CABRAMATTA CREEK
FLOODPLAIN MANAGEMENT STUDY & PLAN

Overlooking Cabramatta Creek and Warwick Farm Racecourse during the 1986 flood (photo courtesy Liverpool City Council)

UPDATED REPORT

October 2004

Bewsher Consulting Pty Ltd
Floodplain Management Consultants

LIVERPOOL CITY COUNCIL
FAIRFIELD CITY COUNCIL

CABRAMATTA CREEK
FLOODPLAIN MANAGEMENT STUDY & PLAN

UPDATED REPORT

OCTOBER 2004

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SUMMARY

Introduction

Bewsher Consulting Pty Ltd was originally commissioned by Liverpool City Council, in conjunction with Fairfield City Council and the Department of Land and Water Conservation (now the Department of Infrastructure, Planning and Natural Resources), to undertake a floodplain management study for Cabramatta Creek.

A number of working papers were prepared during the course of the study and a draft main report issued in May 1999 [Bewsher Consulting, 1999].

The draft report was not finalised at the time, largely due to uncertainties associated with a major highway proposal (referred to as the WSO project in this report) that bisects the Cabramatta Creek catchment. The proposed highway and associated compensatory flood mitigation works has a significant impact on Liverpool Council's detention basin strategy – in particular, whether or not an earlier proposal to construct a large multi-purpose basin in the middle of the catchment, known as Basin 22, would be feasible.

By late 2002 many of the uncertainties regarding the proposed WSO and Basin 22 had been resolved. Subsequently, Liverpool and Fairfield Councils requested that the draft Cabramatta Floodplain Management Study be updated.

This floodplain management study and plan is based on the previous draft report submitted in May 1999, updated where appropriate to account for changes that have occurred since this time.

Bewsher Consulting has been assisted by Don Fox Planning (town planning advice), the University of NSW Water Research Laboratory (hydraulic modelling), Nelson Consulting (environmental matters) and Southern Aerial Surveys (aerial mapping).

The study was overseen by both Liverpool Council's floodplain management committee and Fairfield Council's floodplain management committee. These committees consisted of Councillors and staff from both Councils, community representatives, and officers from other organisations, such as the Department of Land and Water Conservation (now DIPNR), State Emergency Services and the Department of Urban Affairs and Planning.

Principal Outcomes

The outcomes of this study include:

- a comprehensive set of aerial photography and detailed contour mapping of the catchment;
- revised flood information in the form of maps showing flood contours and flood extents for a range of flood events, in digital format for incorporation into both Councils' GIS computer systems and as hard copy plans;
- a comprehensive assessment of floodplain management measures, including a review of planning controls, flood mitigation works and other measures to reduce potential flood problems within the catchment;

- a range of working papers on specific issues investigated throughout the study, which have been progressively presented to the floodplain management committees;
- the Main Report (this document) which summarises the working papers that have been undertaken, and presents an overall outline of the floodplain management study and the recommended floodplain management plan; and
- an Executive Summary which provides a concise summary of the study and recommended floodplain management plan.

Flood Behaviour

Flood behaviour has been analysed using the RAFTS hydrologic model to simulate flows throughout the creek systems, and the RMA-2V two dimensional hydraulic model to simulate the extent and depth of flooding within the catchment. Both models were calibrated to floods that were recorded in August 1986 and April 1988. These models provide the necessary tools to assess the impact of catchment development, compensatory flood mitigation works, and other potential flood mitigation works to alleviate existing flooding problems.

The floodplain has been divided into three flood risk precincts (high, medium and low) as part of the updated study. Different development controls are also proposed for the catchment depending on the type of development and the flood risk precinct that the development is located. These controls are included in a planning matrix to be attached to Flood Risk Management Development Control Plans that have been proposed for both Liverpool and Fairfield Councils.

A flood damages database of potentially flood affected properties has been prepared as part of the study. The database provides details of those properties likely to be inundated in different sized floods and allows the quantification of potential flood damages. Key results from the database indicate that:

- 2,838 residential homes and 218 commercial/industrial buildings would be flooded above floor level in the PMF;
- In the Liverpool LGA, 74 homes and 80 commercial/industrial buildings would be flooded above floor level in the 100 year flood;
- In the Fairfield LGA, 50 homes and 24 commercial/industrial buildings would be flooded above floor level in the 100 year flood;
- The predicted flood damage in the 100 year flood is $16M for Liverpool, and $4.8M for Fairfield.

Community Consultation

Community consultation has also been a major component of the study. This has included liaison with community groups and authorities, regular presentations to both Councils' floodplain management committees, two community newsletters and questionnaires, two public meetings, and the intended public exhibition of the draft Main Report and Executive Summary.

The Floodplain Management Plan

A recommended floodplain management plan showing preferred floodplain management measures for Cabramatta Creek is presented in **Table 11.1** and also shown on **Figure 11.1**. The preferred measures have been determined from a range of available measures, after an assessment of the impacts on flooding, as well as environmental, social, and economic considerations.

Recommended options that modify flood behaviour include:

- a revised detention basin strategy for Liverpool City Council;
- three other detention basins to provide compensatory flood storage for the proposed WSO highway;
- a further detention basin on Brickmakers Creek at Amalfi Park and/or channel improvement measures downstream of Amalfi Park;
- channel works, culvert amplification, and creek rehabilitation works in Brickmakers Creek, between Homepride Avenue and Elizabeth Drive;
- improved flood access along major arterial roads;
- a package of works in the Elizabeth Drive/Tresalam Street area; and
- the preparation of bushland management plans and the clearing of rubbish and debris from the creek waterways.

Recommended options that modify property include:

- voluntary house raising;
- flood proofing individual buildings; and
- controls on new development through a planning matrix approach, which provides guidance on appropriate land uses and other development controls.

Recommended options that modify people's response to flooding include:

- a flood awareness program;
- improved flood warning system and emergency response management; and
- the preparation of flood action plans.

Timing and Funding

Timing of the proposed works will depend on each Council's overall budgetary commitments, and the availability of funds from other sources. Funding will be available through a number of sources, as identified in **Table 11.1**. Components of the Plan will be able to be carried out directly by either Liverpool Council or Fairfield Council, whilst other components that affect both Council areas will need to be carried out jointly.

Oblique aerial photo of Lower Cabramatta Creek (November 1998), viewed from the middle of the catchment downstream to the Georges River. Most of the lower floodplain is located within open space reserves. A formed floodway that was constructed some 30 years ago is prominent in the foreground.

PHOTO 1
Lower Cabramatta Creek

1. INTRODUCTION

1.1 ABOUT THE UPDATED STUDY

Bewsher Consulting Pty Ltd was originally commissioned by Liverpool City Council, in conjunction with Fairfield City Council and the Department of Land and Water Conservation (now the Department of Infrastructure, Planning and Natural Resources), to undertake a floodplain management study for Cabramatta Creek.

A number of working papers were prepared during the course of the study and a draft main report issued in May 1999 [Bewsher Consulting, 1999].

The draft report was not finalised at the time for various reasons, including:

- uncertainties associated with the location of a proposed major highway, known as the Western Sydney Orbital (WSO), which was to traverse the study area;
- issues with flood compensatory measures to be incorporated within the proposed WSO highway;
- uncertainties with a major detention basin, known as Basin 22, which had been proposed in the draft report to satisfy joint flood mitigation and WSO objectives; and
- changes in Council staff following the issue of the draft report.

By late 2002 many of the uncertainties regarding the proposed WSO and Basin 22 had been resolved. Subsequently, Liverpool and Fairfield Councils requested that the draft Cabramatta Floodplain Management Study be updated.

This floodplain management study and plan is based on the previous draft report submitted in May 1999, updated where appropriate to account for changes that have occurred within the study area since this time.

1.2 OBJECTIVES OF THE STUDY

Cabramatta Creek has a history of flooding. Recently, the April 1988 and August 1986 floods caused considerable damage and disruption within the catchment. Numerous residential houses, commercial buildings and industrial buildings were inundated during these flood events. There was also damage to public infrastructure and utilities, such as roads, water supply and sewerage facilities.

The first objective of the Cabramatta Creek Floodplain Management Study was to examine flooding problems throughout the catchment for a range of development conditions. This is to identify the extent and depth of flooding that can be expected within the catchment.

The second objective of the study was to look at flood mitigation works and other measures to reduce flooding problems within the catchment. Environmental, social, economic and engineering issues have been considered in assessing these options. Extensive community consultation has also been an important component of this phase,

to ensure that all practical options were investigated, and that the views of the community are taken into consideration.

The final objective of this study was to present a recommended floodplain management plan for implementation by Liverpool City Council and Fairfield City Council. The plan outlines the best possible measures to reduce flood damages in the Cabramatta Creek catchment.

1.3 THE STUDY AREA

Cabramatta Creek is a major tributary of the Georges River, located in the south-west of the Sydney Metropolitan region. The catchment, which is shown on **Figure 1.1**, has an area of 74 km^2. It is bordered roughly by the South-Western Freeway and the Hume Highway in the east, Denham Court in the South, Sydney Water's "Water Race" at West Hoxton in the west, and the suburbs of Cabramatta, Mt. Pritchard, Heckenberg, Busby, Hinchinbrook, Green Valley and Cecil Hills to the north.

The study area comprises five major subcatchments. These are:

- Upper Cabramatta Creek;
- Hinchinbrook Creek;
- Maxwells Creek;
- Brickmakers Creek; and
- Lower Cabramatta Creek (Liverpool and Fairfield Council areas).

Most of the catchment area is located within the Liverpool City Council area. The north side of Lower Cabramatta Creek, downstream of Elizabeth Drive, is located within the Fairfield City Council area. A small proportion of the upper catchment is also located within the Campbelltown City Council area, and the Ingleburn Military Camp.

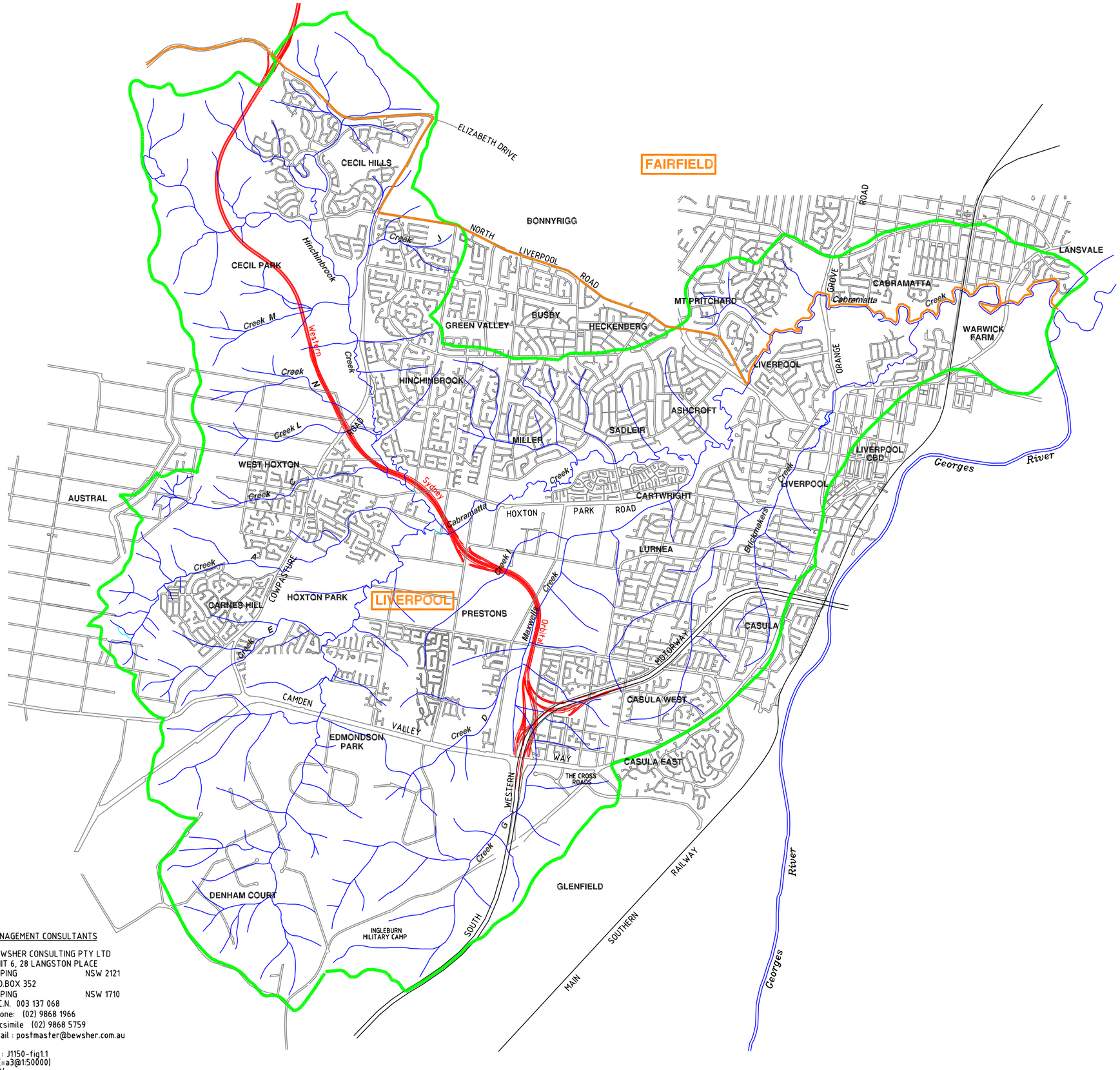
This study is focussed on assessing main stream flood problems within the floodplain of Cabramatta Creek and its main tributaries, and recommending measures to reduce these problems. The floodplain is defined as that land which is potentially subject to flooding by the highest flood that could conceivably occur, which is often referred to as the probable maximum flood (PMF).

1.4 THE GOVERNMENT'S FLOODPLAIN MANAGEMENT PROCESS

The prime responsibility for planning and management of flood prone lands in NSW rests with the local council. The NSW Government provides assistance on state-wide policy issues and technical support. They also provide financial assistance to undertake flood and floodplain management studies, such as this current investigation, and for the implementation of works identified in these studies.

A Flood Prone Land Policy and a Floodplain Management Manual [NSW Government, 2001] forms the basis of floodplain management in NSW.

FIGURE 1.1



LEGEND

- Catchment Boundary
- Local Government Boundary

0 1 2km

Scale

THE STUDY AREA

CABRAMATTA CREEK
FLOODPLAIN MANAGEMENT STUDY

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Date : May 2004

The objectives of the Policy include:

- reducing the impact of flooding and flood liability on existing developed areas by flood mitigation works and measures, including ongoing emergency management measures, the raising of houses where appropriate, and development controls; and
- reducing the potential for flood losses in new development areas by the application of ecologically sensitive planning and development controls.

