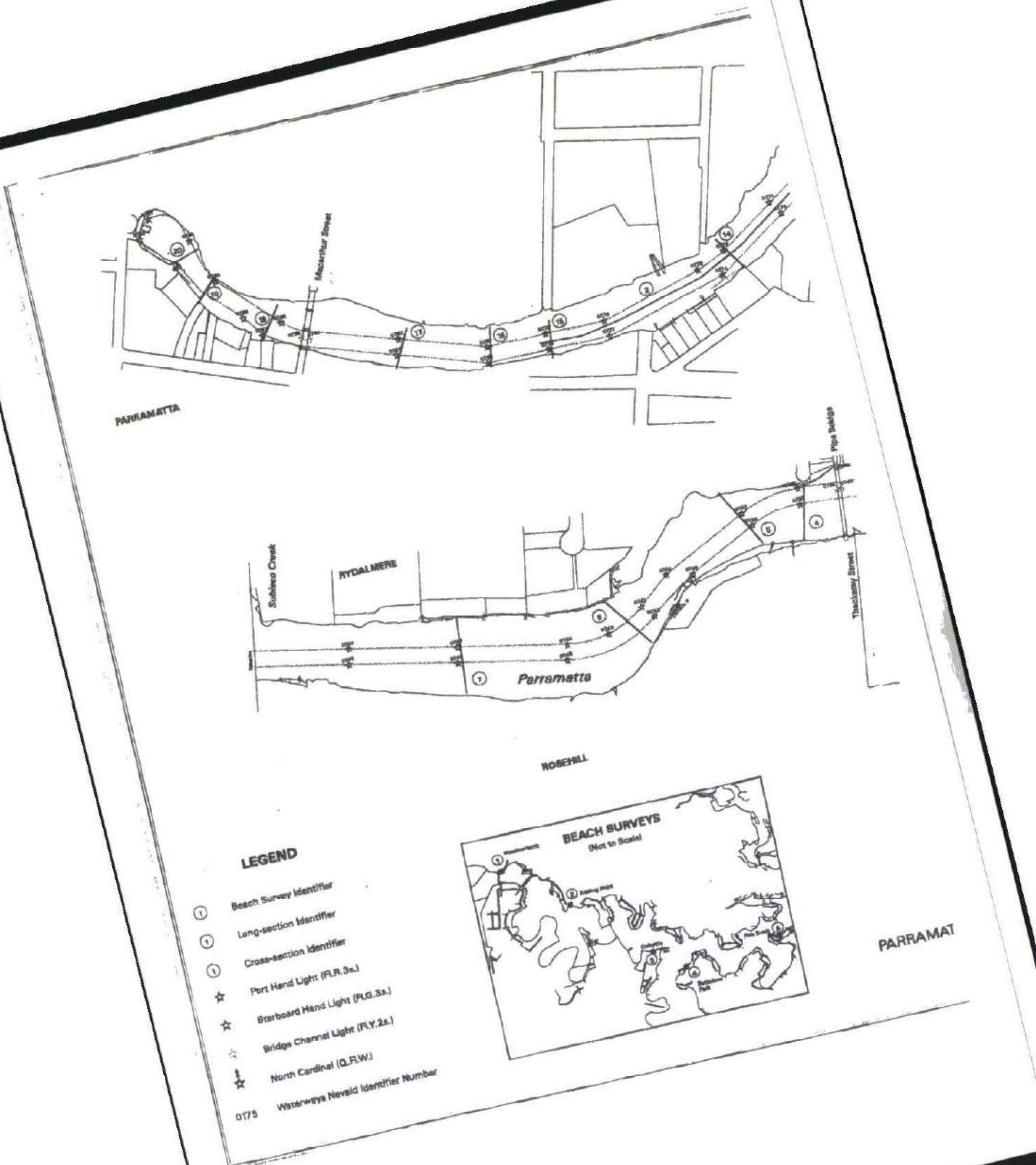
XP Software (Undated) *XP-RAFTS User's Manual Version 5.1*

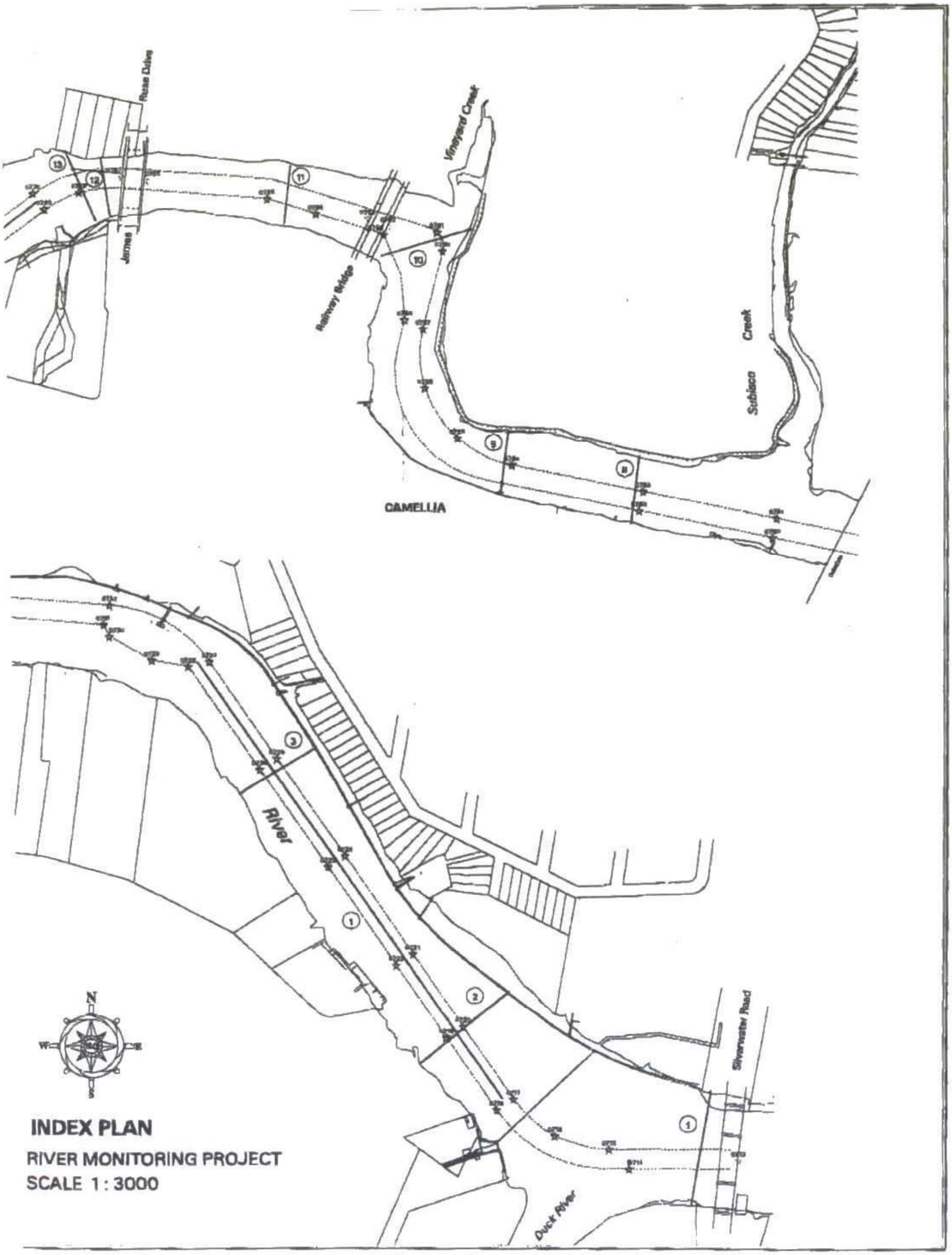
Appendix A Data Available

- **Figure A-1: Sample of airborne laser survey data**





Macarthur Street
PARRAMATTA
Pipe Bridge
Subiaco Creek
RYDALMERE
Thackeray Street
Parramatta
ROSEHILL
LEGEND
Beach Survey Identifier
Long-section Identifier
Cross-section Identifier
Port Hand Light (Fl.R.3s.)
Starboard Hand Light (Fl.G.3s.)
Bridge Channel Light (Fl.Y.2s.)
North Cardinal (Q.Fl.W.)
0175 Waterways Navaid Identifier Number
BEACH SURVEYS
(Not to Scale)
PARRAMAT

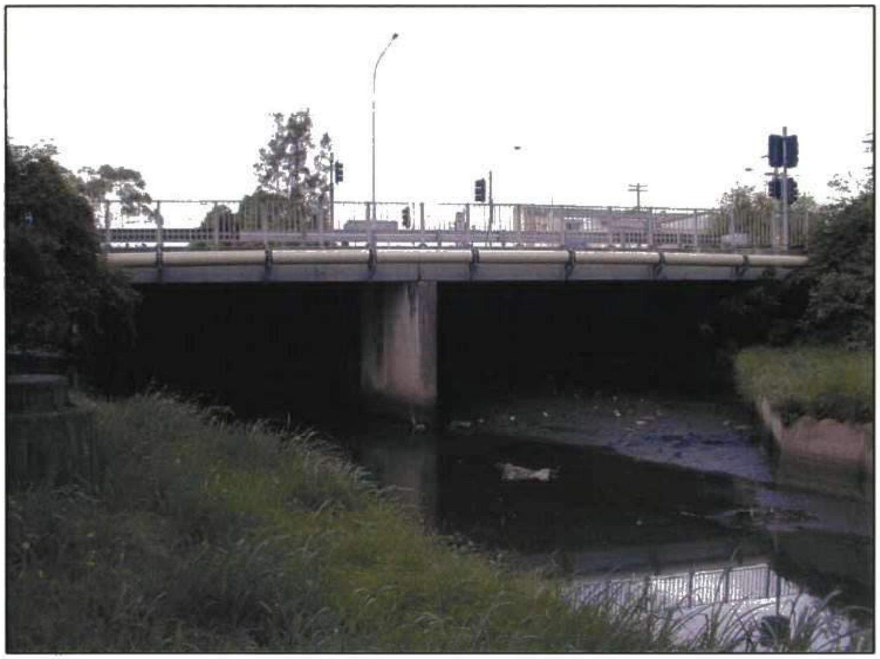


INDEX PLAN

RIVER MONITORING PROJECT

SCALE 1 : 3000

- **Figure A-3: Surveyed cross-section No. 17 (upstream side of James Ruse Drive on Duck Creek)**

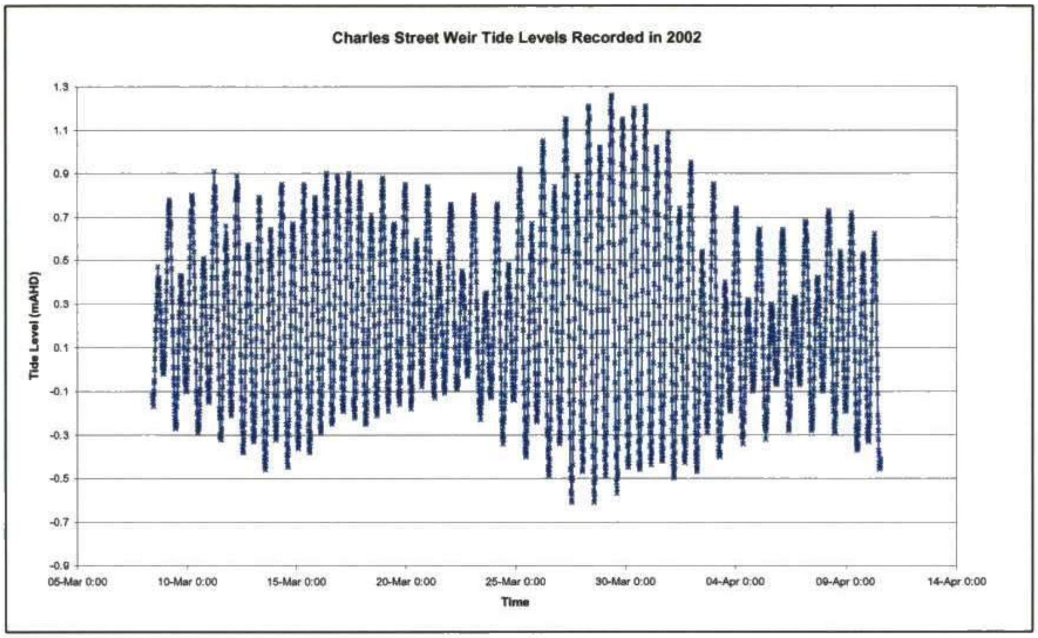


- **Figure A-4: Surveyed cross-section No. 44 (pipe bridge over Duck River, end of River Street)**

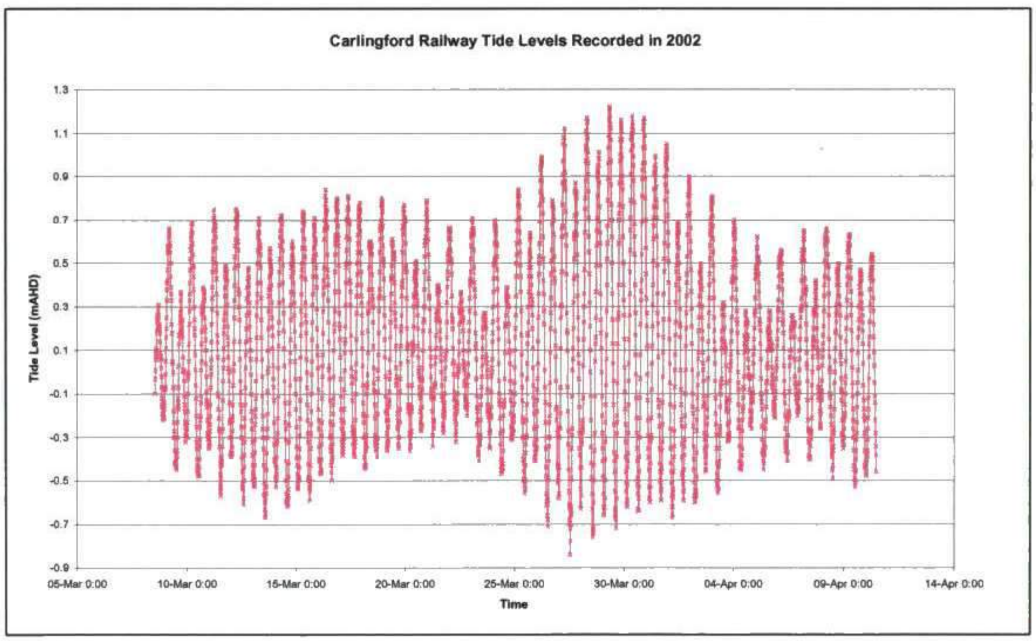
- **Figure A-5: Surveyed cross-section No. 47 (upstream side of Marsden Street, Clay Cliff Creek)**

- **Figure A-6: Surveyed cross-section No. 8 (Subiaco Creek)**

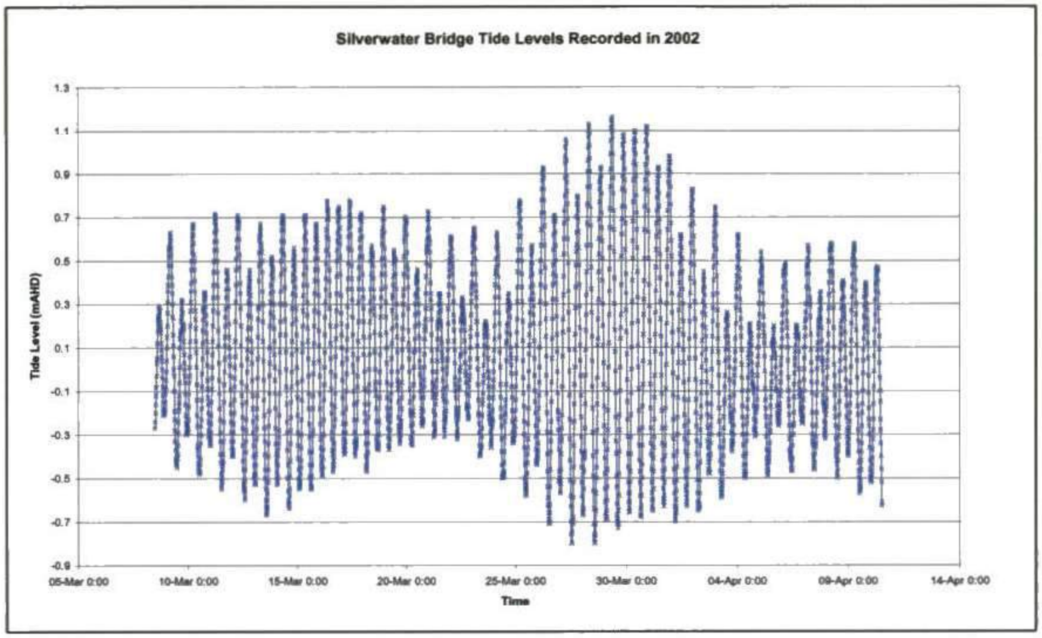
- **Figure A-7: Observed tide levels at Charles Street weir**



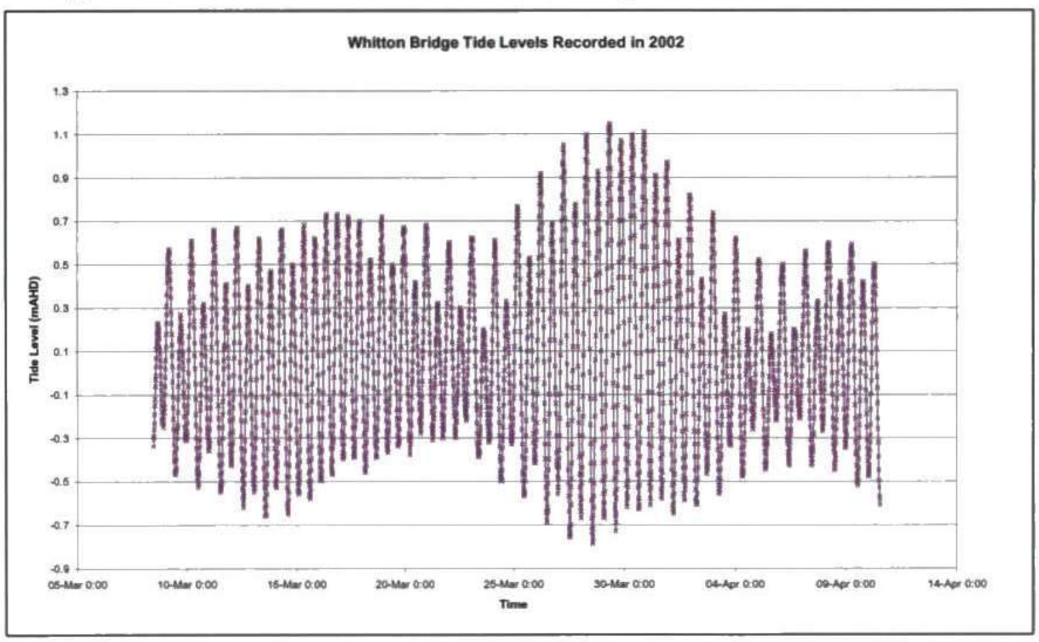
- **Figure A-8: Observed tide levels at Carlingford Railway**



- **Figure A-9: Observed tide levels at Silverwater Bridge**



- **Figure A-10: Observed tide levels at Whitton Bridge**



Lower Parramatta River Floodplain Risk Management Study

We need your help!

As discussed in the letter, the Lower Parramatta Floodplain Management Committee overseeing the Floodplain Management Plan would like to receive feedback from the community on a number of issues and topics related to flooding in your suburb. If you cannot answer any question, or do not wish to answer a question, then leave it unanswered and proceed to the next question. **Your input to this important study will be greatly appreciated.** If you need additional space, please add sheets.

If you would prefer to provide a letter with your comments or respond to this questionnaire by speaking to the consultant by telephone, this would also be welcomed. To discuss any aspects of this questionnaire, please call

Neil Mayo, the Consultant Project Manager
9928 2298, (if not available, leave a message, and you will be contacted) or
fax 02 9928 2504 or
email: nmayo@skm.com.au.

Please complete the Questionnaire by 12 April, 2002 and post in the envelope provided to:

James Carey
Waterway Systems Manager
Parramatta City Council
PO Box 32
PARRAMATTA NSW 2124

Place a tick in the relevant box or write answers.

Question No.		Question and Answer
1.		**Do you live (reside) in the study area shown on the attached plan?**
	☐	Yes (Please mark the location on the plan.)
	☐	No (Go to Question 3)
2.		**Do you own or rent your residence in the study area?**
	☐	Own
	☐	Rent
	☐	How long have you lived in the study area? (Please write number of years.)……….
3.		**Do you own or manage a business in the study area?**
	☐	Yes, For how many years? ……………….
	☐	No (go to Question 5)

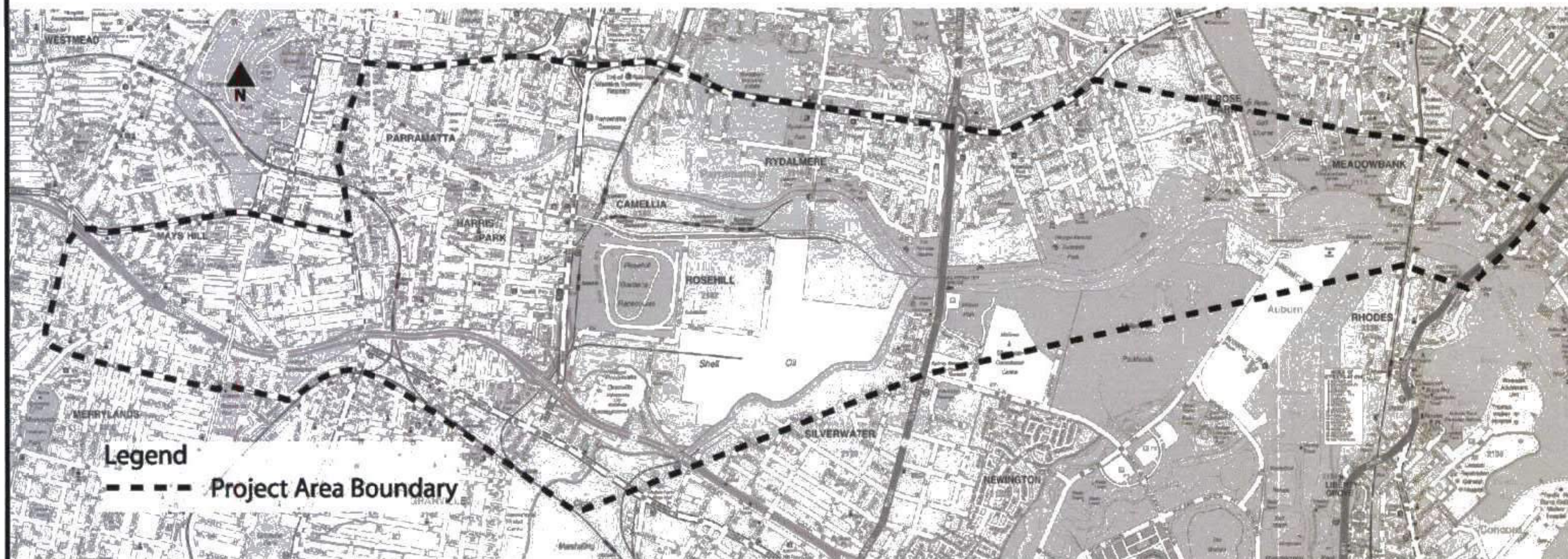
Quest-ion No.		Question and Answer
4.		**What kind of business?**
	☐	Home based business
	☐	Shop/commercial premises
	☐	Light industrial
	☐	Heavy industry
	☐	Others, please write type of business ………………………
5.		**Is your property within the area designated by Parramatta Council as being flood prone (ie subject to flooding in the 100 year average recurrence interval flood?)**
	☐	Yes
	☐	No
	☐	Don't know
6.		**Have you any experience of flooding in and around where you live or work?**
	☐	Yes
	☐	**No (Go to Question 15)**
7.		**How deep was the floodwater in the worst flood that you experienced?**
	☐	Please estimate the depth ……………………..
	☐	What was the year of this flood?……………………
		Where was this flood?
	☐	☐ At your house?
	☐	☐ At work?
	☐	☐ Elsewhere?
		Can you please provide a street location for this flood? ………………………..
8.		**How long did the floodwaters stay up?**
	☐	Few minutes
	☐	Less than one hour
	☐	More than one hour
9.		**If the flooding was where you lived, what damage resulted from this flood?** (Please indicate either "none", "minor", "moderate" or "major".
	………..	Damage to Garden, lawns or backyard
	…………	Damage to external house walls
	…………	Damage to Internal parts of house (floor, doors, walls etc)
	………..	Damage to Possessions (fridge, television etc)
	…………	Damage to car
	………..	Damage to Garage
	☐	Other damage, please list………………………………………
	☐	What was the cost of the repairs, if any?…………………..
10.		**If the flooding was at your business, what damage resulted from this flood?** (Please indicate either "none", "minor", "moderate" or "major".)
	…………	Damage to surroundings?
	…………	Damage to building
	…………	Damage to stock
	…………	Other damages, please list…………………..
		What was the cost of the repairs, if any?………………….

Question No.		Question and Answer
11.		**Was vehicle access to/from your property disrupted due to floodwaters during the worst flooding?**
	☐	Not affected
	☐	Minor disruption (roads flooded but still driveable)
	☐	Access cut off
12.		**What information can you provide on past floods?** (You can tick more than one box). Please write any descriptions at the end of the questionnaire
	☐	(a) No information
	☐	(b) Information on extent or depth of floodwater at particular locations, newspaper clippings or other images on the past floods
	☐	(c) Any permanent marks indicating maximum flood level for particular floods
	☐	(d) memory of flow directions, depth or velocities
13.		**Do you consider that flooding of your property has been made worse by works on other properties, or by the construction of roads or other structures?**
	☐	Yes (please provide further details. Attach extra page if necessary. Provide sketch if possible.
	☐	Unsure
	☐	No
14.		**Do you have any photographs of past floods that would be useful for the consultant to help him understand the area flooded or other flood effects?** If possible please attach the photographs (with dates and location) which will be copied and returned.
	☐	Yes (either attach or the consultant will contact you to arrange for a copy to be made and returned)
	☐	No
15.		**Do you expect to undertake any further development on your land in the future?**
	☐	No (go to Question 16)
	☐	Minor extensions
	☐	New building
	☐	unsure
	☐	Other (please specify) ______________________
16.		**Have you undertaken any steps to obtain approvals for further development on your land?**
	☐	No
	☐	Made preliminary enquires with Council
	☐	Engaged someone to prepare plans
	☐	Lodged plans with Council
	☐	Have approved plans but not proceeded

Quest-ion No.		Question and Answer
17.		**Please rank the following development types according to what you consider should be assigned greatest priority in protecting from flooding** (1 = greatest priority to 7 = least priority).
	☐	Commercial
	☐	Industrial
	☐	Residential
	☐	Community facilities (schools, halls, etc)
	☐	Critical utilities (power substations, telephone exchanges, etc.
	☐	Minor development and additions
	☐	Recreation areas and facilities
18.		**What notifications do you consider Council should give about the potential flood affectation of individual properties?** (Tick more than one box if required.)
	☐	Advise every resident and property owner on a regular basis of the known potential flood affectation
	☐	Advise every resident and property owner on a regular basis of Council's policies on the control of land potentially affected by flooding
	☐	Advise prospective purchasers/developers on the control of development on land potentially affected by flooding
	☐	Provide no notifications
19.		**Please rank from 1 to 4 (1 = highest importance) the following:**
	☐	Protecting Residents/business from flooding
	☐	Protecting land of residents/businesses from flooding
	☐	Maintaining flood free access to property
	☐	Providing flood warning
20.		**Please rank from 1 to 4 (1 = highest importance) the following:**
	☐	Preservation of creeks and waterways in a natural state
	☐	Improving water quality
	☐	Removing litter from creeks and rivers
	☐	Protecting plants and animals in the study area
21.		**Are you satisfied with Parramatta Council's service in the following areas, (please indicate, very satisfied, satisfied, dissatisfied, very dissatisfied)? If you have no opinion on any of these questions, write NA.**
	....	Flood protection during minor storms
	....	Flood protection in major storms
	....	Effectiveness of Street drainage
	....	Protection of plants and animals in the study area
	....	Advice from Council staff on flood issues
22.		**Do you wish to comment on any other issues associated with the development of the Floodplain Management Plan? Please add comments at the back of the questionnaire.**
23.		**Do you wish to remain on the mailing list for further details, Newsletters etc?**
	☐	Yes (please provide contact details, see next question)
	☐	No

Quest-ion No.		Question and Answer
24.		If you would like, please provide details of where you live and how we can contact you if we need to follow up on some details or seek additional comment. Can you please also mark the location of your residence/business with a clear dot on the attached plan. **Name:..** **Address..** **...** **Telephone:........................** **Fax:...........................** **Email:........................**
		Space for additional comments

Study Area


WESTMEAD
N
PARRAMATTA
RYDALMERE
MEADOWBANK
CAMELLIA
HARRIS PARK
MAYS HILL
ROSEHILL
Auburn
RHODES
Shell
Oil
MERRYLANDS
SILVERWATER
NEWINGTON
Legend
Project Area Boundary

Appendix B Hydraulic Modelling Results

Flowpath	Chainage (m)	Peak water levels (m AHD)					Peak flows (m^3/s)					Peak velocities (m/s)				
		20% AEP	5% AEP	2% AEP	1% AEP	PMF	20% AEP	5% AEP	2% AEP	1% AEP	PMF	20% AEP	5% AEP	2% AEP	1% AEP	PMF
ALFRED	0	4.19	5.15	5.45	5.58	9.27	0	0	1	2	19	0.0	0.0	1.4	1.5	2.6
ALFRED	72	3.89	4.45	4.90	5.16	9.20	0	0	0	-2	-180	0.0	0.0	0.0	1.8	3.1
ALFRED	189	3.89	4.47	4.90	5.16	9.22	0	0	0	-1	-180	0.0	0.0	0.0	2.1	-7.3
ALFRED	218	3.89	4.47	4.90	5.16	9.22	0	0	0	0	165	0.0	0.0	0.0	0.0	3.4
ALFRED	311	3.87	4.47	4.89	5.16	9.18	0	0	0	0	-186	0.0	0.0	0.0	0.0	3.6
ALFRED	392	3.87	4.47	4.89	5.16	9.27	0	0	0	2	495	0.0	0.0	0.0	-0.4	2.7
ALFRED	424	3.89	4.44	4.87	5.12	9.02	0	0	0	2	494	0.0	0.0	0.0	1.0	5.7
ALFRED	455	3.89	4.38	4.76	5.02	9.32	0	0	0	2	494	0.0	0.0	0.0	1.0	5.7
ARGUS	0	5.67	6.04	6.33	6.40	9.72	0	0	0	0	72	0.0	0.0	0.0	0.0	1.5
ARGUS	55	5.67	6.04	6.33	6.40	9.70	0	0	0	0	75	0.0	0.0	0.0	0.0	2.7
ARGUS	111	5.01	5.34	5.69	6.25	9.69	0	0	0	0	75	0.0	0.0	0.0	0.0	2.9
ARGUS	177	4.70	5.05	5.36	5.94	9.67	0	0	0	0	74	0.0	0.0	0.0	0.0	3.9
ARTHUR	0	3.89	4.48	4.90	5.15	9.16	0	0	3	4	436	0.0	0.0	1.2	1.4	4.5
ARTHUR	24	3.88	4.48	4.90	5.16	9.11	0	0	3	4	436	0.0	0.0	1.0	1.7	5.4
ARTHUR	110	3.87	4.47	4.90	5.16	9.20	0	0	3	4	436	0.0	0.0	0.4	0.7	3.9
ARTHUR	137	3.87	4.47	4.89	5.16	9.37	0	0	4	6	288	0.0	0.0	0.5	0.9	3.1
ARTHUR	216	3.87	4.47	4.89	5.16	9.17	0	0	4	6	599	0.0	0.0	-1.3	1.6	4.0
ARTHUR	259	3.87	4.47	4.89	5.16	9.43	0	-1	4	6	599	0.0	1.2	-0.2	-0.3	3.5
ARTHUR	290	3.87	4.47	4.89	5.16	9.32	0	0	2	4	356	0.0	0.0	-0.5	-0.5	5.0
ARTHUR	385	3.87	4.47	4.89	5.16	9.15	0	0	2	4	355	0.0	0.0	-0.3	-0.4	3.1
ARTHUR	410	3.89	4.47	4.89	5.16	9.28	0	0	2	4	355	0.0	0.0	-0.5	-0.7	2.7
BUNNINGS	0	3.58	3.71	4.25	4.64	7.29	0	0	3	28	326	0.0	0.0	0.6	1.4	2.7
BUNNINGS	83	3.30	3.62	3.94	4.25	7.49	0	0	3	28	327	0.0	0.0	0.5	1.0	2.1
BUNNINGS	183	3.08	3.62	3.93	4.21	7.26	0	-1	-4	28	327	0.0	2.3	2.4	2.5	3.2
BUNNINGS	295	3.08	3.62	3.93	4.21	7.47	0	-2	-4	28	328	0.0	2.3	2.4	2.5	3.2
CHARLES	0	6.48	7.81	7.91	7.97	9.63	0	0	0	0	-44	0.0	0.0	0.0	0.0	3.6
CHARLES	17	5.51	6.12	6.34	6.40	9.65	0	0	0	0	-44	0.0	0.0	0.0	0.0	2.9
CHARLES	126	5.50	5.97	6.33	6.39	9.69	0	0	0	0	-43	0.0	0.0	0.0	0.0	1.7
CHARLES	160	5.48	5.96	6.33	6.39	9.69	0	0	0	0	-120	0.0	0.0	0.0	0.0	6.4
CHARLES	279	5.03	5.17	5.91	6.21	9.72	0	0	0	0	-121	0.0	0.0	0.0	0.0	3.8
CHARLES	327	5.01	5.17	5.87	6.21	9.74	0	0	0	0	-264	0.0	0.0	0.0	0.0	7.0
CHARLES	431	4.93	5.23	5.76	6.09	9.98	0	0	0	0	-264	0.0	0.0	0.0	0.0	6.1
CHARLES	467	4.93	5.24	5.50	5.68	10.14	0	0	0	0	-264	0.0	0.0	0.0	0.0	-5.7
CHARLES_PARKES	0	7.57	8.03	8.21	8.33	9.70	0	0	0	0	35	0.0	0.0	0.0	0.0	-2.7
CHARLES_PARKES	20	7.85	8.02	8.20	8.33	9.70	0	0	0	0	35	0.0	0.0	0.0	0.0	1.1
CHARLES_PARKES	90	7.73	7.99	8.17	8.28	9.52	0	0	0	0	35	0.0	0.0	0.0	0.0	2.8
CHARLES_PARKES	100	6.48	7.81	7.91	7.97	9.63	0	0	0	0	35	0.0	0.0	0.0	0.0	3.9
CHURCH	0	12.31	12.54	12.76	12.90	14.10	3	6	7	8	147	1.4	1.7	1.9	1.9	3.8
CHURCH	55	12.15	12.52	12.77	12.91	13.95	3	6	7	8	147	2.7	3.4	3.9	4.9	6.0
CHURCH	133	12.15	12.52	12.77	12.91	13.84	2	5	5	6	147	1.5	2.0	2.1	2.1	2.8
CHURCH_CLAYCLIFF1	0	12.15	12.52	12.77	12.91	13.95	2	7	12	16	50	1.3	1.9	2.2	2.4	3.9
CHURCH_CLAYCLIFF1	31	11.74	11.84	11.91	11.95	13.01	2	7	12	16	51	3.7	5.0	3.8	4.6	5.5
CHURCH_CLAYCLIFF1	60	11.46	11.57	11.64	11.68	12.91	2	7	12	16	54	2.1	2.5	2.8	2.8	3.4
CHURCH_CLAYCLIFF1	97	10.30	10.52	10.65	10.74	12.97	2	8	13	18	98	2.2	2.7	4.0	2.7	3.5
CHURCH_CLAYCLIFF1	124	10.29	10.51	10.64	10.73	12.97	2	8	13	18	99	1.7	2.7	3.4	3.8	6.2
CHURCH_CLAYCLIFF1	146	10.04	10.18	10.29	10.38	12.91	2	8	13	18	100	1.7	2.4	2.8	3.1	3.9
CHURCH_CLAYCLIFF1	166	9.54	9.86	10.02	10.18	13.00	2	8	13	18	100	2.9	4.2	4.6	5.0	4.7
CHURCH_PARKES	0	12.15	12.52	12.77	12.91	13.84	2	3	4	4	147	2.9	4.1	4.7	5.7	9.1
CHURCH_PARKES	43	12.06	12.52	12.77	12.91	13.77	2	3	4	4	146	1.9	3.0	3.6	3.8	6.8
CHURCH_PARKES	104	11.65	11.69	11.70	11.75	12.95	0	1	1	2	123	0.0	3.5	3.7	4.0	7.4
CHURCH_PARKES	209	9.81	9.84	9.87	9.92	11.31	0	0	1	2	122	0.0	0.0	1.4	1.4	4.5
CHURCH_PARKES	252	9.26	9.48	9.56	9.65	11.07	0	6	10	15	227	0.0	1.3	1.5	2.1	5.5
CHURCH_PARKES	305	9.03	9.29	9.36	9.44	10.71	0	6	10	15	226	0.0	3.6	3.7	4.0	6.7
CHURCH_PARKES	349	8.50	9.00	9.07	9.15	10.33	0	6	10	15	226	0.0	1.7	1.9	2.2	3.9

Flowpath	Chainage (m)	Peak water levels (m AHD)					Peak flows (m^3/s)					Peak velocities (m/s)				
		20% AEP	5% AEP	2% AEP	1% AEP	PMF	20% AEP	5% AEP	2% AEP	1% AEP	PMF	20% AEP	5% AEP	2% AEP	1% AEP	PMF
CHURCH_PARKES	378	8.49	8.79	8.86	8.94	10.23	0	6	10	15	227	0.0	1.8	2.0	2.1	3.5
CLAYCLIFF	0	21.06	21.39	21.54	21.68	22.97	16	23	27	31	131	0.7	2.3	0.7	0.8	1.7
CLAYCLIFF	85	20.92	21.27	21.44	21.54	22.49	16	23	27	31	131	0.5	2.3	0.6	0.6	1.8
CLAYCLIFF	147	20.86	21.13	21.38	21.47	22.19	15	23	27	31	143	2.9	3.1	3.1	3.2	4.3
CLAYCLIFF	158	20.81	21.15	21.37	21.46	22.16	15	23	27	31	143	0.5	2.4	0.7	0.7	1.4
CLAYCLIFF	172	20.77	21.11	21.36	21.45	22.15	15	22	27	31	143	1.2	2.4	1.4	1.4	1.8
CLAYCLIFF	211	20.31	20.93	21.31	21.38	22.03	15	22	26	30	143	2.3	2.8	3.1	3.3	3.3
CLAYCLIFF	305	19.35	19.92	20.16	20.39	21.31	17	26	31	35	168	2.4	2.9	3.1	3.3	3.6
CLAYCLIFF	399	18.10	18.55	18.75	18.93	20.28	17	26	31	35	168	3.1	3.9	4.2	4.5	5.8
CLAYCLIFF	465	16.49	16.72	16.83	16.91	18.71	20	30	35	40	189	1.6	2.2	2.1	2.2	4.6
CLAYCLIFF	478	15.99	16.17	16.25	16.34	17.96	20	30	35	40	189	0.7	4.3	0.8	0.8	1.5
CLAYCLIFF	500	15.81	16.01	16.09	16.20	17.83	20	30	35	39	188	0.9	3.8	1.1	1.1	2.0
CLAYCLIFF	620	14.87	15.27	15.48	15.60	17.07	19	28	32	37	188	0.7	3.3	0.8	0.8	1.4
CLAYCLIFF	752	14.79	15.22	15.44	15.55	16.80	16	24	28	34	184	0.2	2.9	0.2	0.3	1.0
CLAYCLIFF	772	14.77	15.21	15.42	15.51	16.69	17	24	29	35	190	2.0	2.9	2.7	2.7	2.6
CLAYCLIFF	789	14.68	15.08	15.27	15.40	16.64	17	25	30	35	196	1.4	2.9	1.9	2.0	1.9
CLAYCLIFF	855	14.33	14.86	15.00	15.11	16.58	18	20	21	21	22	1.8	2.6	1.9	1.9	1.9
CLAYCLIFF	880	13.90	14.36	14.53	14.64	16.15	18	25	29	32	121	3.0	3.0	3.0	3.0	2.8
CLAYCLIFF	980	13.84	14.34	14.50	14.61	16.05	19	23	25	26	33	2.4	2.4	2.4	2.4	2.4
CLAYCLIFF	998	13.04	13.32	13.45	13.55	14.73	19	24	26	28	58	3.1	3.0	3.1	3.1	3.0
CLAYCLIFF	1230	12.60	12.80	12.90	13.00	14.41	15	15	15	15	15	2.9	2.9	2.9	2.9	2.9
CLAYCLIFF	1511	9.53	9.84	10.01	10.17	13.00	19	20	20	21	88	2.9	3.0	3.0	3.0	3.5
CLAYCLIFF	1529	9.54	9.86	10.02	10.18	13.00	19	24	29	34	145	2.4	2.5	2.5	2.5	3.0
CLAYCLIFF	1607	9.50	9.92	10.08	10.24	13.01	20	21	23	23	33	2.1	2.1	2.1	2.1	2.4
CLAYCLIFF	1890	7.93	8.02	8.20	8.33	9.88	20	20	22	23	50	2.9	2.9	2.8	2.8	2.5
CLAYCLIFF	1935	7.88	8.02	8.20	8.33	9.70	21	22	22	24	54	2.3	2.3	2.2	2.2	2.8
CLAYCLIFF	1955	7.86	8.01	8.19	8.32	9.68	21	22	22	24	54	2.2	2.3	2.2	2.2	2.8
CLAYCLIFF	1990	7.90	8.07	8.25	8.38	9.81	21	22	22	24	54	2.4	2.4	2.4	2.4	2.2
CLAYCLIFF	1994	7.85	8.02	8.20	8.33	9.70	19	22	23	24	25	2.4	2.4	2.4	2.4	2.3
CLAYCLIFF	2015	7.50	7.62	7.68	7.75	9.59	19	22	24	24	25	2.5	2.5	2.5	2.5	2.4
CLAYCLIFF	2050	7.29	7.39	7.50	7.59	9.43	22	23	25	26	35	2.2	2.2	2.3	2.3	2.4
CLAYCLIFF	2070	6.05	6.13	6.19	6.43	9.44	22	23	25	26	47	4.2	4.3	4.3	4.3	4.2
CLAYCLIFF	2114	5.77	5.88	5.97	6.29	9.44	22	23	25	26	48	3.4	3.5	3.5	3.5	3.3
CLAYCLIFF	2166	5.61	5.77	5.87	6.23	9.44	22	23	25	26	48	3.1	3.2	3.2	3.2	3.0
CLAYCLIFF	2220	5.44	5.60	5.70	6.19	9.44	25	28	29	30	43	2.9	2.9	2.9	2.9	2.9
CLAYCLIFF	2252	4.99	5.21	5.49	5.70	9.48	25	28	29	29	78	3.0	3.1	3.2	3.2	3.5
CLAYCLIFF	2307	4.82	5.23	5.56	5.73	9.48	25	28	31	35	231	2.5	2.6	2.6	2.6	2.7
CLAYCLIFF	2346	4.81	5.24	5.54	5.70	9.47	25	28	31	34	42	1.1	1.1	1.1	1.1	1.3
CLAYCLIFF	2377	4.47	5.17	5.47	5.59	9.24	25	28	31	34	67	2.4	2.5	2.5	2.5	2.6
CLAYCLIFF	2429	4.31	5.18	5.47	5.60	9.24	25	27	31	34	103	0.2	0.2	0.2	0.2	0.2
CLAYCLIFF	2528	4.28	5.16	5.46	5.59	9.23	25	28	30	33	101	2.8	2.7	2.7	2.7	2.7
CLAYCLIFF	2593	4.26	5.16	5.46	5.59	9.23	25	28	30	33	100	2.8	2.7	2.7	2.7	2.7
CLAYCLIFF	2722	4.19	5.16	5.45	5.58	9.26	24	27	29	32	55	2.7	2.7	2.6	2.5	2.5
CLAYCLIFF	2783	4.19	5.15	5.45	5.58	9.27	27	31	32	33	43	2.3	2.3	2.3	2.3	2.3
CLAYCLIFF	2805	4.13	4.96	5.24	5.37	9.17	27	30	31	32	49	1.1	1.2	1.2	1.2	1.2
CLAYCLIFF	2903	4.13	4.96	5.24	5.37	9.17	26	30	32	33	65	0.6	1.4	0.6	0.6	0.8
CLAYCLIFF	3006	4.14	4.96	5.24	5.37	9.17	24	27	29	30	36	0.3	0.3	0.3	0.3	0.3
CLAYCLIFF	3290	3.90	4.48	4.90	5.17	9.34	24	27	28	30	42	1.0	1.0	1.0	1.0	1.1
CLAYCLIFF	3318	3.90	4.48	4.90	5.17	9.34	25	28	29	31	52	1.1	1.1	1.2	1.2	1.7
CLAYCLIFF	3360	3.90	4.48	4.90	5.17	9.34	24	26	27	28	79	0.7	0.7	0.7	0.7	0.7
CLAYCLIFF	3370	3.89	4.48	4.90	5.17	9.34	24	26	27	28	79	1.2	1.2	1.2	1.2	1.4
CLAYCLIFF	3378	3.89	4.47	4.89	5.16	9.32	24	26	27	28	-79	1.2	1.2	1.2	1.2	1.4
CLAYCLIFF	3389	3.89	4.47	4.89	5.16	9.32	24	26	27	28	52	1.1	1.1	1.2	1.1	1.1
CLAYCLIFF	3445	3.89	4.47	4.89	5.16	9.32	24	26	27	28	52	1.0	1.0	1.0	1.0	1.1