The Policy provides some legal protection for councils and other public authorities and their staff against claims for damages resulting from their issuing advice or granting approvals on floodplains, providing they have acted substantially in accordance with the principles contained in the *Floodplain Management Manual*.

The implementation of the Flood Prone Lands Policy generally culminates in the preparation and implementation of a Floodplain Management Plan.

The steps in the floodplain management process are summarised on **Figure 1.2**.

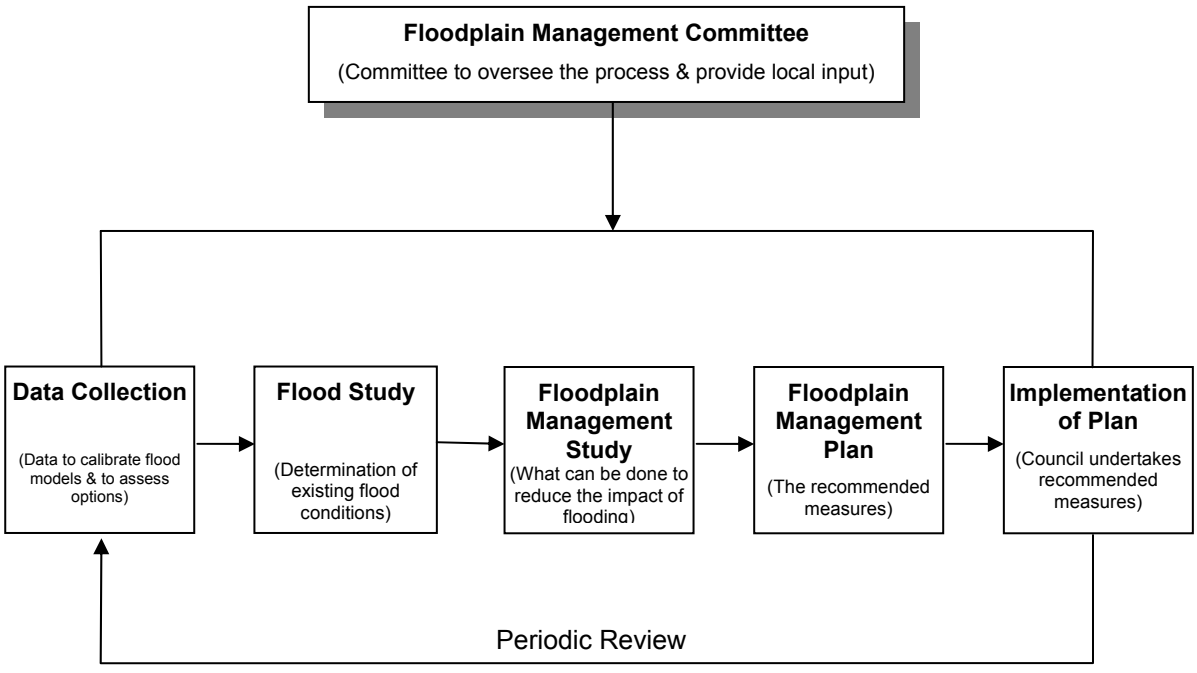


FIGURE 1.2
THE FLOODPLAIN MANAGEMENT PROCESS

1.5 THE STUDY TEAM

A multi-disciplinary team was assembled to undertake this study. The study team, and their key responsibilities, are listed in **Table 1.1**.

TABLE 1.1
The Study Team

Team Member	Key Responsibilities
Bewsher Consulting	Project management, hydrologic modelling, floodplain management, engineering
Don Fox Planning	Town planning
Water Research Laboratory	Hydraulic modelling
Nelson Consulting Pty Ltd	Environmental considerations
Southern Aerial Surveys Pty Ltd	Aerial photography and mapping

Throughout this study, Bewsher Consulting has been guided by both the Liverpool Floodplain Management Committee and the Fairfield Five Creeks Committee. Both committees have provided valuable direction, bringing together views from key Council staff, other departments and agencies, and community representatives.

1.6 OUTCOMES OF THE STUDY

A comprehensive set of aerial photography and detailed contour mapping was produced as part of the initial floodplain management study. The mapping forms the basis of topographic information under 1996 catchment conditions, and for determining the extent of flood inundation for a range of flood events. These maps represent a considerable investment by Council, but one that ensures that the subsequent floodplain management assessments are based on the best available base data. The mapping base is further described in **Section 2.3**.

Revised flood information was also prepared as part of the initial study. Maps of flood contours and flood extents were prepared for Cabramatta Creek and its tributaries, providing information on the flood problems within the catchment. The information has been provided in digital format for both Councils, for incorporation into their graphical information computer systems. The analysis of flood behaviour is presented in more detail in **Section 3**.

A comprehensive assessment of floodplain management measures was also investigated with a view to reducing flood problems within the catchment. The assessment is not only based on hydraulic performance and costs, but is also based on social, environmental and ecological issues, and community views.

A range of technical working papers were prepared as part of the initial floodplain management investigations. This allowed the Liverpool and Fairfield Floodplain Management Committees, as well as staff from both Councils and other Departments,

to monitor the progress of the study, receiving information as various tasks (or working papers) were completed. These working papers are outlined in **Table 1.2.**

Finally, a main report has been produced (this document) that summarises the findings of the various working papers and presents a draft floodplain management plan (**Section 11**) for the consideration of the community and both Councils.

A draft copy of the main report was issued to both Councils in May 1999. This report was updated in 2004 to reflect changes that have occurred within the study area since the previous draft report.

TABLE 1.2
Cabramatta Creek Floodplain Management Study Working Papers

Working Paper	Principle Author	Completed
Hydrologic (RAFTS) Modelling	Bewsher Consulting	June 98
Flood Study Report - Epoch 1 Conditions	Water Research Lab.	Dec 98
Flood Study Report - Epochs 2, 3,& 4	Water Research Lab.	In Prep.
Flood Warning and Emergency Response Management	Bewsher Consulting	#
Western Sydney Orbital - Management of Cross Drainage and Road Stormwater	Bewsher Consulting	Feb 99
Review of Planning Controls in New Release Areas	Don Fox Planning	Oct 98
Review of Section 94 Contributions Plans for Trunk Drainage in New Release Areas	Bewsher Consulting	May 98
Overview of Water Quality, Riverine Ecology and Vegetation Management of Creek Corridors	Nelson Consulting	Nov 98
Flood Damage Assessment	Bewsher Consulting	July 99
Floodplain Management Options	Bewsher Consulting	Nov 98
Strategy for Land Filling in Floodplains and Low Lying Areas	Bewsher Consulting	#
Denham Court Stormwater Management Strategy Report	Bewsher Consulting	#
Review of Local Flood Policies	Don Fox Planning	Oct 98
Total Catchment Management Strategy Report	Nelson Consulting	Dec 98
Community Consultation	Bewsher Consulting	Sep 98
Land Use and Social Profile Report	Don Fox Planning	Nov 98
Hydraulic Modelling of Floodplain Management Options	Water Research Lab.	#
RMA-2 Modelling of Cabramatta Creek at Elizabeth Drive	Water Research Lab.	Apr 98
Bibliography	Bewsher Consulting	June 97
Review of Basin Strategy	Bewsher Consulting	Mar 99

Working Paper omitted from study brief

2. BACKGROUND INFORMATION

2.1 PHYSICAL DESCRIPTION

Cabramatta Creek starts in the rural/residential suburb of Denham Court, which is located at the southern extent of the catchment boundary. From here the creek flows in a northerly direction under Camden Valley Way towards Hoxton Park, and its junction with Hinchinbrook Creek. The Cabramatta Creek and Carnes Hill Urban Release Areas are located within the Upper Cabramatta Creek subcatchment. Substantial residential development has already occurred in these areas, particularly to the west of Cowpasture Road. A number of detention basins have also been constructed in conjunction with the development. The Ingham's poultry farm also occupies a significant landholding in the area.

Hinchinbrook Creek commences at the northern extremity of the catchment, and flows in a southerly direction to join Cabramatta Creek towards the middle of the catchment. The newly developing suburb of Cecil Hills is located towards the top of the Hinchinbrook Creek subcatchment. Substantial development has recently occurred to the east of Cowpasture Road in the Green Valley and Hinchinbrook suburbs. Various flood mitigation works, incorporating a number of detention basins and water quality basins, have also been constructed in conjunction with this development. The Hoxton Park aerodrome is located on the western side of Hinchinbrook Creek, and further to the west a Regional Open Space corridor that has been substantially acquired by the former Department of Urban Affairs and Planning, although it remains partially used for agricultural purposes with existing dwellings being leased back to agricultural proprietors.

Hinchinbrook Creek joins Cabramatta Creek just below Hoxton Park Road. From here, Cabramatta Creek starts to flow in an easterly direction through the lower Cabramatta Creek catchment, towards the Georges River. A more prominent creek "corridor", up to 200m wide, becomes more evident throughout the lower catchment. This primarily consists of public open space, playing fields and golf courses. The Elouera Nature Reserve, which is an important pocket of native bushland, also forms part of this corridor. Cabramatta Creek flows through established residential suburbs in both Liverpool and Fairfield Council areas, including Miller, Cartwright, Sadlier, Ashcroft, Liverpool, Mount Pritchard and Warwick Farm. Major transport routes that cross the lower catchment includes Hoxton Park Road, Elizabeth Drive, Orange Grove Road (The Cumberland Highway), the Hume Highway and the Main Southern Railway.

Other major tributaries of Lower Cabramatta Creek include Maxwells Creek and Brickmakers Creek.

Maxwells Creek starts near the Ingleburn Military Camp and flows in a northerly direction through the existing Edmondson Park rural residential area, which has been identified as a future urban release area. The creek crosses the South Western Freeway and the M5 at The Crossroads, and continues north alongside the Liverpool Showground. This area is presently rural, although it has been zoned for future urban residential and industrial purposes. The creek becomes a grassed trapezoidal channel

downstream of Jedda Road, continuing through the Preston's industrial area and the older established residential suburb of Lurnea, before joining with Cabramatta Creek.

Brickmakers Creek starts upstream of Casula Mall shopping Centre and also flows in a northerly direction towards the lower end of Cabramatta Creek. The catchment comprises predominantly established urban residential areas, plus parts of the Liverpool Central Business District. The upper parts of the catchment are piped, with the creek first emerging at Amalfi Park. The Creek flows north through Pacuillo Park to Hoxton Park Road. The Creek continues beside the Liverpool Council chambers as a formed channel with concrete invert. Brickmakers Creek later reverts to a more natural form, flowing beside the western extent of the Liverpool CBD and peripheral residential area. This area largely contains commercial buildings and residential flat buildings. The Creek continues through Hargrave Park, and finally on to Cabramatta Creek near Durant Oval.

2.2 HISTORY OF FLOODING

Flooding is a natural phenomenon which has been occurring for thousands of years. In Cabramatta Creek it can occur when heavy rain falls over the catchment, from backwater when the Georges River is in flood, or from a combination of these conditions.

Over the last 50 years there has been at least 10 significant floods that have been experienced in Cabramatta Creek. These have resulted in floodwaters overtopping creek banks and flooding large areas of low-lying land adjacent to Cabramatta Creek and its other tributaries. Numerous residential, commercial and industrial properties have been flooded in the past, roads have been cut, public infrastructure has been damaged, and the social well-being of the community has been affected.

The most recent floods have occurred in:

- August 1986;
- April 1988;
- July 1988;
- April 1989;
- February 1990; and most recently in
- January 2001.

There is also some evidence of significantly larger floods occurring in the late 1800's. Floods with an average recurrence interval (ARI) of at least 100 years are believed to have occurred on the Georges River in 1873, 1889, and 1898. Whilst there is no data to confirm that flooding also occurred in Cabramatta Creek, it is nevertheless reasonable to assume that major flooding was also likely to have occurred throughout this catchment.

Oblique aerial photo of Upper Cabramatta Creek (November 1998), viewed from the central catchment looking upstream towards Cowpasture Road. Existing vegetation forms valuable wildlife corridors within the catchment.

PHOTO 2
Upper Cabramatta Creek

2.3 AERIAL MAPPING

A series of special low level aerial photography of the catchment was undertaken in 1996. Photogrammetric analysis of the ground terrain, in conjunction with additional ground level survey, allowed the production of various orthophotomaps of the catchment, consisting of ground contours superimposed on the aerial photography. The mapping base has been used to establish the flood models and to allow an accurate definition of the extent of flood inundation for various design floods.

Three sets of orthophotomaps were produced for this study, as detailed below:

- **A Catchment Map** — comprising four A1 sheets at a scale of 1:10,000 with 2m contours, covering the entire catchment. This was based on aerial photography flown at an altitude of 6,000m, with a resultant ground level accuracy estimated at ±0.6m.
- **A General Map Series** — comprising forty three A1 sheets at a scale of 1:2,000 with 1m ground contours, covering most of the catchment. These maps were subsequently supplemented with formlines at 0.25m intervals. The maps were based on aerial photography flown at an altitude of 1,200m, with a resultant ground level accuracy estimated at ±0.12m.
- **A Detailed Map Series** — comprising seven A1 sheets at a scale of 1:1,000 and with 0.5m contours, covering the Brickmakers Creek floodplain. These maps were based on aerial photography flown at an altitude of 650m, with a resultant ground level accuracy estimated at ±0.06m.

Hard copy prints of the above orthophotomaps have been produced, and a digital copy provided to both Liverpool and Fairfield Councils for integration into their graphical information computer systems. An index sheet for the 1:2,000 general map series is presented in **Figure 2.1**.

2.4 SOCIAL CONTEXT

An understanding of existing land use and population characteristics is an important consideration of this floodplain management study. The population, characteristics and development trends of the study area provide an understanding of the values of the community in regard to the utilisation of the floodplain, as opposed to sterilising its use to minimise the risks of flooding.

A demographic analysis has been undertaken for Cabramatta Creek and its main subcatchments. This analysis has been undertaken utilising 1986, 1991 and 1996 Census data.

During the years 1986 to 1996, the population growth in the Cabramatta Creek catchment increased by 12,953 additional persons, representing a 20% change. This was high compared to the total growth in the Sydney metropolitan region, which saw an 11% increase. The rate of growth within the study area was similar to that which occurred within the total Liverpool LGA (29% increase) and the Fairfield LGA (18% increase). This was mostly due to substantial urban release areas within the

study area. Overall, the Liverpool and Fairfield LGAs experienced the highest rate of new lots/dwelling production in the Sydney region.