Flowpath	Chainage	Peak water levels (m AHD)					Peak flows (m^3/s)					Peak velocities (m/s)				
	(m)	20% AEP	5% AEP	2% AEP	1% AEP	PMF	20% AEP	5% AEP	2% AEP	1% AEP	PMF	20% AEP	5% AEP	2% AEP	1% AEP	PMF
CLAYCLIFF	3490	3.89	4.47	4.89	5.16	9.32	24	27	28	28	35	0.8	0.8	0.8	0.8	0.8
CLAYCLIFF	3511	3.87	4.44	4.87	5.14	9.32	24	27	28	28	51	0.8	0.8	0.8	0.8	0.8
CLAYCLIFF	3515	3.87	4.43	4.87	5.14	9.32	24	27	27	28	51	1.1	1.1	1.1	1.1	1.3
CLAYCLIFF	3701	3.82	4.32	4.70	4.96	9.30	24	26	26	27	50	3.4	2.6	2.7	2.3	4.9
CLAYCLIFF_CHURCH_PARKES	1607	9.50	9.92	10.08	10.24	13.01	0	5	9	13	106	0.0	0.1	0.2	0.2	0.4
CLAYCLIFF_CHURCH_PARKES	1675	9.26	9.50	9.59	9.68	11.16	0	5	9	13	106	0.0	0.5	0.7	0.8	1.8
CLAYCLIFF_CHURCH_PARKES	1685	9.26	9.48	9.56	9.65	11.07	0	5	9	13	106	0.0	1.5	1.7	1.8	2.9
DUCK_RIVER	16486	3.91	4.63	5.12	5.50	8.59	174	243	271	304	748	3.2	3.4	3.5	3.6	3.7
DUCK_RIVER	16500	4.11	4.88	5.38	5.78	8.68	174	243	271	304	747	0.9	1.4	1.1	1.1	1.1
DUCK_RIVER	16516	4.02	4.76	5.26	5.65	8.46	174	241	270	304	747	1.2	1.7	1.3	1.4	1.4
DUCK_RIVER	16730	3.86	4.57	5.08	5.47	8.17	171	240	269	302	742	1.7	1.8	1.9	1.9	2.5
DUCK_RIVER	16849	3.80	4.51	5.04	5.44	8.12	170	237	268	301	742	1.3	1.3	1.4	1.4	1.9
DUCK_RIVER	16859	3.72	4.44	4.83	5.27	7.99	170	237	268	301	743	1.3	1.4	1.4	1.4	1.9
DUCK_RIVER	16916	3.55	4.27	4.67	5.11	7.80	170	237	262	276	452	1.9	2.0	2.1	2.1	2.6
DUCK_RIVER	16939	3.46	4.10	4.40	4.64	7.66	170	238	263	277	456	1.9	2.1	2.1	2.1	2.1
DUCK_RIVER	17256	3.25	3.82	4.11	4.39	7.55	170	237	261	273	454	1.2	1.4	1.4	1.5	1.4
DUCK_RIVER	17438	3.08	3.62	3.93	4.21	7.47	169	234	260	296	743	1.5	1.8	1.9	1.9	1.9
DUCK_RIVER	17555	3.03	3.57	3.88	4.15	7.32	168	232	259	295	735	1.3	1.5	1.5	1.6	2.1
DUCK_RIVER	17671	2.97	3.49	3.80	4.07	6.73	169	234	261	298	756	1.0	1.2	1.2	1.3	1.8
DUCK_RIVER	17700	2.96	3.48	3.79	4.06	6.71	169	234	261	298	755	1.0	1.3	1.2	1.3	1.8
DUCK_RIVER	17796	2.89	3.40	3.70	3.96	6.56	200	270	303	346	895	1.3	1.5	1.6	1.7	2.0
DUCK_RIVER	17932	2.75	3.27	3.59	3.85	6.38	246	321	361	414	1100	1.5	1.6	1.6	1.5	1.7
DUCK_RIVER	18106	2.68	3.19	3.50	3.74	6.13	245	320	361	413	1110	1.2	1.3	1.3	1.4	2.1
DUCK_RIVER	18545	2.50	2.98	3.29	3.52	5.71	246	320	364	416	1149	1.3	1.5	1.5	1.6	2.4
DUCK_RIVER	19061	2.41	2.89	3.19	3.42	5.67	236	307	356	407	1164	0.7	0.8	0.8	0.8	1.0
DUCK_RIVER	19556	2.28	2.73	3.03	3.25	5.54	226	294	340	389	1148	1.4	1.5	1.5	1.7	2.6
DUCK_RIVER	19764	2.25	2.70	2.99	3.21	5.52	224	291	337	383	1145	1.1	1.5	1.3	1.5	2.2
DUCK_RIVER	19874	2.23	2.68	2.98	3.19	5.52	222	288	334	379	1142	1.2	1.6	1.3	1.5	1.9
DUCK_RIVER	20000	2.22	2.66	2.96	3.18	5.52	219	283	329	374	1136	0.9	1.2	1.0	1.2	1.5
DUCK_RIVER	20100	2.22	2.66	2.96	3.18	5.52	218	282	327	372	1134	0.5	1.5	0.6	0.6	1.1
GEORGE	0	5.01	5.17	5.87	6.21	9.74	0	0	0	0	151	0.0	0.0	0.0	0.0	3.6
GEORGE	26	5.01	5.16	5.86	6.20	9.72	0	0	0	0	149	0.0	0.0	0.0	0.0	5.0
GEORGE	89	4.99	5.13	5.84	6.17	9.58	0	0	0	0	149	0.0	0.0	0.0	0.0	5.0
GEORGE	150	4.70	5.05	5.36	5.94	9.67	0	0	0	0	147	0.0	0.0	0.0	0.0	4.0
GEORGE2	0	3.87	4.47	4.89	5.16	9.18	0	0	0	0	328	0.0	0.0	0.0	0.0	3.7
GEORGE2	14	3.87	4.47	4.89	5.16	9.09	0	0	0	0	328	0.0	0.0	0.0	0.0	4.1
GEORGE2	74	3.87	4.47	4.89	5.16	9.22	0	0	0	0	327	0.0	0.0	0.0	0.0	3.4
GEORGE2	200	3.87	4.47	4.89	5.16	9.17	0	0	0	0	326	0.0	0.0	0.0	0.0	3.0
GRAND	0	3.87	4.47	4.89	5.16	9.27	0	0	0	-2	-272	0.0	0.0	0.0	-0.2	-1.4
GRAND	80	3.87	4.47	4.89	5.16	9.25	0	0	0	-2	-272	0.0	0.0	0.0	-0.3	-1.5
GRAND	135	3.87	4.47	4.89	5.16	9.27	0	0	-1	-2	-271	0.0	0.0	-0.2	-0.3	-1.4
GRAND	207	3.87	4.47	4.89	5.16	9.32	0	0	-1	-2	-269	0.0	0.0	-0.1	-0.1	-0.5
GRAND_CLAYCLIFF	0	3.87	4.47	4.89	5.16	9.32	0	-3	-5	-7	85	0.0	2.6	-1.7	-1.9	-1.2
GRAND_CLAYCLIFF	36	3.87	4.47	4.89	5.16	9.32	0	-3	-6	-7	85	0.0	-0.9	-1.0	-1.1	1.0
GRAND_CLAYCLIFF	90	3.89	4.47	4.89	5.16	9.32	0	-3	-6	-8	84	0.0	-0.6	0.7	1.1	1.7
GREGORY	0	4.82	5.16	5.45	5.57	9.35	0	0	0	-2	131	0.0	0.0	0.0	-1.6	-4.3
GREGORY	19	4.83	5.16	5.45	5.58	9.34	0	0	0	-2	131	0.0	0.0	0.0	-0.4	-1.8
GREGORY	79	4.83	5.16	5.45	5.58	9.32	0	0	0	-1	131	0.0	0.0	0.0	-1.3	-6.2
GREGORY	146	4.19	5.16	5.45	5.58	9.28	0	0	0	-1	132	0.0	0.0	0.0	-1.0	-2.0
GREGORY	205	4.19	5.16	5.45	5.58	9.26	0	-2	-2	-2	132	0.0	-0.1	-0.1	-0.1	1.4
HASSALL_MACQUARIE	0	6.00	7.90	8.00	8.06	9.42	0	0	1	2	-50	0.0	0.0	1.8	2.0	2.8
HASSALL_MACQUARIE	29	5.67	7.36	7.39	7.42	9.73	0	0	1	2	-50	0.0	0.0	4.3	4.6	4.5
HASSALL_MACQUARIE	120	5.67	6.04	6.33	6.40	9.74	0	0	1	2	-61	0.0	0.0	0.6	0.7	1.7
HASSALL_MACQUARIE	140	5.67	6.04	6.33	6.40	9.72	0	0	0	2	-62	0.0	0.0	0.0	0.7	1.5

Flowpath	Chainage (m)	Peak water levels (m AHD)					Peak flows (m^3/s)					Peak velocities (m/s)				
		20% AEP	5% AEP	2% AEP	1% AEP	PMF	20% AEP	5% AEP	2% AEP	1% AEP	PMF	20% AEP	5% AEP	2% AEP	1% AEP	PMF
HASSALL_THOMAS	0	5.18	5.47	5.64	5.74	9.50	0	0	0	0	-289	0.0	0.0	0.0	0.0	1.0
HASSALL_THOMAS	50	5.18	5.47	5.64	5.74	9.41	0	0	0	0	-290	0.0	0.0	0.0	0.0	-1.1
HASSALL1	0	6.48	7.81	7.91	7.97	9.63	0	0	0	0	17	0.0	0.0	0.0	0.0	9.3
HASSALL1	58	6.10	7.90	8.00	8.06	9.42	0	0	0	0	17	0.0	0.0	0.0	0.0	-8.0
HASSALL1	94	6.00	7.90	8.00	8.06	9.42	0	2	7	11	147	0.0	-1.1	-2.0	-2.2	-3.1
HASSALL1	174	5.25	6.09	6.23	6.33	9.44	0	2	7	11	147	0.0	1.2	1.9	2.9	6.8
HASSALL1	256	5.18	5.69	5.87	6.00	9.47	0	2	7	11	147	0.0	1.3	1.3	1.4	3.6
HASSALL1	265	5.18	5.69	5.86	6.00	9.50	0	2	7	11	147	0.0	1.2	1.5	1.6	2.3
HASSALL1	277	5.18	5.56	5.83	5.98	9.50	0	2	7	11	133	0.0	0.2	0.4	0.6	1.3
HASSALL1	341	5.18	5.47	5.64	5.74	9.50	0	0	1	1	106	0.0	0.0	1.3	1.8	3.0
HASSALL1	409	5.18	5.45	5.62	5.74	9.50	0	0	0	0	108	0.0	0.0	0.0	0.0	1.6
HASSALL1	455	5.17	5.43	5.60	5.74	9.48	0	0	0	0	107	0.0	0.0	0.0	0.0	2.3
HASSALL2	0	5.35	5.41	5.46	5.69	9.32	0	0	0	0	532	0.0	0.0	0.0	0.0	3.4
HASSALL2	56	4.83	5.15	5.45	5.56	9.41	0	0	0	0	533	0.0	0.0	0.0	0.0	1.6
HASSALL2	89	4.82	5.16	5.45	5.57	9.35	0	0	0	2	428	0.0	0.0	0.0	3.1	6.8
HASSALL2	188	3.89	4.47	4.90	5.16	9.22	0	0	0	-1	180	0.0	0.0	0.0	2.5	8.0
HASSALL2	337	3.81	4.49	4.90	5.17	9.21	0	0	0	-1	180	0.0	0.0	0.0	-1.9	3.3
HASSALL2	409	3.81	4.49	4.90	5.17	9.19	0	0	-2	-5	327	0.0	0.0	-1.4	-1.9	4.5
HASSALL2	441	3.81	4.49	4.90	5.17	9.27	0	0	-2	-5	327	0.0	0.0	-1.0	-1.1	7.9
HASSALL2	524	3.90	4.49	4.90	5.18	9.29	0	0	-2	-5	327	0.0	0.0	-2.1	-1.9	-7.4
HASSALL2	642	3.90	4.49	4.90	5.18	9.36	-1	-2	-3	-5	328	-0.7	-0.9	-1.0	-0.9	-2.9
HOMEBUSH	2344	0.83	0.91	0.95	0.99	2.13	307	319	375	435	-1502	0.4	2.3	0.4	0.4	-1.5
HOMEBUSH	2878	0.83	0.91	0.96	0.99	2.14	274	273	304	350	-1691	0.4	0.3	0.4	0.4	-1.7
HOMEBUSH	3000	0.83	0.90	0.95	0.98	2.10	380	400	461	539	-1899	0.5	1.2	0.5	0.6	-2.0
INKERMAN	0	13.84	14.34	14.50	14.61	16.05	0	1	3	4	47	0.0	1.9	1.4	1.6	4.4
INKERMAN	14	13.43	14.17	14.24	14.28	15.25	0	1	3	4	47	0.0	2.2	2.5	2.5	2.9
INKERMAN	61	13.22	13.80	13.89	13.94	15.20	0	1	3	4	47	0.0	2.7	1.8	2.1	2.8
INKERMAN	76	13.18	13.67	13.82	13.91	15.22	0	1	3	4	47	0.0	2.3	2.5	2.7	4.2
INKERMAN_DIXON_CHURCH	0	13.84	14.34	14.50	14.61	16.05	0	0	1	2	23	0.0	0.0	0.0	0.1	0.3
INKERMAN_DIXON_CHURCH	23	12.04	14.31	14.50	14.60	15.81	0	0	1	1	23	0.0	0.0	2.4	2.6	4.9
INKERMAN_DIXON_CHURCH	54	12.04	14.30	14.50	14.60	15.76	0	0	0	0	23	0.0	0.0	0.0	0.0	6.0
INKERMAN_DIXON_CHURCH	74	12.04	12.67	12.95	13.07	15.71	0	0	0	0	23	0.0	0.0	0.0	0.0	7.0
INKERMAN_DIXON_CHURCH	192	12.04	12.13	12.23	12.32	15.41	0	0	0	0	22	0.0	0.0	0.0	0.0	8.0
INKERMAN_DIXON_CHURCH	387	12.31	12.53	12.76	12.89	15.39	0	0	0	0	21	0.0	0.0	0.0	0.0	-3.7
INKERMAN_DIXON_CHURCH	400	12.32	12.54	12.76	12.90	15.08	0	0	0	0	21	0.0	0.0	0.0	0.0	9.2
INKERMAN_DIXON_CHURCH	498	12.31	12.54	12.76	12.90	14.10	0	0	0	0	21	0.0	0.0	0.0	0.0	-2.6
JAMESRUSE	0	3.90	4.49	4.90	5.18	9.36	0	0	0	0	-254	0.0	0.0	0.0	0.0	0.0
JAMESRUSE	33	3.90	4.49	4.90	5.18	9.36	-2	-3	-3	14	-254	0.0	0.0	0.0	0.0	-0.2
JAMESRUSE	92	3.90	4.49	4.90	5.18	9.36	-4	-6	-8	9	106	-0.2	-0.2	-0.3	-0.3	-0.6
JAMESRUSE	233	3.90	4.48	4.90	5.17	9.35	-6	-10	-12	-13	100	-0.3	1.0	-0.6	-0.6	1.2
JAMESRUSE	282	3.90	4.48	4.90	5.17	9.35	-7	-11	-12	-14	98	-1.3	-1.6	-1.5	-1.5	-3.1
JAMESRUSE	343	3.90	4.48	4.90	5.17	9.34	-7	-11	-13	-14	97	0.9	8.5	1.0	1.0	-1.5
JAMESRUSE	379	3.90	4.48	4.90	5.17	9.34	-7	-11	-13	-14	97	1.3	1.4	1.4	1.4	1.5
KENDALL	0	8.45	8.74	8.84	8.91	10.13	0	0	0	0	54	0.0	0.0	0.0	0.0	3.3
KENDALL	16	8.21	8.72	8.82	8.89	10.09	0	0	0	0	55	0.0	0.0	0.0	0.0	6.0
KENDALL	81	7.74	8.29	8.51	8.56	9.85	0	0	0	0	55	0.0	0.0	0.0	0.0	-5.7
KENDALL	173	7.43	8.02	8.25	8.33	9.72	0	0	0	0	55	0.0	0.0	0.0	0.0	-14.5
KENDALL	210	7.36	8.02	8.18	8.30	9.62	0	0	0	0	55	0.0	0.0	0.0	0.0	2.1
LANSDOWNE	0	13.15	14.71	14.81	14.87	15.80	0	1	4	7	90	0.0	1.9	1.7	1.9	3.5
LANSDOWNE	48	13.18	14.38	14.50	14.56	15.57	0	0	4	7	90	0.0	0.0	4.7	6.2	10.5
LANSDOWNE	113	13.18	13.76	14.00	14.07	15.29	0	0	4	7	90	0.0	0.0	1.2	1.4	-2.8
LANSDOWNE	139	13.18	13.67	13.82	13.91	15.22	0	2	6	11	137	0.0	4.5	-1.7	-2.0	2.8
LANSDOWNE	233	12.33	12.99	13.20	13.31	14.79	0	1	6	10	137	0.0	1.9	3.6	4.4	5.1
LANSDOWNE	357	12.32	12.54	12.76	12.89	14.22	0	1	6	10	137	0.0	-1.8	-3.0	-2.0	2.9

Flowpath	Chainage	Peak water levels (m AHD)					Peak flows (m^3/s)					Peak velocities (m/s)				
	(m)	20% AEP	5% AEP	2% AEP	1% AEP	PMF	20% AEP	5% AEP	2% AEP	1% AEP	PMF	20% AEP	5% AEP	2% AEP	1% AEP	PMF
LANSDOWNE	380	12.32	12.54	12.76	12.91	14.21	5	10	18	23	198	0.0	0.5	0.2	0.4	2.7
LANSDOWNE	450	12.31	12.53	12.75	12.89	14.02	5	10	17	23	198	0.4	7.7	0.9	1.1	3.8
LANSDOWNE	468	12.31	12.54	12.76	12.90	14.10	5	10	17	23	198	1.1	35.2	1.1	1.1	2.0
LANSDOWNE_CLAYCLIFF	0	12.31	12.54	12.76	12.90	14.10	0	2	2	3	22	0.0	1.0	0.9	0.7	1.4
LANSDOWNE_CLAYCLIFF	40	9.50	10.99	12.52	12.57	13.18	0	0	0	1	22	0.0	0.0	0.0	5.1	5.0
LANSDOWNE_CLAYCLIFF	67	9.50	10.22	11.09	11.20	12.98	0	0	0	1	39	0.0	0.0	0.0	5.0	-6.6
LANSDOWNE_CLAYCLIFF	87	9.50	9.74	10.60	11.07	12.98	0	0	0	1	36	0.0	0.0	0.0	2.8	4.0
LANSDOWNE_CLAYCLIFF	136	9.50	9.72	10.46	10.84	13.04	0	0	0	1	29	0.0	0.0	0.0	0.9	1.9
LANSDOWNE_CLAYCLIFF	158	9.50	9.72	10.42	10.78	13.03	0	0	0	0	35	0.0	0.0	0.0	0.0	-1.8
LANSDOWNE_CLAYCLIFF	180	9.53	9.84	10.01	10.17	13.00	0	0	0	0	36	0.0	0.0	0.0	0.0	2.8
MACQUARIE	0	5.48	5.96	6.33	6.39	9.69	0	0	0	0	84	0.0	0.0	0.0	0.0	-2.0
MACQUARIE	23	5.49	6.04	6.33	6.40	9.72	0	0	0	0	84	0.0	0.0	0.0	0.0	-2.3
MACQUARIE	130	5.67	6.04	6.33	6.40	9.72	0	0	0	-1	80	0.0	0.0	0.0	-0.6	-1.1
MARSDEN_LENNOX	0	14.33	14.86	15.00	15.11	16.58	0	1	2	2	90	0.0	0.2	0.1	0.2	1.0
MARSDEN_LENNOX	10	13.15	14.71	14.81	14.87	15.80	0	1	2	2	13	0.0	2.2	3.0	3.2	4.5
MARSDEN_LENNOX	45	13.15	14.65	14.81	14.87	15.80	0	0	0	1	8	0.0	0.0	0.0	3.3	5.7
MARSDEN_LENNOX	100	13.13	14.59	14.81	14.87	15.80	0	0	0	0	2	0.0	0.0	0.0	0.0	3.0
MARSDEN_LENNOX	131	12.64	13.36	13.44	13.52	14.65	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
MARSDEN_LENNOX	192	12.33	12.68	12.86	13.06	14.79	0	0	0	0	-1	0.0	0.0	0.0	0.0	-6.1
MARSDEN_LENNOX	308	12.33	12.99	13.20	13.31	14.79	0	0	0	0	-8	0.0	0.0	0.0	0.0	-1.8
OAK	0	3.89	4.45	4.90	5.16	9.20	0	0	0	3	192	0.0	0.0	0.0	1.1	1.9
OAK	22	3.89	4.45	4.90	5.16	9.17	0	0	0	3	192	0.0	0.0	0.0	0.7	2.2
OAK	107	3.89	4.46	4.90	5.16	9.20	0	0	0	3	192	0.0	0.0	0.0	-0.7	-3.2
OAK	212	3.89	4.48	4.90	5.15	9.16	0	0	4	14	-257	0.0	0.0	-0.8	-1.1	-4.3
OAK	241	3.90	4.49	4.90	5.17	9.22	0	0	4	14	-256	0.0	0.0	0.7	1.7	5.6
OAK	363	3.90	4.49	4.90	5.17	9.21	0	0	4	14	-256	0.0	0.0	0.5	0.5	2.9
OAK	456	3.90	4.49	4.90	5.17	9.30	-1	-2	4	14	-255	0.3	-0.3	-0.4	-0.3	2.2
OAK	475	3.90	4.49	4.90	5.18	9.36	-1	-2	3	14	-255	-0.1	-0.1	-0.1	-0.1	0.6
OFFARGUS	0	4.70	5.05	5.36	5.94	9.67	0	0	0	0	191	0.0	0.0	0.0	0.0	7.1
OFFARGUS	23	4.13	4.60	4.97	5.22	9.82	0	0	0	0	191	0.0	0.0	0.0	0.0	8.0
OFFRIVER	0	3.89	4.47	4.89	5.16	9.28	0	0	2	4	8	0.0	0.0	0.2	0.2	0.3
OFFRIVER	53	3.86	4.36	4.75	5.02	9.42	0	0	2	4	-11	0.0	0.0	-1.0	-1.1	4.2
OFFRIVER	147	3.86	4.36	4.75	5.01	9.42	0	0	2	5	-15	0.0	0.0	-0.3	0.6	3.0
PARKES	40	8.49	8.79	8.86	8.94	10.23	0	6	10	14	172	0.0	1.7	1.6	1.9	2.6
PARKES	70	8.04	8.71	8.81	8.89	10.21	0	6	10	14	149	0.0	4.6	5.1	5.5	5.5
PARKES	183	7.57	8.03	8.21	8.33	9.70	1	4	9	14	154	-0.8	-1.1	-1.1	-1.0	3.2
PARKES	227	7.57	8.02	8.18	8.30	9.61	0	0	2	3	42	0.0	0.0	1.0	2.0	4.0
PARKES	333	7.02	8.02	8.18	8.30	9.57	0	0	0	0	42	0.0	0.0	0.0	0.0	5.0
PARKES	393	5.56	5.73	5.77	5.77	9.31	0	0	0	0	43	0.0	0.0	0.0	0.0	3.5
PARKES	470	5.56	5.73	5.76	5.76	9.24	0	0	0	0	68	0.0	0.0	0.0	0.0	6.7
PARKES	567	5.37	5.43	5.47	5.70	9.25	0	0	0	0	340	0.0	0.0	0.0	0.0	-2.3
PARKES	674	5.35	5.41	5.47	5.70	9.34	0	0	0	0	341	0.0	0.0	0.0	0.0	2.0
PARKES	731	5.35	5.41	5.46	5.69	9.32	0	0	0	0	341	0.0	0.0	0.0	0.0	2.1
PARKES_ANDERSON	0	11.65	11.69	11.70	11.75	12.95	0	1	1	2	48	0.0	0.6	0.6	0.6	1.9
PARKES_ANDERSON	85	10.32	10.52	10.65	10.74	12.97	0	1	1	2	47	0.0	0.5	-1.0	-1.5	-5.0
PARKES_ANDERSON	125	10.30	10.52	10.65	10.74	12.97	0	-1	-2	2	49	0.0	-2.6	-3.8	-2.6	-3.7
PARRAMATTA_R	2879	4.86	5.16	5.41	5.57	9.76	597	697	788	847	2480	3.0	3.2	3.4	3.5	5.1
PARRAMATTA_R	2940	4.93	5.24	5.50	5.68	10.14	597	697	788	847	2480	2.4	2.6	2.7	2.8	3.5
PARRAMATTA_R	2944	4.23	4.71	5.11	5.36	10.09	597	697	787	847	2275	1.0	1.6	0.8	0.8	0.8
PARRAMATTA_R	3028	4.28	4.77	5.16	5.42	10.03	597	697	788	847	2260	1.7	1.8	1.9	1.9	2.9
PARRAMATTA_R	3083	4.13	4.60	4.97	5.22	9.82	597	697	788	848	2397	2.4	2.5	2.7	2.8	3.9
PARRAMATTA_R	3196	4.21	4.70	5.09	5.35	10.06	596	696	789	848	2390	1.5	1.6	1.7	1.7	2.5
PARRAMATTA_R	3248	4.18	4.67	5.06	5.32	10.06	596	696	789	848	2388	1.6	1.7	1.7	1.8	2.4
PARRAMATTA_R	3275	4.04	4.52	4.91	5.16	9.43	596	696	789	848	2339	1.7	1.8	1.9	1.9	2.5