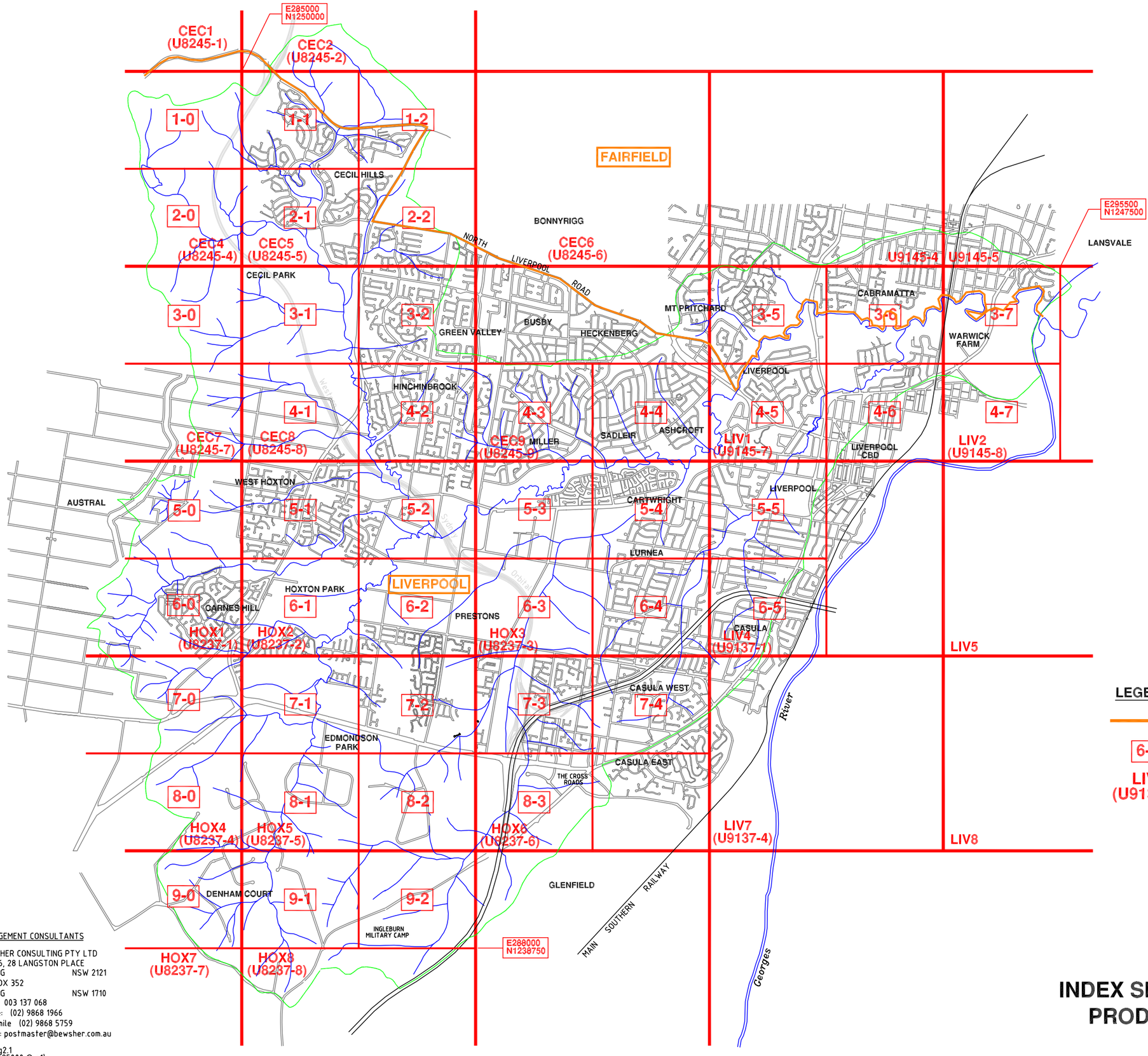
Dwelling and population growth between 1986 and 1996 Censuses for each of the catchment areas are depicted in **Figure 2.2** (A and B). Salient observations include:

- the Lower Cabramatta Creek catchment is a relatively established area which has had effectively no increase in dwelling numbers and an overall decrease in total persons primarily due to a fall in dwelling occupancy ratios;
- the Upper Cabramatta Creek catchment is primarily a rural residential area and has had negligible growth in population, but has had substantial growth in the number of dwellings, between 1986 and 1996;
- the Hinchinbrook Creek catchment contains new urban release areas which have contributed to population growth between 1986 and 1996, during which 2,900 new dwellings were formed;
- the Maxwells Creek catchment area is partially comprised of future urban release areas and partially rural and rural residential areas and had a high increase in dwelling numbers (476) between 1986 and 1996, but with a modest rise in population primarily due to falling dwelling occupancy ratios;
- the Brickmakers Creek catchment is predominantly in an established area, but also includes an urban release area in Casula West, which has seen a substantial increase in population (1,042 persons) during 1986 to 1996, with a corresponding increase in dwelling numbers (1,045); and
- the Fairfield Council side of Lower Cabramatta Creek is a relatively established area and had modest population growth (199 persons) and dwelling growth (320 households) between 1986 and 1996.

The proportion of people born overseas is depicted in **Figure 2.2** (C). A high proportion of the population in the study area is overseas born and/or speaks English poorly, particularly in comparison to the Sydney region. At the 1996 Census, 40% of the study area population were overseas born. Some areas like the Fairfield side of Lower Cabramatta Creek has a substantial (59%) proportion of overseas born people.

Individual and household incomes within the study area are low relative to the Sydney region. Correspondingly, unemployment is significantly higher in the study area in comparison to the Sydney region.

FIGURE 2.1



INDEX SHEET FOR 1:2000 MAPPING PRODUCED FOR THIS STUDY

CABRAMATTA CREEK
FLOODPLAIN MANAGEMENT STUDY

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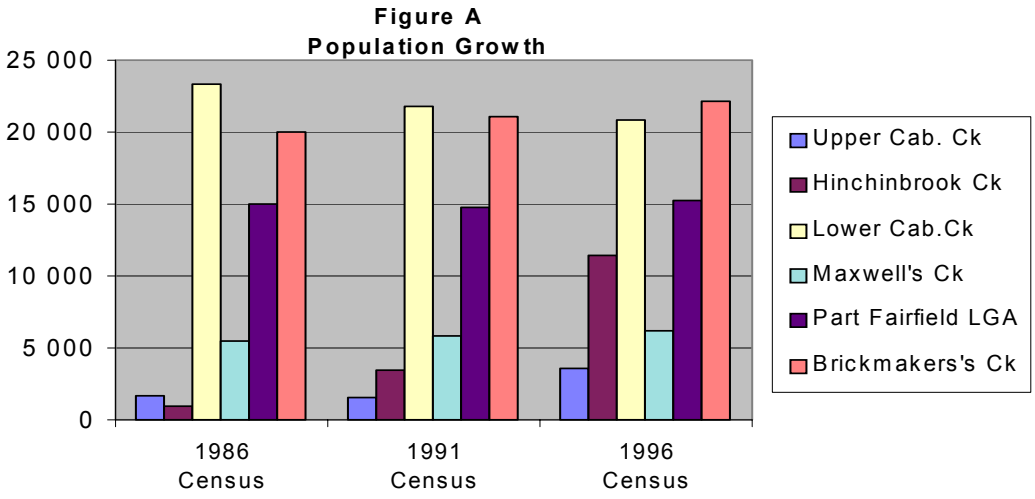
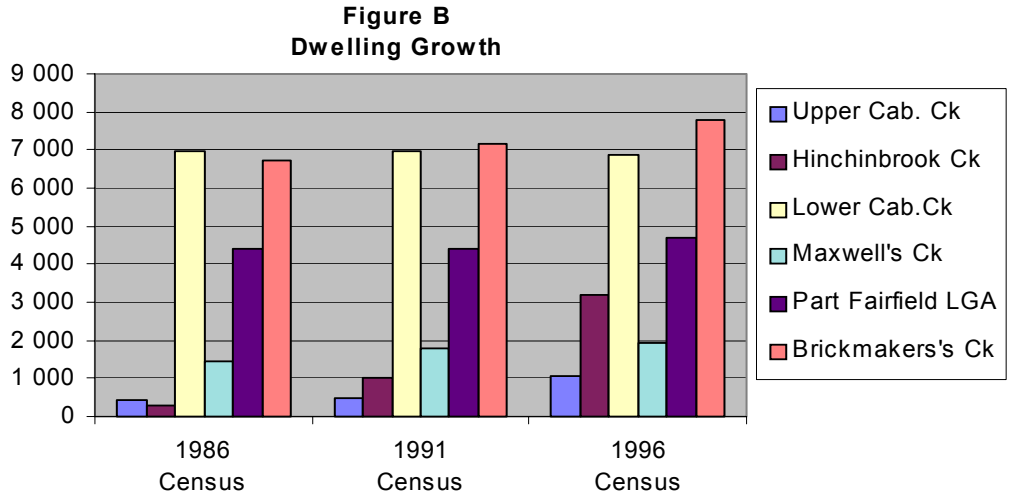
Date : May 2004





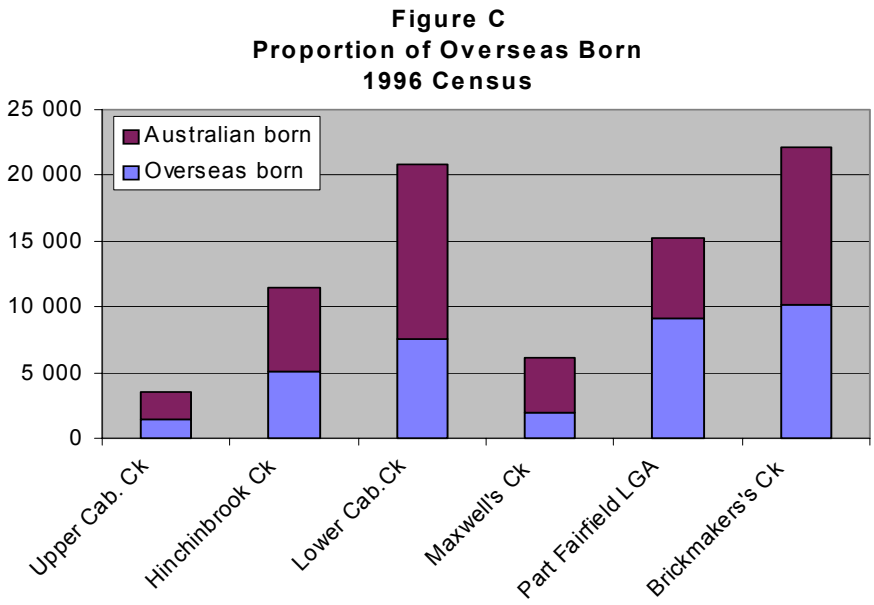


FIGURE 2.2
Demographic Trends in the Catchment Area

2.5 ENVIRONMENTAL ISSUES

Environmental issues associated with the Cabramatta Creek catchment are a key component of this floodplain management study. Whilst the objective of the study is primarily to address flooding issues, the impact on the environment of potential flood mitigation works needs to be carefully assessed. Wherever possible, flood mitigation works should be designed to enhance the environmental qualities of the catchment, rather than harming or exacerbating existing environmental problems.

Environmental issues affecting Cabramatta Creek and its tributaries include:

- poor water quality due to urban and rural runoff, septic tank seepage and sewage overflows, and possible leachate from contaminated sites. Water quality generally fails to meet ANZECC guidelines for recreation in terms of faecal coliform levels, and protection of aquatic ecosystems in terms of nutrient concentrations;
- the importance of the natural creek system and existing creek side vegetation in forming valuable wildlife corridors that span the catchment;
- modification of creek lines through channelisation, filling, formation of grassed verges, or exotic plantings, which limit the natural treatment processes of the creek system, fragment habitat for native species and can result in bank erosion through the formation of steep banks;
- clearing for urban development and the formation of informal tracks by trail bikes and four wheel drive vehicles, resulting in soil erosion, impacts on habitat values, degradation of Aboriginal sites and sedimentation of watercourses;
- the dumping of garden refuse, litter and large objects such as car bodies and shopping trolleys in and along creek lines; and
- weed invasion, including both terrestrial and aquatic noxious weeds, particularly creepers and vines which smother native species and nuisance aquatic plants which choke waterways.

2.6 PLANNING ISSUES

Floodplain management is about occupying the floodplain and optimising its use in a manner which is compatible with the flood hazard and at a level of risk which is acceptable to the community.

The Cabramatta Creek floodplain is part of a wider urban release area for the Sydney region, and there are expectations that development will occur in the area to satisfy both the housing needs of the expanding Sydney metropolitan region, and the development expectations of landowners. Development in the catchment will impact upon floodplain management in the following three ways:

- development in the catchment area which will contribute to the extent of impervious areas and ultimately an increase in runoff and flood levels, unless compensatory flood mitigation measures are instigated;
- development in the floodplain, but above the Flood Planning Level (FPL), which will be subject to the flood hazard but at a level of risk that is considered acceptable; and

- development in the floodplain and below the FPL which may be prohibited due to the severity of flooding (eg. in a high flood risk area) or permitted subject to appropriate controls being imposed relative to the type of land use and the nature of the flood hazard.

Flooding is only one issue which planners need to take into consideration when formulating land use strategies. However, flooding may become an important issue, particularly where there is a direct and significant risk to the community because of the potential for loss of life or high flood damage losses. These risks must be clearly understood by decision makers as they result directly from planning decisions, and are foreseeable. The minimum the community expects is that these decisions are made on an informed and reasonable basis.

2.7 PREVIOUS INVESTIGATIONS

A number of investigations have already been completed within the Cabramatta Creek catchment that deal with flooding issues. These include investigations undertaken as part of the current floodplain management study, and earlier investigations undertaken by other parties. These documents provide valuable insight into problem areas within the catchment, and possible solutions that may alleviate these problems.

A summary of previous investigations which are relevant to the assessment of floodplain management measures for Cabramatta Creek is provided below.

2.7.1 Lower Cabramatta Creek Floodplain Management Study

This study [Kinhill, 1991] was completed by Kinhill Consultants for Fairfield City Council. The study presents a floodplain management plan for the Lower Cabramatta Creek, between its confluence with the Georges River and Elizabeth Drive.

A series of flood mitigation measures were proposed comprising levees, channel works, formalised floodways and house raising. Specific works included;

- channel works near Elizabeth Drive Bridge;
- raising and lengthening the existing levee adjacent to Tresalam Street;
- extension of the floodway immediately downstream of Elizabeth Drive;
- channel clearing downstream of the floodway;
- removal of the fence around Cabramatta Golf Course;
- floodway construction upstream of Orange Grove Road;
- flood proofing of properties upstream of the Main Southern Railway;
- formation of a floodway both upstream and downstream of the Main Southern Railway; and
- flood proofing of two houses near the Georges River.