Flowpath	Chainage (m)	Peak water levels (m AHD)					Peak flows (m^3/s)					Peak velocities (m/s)				
		20% AEP	5% AEP	2% AEP	1% AEP	PMF	20% AEP	5% AEP	2% AEP	1% AEP	PMF	20% AEP	5% AEP	2% AEP	1% AEP	PMF
PARRAMATTA_R	3403	4.05	4.54	4.93	5.19	9.50	595	695	788	848	2195	1.1	1.5	1.2	1.3	1.7
PARRAMATTA_R	3538	4.02	4.51	4.90	5.16	9.50	594	694	785	849	2090	1.1	1.1	1.2	1.2	1.4
PARRAMATTA_R	3636	3.95	4.45	4.84	5.10	9.44	593	693	785	849	2084	1.5	1.4	1.5	1.5	1.7
PARRAMATTA_R	3799	3.89	4.38	4.76	5.02	9.32	592	692	786	851	2427	1.4	1.5	1.5	1.6	2.1
PARRAMATTA_R	3937	3.87	4.37	4.76	5.02	9.40	591	691	785	851	2429	1.2	1.7	1.2	1.3	1.8
PARRAMATTA_R	4065	3.86	4.36	4.75	5.01	9.42	591	691	787	855	2422	1.0	2.0	1.0	1.0	1.5
PARRAMATTA_R	4185	3.82	4.32	4.70	4.96	9.30	599	703	802	873	2418	1.1	1.6	1.2	1.3	2.0
PARRAMATTA_R	4218	3.77	4.26	4.63	4.88	9.14	599	703	802	873	2417	1.5	1.9	1.7	1.7	2.8
PARRAMATTA_R	4243	3.72	4.21	4.58	4.83	9.06	599	703	802	873	2417	1.7	1.8	1.9	2.0	3.1
PARRAMATTA_R	4268	3.66	4.14	4.51	4.75	8.99	599	703	802	873	2416	1.8	1.9	2.0	2.1	3.1
PARRAMATTA_R	4452	3.61	4.09	4.46	4.70	8.99	600	704	804	875	2416	1.5	1.6	1.7	1.8	2.6
PARRAMATTA_R	4559	3.56	4.04	4.41	4.65	8.89	606	712	814	885	2417	1.6	1.7	1.8	1.9	2.8
PARRAMATTA_R	4572	3.56	4.04	4.40	4.64	8.40	609	714	817	888	2417	1.4	1.8	1.6	1.7	2.7
PARRAMATTA_R	4594	3.54	4.01	4.37	4.61	8.33	605	711	813	884	2417	1.4	1.8	1.6	1.7	2.7
PARRAMATTA_R	4634	3.56	4.04	4.40	4.64	8.48	615	730	828	901	2430	1.0	1.5	1.1	1.2	1.9
PARRAMATTA_R	4823	3.44	3.92	4.29	4.52	8.36	614	728	827	900	2429	1.3	1.7	1.4	1.4	1.9
PARRAMATTA_R	4987	3.28	3.75	4.10	4.33	7.99	614	728	828	901	2430	1.7	1.8	1.9	2.0	3.1
PARRAMATTA_R	5153	3.19	3.66	4.00	4.22	7.80	614	728	829	901	2431	1.7	1.8	1.9	2.0	3.3
PARRAMATTA_R	5278	3.18	3.65	4.00	4.23	7.99	614	728	829	902	2431	1.4	1.5	1.5	1.6	2.1
PARRAMATTA_R	5353	3.14	3.61	3.95	4.18	7.89	660	793	901	974	2493	1.5	1.7	1.7	1.7	2.4
PARRAMATTA_R	5490	3.08	3.55	3.89	4.12	7.83	660	793	902	975	2492	1.6	1.8	1.7	1.8	2.3
PARRAMATTA_R	5653	3.05	3.51	3.85	4.08	7.74	660	793	902	976	2491	1.3	1.8	1.5	1.6	2.4
PARRAMATTA_R	5795	2.99	3.46	3.80	4.03	7.75	660	793	902	976	2492	1.4	2.1	1.5	1.5	2.0
PARRAMATTA_R	5931	2.90	3.35	3.68	3.90	7.48	660	793	902	977	2492	1.6	1.7	1.8	1.9	2.9
PARRAMATTA_R	6167	2.78	3.24	3.57	3.78	7.40	660	793	903	978	2493	1.6	1.7	1.8	1.9	2.7
PARRAMATTA_R	6256	2.70	3.14	3.46	3.67	7.17	660	793	903	978	2504	1.8	2.0	2.1	2.2	3.3
PARRAMATTA_R	6304	2.71	3.16	3.48	3.70	7.30	660	793	903	979	2581	1.6	1.7	1.8	1.8	2.6
PARRAMATTA_R	6387	2.67	3.13	3.45	3.67	6.12	661	794	904	980	2550	1.5	1.6	1.7	1.7	2.6
PARRAMATTA_R	6598	2.59	3.04	3.36	3.57	6.00	661	794	904	981	2494	1.4	1.5	1.6	1.6	2.5
PARRAMATTA_R	6775	2.48	2.92	3.23	3.44	5.79	662	795	906	983	2496	1.6	1.7	1.8	1.8	2.8
PARRAMATTA_R	6960	2.37	2.81	3.12	3.33	5.65	662	796	907	984	2499	1.6	1.7	1.8	1.8	2.6
PARRAMATTA_R	7179	2.28	2.72	3.03	3.24	5.56	664	797	909	989	2506	1.3	1.8	1.4	1.4	2.1
PARRAMATTA_R	7352	2.27	2.71	3.01	3.23	5.61	665	798	911	992	2510	0.9	1.9	1.0	1.0	1.4
PARRAMATTA_R	7417	2.22	2.66	2.96	3.18	5.52	861	1068	1222	1341	3054	1.2	1.8	1.3	1.4	1.9
PARRAMATTA_R	7528	2.16	2.60	2.89	3.10	5.47	861	1069	1222	1342	3055	1.6	1.8	1.8	1.8	2.0
PARRAMATTA_R	7556	2.12	2.55	2.83	3.04	5.27	862	1069	1222	1342	3055	1.7	1.9	2.0	2.1	2.9
PARRAMATTA_R	7572	2.07	2.48	2.76	2.97	5.13	862	1069	1223	1342	3055	1.7	2.1	2.0	2.1	3.0
PARRAMATTA_R	7592	2.08	2.49	2.78	2.98	5.18	862	1069	1223	1343	3055	1.6	1.9	1.9	2.0	2.7
PARRAMATTA_R	7705	2.00	2.40	2.66	2.85	4.95	862	1070	1224	1344	3057	1.7	1.9	2.1	2.2	3.2
PARRAMATTA_R	7944	1.87	2.26	2.52	2.71	4.75	863	1071	1226	1346	3058	1.6	1.8	1.9	1.9	2.8
PARRAMATTA_R	8096	1.71	2.06	2.30	2.48	4.41	864	1073	1227	1348	3061	1.9	2.2	2.3	2.4	3.4
PARRAMATTA_R	8344	1.49	1.81	2.04	2.20	4.08	866	1074	1229	1350	3062	1.9	2.2	2.2	2.3	3.2
PARRAMATTA_R	8429	1.48	1.79	2.01	2.16	3.99	866	1075	1230	1351	3064	1.6	1.8	1.9	2.0	3.0
PARRAMATTA_R	8745	1.27	1.51	1.70	1.82	3.44	869	1078	1233	1354	3067	1.6	1.8	2.0	2.1	3.1
PARRAMATTA_R	9052	1.27	1.39	1.55	1.67	3.42	873	1082	1237	1358	3070	1.9	2.0	1.9	1.9	1.5
PARRAMATTA_R	9203	1.27	1.34	1.43	1.54	3.28	876	1086	1241	1362	3073	2.1	2.1	2.4	2.4	2.0
PARRAMATTA_R	9348	1.27	1.34	1.39	1.42	3.00	880	1090	1245	1367	3077	1.8	2.0	2.2	2.3	2.9
PARRAMATTA_R	9664	1.27	1.34	1.39	1.42	3.07	887	1097	1253	1375	3083	0.9	1.7	1.0	1.1	1.3
PARRAMATTA_R	9819	1.27	1.34	1.39	1.42	2.79	890	1101	1257	1379	3085	1.5	1.7	1.9	2.0	2.9
PARRAMATTA_R	10020	1.27	1.34	1.39	1.42	2.42	892	1103	1259	1381	3086	2.0	2.3	2.6	2.8	4.0
PARRAMATTA_R	10429	1.27	1.34	1.39	1.42	2.41	903	1116	1274	1396	3104	1.4	1.6	1.7	1.7	2.1
PARRAMATTA_R	10663	1.27	1.34	1.39	1.42	2.30	927	1147	1311	1438	3156	1.5	1.7	1.8	1.9	2.1
PARRAMATTA_R	10884	1.27	1.34	1.39	1.42	2.16	932	1152	1317	1443	3158	1.4	1.5	1.9	2.0	2.2
PARRAMATTA_R	11030	1.27	1.34	1.39	1.42	2.10	1201	1508	1715	1899	4038	1.0	1.6	1.3	1.4	2.3

Flowpath	Chainage (m)	Peak water levels (m AHD)					Peak flows (m³/s)					Peak velocities (m/s)				
		20% AEP	5% AEP	2% AEP	1% AEP	PMF	20% AEP	5% AEP	2% AEP	1% AEP	PMF	20% AEP	5% AEP	2% AEP	1% AEP	PMF
PARRAMATTA_R	11267	1.27	1.34	1.39	1.42	1.93	1150	1435	1633	1795	3667	1.3	1.7	1.9	2.0	3.1
PARRAMATTA_R	11296	1.27	1.34	1.39	1.42	1.67	1151	1436	1633	1796	3669	1.4	1.7	1.9	2.1	3.2
PARRAMATTA_R	11578	1.27	1.34	1.39	1.42	1.80	1158	1443	1641	1804	3678	1.0	1.8	1.4	1.6	2.1
PARRAMATTA_R	11733	1.27	1.34	1.39	1.42	2.07	1163	1448	1647	1810	3687	1.3	2.6	1.8	2.0	3.2
PARRAMATTA_R	11860	1.27	1.34	1.39	1.42	1.92	1165	1450	1649	1813	3688	1.1	2.7	1.5	1.6	2.5
PARRAMATTA_R	11897	1.27	1.34	1.39	1.42	1.50	1166	1451	1650	1813	3688	1.0	2.9	1.4	1.6	2.4
PARRAMATTA_RD	740	3.58	3.71	4.24	4.70	7.35	0	0	6	29	301	0.0	0.0	0.6	0.9	2.4
PARRAMATTA_RD	842	3.58	3.71	4.25	4.68	7.40	0	0	5	29	301	0.0	0.0	0.3	0.7	2.2
PARRAMATTA_RD	966	3.58	3.71	4.25	4.64	7.29	0	0	1	5	-42	0.0	0.0	-0.8	0.9	2.5
PARRAMATTA_RD	1047	4.03	4.03	4.25	4.64	7.30	0	0	0	2	-41	0.0	0.0	0.0	2.2	2.2
PARRAMATTA_RD	1153	4.53	4.53	4.53	4.64	7.30	0	0	0	0	-40	0.0	0.0	0.0	0.0	1.2
PARRAMATTA_RD	1204	4.62	4.62	4.62	4.62	7.30	0	0	0	0	-39	0.0	0.0	0.0	0.0	3.2
PARRAMATTA_RD	1320	3.28	3.57	3.88	4.15	7.32	0	0	1	1	-39	0.0	0.0	2.7	2.7	2.7
PARRAMATTA_RD	1468	3.03	3.57	3.88	4.15	7.32	0	0	1	1	-38	0.0	0.0	0.3	0.3	0.3
PURCHASE	0	5.35	5.41	5.46	5.69	9.32	0	0	0	0	-194	0.0	0.0	0.0	0.0	-1.2
PURCHASE	19	5.35	5.41	5.46	5.69	9.25	0	0	0	0	-194	0.0	0.0	0.0	0.0	4.6
PURCHASE	72	5.24	5.29	5.35	5.51	9.34	0	0	0	0	-193	0.0	0.0	0.0	0.0	-5.0
PURCHASE	103	4.60	4.87	5.21	5.36	9.46	0	0	0	0	-138	0.0	0.0	0.0	0.0	-4.3
PURCHASE	136	4.53	4.68	5.11	5.31	9.48	0	0	0	0	-139	0.0	0.0	0.0	0.0	-1.6
RIVERW	0	3.87	4.47	4.89	5.16	9.27	0	0	0	0	-374	0.0	0.0	0.0	0.0	-2.3
RIVERW	149	3.89	4.47	4.89	5.16	9.05	0	0	0	0	-374	0.0	0.0	0.0	0.0	-3.8
RIVERW	240	3.89	4.47	4.89	5.16	9.28	0	0	2	3	-19	0.0	0.0	-0.4	-0.5	-2.5
RIVERW	297	3.89	4.47	4.89	5.16	9.28	0	-1	-1	-2	-12	0.0	-0.6	-0.6	-0.7	-0.8
RIVERW	330	3.89	4.47	4.89	5.16	9.28	0	-1	-2	-2	-12	0.0	4.6	0.6	0.6	-0.6
RIVERW	355	3.89	4.47	4.89	5.16	9.32	0	-1	-2	-2	-11	0.0	0.0	0.0	0.0	-0.1
ROSEHILL	0	2.28	2.73	3.03	3.24	5.56	-6	-11	-15	-18	-26	0.4	1.5	0.4	0.4	0.4
ROSEHILL	156	2.28	2.73	3.03	3.24	5.56	-6	-11	-15	-18	-26	0.3	1.3	0.3	0.3	0.3
ROSEHILL	304	2.28	2.73	3.03	3.24	5.56	-12	-22	-30	-35	-45	2.6	4.2	2.7	2.7	2.7
ROSEHILL	400	2.28	2.72	3.03	3.24	5.56	-12	-22	-31	-36	-47	0.0	0.0	-0.1	-0.1	-0.1
SHELLOIL	0	3.89	4.01	4.09	4.16	6.39	8	10	10	12	19	0.3	0.3	0.3	0.3	0.3
SHELLOIL	210	3.50	3.61	3.61	3.85	6.39	8	10	10	12	19	2.0	2.2	2.2	2.2	2.2
SHELLOIL	356	2.95	3.28	3.59	3.85	6.38	8	10	10	11	16	1.9	2.1	2.2	2.2	2.2
SHELLOIL	461	2.75	3.27	3.59	3.85	6.38	8	10	10	11	13	7.6	7.9	7.1	7.9	6.1
SHELLOIL	570	2.75	3.27	3.59	3.85	6.38	8	10	10	11	11	0.1	0.1	0.1	0.1	0.1
STATIONE	24	8.49	8.79	8.86	8.94	10.23	0	0	0	0	55	0.0	0.0	0.0	0.0	2.4
STATIONE	74	8.45	8.74	8.84	8.91	10.13	0	0	0	0	55	0.0	0.0	0.0	0.0	2.7
STATIONE_ADA_WIGRAM	0	8.45	8.74	8.84	8.91	10.13	0	0	0	0	8	0.0	0.0	0.0	0.0	7.8
STATIONE_ADA_WIGRAM	23	7.52	8.45	8.84	8.91	10.13	0	0	0	0	7	0.0	0.0	0.0	0.0	4.8
STATIONE_ADA_WIGRAM	42	7.50	8.31	8.73	8.78	10.13	0	0	0	0	6	0.0	0.0	0.0	0.0	6.0
STATIONE_ADA_WIGRAM	100	7.39	7.82	8.00	8.08	10.13	0	0	0	0	3	0.0	0.0	0.0	0.0	5.0
STATIONE_ADA_WIGRAM	170	7.38	7.79	7.94	8.03	10.14	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
STATIONE_ADA_WIGRAM	220	7.37	7.92	8.07	8.18	9.74	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
STATIONE_ADA_WIGRAM	283	7.36	8.01	8.18	8.30	9.62	0	0	0	0	-2	0.0	0.0	0.0	0.0	-2.0
STATIONE_ADA_WIGRAM	322	7.36	8.02	8.18	8.30	9.62	0	0	-1	-1	55	0.0	0.0	-3.6	-5.3	-7.6
STATIONE_ADA_WIGRAM	335	7.57	8.02	8.18	8.30	9.61	0	-1	-1	-2	55	0.0	-1.5	-1.7	-2.1	-2.7
SUBIACO_CK	5000	3.14	3.61	3.95	4.18	7.89	69	94	110	123	346	1.0	1.2	1.2	1.2	2.0
SUBIACO_CK	5090	3.14	3.61	3.95	4.18	7.89	67	92	107	120	346	0.2	0.4	0.3	0.3	0.7
THOMAS_GEORGE	0	5.17	5.43	5.60	5.74	9.48	0	0	0	0	43	0.0	0.0	0.0	0.0	1.8
THOMAS_GEORGE	48	4.90	5.15	5.27	5.41	9.47	0	0	0	0	44	0.0	0.0	0.0	0.0	2.2
THOMAS_GEORGE	92	4.86	5.01	5.20	5.37	9.48	0	0	0	0	44	0.0	0.0	0.0	0.0	2.5
THOMAS_GEORGE	137	4.85	5.00	5.20	5.37	9.48	0	0	0	0	45	0.0	0.0	0.0	0.0	1.2
THOMAS_GEORGE	148	4.53	4.68	5.11	5.31	9.48	0	0	0	0	-128	0.0	0.0	0.0	0.0	4.9
THOMAS_GEORGE	167	4.02	4.51	4.90	5.16	9.50	0	0	0	0	-128	0.0	0.0	0.0	0.0	8.5
THOMAS_PURCHASE	0	5.17	5.43	5.60	5.74	9.48	0	0	0	0	65	0.0	0.0	0.0	0.0	0.9

Flowpath	Chainage (m)	Peak water levels (m AHD)					Peak flows (m^3/s)					Peak velocities (m/s)				
		20% AEP	5% AEP	2% AEP	1% AEP	PMF	20% AEP	5% AEP	2% AEP	1% AEP	PMF	20% AEP	5% AEP	2% AEP	1% AEP	PMF
THOMAS_PURCHASE	51	5.17	5.41	5.58	5.72	9.47	0	0	0	0	64	0.0	0.0	0.0	0.0	4.5
THOMAS_PURCHASE	102	5.08	5.19	5.28	5.46	9.46	0	0	0	0	64	0.0	0.0	0.0	0.0	4.5
THOMAS_PURCHASE	150	4.60	4.87	5.21	5.36	9.46	0	0	0	0	65	0.0	0.0	0.0	0.0	2.6
THOMAS1	0	5.18	5.47	5.64	5.74	9.41	0	0	0	0	-101	0.0	0.0	0.0	0.0	1.8
THOMAS1	39	4.95	5.31	5.44	5.60	9.42	0	0	0	0	-100	0.0	0.0	0.0	0.0	1.2
THOMAS1	62	4.50	5.20	5.33	5.49	9.42	0	0	0	0	-99	0.0	0.0	0.0	0.0	3.2
THOMAS1	90	4.04	4.52	4.91	5.16	9.43	0	0	0	0	-98	0.0	0.0	0.0	0.0	6.1
THOMAS2	0	5.18	5.47	5.64	5.74	9.41	0	0	0	0	-194	0.0	0.0	0.0	0.0	2.5
THOMAS2	81	3.89	4.37	4.84	5.15	9.49	0	0	0	0	-193	0.0	0.0	0.0	0.0	3.1
THOMAS2	147	4.05	4.54	4.93	5.19	9.50	0	0	0	0	-192	0.0	0.0	0.0	0.0	6.1
VINEYARD_CK	3000	3.56	4.04	4.40	4.64	8.48	39	59	67	77	192	0.7	1.2	1.0	1.1	1.3
VINEYARD_CK	3065	3.56	4.04	4.40	4.64	8.48	37	57	64	74	197	0.1	1.1	0.1	0.2	0.3
WIGRAM	0	7.57	8.02	8.18	8.30	9.61	0	3	9	14	168	0.0	0.8	1.0	1.3	4.9
WIGRAM	45	7.45	7.94	8.08	8.17	9.43	0	3	8	13	154	0.0	0.8	1.1	1.2	4.9
WIGRAM	115	6.00	7.90	8.00	8.06	9.42	0	3	8	13	154	0.0	1.2	1.5	1.7	5.4

Notes:

Peak flows at modelled cross sections were extracted from MIKE-11 model results (ie. Minimum and Maximum flows at H points)
- ve indicates the direction of flow opposite to that assigned in the MIKE-11 model set up
Peak flood level, flow and velocity at a cross section may not necssarily result from the same storm duration for the same flood event.

Appendix C Flood Inundation Maps

Lower Parramatta
Flood Inundation Maps
1% AEP Flood
Map 1 of 9
Legend
Lower Parramatta Model Cross Sections
1% AEP Flood Inundation
Cadastre Boundaries
PARRAMATTA
HARRIS PARK
Metres
SKM

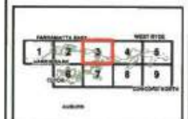
Lower Parramatta
Flood Inundation Maps
1% AEP Flood
Map 2 of 9
Legend
Lower Parramatta Model Cross Sections
1% AEP Flood Inundation
Catchment Boundaries
THOMAS ST
MACARTHUR ST
HARVEY ST
NEW ZEALAND ST
RANGIHOU CR
GORE ST
MORTON ST
MELVILLE ST
PEMBERTON ST
BROUGHTON ST
TENNYSON ST
IRVING ST
JAMES RUSE DR
MILLER PDE
GEORGE ST
HASSALL ST
GREGORY PL
OAK ST
RUSE ST
ALICE ST
HOPE ST
GOOD ST
WESTON ST
CROWN ST
PROSPECT ST
ALFRED ST
ARTHUR ST
BRISBANE ST
VIRGINIA ST
ALLEN ST
ELEANOR ST
GRAND AV NORTH
GRAND AV SOUTH
CAMELLIA
COLQUHOUN ST
BRIDGE ST
MURIEL AV
MARY PDE
ALAN ST
CLYDE ST
Metres
SKM

Lower Parramatta
Flood Inundation Maps

1% AEP Flood

Map 3 of 9

Legend
- Lower Parramatta Model Cross Sections
- 1% AEP Flood Inundation
- Cadastre Boundaries



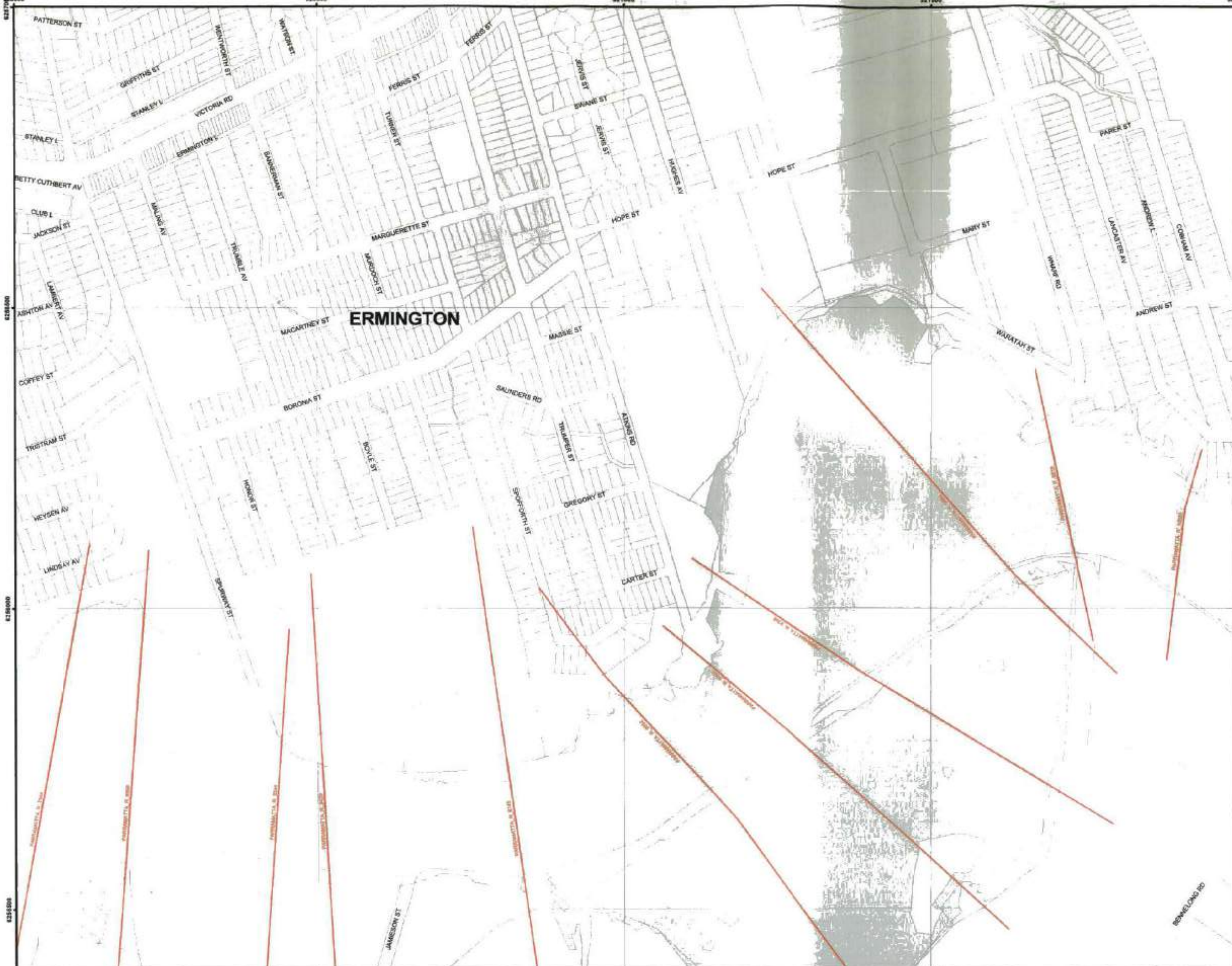
0 25 50 100 150 200
Metres

SKM

Lower Parramatta
Flood Inundation Maps

1% AEP Flood

Map 4 of 9



Legend

- Lower Parramatta Model Cross Sections
- 1% AEP Flood Inundation
- Cadastre Boundaries

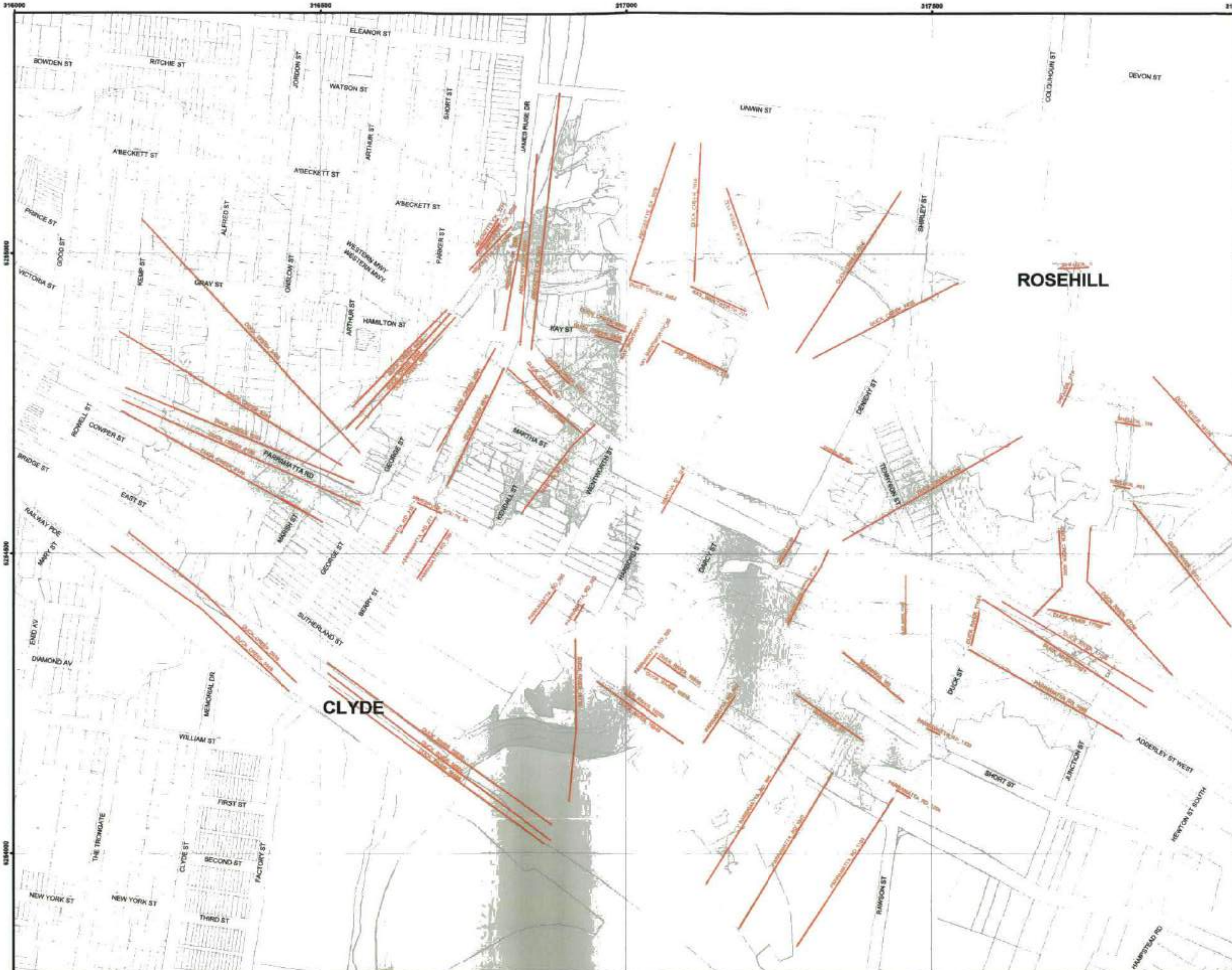
0 25 50 100 150 200
Metres

SKM

Lower Parramatta
Flood Inundation Maps

1% AEP Flood

Map 5 of 9



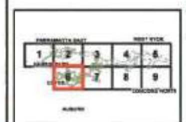
Lower Parramatta
Flood Inundation Maps

1% AEP Flood

Map 6 of 9

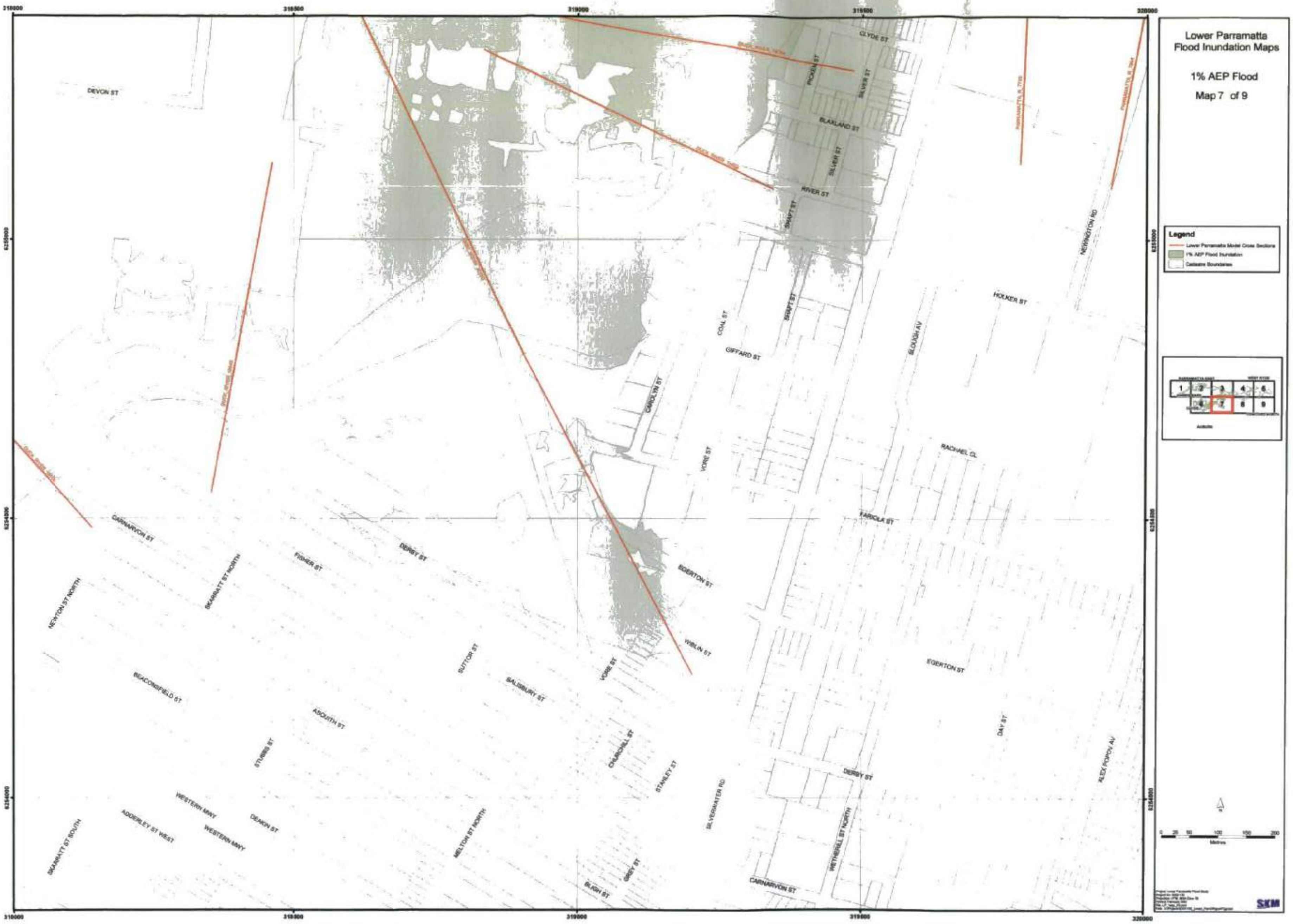
Legend

- Lower Parramatta Model Cross Sections
- 1% AEP Flood Inundation
- Cadastre Boundaries



0 25 50 100 150 200
Metres

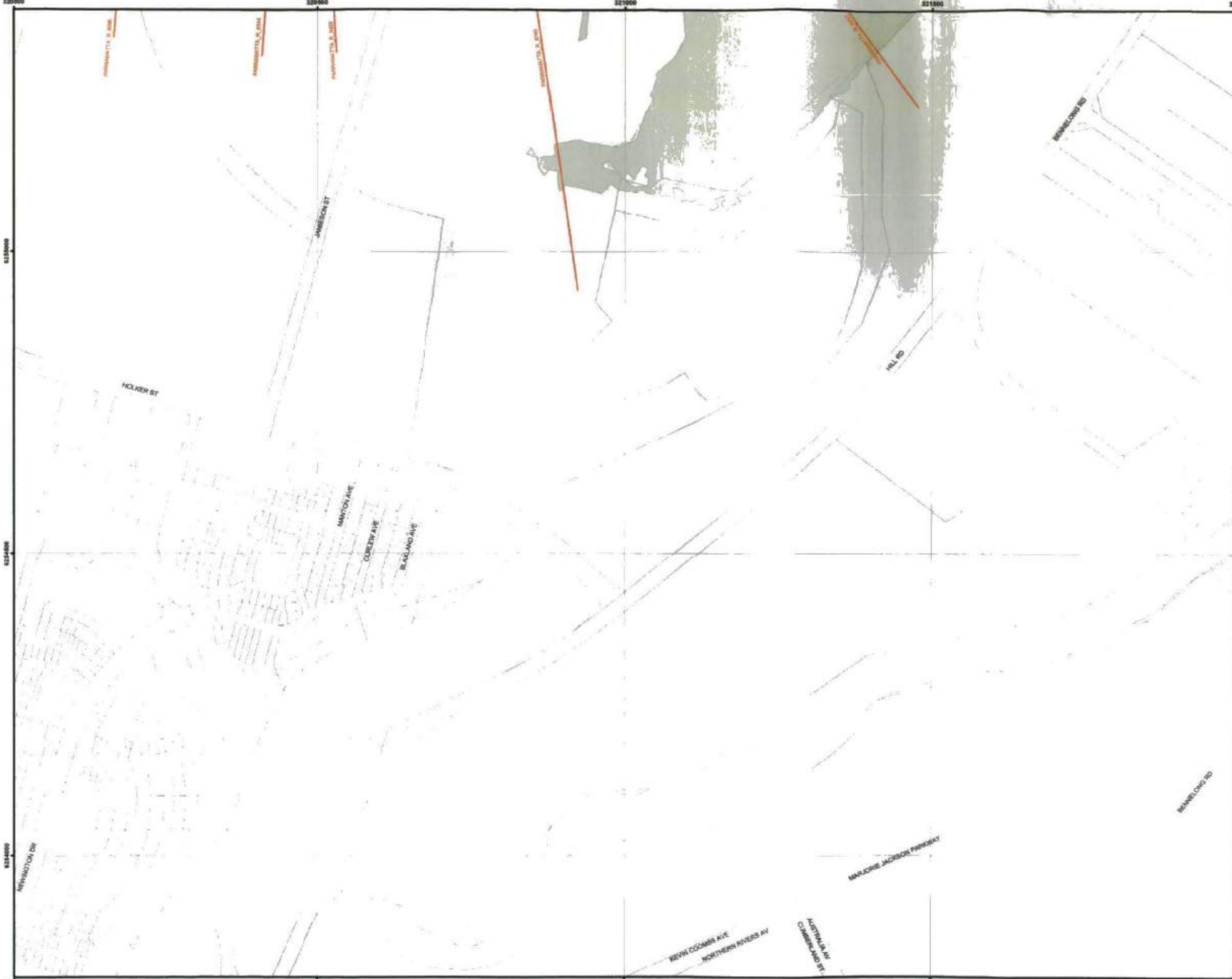
SKM


Lower Parramatta
Flood Inundation Maps
1% AEP Flood
Map 7 of 9
Legend
Lower Parramatta Model Cross Sections
1% AEP Flood Inundation
Cadastre Boundaries
Metres
SKM
DEVON ST
CLYDE ST
PICKEN ST
SILVER ST
BLAXLAND ST
RIVER ST
SHAFT ST
NEWINGTON RD
HOLKER ST
COAL ST
GIFFARD ST
SLOUGH AV
CAROLIN ST
VORE ST
RACHAEL CL
FARIOLA ST
CARNARVON ST
FISHER ST
DERBY ST
SKARRATT ST NORTH
NEWTON ST NORTH
EGERTON ST
WIBLIN ST
SUTTOR ST
SALISBURY ST
BEACONSFIELD ST
ASQUITH ST
STUBBS ST
CHURCHILL ST
STANLEY ST
SILVERWATER RD
DAY ST
ALEX POPOV AV
WESTERN MWY
DEAKIN ST
ADDERLEY ST WEST
SKARRATT ST SOUTH
MELTON ST NORTH
WETHERILL ST NORTH
GREY ST
BLIGH ST

Lower Parramatta Flood Inundation Maps

1% AEP Flood

Map 8 of 9



Legend
- Lower Parramatta Model Cross Sections
- 1% AEP Flood Inundation
- Cadastre Boundaries

0 25 50 100 150 200

Metres

SKM

Lower Parramatta
Flood Inundation Maps
1% AEP Flood
Map 9 of 9
Legend
Lower Parramatta Model Cross Sections
1% AEP Flood Inundation
Cadastre Boundaries
RHODES
CROPLEY ST
CAVELL AV
LLEWELLYN ST
GAUTHORPE ST
BLAXLAND RD
WALKER ST
MARQUET ST
MARY ST WEST
MARY ST EAST
ALFRED ST
LOCH MAREE PDE
TULLOCH AV
KILLOOLA ST
PHOENIX AV
FREMONT ST
HARRISON AV
MEMVILLE ST
HOSPITAL RD
QUEEN ST
CONCORD RD
CURRAWANG ST
NULLAWARRA AV
BORONIA ST
WALLAROY ST
MOALA ST
BENNELONG RD
322000
322500
323000
323500
324000
6255000
6254500
6254000
0 25 50 100 150 200
Metres
SKM

Appendix D Review of Historical and Proposed Design Flood Levels

D.1 Historical Flood Levels

D.1.1 Lower Parramatta River and Tributaries

Historical flooding has occurred in 1898, 1914, 1956, 1961, 1967, 1969, 1974, 1975 (PWD, 1986). Since this report there has been major flooding in 1986, 1988, 1990 and 1991.

Flood level data for these floods is very limited, perhaps due to the relatively few houses and businesses that directly access the river or because the flood rise and fall is too rapid to be recorded effectively.

Set out in **Table D1** is a list of flood data that has been extracted from a number of flood studies and flood reports. The source of the data is also shown. In order to provide a comparison, the design flood levels from this study for the 20 year and 100 year ARI flood has been included, based on the flood level for the nearest cross section in the MIKE 11 model. Generally the recorded flood levels are close to the design flood levels but in some locations the design flood is somewhat different to the historical recorded flood level. There may be due to one or more reasons including:

- Not sufficient recorded levels from past floods,
- Changes to the catchment resulting in increased design floods (such as increased impervious areas)
- Provision of storages such as Darling Mills Retarding Basin
- Combination of major flood events in tributary catchments with Upper Parramatta River flood have not been great enough to trigger a major flood in Parramatta River.

The Parramatta River Flood Level Survey, PWD 1988, provided photographs of the location and a visual indication of the height of the flood but did not provide actual AHD levels. As they provided valuable information, an attempt has been made to estimate the flood height to AHD. Each relevant site was visited and the location of the flood mark determined and the ground level estimated from the airborne laser survey. The approximate depth of flood above the ground level was estimated from the photo and added to the ground level. Using this method, there would be some error, perhaps in the order of up to 0.5 metres in the estimated level. The flood locations could be surveyed but it is not thought to be warranted at this time.