The above measures have been reviewed as part of the current study, in light of new flood level estimates and other works proposed in the rest of the catchment.

2.7.2 Hoxton Park Stage 2 Release Area Total Catchment Management Study

In 1989 Kinhill Consultants were commissioned by Liverpool City Council to undertake a study [Kinhill, 1992] of flooding issues associated with a major urban release area within the upper catchment, known as the Hoxton Park Stage 2 Release Area.

The study assessed the impact of proposed development both in terms of the quantity and quality of runoff from the new Release Area. The investigation assessed the likely increase in peak flows throughout the catchment as a result of the proposed development, and investigated means of limiting post-developed 100 year ARI flows to pre-developed conditions.

A trunk drainage strategy, know as Option A-3, was recommended that included the construction of 9 detention basins that would act as both flood mitigation and water quality control structures. The basins ranged in size from 50,000 m^3 to 183,000 m^3, with a combined total storage of 1,100,000 m^3.

Whist this study developed a basin strategy capable of alleviating the increased flows estimated to result due to the development of this release area, it did not address the issue of reducing existing flood problems, either by way of larger or additional basins, or by other flood mitigation measures.

2.7.3 Cabramatta Creek Total Catchment Management Study

This study [Kinhill, 1993], prepared for the Water Board, was an extension of the earlier Kinhill study, with the study area increased to incorporate the areas of existing development downstream of the new release areas.

In addition to the flood mitigation measures previously recommended for the Hoxton Park Stage 2 Release Area, and works identified in the Lower Cabramatta Creek Floodplain Management Study, several other flood mitigation works and measures were also presented within the existing Liverpool urban area. The main additional measures that were recommended include:

- implementation of an urban bush management program within the Elouera Nature Reserve, Hinchinbrook Creek and Lower Brickmakers Creek;
- channel maintenance programs for Brickmakers Creek and Maxwells Creek;
- the development of flood management plans for industrial properties in Maxwells Creek and Brickmakers Creek and Creek A;
- channel enlargement works in Brickmakers Creek, between Orange Grove Road and Moore Street;
- an additional culvert under Elizabeth Drive in Brickmakers Creek;
- road raising in the vicinity of Carboni Street and Collimore Avenue, in Brickmakers Creek;
- channel works along Maxwells Creek upstream of Jedda Road;

- elimination of a flood breakout in the Bernera Road area by the construction of a small levee;
- flood proofing the Liverpool Catholic Club;
- extension of a large floodway on Upper Cabramatta Creek, between Hoxton Park Road and Camden Valley Way, including bridgeworks;
- bridge works and road raising of Cowpasture Road on Hinchinbrook Creek;
- building and development controls;
- erection of flood warning signs; and
- a flood warning and evacuation study.

2.7.4 Cabramatta Creek Floodplain Management — Identification of Issues

This background paper was prepared by Lyall and Macoun Consulting Engineers for Liverpool City Council in 1995 [Lyall and Macoun, 1995]. It presents a critical review of reports previously undertaken for Cabramatta Creek and identifies current issues and concerns that should be considered in the preparation of a Floodplain Management Plan for the catchment.

Identified issues include:

- Access during Flooding — A number of arterial roads through the area are flooded during relatively minor floods, in particular Hoxton Park Road between First Avenue and Joadja Road, and Cowpasture Road at various locations. Determination of an appropriate level of service for these roads was seen as a key issue, along with improvements to signposting of road closures.
- Development Controls — Planning controls were seen as a key element for a future floodplain management study, with a review of current planning controls recommended.
- Flood Standard — There was concern over the blanket adoption of the 100 year ARI flood standard, and that there may be a perception that all land above this level would be free from flooding.
- Management of Public Lands — There is a perception that Council has inherited a legacy of drainage infrastructure and designated open space that has not been well planned or co-ordinated. It was recommended that any future floodplain management plan carefully examine options for preserving the conveyance capacity of the creek and floodplain whilst meeting community expectations for the provision of a bushland environment.
- Policies on Filling of Land — The preparation of guidelines for the filling of land, particularly flood prone land, was recommended.
- Environmental Issues — Whilst the focus of any future Floodplain Management Plan would be expected to be on flood related issues, it was recommended that a framework should be provided in which valuable ecological features can be preserved and water quality can be appropriately managed.

2.8 INVESTIGATIONS UNDERTAKEN SINCE 1999

A number of flood-related investigations have been undertaken within the study area since the draft floodplain management study report was prepared in May, 1999. Some of these investigations will impact on the recommended floodplain management plan, and have been considered in the preparation of this updated report. The main investigations that have been considered are discussed further in this Section.

2.8.1 Western Sydney Orbital Investigations

Bewsher Consulting, in conjunction with WBM Oceanics Australia, was commissioned by the Roads and Traffic Authority to assess the flooding impacts of the proposed WSO highway in July, 2001.

The main objective of these investigations was the development of a detailed hydraulic model to assist in:

- the sizing and location of waterway openings under the WSO highway;
- the sizing and location of detention basins; and
- definition of flooding impacts from various proposals for the highway.

The original RAFTS model developed for the Cabramatta Creek Floodplain Management Study was adopted for hydrologic modelling of catchment runoff. This model was refined to account for changes in the catchment since the previous analysis, to reflect 2001 catchment conditions. Other model parameter changes were also considered appropriate for these investigations, which are further discussed in **Section 3.2**.

A new two-dimensional hydraulic model, referred to as *TUFLOW*, was developed to model the flooding impacts of the proposed highway and flood mitigation measures. This model was dynamically linked to a one-dimensional model representing the main creek channel. The model is considered to be more detailed than the model used in the floodplain management study (RMA-2) in the vicinity of the proposed highway. However, the model does not cover the full extent of the study area provided in the floodplain management study.

Findings from the investigation [Bewsher Consulting, WBM, 2001] recommended various bridge and culvert sizes along the route of the proposed highway within the Cabramatta Creek catchment. It also recommended the construction of detention basins on Maxwells Creek, Cabramatta Creek and Hinchinbrook Creeks to mitigate any adverse flooding impacts from the proposed highway.

The proposed WSO highway has significant implications for the Cabramatta Creek Floodplain Management Plan. Some detention basins that were previously proposed within the catchment can no longer be built, due to the proposed route of the highway. Other proposed WSO basins can be enlarged to perform dual purposes.

The most significant implication of the subsequent investigations is the reduced size of the basin on Cabramatta Creek (Basin 22). This had originally been proposed as a

large dual-purpose RTA/Council basin to mitigate the flooding impacts of the proposed WSO, future development within the catchment, and to also reduce existing downstream flooding problems. Whilst a basin is still proposed at this location, its size is much reduced due to land acquisition costs and other technical difficulties (including a high saline water table at this location). Consequently, a significant reduction in downstream flood levels is unlikely as a result of this revised Basin.

A consortium has been chosen by the RTA to design and construct the proposed WSO highway. This consortium has been provided with the flood models developed by Bewsher Consulting and WBM Oceanics to further refine the size of bridge openings and WSO detention basins.

2.8.2 Brickmakers Creek Flood Investigations

This investigation was commissioned by Liverpool City Council in September 2003.

The objectives of the investigations were to:

(i) provide more detailed modelling of the reach of Brickmakers Creek, between Memorial Avenue and Homepride Avenue;

(ii) provide revised flood extents and flood contours for the 20 year, 100 year and PMF floods, if these need to be revised;

(iii) investigate flood mitigation works to reduce the impact of flooding on affected properties in this reach of Brickmakers Creek, particularly creek rehabilitation works previously proposed by other consultants

A detailed 2-dimensional *TUFLOW* model, dynamically lined to a one-dimensional model of Brickmakers Creek, was adopted for these investigations. The new model more accurately defined the break-out of floodwater from the creek into the Liverpool CBD area.

A report outlining the results of the investigations was provided in December 2003. This report is reproduced in Appendix C.

2.8.3 Edmondson Park Master Plan

Edmondson Park forms part of the Hoxton Park release area that was identified for urban expansion by the Minister of Environment and Planning in the mid 1980's. The Edmondson Park release area is located south of Camden Valley Way, within the upper Cabramatta Creek and Maxwells Creek catchment areas.

A master plan for this new release area is currently being developed. Details of proposed flood management measures within the release area are provided in a report titled "*Edmondson Park Master Planning - Water Cycle Management: Stormwater*" [GHD, 2003].

Two detention basins had initially been proposed within the Edmondson Park Release Area in the draft floodplain study. The master plan has further evaluated the floodplain management strategy for this site, based on more detailed consideration of planning

objectives and other site constraints. A revised strategy has been proposed that includes the construction of four wet/dry detention basins, and drainage corridors/easements/bioengineered channels within Upper Cabramatta Creek and Maxwells Creek. The overall objective of the strategy – to limit post development flows to pre development flows – appears to be met by this revised strategy.

2.8.4 Southern Hoxton Park Aerodrome Precinct

The Southern Hoxton Park Precinct also forms part of the Hoxton Park release area for future urban development. The site is located in the Hinchinbrook Creek subcatchment, west of Cowpasture Road and the proposed WSO highway.

A master plan for the new release area is currently being developed. Details of proposed flood management measures are provided in a report titled "*Southern Hoxton Park Aerodrome Precinct – Hydrological & Hydraulic Study*" [JWP, 2004].

One detention basin (Basin 6) had originally been proposed within this new release area on Creek M, as part of Liverpool Council's detention basin strategy [Kinhill, 1992]. The proposed route of the WSO highway later compromised the construction of a basin at this location. The draft floodplain management study recognised that Basin 6 could be omitted from Council's basin strategy providing a large central basin (Basin 22) could be constructed within the catchment. However, subsequent investigations have led to a much reduced Basin 22, with the result that detention storage within the new release area will now be imperative.

The master plan proposes a number of wetlands within the precinct. These wetlands also incorporate some detention storage. The combined detention storage volume provided is significantly less than the basin that was included in Council's original strategy, although model results appear to suggest that these are sufficient to restrict post developed flows leaving the site to pre developed flows.

Oblique aerial photo of Maxwells Creek (November 1998), viewed from Jedda Road upstream towards Camden Valley Way. Downstream of Jedda Road the creek consists of a formed channel with concrete invert. The creek reverts to a more natural form between Jedda Road and Kurrajong Road.

PHOTO 3
Maxwells Creek

3. ANALYSIS OF FLOOD BEHAVIOUR

3.1 METHODOLOGY

There are no long term historical flood records available within the Cabramatta Creek catchment on which flood frequency analysis can be undertaken. Consequently, the approach undertaken for this study has been to estimate flow hydrographs throughout the catchment using a hydrologic computer model, and then to input these flows into a separate hydraulic model to compute flood levels and velocities.

The RAFTS hydrologic model was adopted for the analysis of catchment flows. This was based on a model that had previously been established for the catchment, as part of earlier investigations [Kinhill, 1992]. Flood behaviour was then analysed using the RMA-2V hydraulic model. RMA-2V is a sophisticated hydraulic model capable of simulating the 2-dimensional nature of flow along and across wide floodplains.

All models require calibration and verification to be able to confidently predict flood behaviour. This involves modelling historic events and comparing computed results with observed flood levels. Model parameters are then adjusted to improve the fit between computed and recorded levels.

Following calibration, the models have been used to analyse flood behaviour for various design flood conditions. Design flood level estimates have been computed for the 20, 50 and 100 year average recurrence interval (ARI) floods, as well as a probable maximum flood.

These models then form the basis for assessing the impacts of catchment development, and for testing the effects of various flood mitigation measures to reduce flood problems within the catchment.

3.2 RAFTS HYDROLOGIC MODELLING

At the onset of this study, Liverpool City Council provided Bewsher Consulting with existing RAFTS data files that had been prepared for the Hoxton Park Total Catchment Management Study [Kinhill, 1992]. These files had been generated using an earlier version of the RAFTS program (Version 2.54), and required conversion to a form compatible with the current version of the RAFTS program (Version 4.02).

The RAFTS data files were updated by WP Software, the authors of the RAFTS program. Initial results from the updated model revealed some variation in flow estimates from the earlier model. WP Software consequently recommended that a recalibration of the RAFTS model be undertaken.

Since the model required recalibration, the opportunity was also taken to refine the subcatchment layout in the upper catchment areas. The adopted RAFTS catchment plan is included as **Figure 3.1**. It was also deemed appropriate to adjust a runoff parameter, know as the PERN value, on a subcatchment basis to better reflect the different land uses within the catchment.

The RAFTS model was calibrated against recorded data available at a DIPNR stream gauging station located on Cabramatta Creek at Orange Grove Road. Historic floods that occurred in April 1988, August 1986, April 1989, and July 1988 were considered for this purpose. Different RAFTS calibration coefficients of Bx=1,2,&3 were trialled, with the computed hydrograph from both RAFTS and RMA-2V compared against the recorded hydrograph.

A calibration coefficient of Bx=2 was considered to give the best overall fit for the four recorded floods. This was subsequently adopted for all further modelling of design flood conditions, development scenarios, and flood mitigation options.

Further details and results from the RAFTS hydrologic modelling can be found in the "RAFTS (Hydrologic) Modelling" working paper [Bewsher Consulting, 1998a].

3.3 UPDATED RAFTS MODEL

Subsequent to investigations undertaken for the draft floodplain management study, detailed flood investigations were undertaken for the Roads and Traffic Authority, in connection with the proposed WSO highway [Bewsher Consulting and WBM Oceanics Australia, 2002]. These investigations utilised the RAFTS model that was developed for the floodplain management study, and further updated this model to account for recent changes within the catchment and other improved modelling techniques.