The location of each of the flood levels shown in **Table D1** is shown in **Figure D1 flood level locations**. It can be seen that the number of points of flood information is much denser in Duck Creek and Duck River than Parramatta River. This may be due to the greater number of residents in this area and so flooding had a bigger impact. In the Annexure at the end of this Appendix, are copies of the major relevant flood information from the earlier reports

SKM

Table D1 - Parramatta Flood Study - Historical Flood Levels

Date of Flood	Location of Measurement	Ref No. on Fig. D1	Histori-cal Flood Level (Note 1)	Design Flood Level (Note 2)	Design Flood Level (Note 3)	Reference
			m AHD	5% AEP	1% AEP	
1974	Duck Creek at James Ruse Drive	1	5.20			Duck Creek Catchment Management Study, SKM 1991
1974	Duck Creek at Carlingford Railway Line	2	5.30			Duck Creek Catchment Management Study, SKM 1991
Aug-86	Duck Creek at Wentworth St	3	4.63			Duck Creek Catchment Management Study, SKM 1991
Aug-86	Duck Creek at Deniehy St	4	3.20	Outside modelled floodplain		Duck Creek Catchment Management Study, SKM 1991
Aug-86	Duck Creek at Tennyson St	5	3.14			Duck Creek Catchment Management Study, SKM 1991
Apr-88	Parramatta River at Charles St	6	5.00	5.24	5.68	Parramatta River Flood Level Survey, April 1988, Public Works, 1988
Apr-88	Parramatta River at Morton St	7	4.00	4.45	5.10	Parramatta River Flood Level Survey, April 1988, Public Works, 1989
Apr-88	Parramatta River at Confluence with Vineyard Creek	8	3.50	4.04	4.64	(Note 5) Parramatta River Flood Level Survey, April 1988, Public Works, 1988
Apr-88	Parramatta River at Pike St	9	3.60	3.35	3.90	(Note 5) Parramatta River Flood Level Survey, April 1988, Public Works, 1988
Apr-88	Parramatta River at Thackeray St	10	3.00	3.16	3.70	(Note 5) Parramatta River Flood Level Survey, April 1988, Public Works, 1988
Apr-88	Parramatta River at Silverwater Rd	11	2.00	2.49	2.98	(Note 5) Parramatta River Flood Level Survey, April 1988, Public Works, 1988
Apr-88	A'Beckett's Creek at Arthur St	12	5.30	Outside modelled floodplain		(Note 5, 6) Parramatta River Flood Level Survey, April 1988, Public Works, 1988
Apr-88	A'Beckett's Creek at James Ruse Drive	13	4.80			(Note 5) Parramatta River Flood Level Survey, April 1988, Public Works, 1988
Apr-88	Duck River at Clyde St	14	2.40	2.68	3.19	(Note 5) Parramatta River Flood Level Survey, April 1988, Public Works, 1988
Jun-91	Clay Cliff Creek at 15 Oak St	15	No flood level recorded			PCC Records
Apr-88	Clay Cliff Creek at Glebe/Bobart St	16	No flood level recorded (Note 4)			Clay Cliff Creek Catchment Management Study, Dalland and Lucas, 1992
Apr-88	Clay Cliff Creek at 8 Landsdowne St	17	No flood level recorded (Note 4)			Clay Cliff Creek Catchment Management Study, Dalland and Lucas, 1992
Apr-88	Clay Cliff Creek at 60 Marsden St	18	No flood level recorded (Note 4)			Clay Cliff Creek Catchment Management Study, Dalland and Lucas, 1992

Notes
1 Historical flood levels as surveyed or estimated
2 5% AEP Design Flood Levels from Appendix B.
3 1% AEP Design Flood Levels from Appendix B.
4 Properties noted as 'flood affected' but no levels given
5 Flood levels not surveyed by PWD in 1989. Flood levels estimated from ground levels, see Section D1.1.
6 Design flood levels are based on most upstream cross section at James Ruse Drive

Table D1 (Cont) - Parramatta Flood Study - Historical Flood Levels

Date of Flood	Location of Measurement	Ref No. on Fig. D1	Histori-cal Flood Level (Note 1)	Design Flood Level (Note 2)	Design Flood Level (Note 3)	Reference
			m AHD	5% AEP	1% AEP	
Apr-88	Clay Cliff Creek at 65 Marion St	19	No flood level recorded (Note 4)			Clay Cliff Creek Catchment Management Study, Dalland and Lucas, 1992
Apr-88	Clay Cliff Creek at Weston St	20	No flood level recorded (Note 4)			Clay Cliff Creek Catchment Management Study, Dalland and Lucas, 1993
Apr-88	Clay Cliff Creek at 130 Alfred St, across Rd cnr Oak and Alfred	21	4.80	4.45	5.16	Clay Cliff Creek Catchment Management Study, Dalland and Lucas, 1992 Ground level, 4.5m AHD, say 300 mm water, FL=4.8m AHD
Apr-69	Duck River at u/s Parramatta Rd	22	4.10	4.27	5.11	Lot 15, Duck River Flood Study, Brian O'Mara and Associates, 1994?
Apr-74	Duck River at u/s Parramatta Rd	23	3.60	4.27	5.11	Lot 15, Duck River Flood Study, Brian O'Mara and Associates, 1994?
Apr-88	Duck River at d/s Parramatta Road	24	4.60	4.10	4.64	Parramatta River Flood Level Survey, April 1988, Public Works, 1988
Jun-75	u/s side Charles St Weir	25	2.98	5.24	5.68	Willing/PWD Lower Parramatta River Flood Study 1986
1956?	Parramatta River Morton St	26	3.38	4.45	5.10	PWD Lower Parramatta River Flood Study, 1986
1956?	Parramatta River Broughton St	27	2.50	4.36	5.01	PWD Lower Parramatta River Flood Study, 1986
1974?	Parramatta River - Naval Store, Ermington	28	1.50	1.81	2.20	PWD Lower Parramatta River Flood Study, 1986
Apr-69	Duck River/Duck Creek Hill St	29	2.47	3.40	3.96	PWD Lower Parramatta River Flood Study, 1986
Apr-74	Duck Creek, Hamilton St	30	4.84	Outside modelled floodplain		PWD Lower Parramatta River Flood Study, 1986
Apr-69	Duck Creek, Hamilton St	31	3.82			PWD Lower Parramatta River Flood Study, 1986
Apr-69	Duck Creek, George St	32	3.95			PWD Lower Parramatta River Flood Study, 1986
May-69	Duck Creek, George St	33	5.12			PWD Lower Parramatta River Flood Study, 1986
Apr-74	Duck Creek, Memorial Drive	34	6.41			(Note 7) PWD Lower Parramatta River Flood Study, 1986
Apr-74	Duck Creek, south side of Parramatta Rd	35	3.82			PWD Lower Parramatta River Flood Study, 1986
Apr-69	Duck River, west side, south of Parramatta Rd	36	4.10	4.38	5.18	PWD Lower Parramatta River Flood Study, 1986
Apr-74	Duck River, west side, south of Parramatta Rd	37	3.60	4.38	5.18	PWD Lower Parramatta River Flood Study, 1986

Notes
1. Historical flood levels as surveyed or estimated
2. 5% AEP Design Flood Levels from Appendix B
3. 1% AEP Design Flood Levels from Appendix B
4. Properties noted as 'flood affected' but no levels given
5. Flood levels not surveyed by PWD in 1989. Flood levels estimated from ground levels, see Section D1.1.
6. Design flood levels are based on most upstream cross section modelled at James Ruse Drive
7. Design flood levels are based on most upstream cross section modelled downstream of railway line

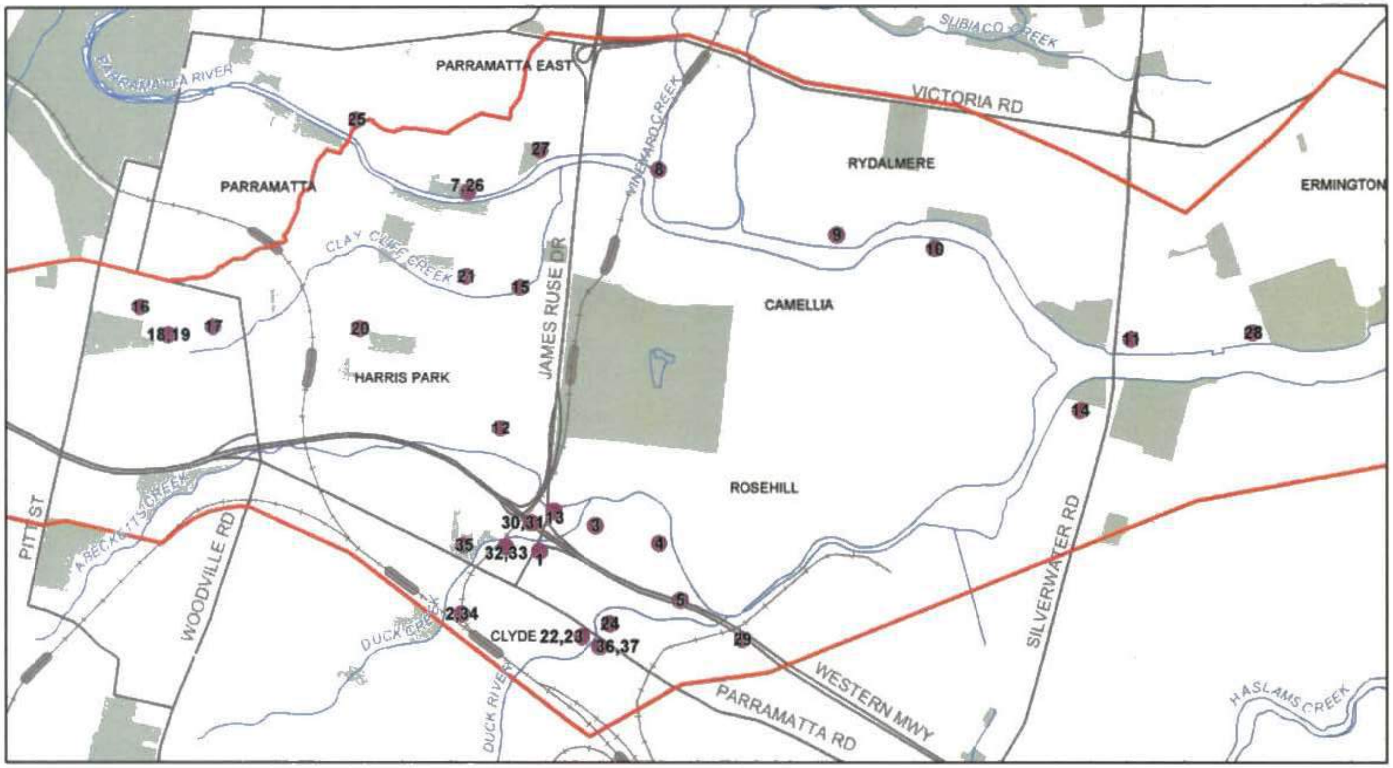


Figure D-1
Flood Level Locations

D.2 Use of Historical Data for Calibration

In some catchments, it is possible to use historical data to calibrate hydrographic and hydraulic computer models. These models can be set up when the following information is available:

- Pluviograph rainfall data for floods of interest over the whole catchment
- Flood levels recorded for each flood at a number of locations
- Flow measurement for the river, preferably at a number of locations
- Suitably large floods have occurred, have included all the catchment
- Only small changes to the catchment landuse
- Tidal data in the area of interest

While some pluviometers do exist in the Lower Parramatta River catchment, there is no flood flow or flood level measurements made on a systematic basis. This makes calibration against historical floods impossible.

A further difficulty of using the flood levels for calibration of the model is that the catchment characteristics has changed over time with the catchment gradually becoming more developed. More recently the construction of Darling Mills Storage has also changed the peak design flow for the Upper Parramatta River catchment.

In order to provide as much data for calibration as possible, a program of tide measurement over a one month period was undertaken and see **Section 4.3.5.2**. The roughness of the main channel was varied to provide a fit to this tidal data. Therefore it can be said that a partial calibration was undertaken based on using the tide data.

D.3 Check of Flood Hydrograph

D.3.1 Comparison with Historical Flow

The only flow gauge available in the study area is the Parramatta Hospital Site, Gauge 213004. The gauge commenced recording on 31 January 1979. This gauge is some 500 metres upstream of the Charles St Weir and so represents the Upper Parramatta River flow. There is data available for the flood of 1988 as discussed below.

The flood started on 29 April 1988 and a small peak of 450 m^3/s occurred at midnight of the same day. The flow then reduced back to 50 m^3/s by 5 AM before starting to rise again to peak at nearly 800 m^3/s at about midday on 30 April 1988. By midnight on 30 April, the flow had dropped back to about 30 m^3/s.

There is insufficient rainfall and flow data for tributaries to use this flood for calibration. However it has been used to assess the probability of the flow compared to the flows calculated for the design flood estimation.

The following procedure was used:

The Upper Parramatta River Catchment Trust's MIKE 11 model was run for a series of design floods using the same critical storm duration as for the design storm, namely a 9 hour storm. This generated a series of flood hydrographs for each of the ARIs under review. It was found that the peak flow and volume of the 1988 flood almost exactly matched the 9 hour, 50 year ARI design storm.

The hydrographs of the UPRCT model and the historical flood is shown in **Figure D2**. The flood of 1988 was thought to have a return period at the time of about 1:20 or 30 year flood. Now with the construction of the Darling Mills Retarding Basin, this flow would equate to about a 50 year ARI event.

D.4 Sensitivity of Varying Tributary Inflows

D.4.1 Methodology used to derive the Design Flood Level

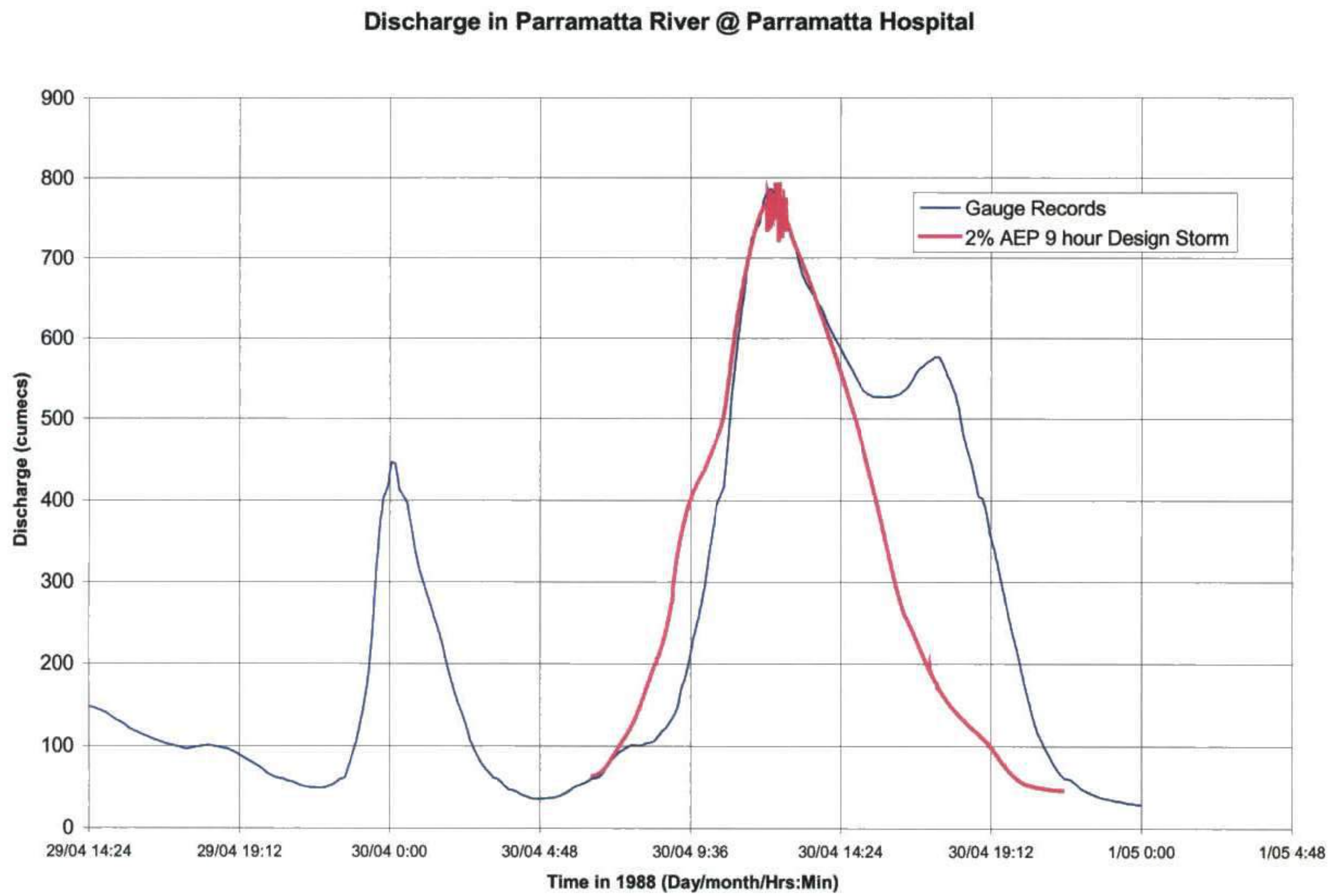
The peak flood level for the design flood was obtained by the following process:

- For a given ARI, (say 100 year) generate from the rainfall-runoff model, 30 minutes to 12 hours (1, 2, 3 hour etc hydrographs for each sub-catchment such as Parramatta River, Subiaco Creek, Duck River etc)
- Input all the hydrographs for say the 4 hour storm for all the rivers and tributaries into the MIKE 11 model. Run the MIKE-11 model for the 4 hour storm for say the 100 year ARI event. Generate peak water levels for all locations in the hydraulic model.
- Rerun the hydrological model and the hydraulic model for different storm durations for the 100 year storm.
- Summarise the flood level results at each cross section for each storm duration. Pick the highest value to be the design flood level for that location for the given ARI
- Repeat the above process for each of the ARIs being considered.

Thus the design flood level can be a combination of different storm durations. For instance in the downstream reaches of the Parramatta River, the 9 hour storm produces the greatest flood depth, while further up the tributaries, the 2 hour storm is critical. (For the 2 hour storm duration, the flood level in the Parramatta River is much lower but the effect of the larger tributary flow results in a higher water level.)

For the Parramatta River, the 9 hour storm produces the highest flood levels in the river and based on the description in dot point above, the same duration rainfall, 9 hours would be assumed to occur on the catchments of say Duck Creek and Duck River. This inflow is less than would occur in a peak flood for the catchment alone as for say Duck River; the 2 hour storm is critical.

Figure D2 - Parramatta Hospital Hydrographs



In order to assess, if the sensitivity of the flood heights to the tributary inflows, the tributary flow was varied as follows:

Reduce the tributary inflows to the runoff from a 20 year ARI rainfall over 9 hours rather than the 100 year ARI 9 hour rainfall used in the design flood.

Reduce the tributary inflows to negligible rainfall (ie only flow is from the Upper Parramatta River Catchment and no inflow from Duck River and other tributaries.

D.4.2 Conclusions

The result of this analysis is shown in **Figure D3**. It can be seen that the flood levels are relatively insensitive to the magnitude of tributary inflows. When the tributary inflows are reduced to 20 year ARI runoff, the flood level drops by only 0.1 to 0.2 metres compared to the Design Flood level.

The sensitivity run with zero inflow in the tributaries, is an extreme condition, is not likely to occur in practice. If there is a 100 year ARI 9 hour rainfall on the Upper Parramatta River catchment, then it is a widespread type of rainfall and will generate significant rain on the tributary catchments. However, for this extreme condition, flood levels drop by between 0.3 and 0.9 metres.

Also plotted in **Figure D3**, is the design Flood Level from the PWD, 1986 Report. It can be seen that the design flood level, shown dotted, drops below even the design flood level with zero inflow from the tributaries in the Duck River area.

This suggests that the estimation of flood levels in the Parramatta River was underestimated and that probably insufficient allowance was made for tributary inflows in the previous modelling.

This conclusion is reinforced when one looks at historical and designs flood levels. **Table D2** below, compares historical recorded flood levels at locations along the Parramatta River, with design flood levels from the 1986 Willings/PWD Flood Study and this flood study. This table shows the following trends:

- Recorded historical flood levels from the Charles St Weir to Thackeray St are lower than both PWD and SKM 100 year ARI design flood levels
- From Charles St Weir to Pike St, PWD and SKM design flood levels are very similar
- From Thackeray St to Ermington, PWD levels are lower than historically recorded flows.

The 1988 flood was not as large as a 100 year ARI flood and so it would be expected that the design flood levels would be higher than those recorded in the 1988 flood. However the PWD's 100 year design levels, downstream of Duck River, are lower than the 1988 flood levels. This seems inconsistent and indicates that the PWD design flood levels are too low.