Changes made to the RAFTS model include:

(i) it was updated to represent catchment conditions in 2001;

(ii) a split sub-area method was adopted to model the effects of catchment development, in line with current practice;

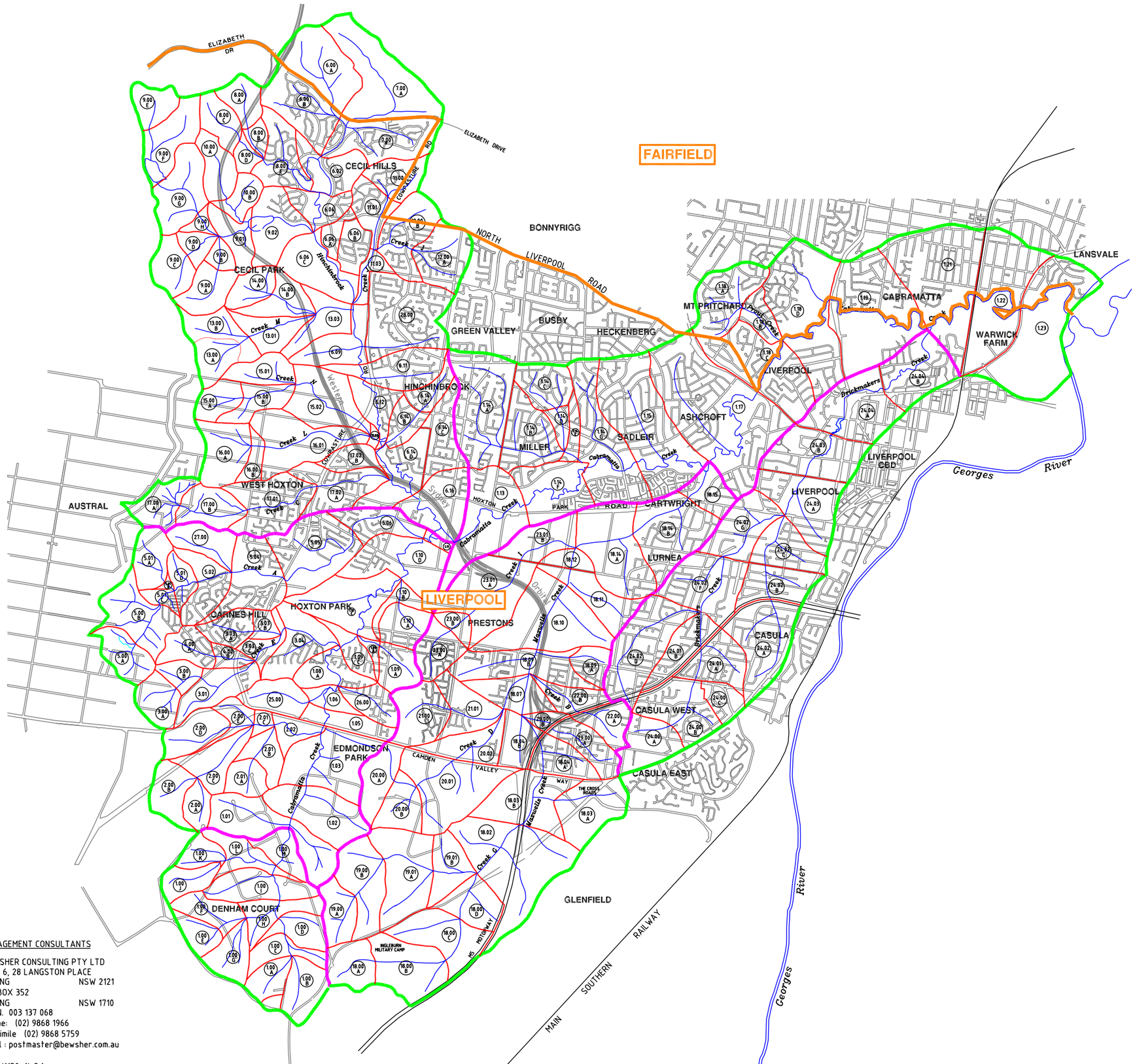
(iii) adoption of revised Intensity-Frequency-Duration rainfall data, as provided by Liverpool Council;

(iv) the areal reduction factor that had been applied to rainfall was removed, as this was less appropriate in the smaller subcatchment areas;

(v) the RAFTS calibration parameter was reduced from Bx=2 to Bx=1, as it was found that the higher value tended to underestimate flows in the smaller subcatchment areas.

Details of catchment flows provided by this updated model are provided in Appendix B. It is recommended that any future analysis of flood behaviour incorporate flows from this updated model, or other more detailed models where these are developed for specific areas.

FIGURE 3.1



FLOODPLAIN MANAGEMENT CONSULTANTS

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Plot file name : J1150-fig3.1
Plot scale : 50 (=a3 @ 1:50000)
Date : May 2004

RAFTS CATCHMENT LAYOUT PLAN

CABRAMATTA CREEK FLOODPLAIN MANAGEMENT STUDY

3.4 RMA-2V HYDRAULIC MODELLING

Hydraulic modelling is the process of converting flows generated from the hydrologic model into flood levels throughout the river or creek system. The hydraulic modelling for this study was undertaken by the University of NSW Research Laboratory (WRL), using the RMA-2V computer model.

RMA-2V is a finite element computer model designed to simulate two dimensional flood behaviour within estuaries, rivers, and creeks. It is particularly well suited to modelling wide floodplains, as is the case in the lower reaches of Cabramatta Creek, or where flood breakouts may occur from one creek system to another. The model was originally developed in the United States by Professor I. P. King and W. R. Norton. It has since undergone further development by staff at the WRL.

A finite element mesh, consisting of elements and nodes distributed along and across the creek system, describes the topography of the creek and floodplain. Flood heights are computed at each of these nodes over the full duration of flooding. As a large number of nodes and elements were necessary to accurately simulate flood behaviour throughout the whole area of interest, it was necessary to divide the catchment into 8 individual sub-models. This consisted of a main Lower Cabramatta Creek model with over 18,000 nodes, and seven smaller models representing the upstream creek systems, with the number of nodes ranging from 360 to over 4,700. An illustration of the main Lower Cabramatta Creek model is presented on **Figure 3.2**.

The model was calibrated to flood data that was observed during the April 1988 flood. This involved comparing computed flood levels to observed flood levels, and adjusting model parameters until a satisfactory fit between computed and observed level flood behaviour was achieved. The model was then verified against data collected from the August 1986 flood, without further change to model parameters.

With the model calibrated and sufficiently verified, it was then used to evaluate flooding behaviour throughout the catchment under 1996 catchment conditions. Flood behaviour was simulated for the 20 year, 50 year, and 100 year ARI design floods, as well as a probable maximum flood.

The model was also used to assess the impact of different states of catchment development, ranging from 1989 catchment conditions to anticipated future conditions in 50 years time (i.e. 2046).

A full description of hydraulic modelling can be found in the “Flood Study Report” working paper [WRL, 1998a].

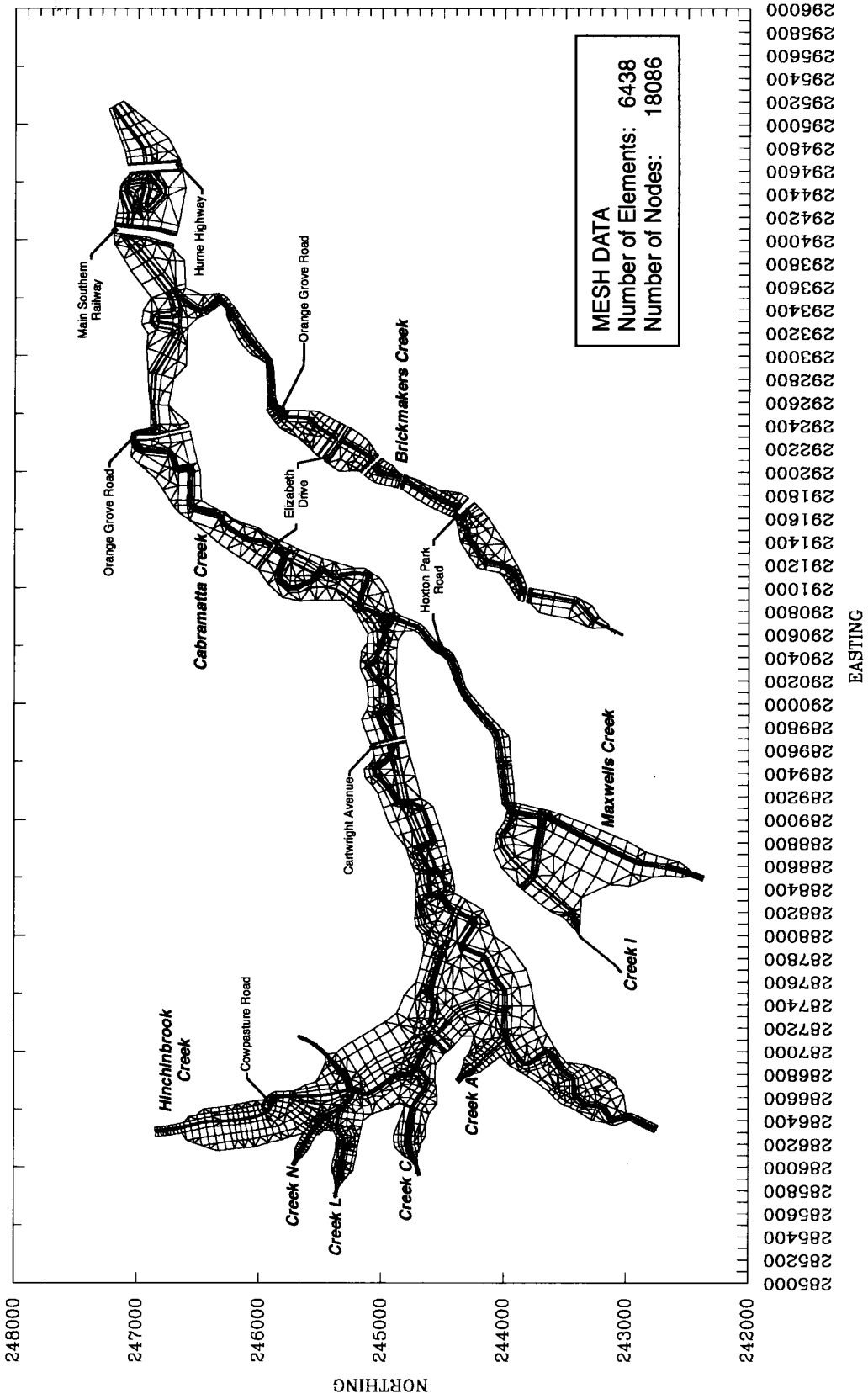


FIGURE 3.2
RMA-2V Finite Element Mesh for Lower Cabramatta Creek

3.5 EXISTING FLOOD CONDITIONS

Flood extents have been calculated on the basis of topographic ground data derived from the aerial mapping and spatial flood level information determined at over 35,000 nodes within the catchment's floodplains. Areas of inundation have been determined by comparing ground levels with computed flood levels on the basis of an interpolated 1m square grid over the floodplain.

Plans showing the extent of flood inundation and flood contours for the 100 year ARI flood, and the extent of the probable maximum flood, are represented on **Figures 3.3**, **3.4** and **3.5**. These plans have also been produced for Council's use as three A1 size plans at a scale of 1:10,000.

Flood level information for the 20 year, 50 year, 100 year and probable maximum flood has also been provided to both Councils in digital form, for incorporation into their respective GIS computer based systems. Further development of Liverpool Council's GENAMAP computer system is currently under consideration to facilitate reporting of flood data within a region or on an individual property basis. This could allow the generation of a detailed report for any property within the floodplain, providing:

- design flood levels at the site under Epoch 1 (1996) catchment conditions, for the 20 year, 50 year, and 100 year ARI floods, as well as the probable maximum flood;
- minimum ground level on the property, based on an interpolated 10m spatial grid determined from the aerial mapping undertaken in 1996;
- the surveyed floor level of the building on the property, where available; and
- a graphical representation of the extent of flooding and depth of flooding over the property for any nominated design flood.

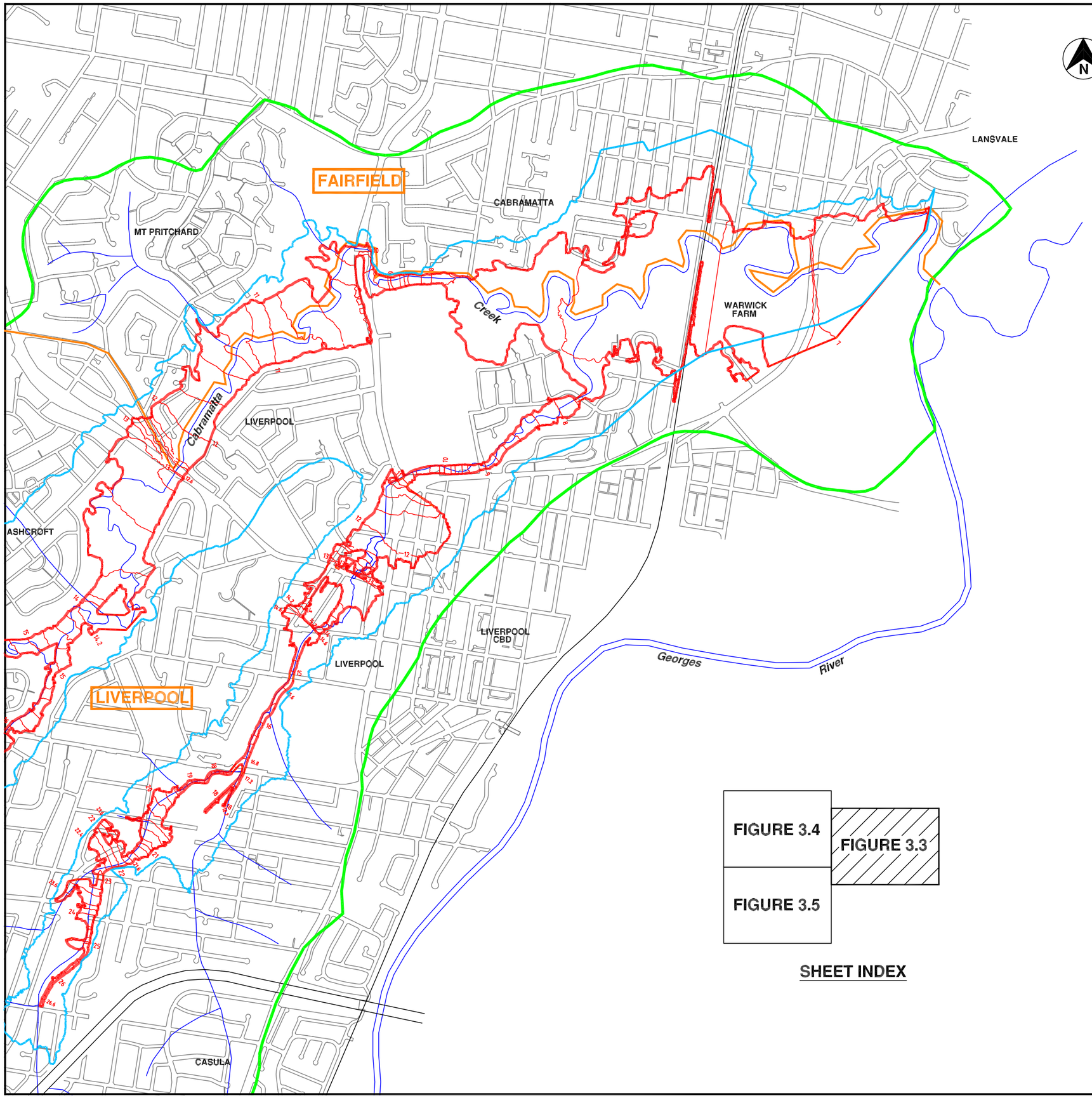
The system could also be extended to cover the Fairfield part of the catchment, should Fairfield Council decide to implement a similar computer based system.

Areas of land that are currently zoned for urban development that contain significant areas of land subject to flooding include:

- **Lower Cabramatta Creek Catchment (including part of Fairfield LGA)** — Within the Liverpool LGA, the majority of the 100 year ARI floodplain is located within open space zones. However, in some areas the 100 year ARI flood extent intrudes upon adjoining urban zones, such as the Residential zoned land near the northern extent of Lawrence Hargrave Road, the central section of Williamson Crescent, parts of industrial zoned land within Warwick Farm (between the Hume Highway and the railway line) and the north-eastern extent of the industrial estates abutting Orange Grove Road. The majority of the 100 year ARI floodplain within the Fairfield LGA component is similarly within open space zoned land, although there are some residential zoned lands within the 100 year ARI floodplain such as the land to the south-west of Jasmine Crescent, Cabramatta and the land at the southern end of Church Street, Cabramatta. The small industrial area to the east and south of Church Street, Cabramatta is also located within the 100 year ARI floodplain.

- **Brickmakers Creek Catchment** — The majority of the 100 year ARI floodplain is located within Open Space zones. In many places the 100 year ARI flood extent intrudes marginally upon adjoining Residential zoned land. In some isolated sections, the 100 year ARI floodplain extends significantly into Residential zoned land, such as the area to the south-east and south-west of the intersection of the Hume Highway and Copeland Street and the Residential zoned land in the vicinity of Coolaroo Crescent and Wonga Road.
- **Hinchinbrook Creek Catchment** — This area is only partially developed comprising newly constructed roads and subdivisions and sparse detached housing. In conjunction with the residential development proposed are various flood mitigation works along Hinchinbrook Creek incorporating stormwater detention basins and wetlands. The majority of the 100 year ARI floodplain is located within open space, special use -drainage, or within the abutting future urban zone. The 100 year ARI floodplain extends into residential zones in some areas, but this is basically to a minor extent and often in locations where urban development is yet to occur, which may be accompanied by land filling or other flood mitigation works.
- **Maxwells Creek Catchment** — Within the more established northern extent of this sub-catchment, the 100 year ARI floodplain is contained primarily within a special uses drainage zone, but extends in an irregular pattern into adjoining industrial and residential zones. The Prestons Industrial Area Stage II, located to the north-west of Kurrajong and Ash Roads, is presently zoned 1(e) Future Urban but contains a significant area of the 100 year ARI floodplain. To the south of Kurrajong Road and north of the Hume Highway is located the Prestons Residential Release Area which has been zoned for residential purposes with no major development as yet, but is subject to significant flooding in the 100 year ARI event. The Cross Roads site (bounded by the Hume Highway, the Motorway and Campbelltown Road) is zoned for industrial purposes and has a significant proportion affected by the 100 year ARI flood. To the south of the Hume Highway is the existing Edmondson Park rural residential area, identified for future urban release and is partially affected by the 100 year ARI flood near the Hume Highway end and the southern extent of Croatia Avenue. The adjoining military zoned land further to the south is substantially affected by the 100 year ARI flood.
- **Upper Cabramatta Creek Catchment** — The northern extent of this catchment comprises predominantly the Cabramatta Creek and Carnes Hill Urban Release Areas containing undeveloped residential zoned land with a substantial corridor of land flanking the creek which is within the 100 year ARI floodplain. The 100 year ARI floodplain within the southern extent of this catchment cuts through allotments within the Edmondson Park and Denham Court Rural Residential Areas.

FIGURE 3.3



INFORMATION

LEGEND:

- EXTERNAL CATCHMENT BOUNDARY
- 100 YEAR FLOOD CONTOUR (mAHD)
- 100 YEAR FLOOD EXTENT LINE
- PMF FLOOD EXTENT LINE
- LOCAL GOVERNMENT BOUNDARY
- CAUTION LINE (refer to details below)
- AREA SUBJECT TO FLOODING DUE TO POTENTIAL BREAKOUT

SOURCE DATA:

DATA	DETAILS	SOURCE	DATE
TOPOGRAPHY	0.25m formlines	Southern Aerial Surveys Pty Ltd	1996
HYDROLOGY	RAFTS Epoch1 100 Year ARI 09hr Event	Bewsher Consulting Pty Ltd	06/98
	RAFTS Epoch1 100 Year ARI 12hr Event		06/98
HYDRODYNAMICS	RMA Epoch1 100 Year ARI 09hr Event	Unisearch WRL	06/98
	RMA Epoch1 100 Year ARI 12hr Event		06/98

IMPORTANT INFORMATION:

When interpreting the results contained in this drawing, reference should be made to BC Report 'Hydrologic (RAFTS) Modelling-June 1998 and to WRL Technical Report 97/41. In particular, the following should be noted:

Flood levels are shown at 0.2m intervals unless otherwise indicated.

In all areas the extents indicated should be verified with a detailed ground survey.

In some areas, the reconciliation between the flood level and ground level surfaces is inconsistent - the indicated flood extents and contours in these areas need to be treated with caution. In this drawing, these areas have been highlighted with 'CAUTION LINES'

Levels provided in the calibrated regions of the model are indicative of what is likely to occur and are considered to be within +/- 0.2m of what might actually occur in an event similar to that simulated. However, in the uncalibrated regions this accuracy is expected to be +/- 0.5m, but this cannot be confirmed due to the lack of information. Please refer to WRL Technical Report 97/41 for details concerning model calibration. Calibrated regions of the model are represented on Figure 3.6

Rev.	Drawing Details	Date
2	E1-100YR.DWG	02/11/98
BASE	../EPOCH1/WRL100YR.DWG	02/11/98

FIGURE 3.4	
FIGURE 3.3	
FIGURE 3.5	

SHEET INDEX

0 0.5 1km
Scale

FLOOD EXTENTS AND 100 YEAR ARI FLOOD CONTOURS EXISTING (1996) CONDITIONS

(SHEET 1 OF 3)

CABRAMATTA CREEK FLOODPLAIN MANAGEMENT STUDY

Plot file : J1150-fig3.3
Plot scale : 20
Date : May 2004

FIGURE 3.4

CABRAMATTA CREEK FLOODPLAIN
MANAGEMENT STUDY

FLOOD EXTENTS AND 100 YEAR ARI FLOOD CONTOURS EXISTING (1996) CONDITIONS

(SHEET 2 OF 3)

0 0.5 1km
Scale

FOR LEGEND AND NOTES SEE FIGURE 3.3

FIGURE 3.4

FIGURE 3.3

FIGURE 3.5

SHEET INDEX

CECIL HILLS
CECIL PARK
NORTH
BONNYRIGG
FAIRFIELD
LIVERPOOL
ROAD
BUSBY
GREEN VALLEY
HECKENBERG
Creek M
Hinchinbrook
Western
Creek
AUSTRAL
HINCHINBROOK
LIVERPOOL
Creek L
Sydney
MILLER
SADLEIR
Creek
WEST HOXTON
Cabramatta
CARTWRIGHT
AUSTRAL

Plot file : J1150-fig3.4
Plot scale : 20
Date : May 2004

CARNES HILL

HOXTON PARK

Cabramatta Creek

PRESTONS

Maxwells Creek

LURNEA

CASULA WEST

CASULA EAST

THE CROSS ROADS

EDMONDSON PARK

LIVERPOOL

DENHAM COURT

INGLEBURN MILITARY CAMP

FIGURE 3.4

FIGURE 3.3

FIGURE 3.5

SHEET INDEX

N

FOR LEGEND AND NOTES SEE FIGURE 3.3

0 0.5 1km

Scale

FIGURE 3.5

FLOOD EXTENTS AND 100 YEAR ARI FLOOD CONTOURS EXISTING (1996) CONDITIONS

(SHEET 3 OF 3)

CABRAMATTA CREEK FLOODPLAIN MANAGEMENT STUDY

Plot file : J601-100yr
Plot scale : 20
Date : May 1999

3.6 FLOOD BEHAVIOUR FOR DIFFERENT DEVELOPMENT SCENARIOS

Flood behaviour has been analysed for four different time frames, or epochs:

- *previous catchment conditions (Epoch 2)*, prior to any new release area development, corresponding to the year 1989;
- *existing catchment conditions (Epoch 1)*, based on aerial photography of the catchment taken in 1996;
- *future catchment conditions (Epoch 3)*, on completion of all development associated with the new release areas and the construction of all detention basins; and
- *ultimate catchment conditions (Epoch 4)*, based on the maximum development likely to occur over the next 50 years.

Results from the RAFTS hydrologic model indicate that between 1989 and 1996, peak flows for the 100 year ARI flood are estimated to have increased by up to 10% throughout much of Upper Cabramatta Creek and Hinchinbrook Creek. This is a result of the development that has taken place within these subcatchments, despite the construction of a number of detention basins. Little change is evident in Maxwells Creek, and towards the downstream end of Cabramatta Creek peak flows have increased by around 5%.

After ultimate catchment development, it is estimated that peak flows will be reduced to 1989 levels, or lower, throughout much of Upper Cabramatta Creek and Hinchinbrook Creek. This is largely a result of the construction of further detention basins in these areas. In Maxwells Creek, it was found that ultimate 100 year ARI peak flows would increase by as much as 15% over 1989 levels. In the downstream reaches of Lower Cabramatta Creek it was also estimated that peak flows could increase by up to 10%.

The impact of increased flow rates on flood levels vary depending on location. Throughout Lower Cabramatta Creek, the increase in flood levels between 1989 conditions and ultimate conditions is in the range of 0.1 to 0.2m.

The implication of these findings is that additional compensatory flood mitigation works are necessary within the catchment to ensure that future flood conditions are not exacerbated, in addition to flood mitigation works investigated with a view to reducing existing flood problems.

3.7 ACCURACY OF MODEL RESULTS

All flood models require calibration to be able to confidently predict flood behaviour in a particular catchment. The reliability, or accuracy of model results, is therefore dependent on the availability of recorded flood data.

Significant floods were recorded in the Cabramatta Creek catchment in August 1986 and April 1988. The 1988 flood was the larger of the two events, with a magnitude similar to the estimated 100 year ARI flood.

Streamflow data is required for calibration of the hydrologic model, whilst flood heights are required for calibrating the hydraulic model. Streamflow data was available for these two floods at the Orange Grove Road gauging station, whilst peak flood levels were available at various locations throughout the catchment.

The hydrologic model was calibrated to the Orange Grove Road streamflow data. Whilst this provides confidence in flow estimates towards the downstream end of the model, there is unfortunately no data to confirm the applicability of these same calibration parameters in the upstream areas of the model.

Substantial flood level data was recorded for the two historical floods throughout Lower Cabramatta Creek, parts of Upper Cabramatta Creek and Hinchinbrook Creek, and the lower reaches of Maxwells Creek. Within these regions, the hydraulic model was able to match the recorded data within an accuracy of ±0.2m. The accuracy of model results for floods up to the 100 year ARI event is therefore estimated to be ±0.2m in areas where flood height calibration data exists.

In other areas of the catchment, particularly the upper reaches of the catchment where there is no calibration data, the same level of accuracy can not be guaranteed. In these regions, the accuracy of model results is likely to be approximately ±0.5m.

The region of available calibration data and consequently the confidence limits for model results are represented in **Figure 3.6**.

Despite the lower confidence limits in the upper parts of the catchment, the flood level estimates are considered suitable for the purpose of this catchment-wide floodplain management study. More detailed investigations may be warranted when considering future development proposals, particularly in the upper catchment areas.

3.8 RECENT FLOOD MODELLING

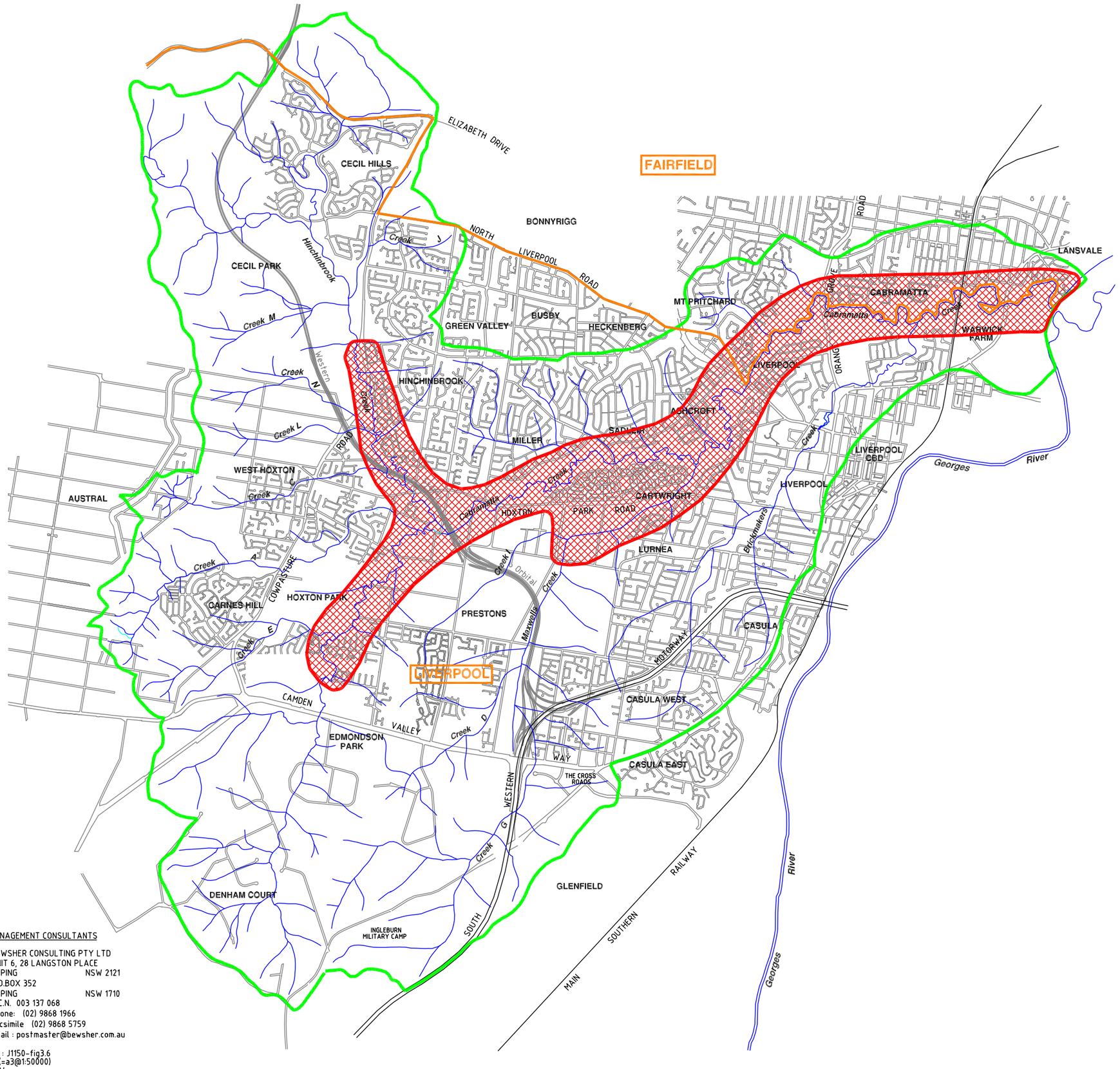
There have been other flood investigations undertaken within the Cabramatta Creek catchment since the initial floodplain management study.