Figure D3 – Longitudinal profile for Alternative Scenarios

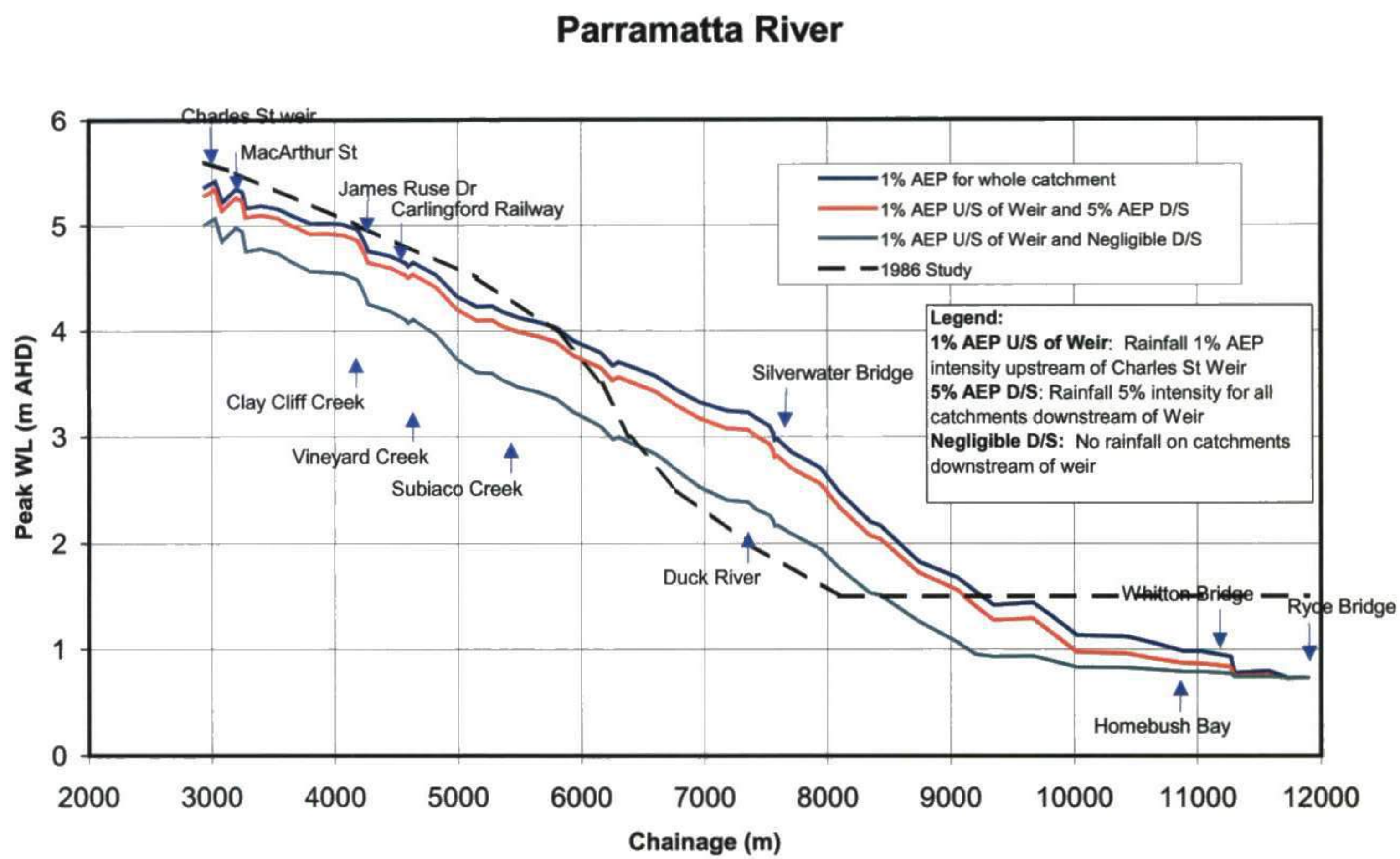


Table D2 – Flood Level Comparison

Date of Flood	Location of measurement	Ref No. from Fig D1	Historical Recorded Flood Level	PWD, 1986 Flood Report 1% AEP Flood Level	This study 1% AEP Design Flood Level
			(m AHD)		
Apr-88	Parramatta River u/s Charles St	6	5.00	5.60 (1)	5.68
Jun-75	u/s side Charles St Weir	25	2.98	5.60 (1)	5.68
Apr-88	Parramatta River at Morton St	7	4.00	5.20	5.10
1956?	Parramatta River Morton St	26	3.38	5.20	5.10
1956?	Parramatta River Broughton St	27	2.50	5.00	5.01
Apr-88	Parramatta River at Confluence with Vineyard Ck	8	3.50	4.80	4.64
Apr-88	Parramatta River at Pike St	9	3.60	4.00	3.90
Apr-88	Parramatta River at Thackeray St	10	3.00	3.20	3.70
Apr-88	Duck River at Clyde St	14	2.40	1.90	3.19
Apr-88	Parramatta River at Silverwater Rd	11	2.00	1.80	2.98
1974?	Parramatta River - Naval Store, Ermington	28	1.50	1.50	2.20
Note 1: Level Downsteam of Weir (no level available u/s of Weir)					

Further discussion and possible reasons for the low flood levels estimate in the 1986 study, is discussed in the next section.

D.5 Possible Explanation for Differences between the PWD 1986 Study and the Current Study

The 1986 flood study does not provide a detailed description of the hydrological and hydraulic process undertaken to determine the peak flood height. However the following observations can be made:

D.5.1 Storm Duration and Flow Estimation

Exhibit 18 of the PWD, 1986 Report shows that the adopted critical design storm duration and flows in the Lower Parramatta River (included in Annexure to this Appendix). These flows are compared with those estimated as part of this study and shown in **Table D3**. The numbers in brackets are the critical storm duration in hours.

Table D3 – Comparison of Flows and Critical Storm Duration

Location	Flood Study	5% AEP Flow (m^3/s)	1% AEP Flow (m^3/s)
Charles St Weir	1986 Study	780 (2)	1,050 (2)
	Current Study*	697 (9)	847 (9)
Downstream of Duck River Confluence	1986 Study	1,025 (6)	1,330 (6)
	Current Study	1,068 (9)	1,341 (9)
Ryde Bridge	1986 Study	1,315 (12)	1,695 (12)
	Current Study	1,435 (9)	1,795 (9)

* Flows now lower due to the effects of Darling Mills Storage

SKM's flows are generally consistent with the PWD, 1986 study but this current study identified that the 9 hour storm was critical in all locations along Parramatta River. It should be noted that the critical duration storm adopted by UPRCT is also 9 hours.

The reason that the critical duration for the PWD 1986 study was only 2 hours at Charles Street Weir may have been because PWD/Willings did not have a hydraulic model for the Upper Parramatta River and had to rely on hydrological routing to determine the critical duration. It is now believed that the critical storm duration is far longer than 2 hours. The use of a two hour storm may have significantly underestimated the volume of floodwaters in the hydrograph. This would therefore result in lower flood levels downstream.

It is also not clear how the flow rates from the steady state modelling were added to the unsteady model. With a steady state model there is no hydrograph so it is difficult to see how the flow could be added to the Parramatta River flow unless some form of synthetic hydrograph was developed. Furthermore if it was assumed that the flows from the tributaries, with shorter duration critical storms, were added to the Parramatta River flow at the start of the simulation, then the peak flow from the tributaries would have passed down the Parramatta River before the peak flow from the Parramatta River arrived. This would seriously underestimate the peak flow and volume of water that needed to pass down the river.

This study was able to use the UPRCT MIKE 11 model to route the flow down the catchment and determine that the 9 hour storm was critical. The full tributary flow hydrographs have been used in the simulation and because we have assumed a 9 hour storm on the tributary catchments, the effects of any coincidental flooding is allowed for.

D.5.2 Waterway Area

The 1986 report seems to have used 29 cross sections in the Parramatta River. None of the road or rail structures in the river appear to have been modelled (there is no structures shown or afflux at the bridges). SKM has used 51 cross sections and a further 14 cross sections to define the structures across the river.

For the 1986 report, the section of Parramatta River from Charles St Weir to Duck River, utilised survey (hydrographic) data gathered in 1926 and 1938. Cross sections are not provided in the 1986 report and so they cannot be compared to the current study's cross sections. However anecdotal evidence suggests that the river has become more restricted over time due to development, siltation and mangroves.

Review of the maximum bed level from the 1986 report and this report shows that the minimum river bed level has dropped between Charles Street Weir and Thackeray Street by about one metre, from – 2.00 m AHD in 1986 to –3.00 m AHD in 2002. This is probably due to the dredging required for the Rivercat to travel up to Parramatta. Wharf. The width of the dredging is only about 30 metres.

The minimum bed level in the river section from Silverwater Road to Ryde Bridge has risen from an average of – 4.60 m AHD in 1986 study to about - 3.8 m AHD in 2002, a rise of 0.8 metres.

This rise in river bed level may suggest part of the reason for the flood rise. It can be seen in **Figure D3** that in the lower reaches the design flood level is now about metre higher than the design flood level in the 1986 study. In the same time the bed level has risen by about 0.8 metres. This rise in bed level would have contributed to an increase in flood level.

D.5.3 Flood Modelling

The 1986 flood report discusses a number of steady and unsteady state models that were used in the study. The unsteady hydraulic model was USTFLO and the steady state model FLOWBD. The text does not explicitly state how these models were used but it seemed that the unsteady model was used for the Parramatta River and the steady state model for the tributaries. This could potentially cause problems on not being able to account for the volume of flow coming from the tributaries. For instance if the short duration tributary flow was to included in the model at the start of the much longer duration storm in Parramatta River, then the flood may well have passed down the tributary and the Parramatta River, before the main peak from the Upper Parramatta River has occurred.

SKM has used a single integrated unsteady model (MIKE-11) for the whole of the project area and so total mass balance, travel time and flood volume is maintained throughout the model and the probability of co-incident floods is explicitly included in the overall flood assessment.

It should be noted that the adopted method of calculating the hydrological and hydraulic data is exactly the same as has been used by UPRCT.

Annexure to Appendix D

Relevant Extracts from Parramatta River Flood Level Survey April 1988 Flood Event

Public Works, August 1988

TABLE D1 - REF 6.

RIVER: PARRAMATTA

DATE: 30/4/88 TIME:

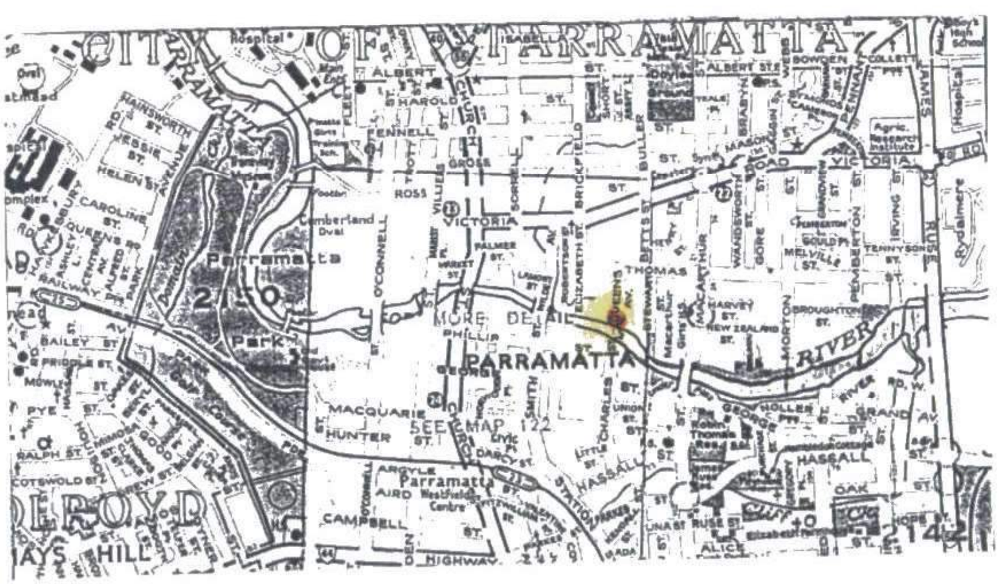
REMARKS: Flood Levels
- looking south from Queen's Ave across Weir towards Charles St. Parramatta.

NOTE: Debris (incl. 4 shop trolleys) being extracted from weir inlets utilising winch lin off council vehicle.

PHOTOGRAPH:

ESTIMATED FLOOD LEVEL 5.00m AHD.

SITE SKETCH:



TABLED1 - REF 7

RIVER: PARRAMATTA

DATE: 30/4/88.   TIME:

REMARKS:
Flood Levels.
- derelict factory at end Morton St. Parramatta., opp. Department of Health facility.
- adjacent northern river bank.

PHOTOGRAPH:

ASSUMED GROUND LEVEL = 3.5m AHD

FLOOD LEVEL = 4.0m AHD

N.B. Support $\frac{R.7}{5}$ Western Face.

SITE SKETCH:

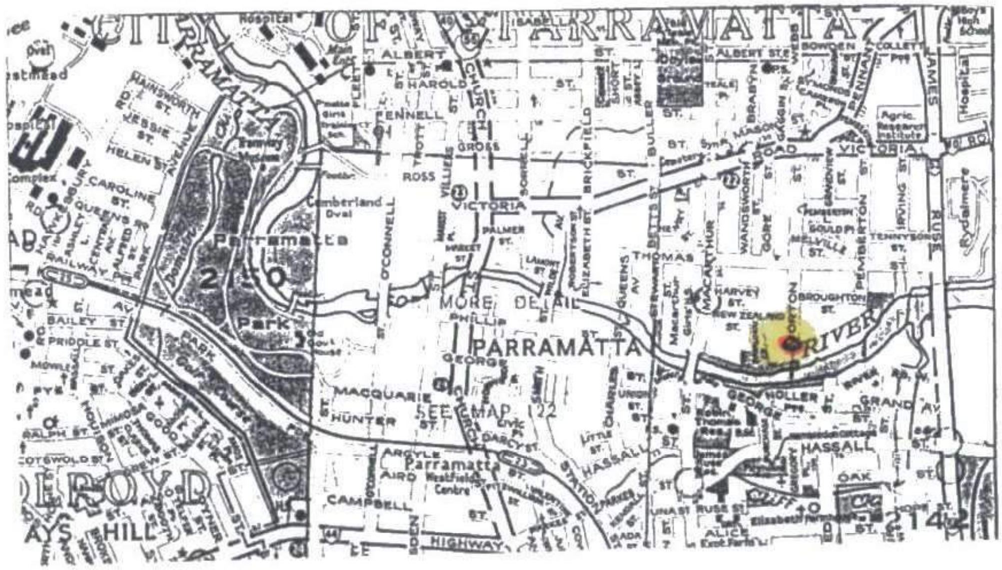


TABLE D1 – REF 8

RIVER: PARRAMATTA RIVER

DATE: 30/4/88 TIME:

REMARKS: – confluence with Vineyard Ck.
– northern pylon of the Rail Bridge inside Rydalmere Hospital grounds
N.B. 2 marks shown on pylons.

ALS GROUND LEVEL = 2.0m AHD
FLOOD LEVEL = 3.5m AHD

PHOTOGRAPH:

SITE SKETCH:

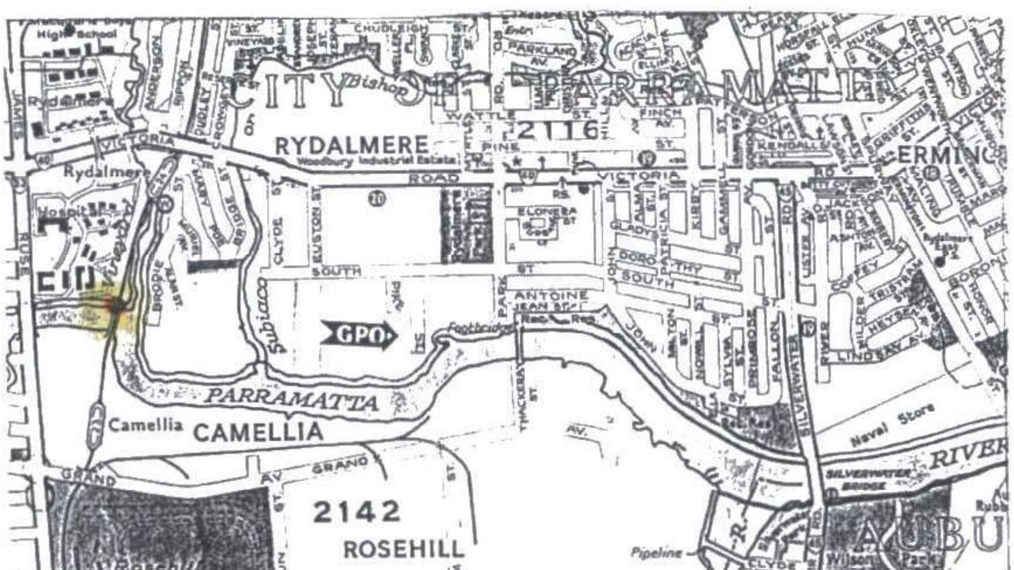


TABLE D1.
REF 9

RIVER: PARRAMATTA 1+

TIME:

DATE: 30/12/88

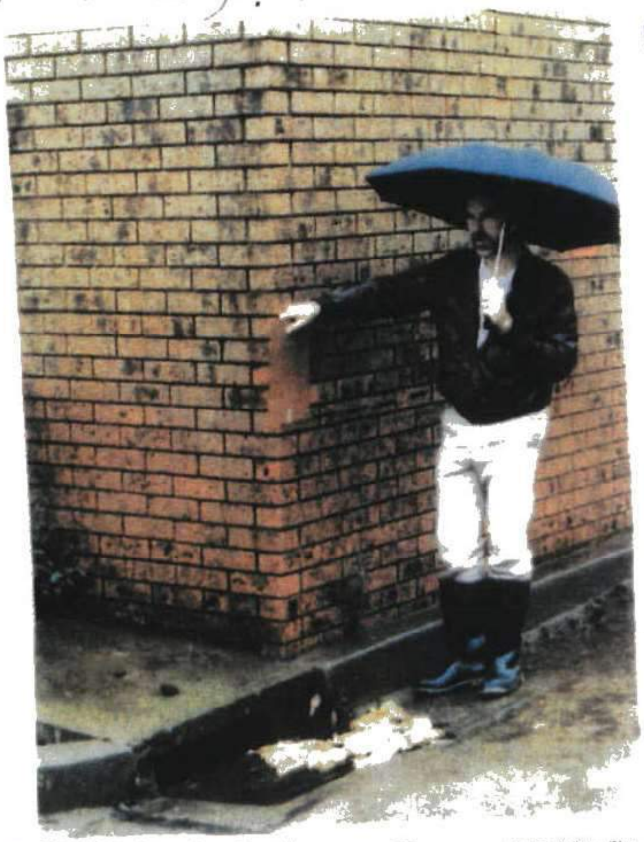
REMARKS:

[illegible]

ALS GROUND LEVEL = 2.6m AHD

FLOOD LEVEL = 3.6m AHD.

PHOTOGRAPH:



SITE SKETCH:

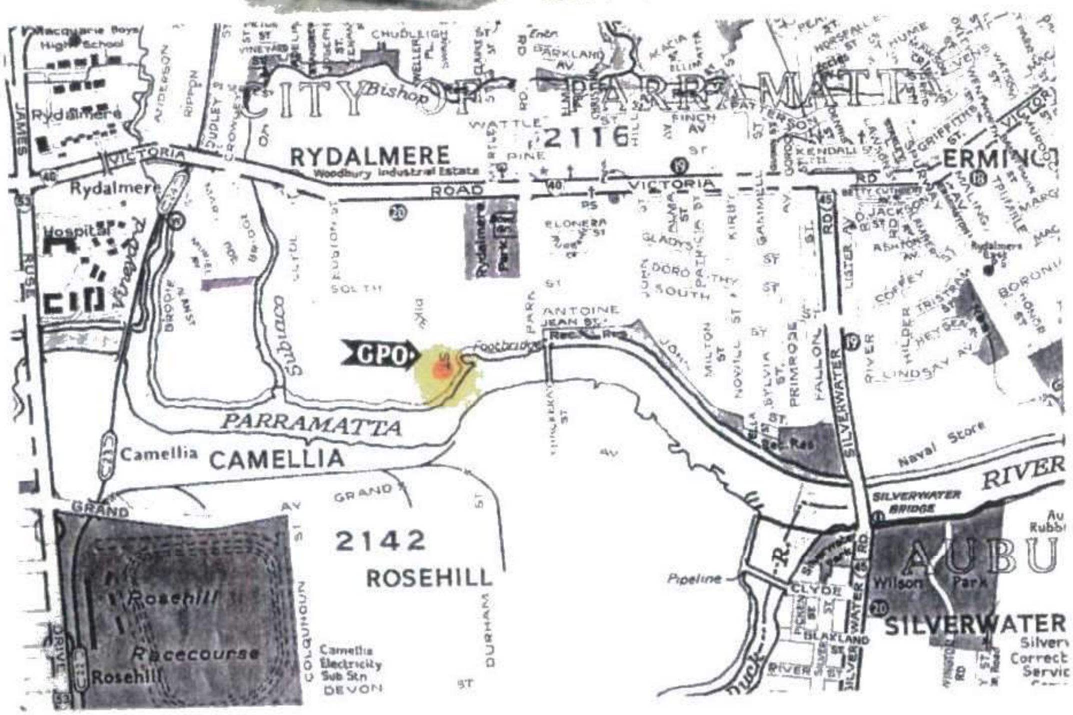


TABLE D1 - REF 10

FLOOD MARKING DATA SHEET

RIVER: PARRAMATTA

DATE: 30/4/88 TIME:

REMARKS:

Flood Levels.

- concrete bridge pylons (footbridge) at end of Thackeray St. Rosehill.

ALS GROUND LEVEL = 2.0m
FLOOD LEVEL = 3.0m AHD

PHOTOGRAPH:

SITE SKETCH:

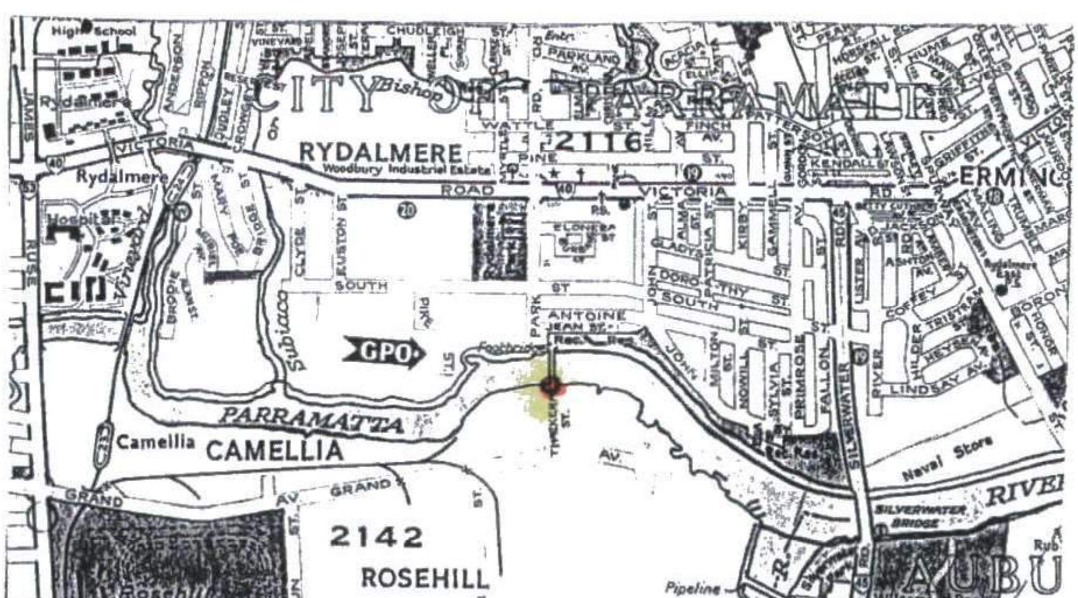


TABLE D1-REF 11

RIVER: *PARRAMATTA*

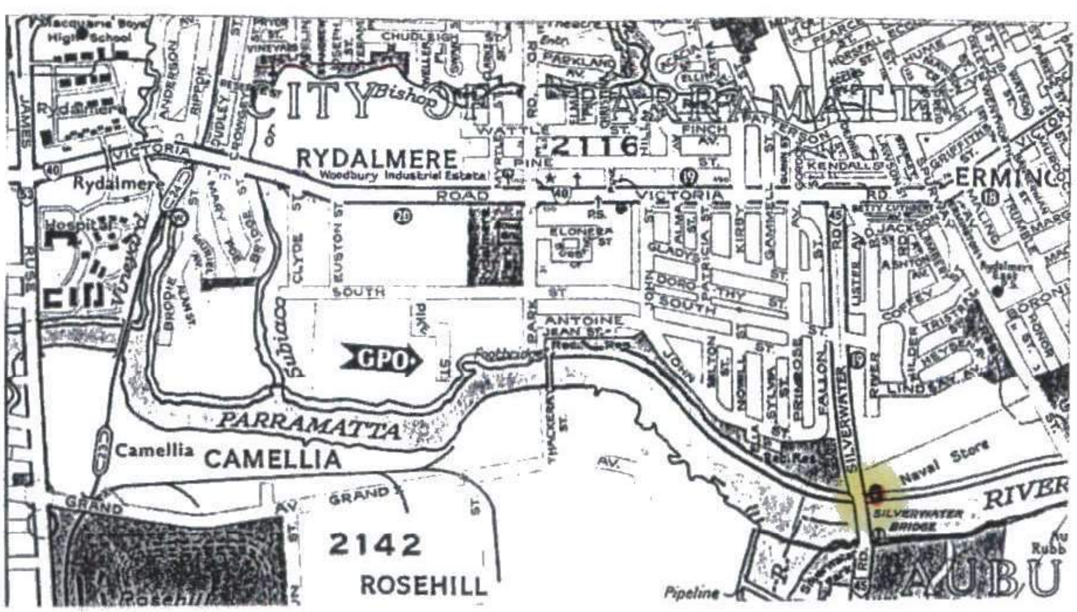
DATE: *30/4/88* TIME:

REMARKS:
- opposite confluence with Duck River
- debris line on river fence to naval store on eastern side of Silverwater Bridge looking eastward.