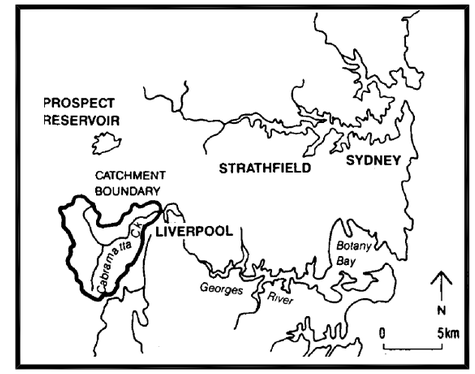
The investigations for the RTA on the proposed WSO highway [Bewsher Consulting and WBM Oceanics Australia, 2002] led to an updated *RAFTS* hydrologic model and a new *TUFLOW* 2D/1D hydraulic model of part of the catchment. A comparison of flood level results between the RMA-2V model used for the floodplain management study and the TUFLOW model indicated close agreement (generally within ±0.2m) for the 100 year flood. This close agreement is largely due to the fact that both models were calibrated to the same source data.

A review of flood behaviour on Brickmakers Creek, between Homepride Avenue and Memorial Avenue, was recently undertaken for Liverpool Council (see **Appendix C**). These investigations utilised the updated RAFTS hydrologic model and a new TUFLOW hydraulic model of this specific area. As no calibration data is available on Brickmakers Creek, results are sensitive to both the hydrologic flow estimates and the hydraulic model used to generate flood levels. The new results indicate higher flows and flood levels within Brickmakers Creek than previously provided by the floodplain management study, and are considered to be more reliable.

There have also been a number of site specific flood investigations associated with various development proposals within the catchment, and further investigations are likely in the near future. Council's GIS flood records will need to be constantly reviewed and updated as these investigations/catchment changes occur.

FIGURE 3.6





LEGEND

- Catchment Boundary
- Local Government Boundary
- Confidence limit for flood flows and levels
- Region of model calibration

0 1 2km
Scale

CONFIDENCE LIMITS FOR MODEL RESULTS

CABRAMATTA CREEK FLOODPLAIN MANAGEMENT STUDY

FLOODPLAIN MANAGEMENT CONSULTANTS

BEWSHER CONSULTING PTY LTD
UNIT 6, 28 LANGSTON PLACE
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Phone: (02) 9868 1966
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Plot file name : J1150-fig3.6
Plot scale 50 (=a3@1:50000)
Date : May 2004

3.9 FLOOD RISK MAPPING

Floodplain management is all about managing the risk of flooding across the floodplain. In doing so, it should be recognised that different parts of the floodplain are subject to different degrees of hazard, or flood risk. Controls on future development should not only consider the type of development proposed, but also the flood risk of the area where the development is to be located.

Mapping of different flood risks was not undertaken during the initial floodplain management investigations, but has been undertaken as part of the updated study.

Both Liverpool and Fairfield Councils agreed that the study area should be categorised into three different grades of flood risk, namely high, medium and low. This approach is similar to that which was recently adopted by the Georges River Floodplain Management Committee for the Georges River. It is also consistent with the categorisation of other natural risks, such as bush fire risk.

The three flood risk areas, which are defined below, are shown on **Figure 3.7**.

High Flood Risk	Land below the 100 year flood that is either subject to a high hydraulic hazard (ie provisional high hazard in accordance with the criteria outlined in the *Floodplain Management Manual*) or where there are significant evacuation difficulties.
Medium Flood Risk	Land below the 100 year flood level that is not subject to high hydraulic hazard and where there are no significant evacuation difficulties.
Low Flood Risk	All land within the floodplain (ie. within the PMF extent) but not identified as either in a high flood risk or medium flood risk area.

The high flood risk area is where high flood damages, potential risk to life, or evacuation problems are anticipated. Most development should be restricted in this area.

The medium flood risk area is where there is still a significant risk of flood damage, but where these damages can be minimised by the application of appropriate development controls.

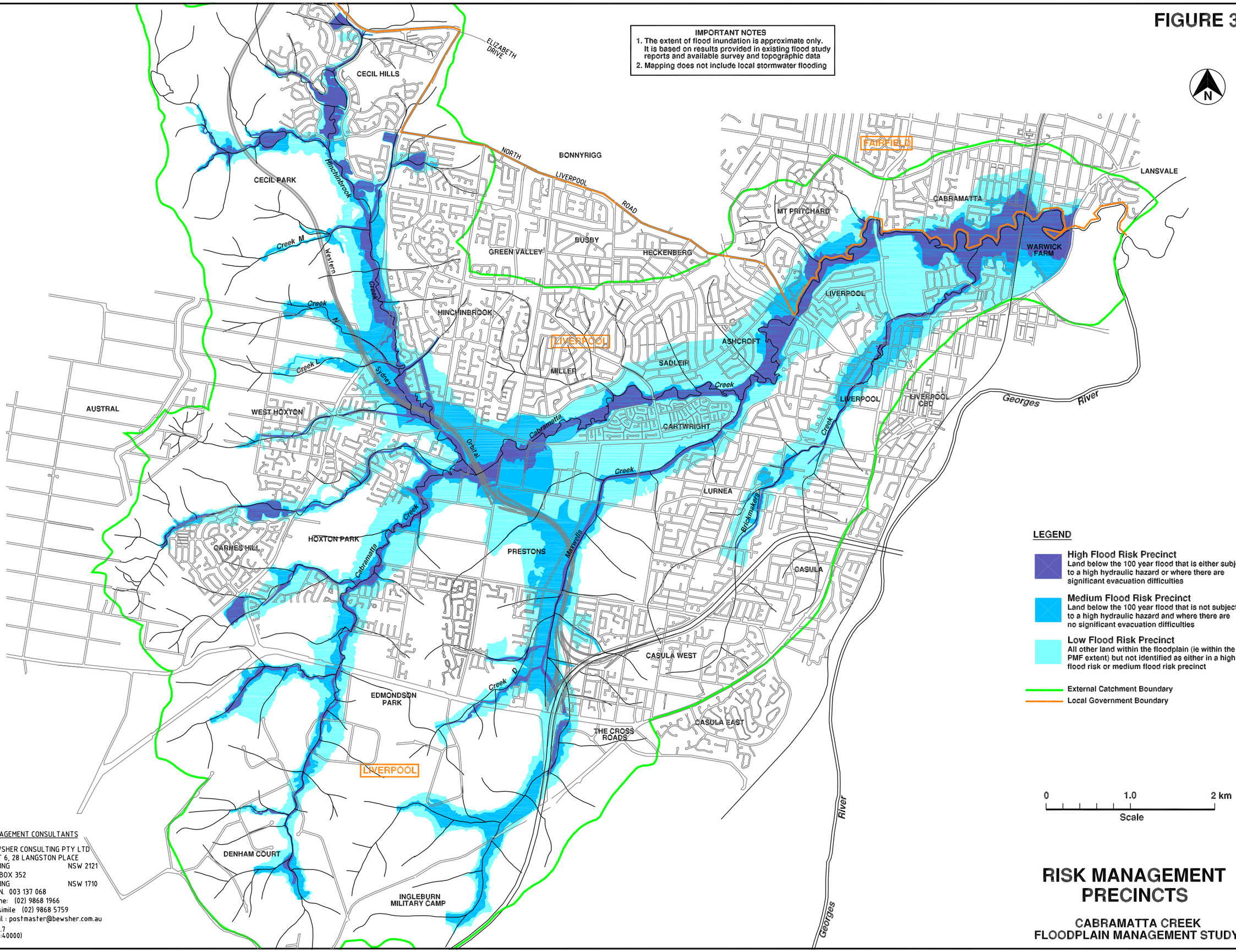
The low flood risk area is that area above the 100 year flood, where the risk of damage is low. Most land uses would be permitted within this area.

The risk mapping is intended to be ultimately incorporated in GIS computer systems of both councils. This will provide a valuable source of information for Council to manage the flood risk, and will also assist with future emergency management operations.

FIGURE 3.7

IMPORTANT NOTES

1. The extent of flood inundation is approximate only. It is based on results provided in existing flood study reports and available survey and topographic data
2. Mapping does not include local stormwater flooding



LEGEND

High Flood Risk Precinct
Land below the 100 year flood that is either subject to a high hydraulic hazard or where there are significant evacuation difficulties

Medium Flood Risk Precinct
Land below the 100 year flood that is not subject to a high hydraulic hazard and where there are no significant evacuation difficulties

Low Flood Risk Precinct
All other land within the floodplain (ie within the PMF extent) but not identified as either in a high flood risk or medium flood risk precinct

External Catchment Boundary

Local Government Boundary

0 1.0 2 km
Scale

RISK MANAGEMENT PRECINCTS

CABRAMATTA CREEK FLOODPLAIN MANAGEMENT STUDY

FLOODPLAIN MANAGEMENT CONSULTANTS

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Plot file : J1150-fig3.7
Plot scale : 40(a3@1:40000)
Date : May 2004

4. FLOOD DAMAGE ASSESSMENT

4.1 FLOOD DAMAGES DATA BASE

A “flood damages data base” has been designed specifically for this study, in order to quantify the impacts of flooding in dollar terms and to allow an economic appraisal of floodplain management options.

The data base includes information on potential flood affected properties within the catchment up to the probable maximum flood. Property details, such as address, land use, and area of property have been extracted from both Councils’ rates data base. Property details were provided by Liverpool Council in 1997 and Fairfield Council in 1998.

The maximum flood level experienced for each potential flood affected property has been determined from the two dimensional hydraulic model. This data has been prepared in the form of flood levels over the floodplain on a regular 10m wide grid. Minimum ground levels have also been determined for each property based on the aerial mapping undertaken in 1996, also prepared in the form of the same 10m wide grid. Assumed flood depths for each property are based on a comparison of the maximum flood level with the minimum ground level for that property. This approach is suitable for most of the properties in the catchment, but may produce a conservatively high indication of flood affectation on large properties.

Separate data bases have been prepared for 11 different catchment zones. These same zones were used to analyse the results of the community questionnaires, and allows specific consideration of flooding issues within different parts of the catchment.

The flood damages data base provides the following information for each potentially flood-affected residential, commercial and industrial property:

- property details;
- flood level for a range of flood events (20 year, 50 year, 100 year ARI and a probable maximum flood);
- minimum ground level for the property, based on 1996 aerial mapping and an interpolated 10m data grid;
- floor levels for buildings, based on actual survey where available (most properties below the 100 year flood), or estimated level based on the minimum ground level and a derived relationship; and
- the potential flood damage for each flood event.

The number of properties included in the flood damages data base, for different zones within the catchment, is indicated in **Table 4.1**.

Further information on the flood damages data base is provided in the “*Flood Damages Assessment*” working paper [Bewsher Consulting, 1999c].

TABLE 4.1
Properties Included in Flood Damages Data Base

CATCHMENT ZONE			SINGLE HOUSES	FLATS UNITS TOWN-HOUSES	BUSIN.(1)
NO.	CREEK	LOCATION			
1A	Cabramatta	Georges River to Elizabeth Drive (Liverpool)	483	68	35
1B	Cabramatta	Georges River to Elizabeth Drive (Fairfield)	763	2	41
2	Cabramatta	Elizabeth Drive to Hoxton Park Road	553	110	10
3	Cabramatta	Hoxton Park Road to Jardine Drive	49	0	27
4	Cabramatta	Denham Court	156	0	0
5	Creek A	Cabramatta Creek to Cowpasture Road	66	0	7
6	Hinchinbrook	Cabramatta Creek to Cecil Hills Wetland	157	0	9
7	Maxwells	Cabramatta Creek to Campbelltown Road	152	0	76
8	Brickmakers	Cabramatta Creek to Elizabeth Drive	325	43	27
9	Brickmakers	Elizabeth Drive to Hoxton Park Road	136	175	7
10	Brickmakers	Hoxton Park Road to Graham Avenue	383	13	5
		TOTALS	**3,223**	**411**	**244**

Note: (1) Businesses include commercial, industrial and public authority properties.

4.2 TYPES OF FLOOD DAMAGE

The definitions and methodology used in estimating flood damage have been established by a number of previous investigations. The types of flood damage examined in this study are summarised in **Figure 4.1**. The two main categories are referred to as “tangible” or “intangible” flood damages. Tangible flood damages are those that can be more readily evaluated in monetary terms, while intangible damages relate to the social cost of flooding and therefore are more difficult to quantify.

Tangible flood damages are divided into two subcategories - direct and indirect. Direct flood damages relate to the loss, or loss in value, of an object or a piece of property caused by direct contact with floodwaters. Indirect flood damages relate to loss in production or revenue, loss of wages, additional accommodation and living expenses, and any extra outlays that occur because of the flood.