GROUND LEVEL = FLOOD LEVEL = 2.0m AHD

PHOTOGRAPH:

SITE SKETCH:



FLOOD MARKING DATA SHEET

TABLE D1 - REF 12

RIVER: PARRAMATTA ; A'Becketts Ck.

DATE: 30/4/88. TIME:

REMARKS:

57 Arthur St. Granville.

(1986 flood was 4 inches through the house,

ALS - GROUND LEVEL = 5.1m

FLOOD LEVEL = 5.3m AHD

PHOTOGRAPH:

SITE SKETCH:

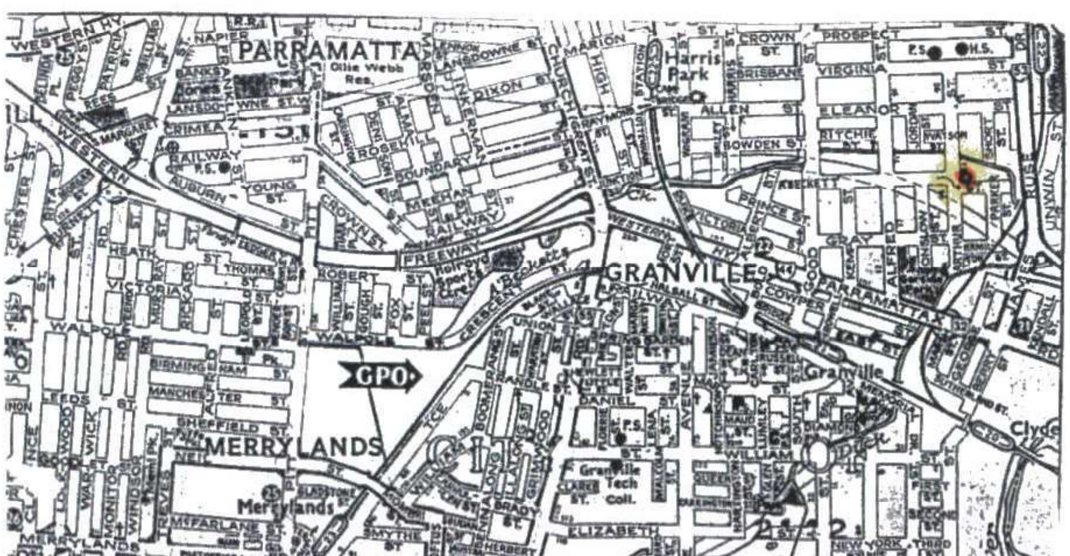


TABLE D1 – REF 13

RIVER: PARRAMATTA ; A'BECKETTS CK.

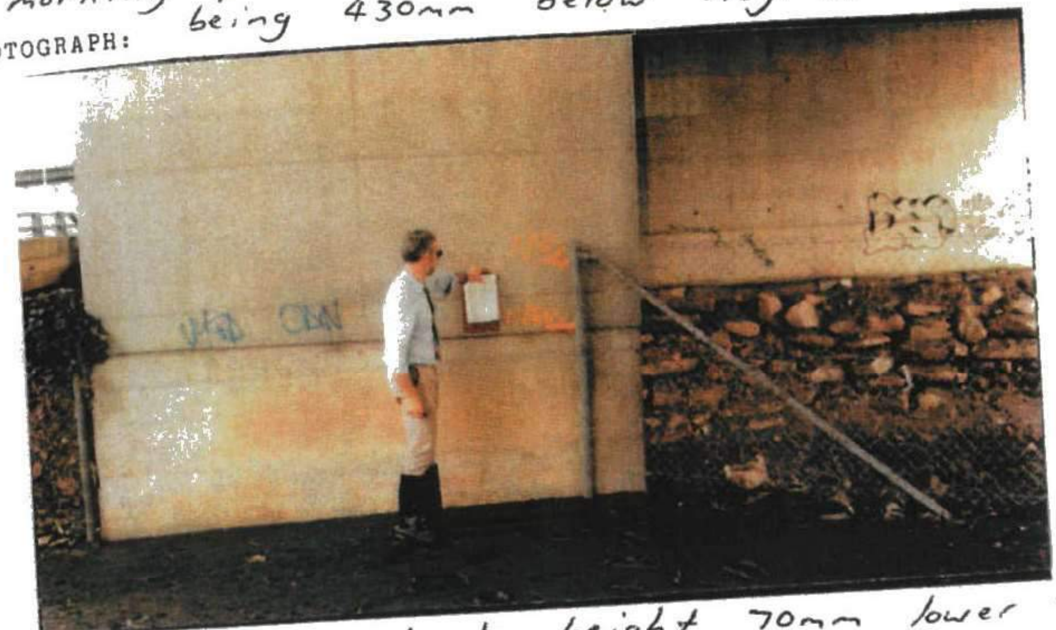
TIME:

DATE: 30/4/88

REMARKS: Southern most bridge pylon under James Ruse Drive Bridge off Unwin St Rosehill. Opposite DMR facility and used for DMR car parking area.

- previous flood height marks evident.
- morning peak to same height Nov.'86, this being 430mm below Aug. '86

PHOTOGRAPH:



Afternoon peak to height 70mm lower than a.m

SITE SKETCH:

NOT CLEAR ALS LEVEL.
SAY ALS = 3.6m AHD
FLOOD LEVEL = 4.8m AHD

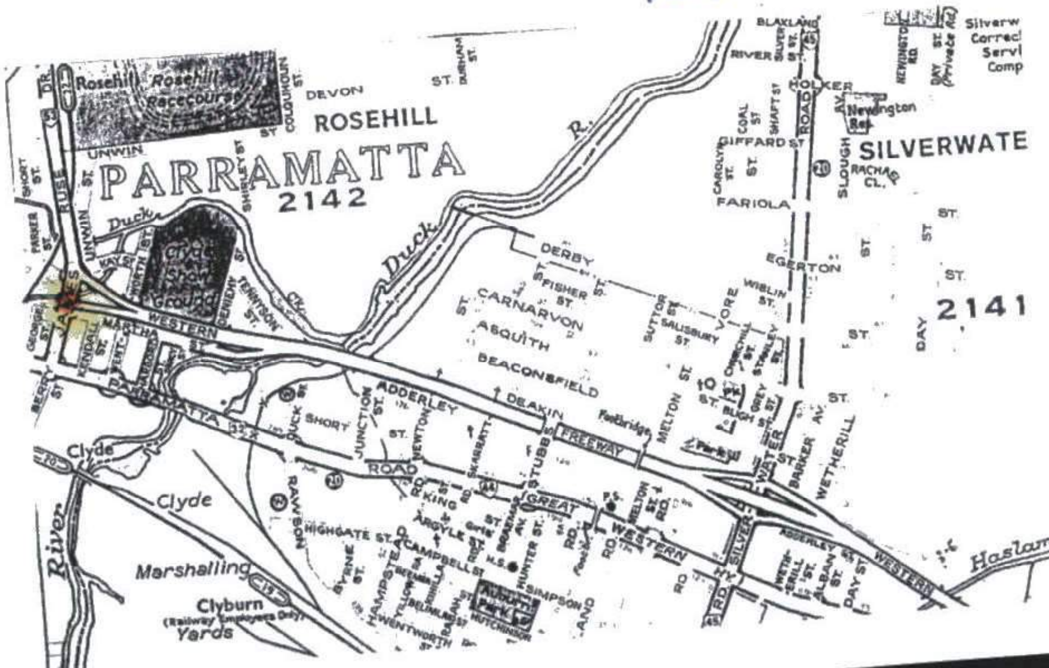


TABLE D1 - REF 14

RIVER: Duck

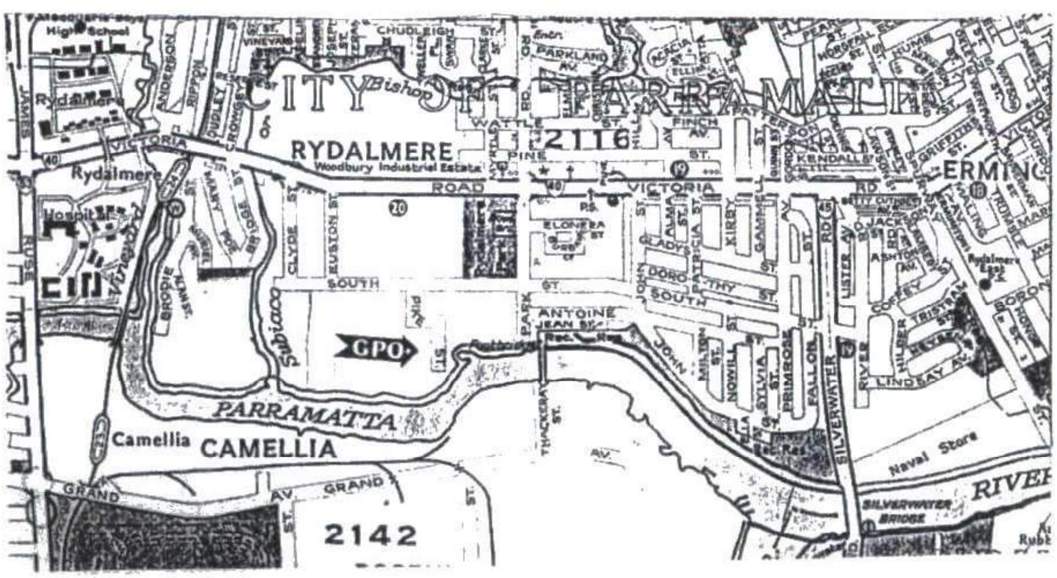
DATE: 30/4/88 TIME:

REMARKS: - concrete wall facing river adjacent Silverwater Pk., Silverwater
- at end of Clyde St near cnr Picken St.
- near confluence of Duck River and Parramatta River.

ALS TOP OF WALL = 2.7m AHD
FLOOD LEVEL = 2.4m AHD

PHOTOGRAPH:

SITE SKETCH:



<u>FLOOD MARKING DATA SHEET</u> TABLE D1 - REF 24

RIVER: Duck.

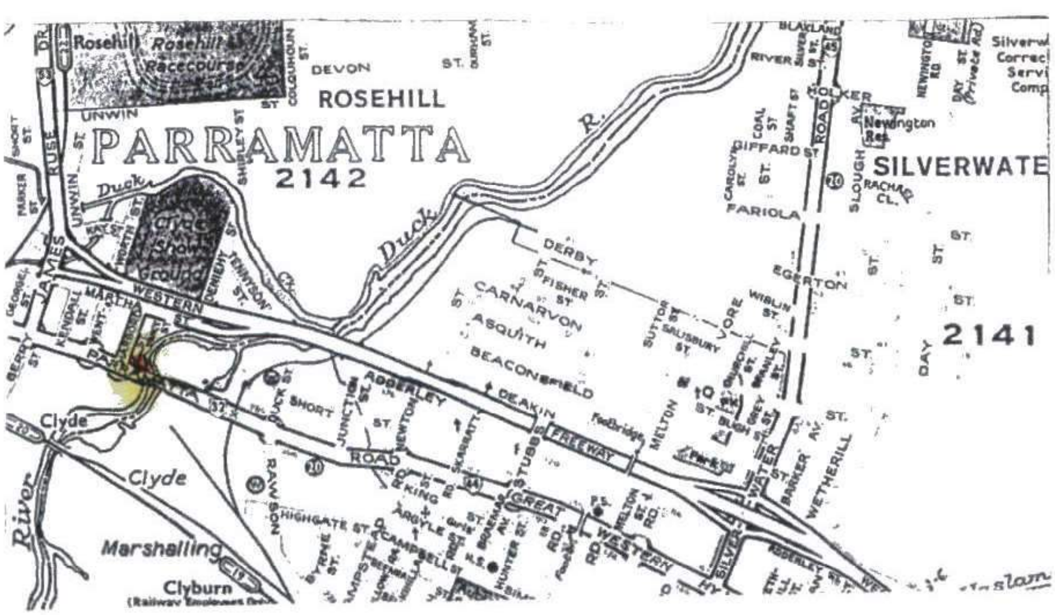
DATE: 30/4/88 TIME:

REMARKS: Flood levels.
- burned out building in industrial complex off Parramatta Rd. (Northside)

FROM ALS - GL. ≐ 4.2 m AHD
FLOOD LEVEL = 4.6m AHD

PHOTOGRAPH:

SITE SKETCH:



Relevant Recorded Flood Level Data from PWD, 1986 Lower Parramatta River Flood Study

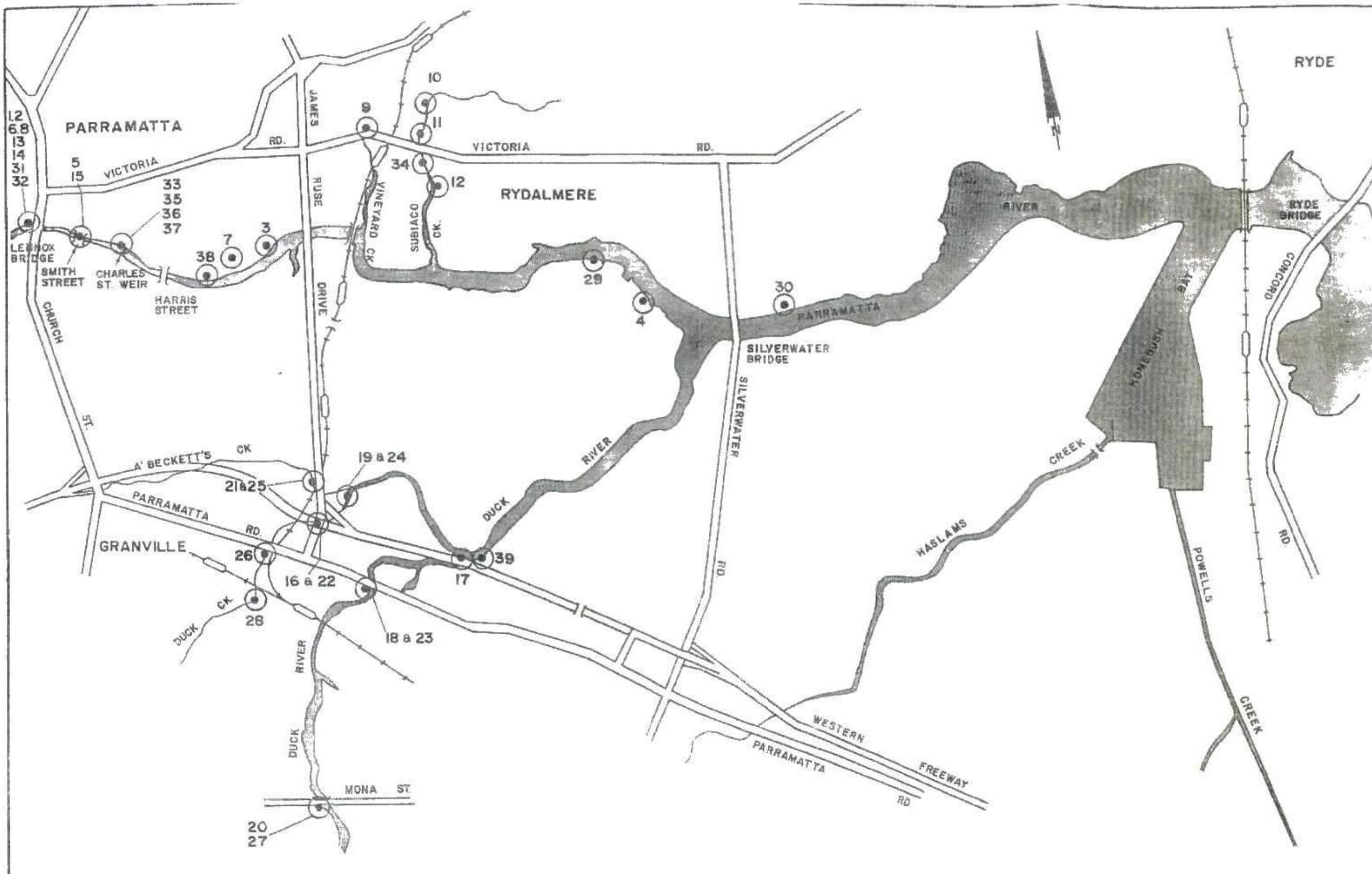
- Recorded Flood Levels
- Exhibit 8 – Positions of Observed Flood Levels
- Exhibit 18 – Adopted Peak Design Flows

C.5: RECORDED FLOODLEVELS

No.	DATE OF FLOOD	LOCATION / DESCRIPTION	RL (AHD)	SOURCE	RELIABILITY
1.	27.05.1889	Lennox Bridge, Parramatta upstream of drawdown	7.9	Sydney Morning Herald	fair
2.	21.03.1914	Lennox Bridge, Parramatta upstream of drawdown	7.3	Sydney Morning Herald	fair
3.	1956?	North bank Parramatta River, East end Broughton St	2.5	Resident	date uncertain
4.	02.1956	South bank Parramatta River, East end Grand Parade	1.6	Factory records	poor
5.	02.1956	Smith Street footbridge, Parramatta	3.4 4.67	Parramatta Advertiser Parramatta C.C.	poor good
6.	02.1956	Upstream side Lennox Bridge, Parramatta	6.34	Parramatta C.C.	good
7.	1956?*	North bank Parramatta River, East side Morton St	3.38	Parramatta C.C.- F.L. 45	date uncertain
8.	11.1961	Lennox Bridge, Parramatta upstream of drawdown	5.8	Parramatta C.C.- photos	fair
9.	6.03.1967	East side Vineyard Ck, between Victoria Rd and Anderson St	8.90	Parramatta C.C.- F.L. 22	good
10.	1967?	East side Subiaco Ck, opposite Crowgey Reserve	3.82	Parramatta C.C.- F.L. 26	date uncertain
11.	6.03.1967	West side Subiaco Ck, just north of Victoria Road	4.90	Parramatta C.C.- F.L. 27	good
12.	1967?	Subiaco Ck, opposite lot 9 Clyde St, Rydalmere	3.18	Parramatta C.C.- F.L. 28	date uncertain
13.	6.03.1967	Upstream side Lennox Bridge, Parramatta	6.10	Parramatta C.C.	good
14.	6.03.1967	Downstream side Lennox Bridge, Parramatta	4.72	Parramatta C.C.	good
15.	6.03.1967	Smith Street footbridge, Parramatta	5.01	Parramatta C.C.	good
16.	15.04.1969	South side Duck Creek, just north of George St	3.95	Parramatta C.C.- F.L. 41	good
17.	15.04.1969	Just west of Duck Ck/ Duck River confluence, Hill St	2.47	Parramatta C.C.- F.L. 42	good
18.	15.04.1969	West side Duck River, just south of Parramatta Rd	4.10	Parramatta C.C.- F.L. 43	good
19.	15.04.1969	Hamilton St, just west of Duck Ck/A'Becketts Ck	3.82	Parramatta C.C.- F.L. 44	good
20.	15.04.1969	West side Duck River, just upstream of Mona St Bridge	6.57	Parramatta C.C.- F.L. 37	good

No.	DATE OF FLOOD	LOCATION / DESCRIPTION	RL (AHD)	SOURCE	RELIABILITY
21.	16.10.1972	A'Becketts Ck, east end of A'Beckett St	4.00	Parramatta C.C.- F.L. 54	good
22.	25.04.1974	South side Duck Creek, just north of George St	5.12	Parramatta C.C.- F.L. 41	good
23.	25.04.1974	West side Duck River, just south of Parramatta Rd	3.60	Parramatta C.C.- F.L. 43	good
24.	25.04.1974	Hamilton St, just west of Duck Ck/A'Beckett's Ck	4.84	Parramatta C.C.- F.L. 44	good
25.	25.04.1974	A'Becketts Ck, east end of A'Beckett St	5.00	Parramatta C.C.- F.L. 54	good
26.	25.04.1974?	West side Duck Creek, just south of Parramatta Rd	3.82	Parramatta C.C.- F.L. 75	good
27.	25.04.1974	Duck River, under Mona St Bridge	6.06	Parramatta C.C.- F.L. 37	good
28.	25.04.1974	East side Duck Creek, just upstream of Memorial Dr	6.41	Parramatta C.C.- F.L. 74	good
29.	1974?	South bank Parramatta River, East side Thackeray St	2.3	Works Manager	poor
30.	1974?	North bank Parramatta River, Naval Store Ermington	1.5	Stores Personnel	fair
31.	21.06.1975	Upstream side Lennox Bridge, Parramatta	3.20	Parramatta C.C.	good
32.	21.06.1975	Downstream side Lennox Bridge, Parramatta	3.11	Parramatta C.C.	good
33.	21.06.1975	Upstream side Charles St weir, Parramatta	2.98	Parramatta C.C.- F.L. 76	good
34.	21.06.1975	West side Subiaco Ck, No. 11 Bridge St, Rydalmere	3.68	Resident	good
35.	4.03.1977	Upstream side Charles St weir, Parramatta	2.96	Parramatta C.C.- F.L. 76	good
36.	20.03.1978	Upstream side Charles St weir, Parramatta	2.95	Parramatta C.C.- F.L. 76	good
37.	2.11.1981	Upstream side Charles St weir, Parramatta	2.33	Parramatta C.C.- F.L. 76	good
38.	Unknown	North bank Parramatta River, Rangihou Crescent	1.9	Resident	poor
39.	Unknown	East side Duck River, near confluence Duck Ck	1.7	Factory Manager	poor

* Note: A question mark alongside the date of a flood indicates that the actual date was not recorded.



LEGEND

HISTORICAL FLOOD LEVEL AND REF. No. (APPENDIX C-5)

NOTE: LOCATIONS REFERRED TO IN REPORT SECTION 5·1

0.5 0 0.5 1 kilometre

SCALE

LOWER PARRAMATTA RIVER FLOOD STUDY

POSITIONS OF OBSERVED FLOOD LEVELS

EXHIBIT 8