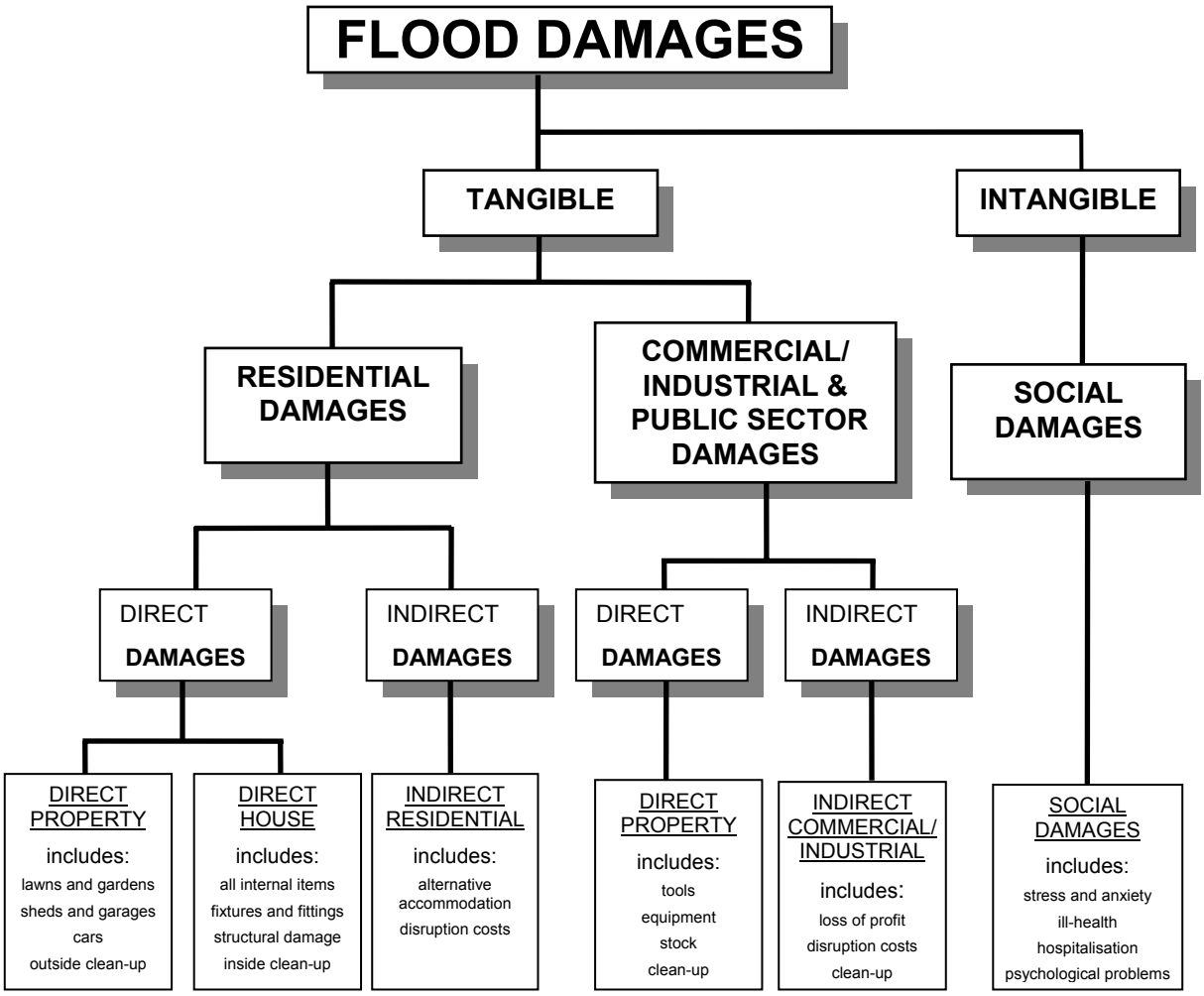


FIGURE 4.1
Types of Flood Damages

4.3 BASIS OF FLOOD DAMAGES CALCULATIONS

Flood damages have been calculated using the data base of potentially flood affected properties and a number of stage-damage curves derived for different types of property within the catchment. These curves relate the amount of flood damage that would potentially occur at different depths of inundation, for a particular property type.

The stage-damage curves for Cabramatta Creek have been based on specific consideration of the types of development within the catchment, information available from previous investigations, and flood damage surveys undertaken following recent major floods in Coffs Harbour (1996); Inverell (1991); Forbes(1990); Nyngan (1990); and the Georges River (1986).

Three different stage-damage curves have been derived for dwellings, to represent units or town houses, average houses, and more prestigious houses. External property damage curves have also been derived, which includes allowance for damage to gardens, motor vehicles and clean-up costs.

Stage-damage curves have also been derived for commercial properties, industrial properties, large retailers, industrial properties, and public authority properties. These categories have been further divided into a number of sub-categories.

Apart from the direct potential direct flood damages calculated from the derived stage-damage curves for each flood affected property, other forms of flood damage include:

- indirect residential, commercial and industrial damages, taken as a percentage of the direct damages;
- infrastructure damage, based on a percentage of the total value of residential and business flood damage; and
- intangible or social damages, based on an average cost per flood affected household.

All adopted stage-damage curves and other flood damages assumptions are provided in the "Flood Damages Assessment" working paper [Bewsher Consulting 1999c].

4.4 SUMMARY OF FLOOD DAMAGES

'Average annual damage' (AAD) and 'present value' are financial terms that are often used in the economic appraisal of flood damages and flood mitigation measures. The AAD is a measure of the cost of flood damage that could be expected each year, on average, by the community. The present value of flood damage is usually calculated to allow a direct comparison with the capital and on-going costs of proposed flood mitigation measures. This has been determined on the basis of a 7% discount rate and an expected life of 20 years, in accordance with guidelines provided by the NSW Treasury.

Flood damage calculations for each of the eleven catchment zones have been determined from the flood damages database. **Table 4.2** provides an overall summary of the "predicted actual" flood damage bill for each of the catchment zones from the flood damages database. This Table also presents the average annual damage and the present value of flood damage (assuming a discount rate of 7% and period of 20 years).

The following key points are relevant from these results:

- the ratio of predicted *actual* flood damage to *potential* flood damage throughout the Cabramatta Creek catchment is estimated to be 88%;
- The total expected flood damage estimated to occur in a 100 year flood is $21M ($16M for Liverpool Council and $4.8M for Fairfield);
- Flood damage for the PMF is estimated to be as high as $230M
- Components of average annual flood damages within the study area are estimated to be:

- Direct House Damage	$ 616,000	(23%)
- Direct Property Damage	$ 242,000	(9%)
- Indirect Residential Damage	$ 43,000	(2%)
- Direct Industrial & Commercial	$ 721,000	(26%)
- Indirect Industrial & Commercial	$ 397,000	(15%)
- Infrastructure & Public Sector Damage	$ 492,000	(18%)
- Social Damages	$ 184,000	(7%)
- TOTAL	$ 2,700,000	

- The present value of expected flood damages within the catchment is estimated at $29 M;

The different components of flood damage in Cabramatta Creek are summarized in Figure 4.2.

The flood damages database provides a valuable tool for assessing the economic merits of various flood mitigation options that may be considered for the Georges River. Flood level estimates within the flood damages database can be readily updated to reflect new conditions arising from proposed flood mitigation measures. The flood damages are then recalculated and the savings in flood damages can be calculated.

TABLE 4.2
Predicted Total Flood Damages under Existing Conditions
(1999 Estimates [Bewsher Consulting, 99b])

Location		Damage in Flood Event ($)			Average Annual Damage	Present Value of Damage
		20 Year	100 Year	PMF		
Liverpool City Council Area						
1A	Cab Ck – Georges R to Eliz Dr	10,000	950,000	54,270,000	290,000	3,100,000
2	Cab Ck – Eliz Dr to Hoxton Pk Rd	850,000	1,070,000	32,090,000	270,000	2,810,000
3	Cab Ck – Hoxton Pk Rd to Jardine Dr	2,390,000	4,340,000	13,700,000	380,000	4,040,000
4	Cab Ck – Denham Court	1,700,000	1,880,000	3,840,000	230,000	2,400,000
5	Creek A – Cab Ck to Cowpasture Rd	390,000	550,000	2,150,000	60,000	630,000
6	Hinchinbrook Ck	670,000	870,000	4,790,000	110,000	1,120,000
7	Maxwells Ck	3,250,000	4,570,000	17,400,000	490,000	5,230,000
8	Brickmakers Ck – Cab Ck to Eliz Dr	400,000	1,010,000	37,720,000	250,000	2,640,000
9	Brickmakers Ck – Eliz Dr to HP Rd	130,000	430,000	7,610,000	60,000	590,000
10	Brickmakers Ck – HP Rd to Graham	170,000	290,000	4,960,000	50,000	500,000
	Sub-Total	*9,960,000*	*15,960,000*	*178,530,000*	*2,190,000*	*23,060,000*
Fairfield City Council						
1B	Cab Ck – Georges R to Eliz Dr.	1,780,000	4,810,000	48,900,000	520,000	5,480,000
TOTAL (both Councils)		**11,740,000**	**20,770,000**	**227,430,000**	**2,710,000**	**28,540,000**

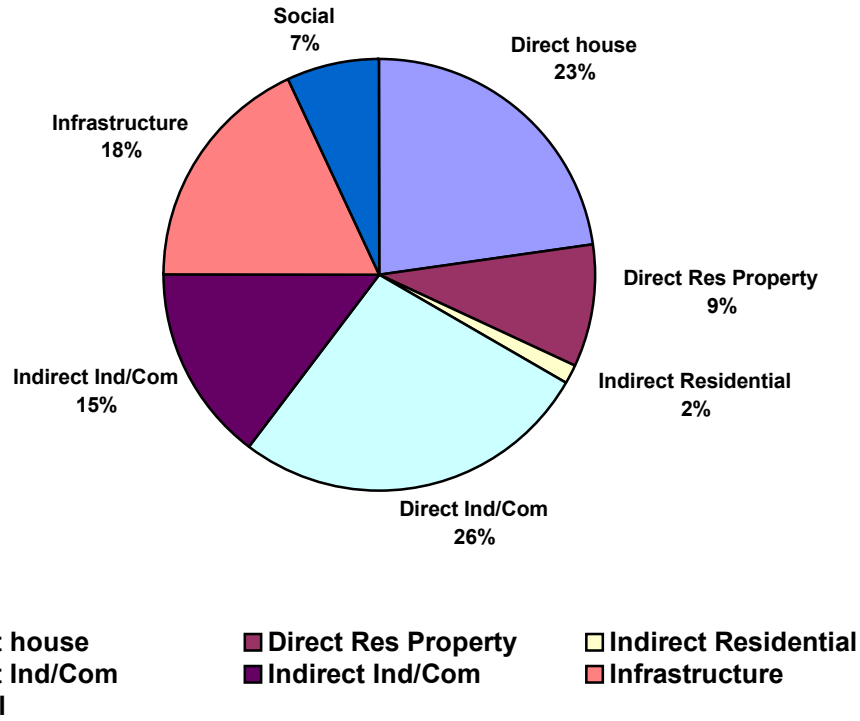


FIGURE 4.2
COMPONENTS OF FLOOD DAMAGE FOR CABRAMATTA CK
(Average Annual Damage)

4.5 SUMMARY OF PROPERTY INUNDATION

The flood damages database also provides details on properties and buildings that would be affected by various floods. **Table 4.3** provides a summary of the number of residential properties (ie yards and surrounds) and residential homes that would be inundated during a 20 year, 50 year, 100 year and PMF flood event. Similar details are provided in **Table 4.4** for industrial and commercial properties.

Results from the database show that:

- 3,258 residential properties and 223 commercial/industrial properties would be inundated in the PMF;
- 2,838 residential homes and 218 commercial/industrial buildings would be flooded above floor level in the PMF;
- 851 residential properties and 159 commercial/industrial properties would be inundated in the 100 year flood;
- 124 residential homes and 104 commercial/industrial buildings would be flooded in the 100 year flood;
- The majority of flooded homes in the 100 year flood are located in lower Cabramatta Creek (zones 1A, 1B, 2) and the lower parts of Maxwells Creek (part zone 7) and Brickmakers Creek (zone 8);

Further details on the inundation depths experienced by flood affected homes and buildings in the 100 year flood are provided on **Tables 4.5** and **4.6**. Results indicate that:

- 75 of the 124 homes that would be flooded in a 100 year flood would be inundated by less than 0.5m of floodwater;
- If the estimates for the 100 year flood levels were to increase by 0.2m, the number of flooded homes in this event would increase from 124 to 240;
- An increase of 0.5m in the estimates for the 100 year flood levels would result in the number of flooded homes in this event increasing from 124 to 416;
- Commercial and industrial buildings are generally flooded by greater depths than residential homes.

TABLE 4.3
Residential Property Inundation Details (1996 Conditions)

Location		20 Year Flood		50 Year Flood		100 Year Flood		PMF	
		Props	Homes	Props	Homes	Props	Homes	Props	Homes
Liverpool City Council Area									
1A	Cab Ck – Georges R to Eliz Dr	25	0	67	0	110	13	551	551
2	Cab Ck – Eliz Dr to Hoxton Pk Rd	13	0	18	0	49	0	642	592
3	Cab Ck – Hoxton Pk Rd to Jardine Dr	22	6	24	6	29	8	41	29
4	Cab Ck – Denham Court	31	7	31	7	31	8	35	27
5	Creek A – Cab Ck to Cowpasture Rd	4	0	4	0	7	0	63	20
6	Hinchinbrook Ck	14	8	15	8	25	12	117	77
7	Maxwells Ck	40	11	46	15	56	21	146	145
8	Brickmakers Ck – Cab Ck to Eliz Dr	81	1	87	1	112	3	346	344
9	Brickmakers Ck – Eliz Dr to HP Rd	69	0	76	0	107	7	286	244
10	Brickmakers Ck – HP Rd to Graham	48	1	55	2	71	2	269	114
	Sub-Total	*347*	*34*	*423*	*39*	*597*	*74*	*2496*	*2143*
Fairfield City Council									
1B	Cab Ck – Georges R to Eliz Dr.	139	14	191	28	254	50	762	695
TOTAL (both Councils)		**486**	**48**	**614**	**67**	**851**	**124**	**3,258**	**2,838**

TABLE 4.4
Commercial & Industrial Property Inundation Details (1996 Conditions)

Location		20 Year Flood		50 Year Flood		100 Year Flood		PMF	
		Props	Bldgs	Props	Bldgs	Props	Bldgs	Props	Bldgs
Liverpool City Council Area									
1A	Cab Ck – Georges R to Eliz Dr	24	0	24	1	24	1	35	35
2	Cab Ck – Eliz Dr to Hoxton Pk Rd	3	1	3	2	4	2	10	10
3	Cab Ck – Hoxton Pk Rd to Jardine Dr	18	10	18	12	18	13	18	17
4	Cab Ck – Denham Court	0	0	0	0	0	0	0	0
5	Creek A – Cab Ck to Cowpasture Rd	4	4	5	4	6	4	7	7
6	Hinchinbrook Ck	6	3	6	3	6	3	7	7
7	Maxwells Ck	66	50	66	50	66	56	72	71
8	Brickmakers Ck – Cab Ck to Eliz Dr	3	0	4	1	7	1	23	22
9	Brickmakers Ck – Eliz Dr to HP Rd	0	0	0	0	1	0	6	6
10	Brickmakers Ck – HP Rd to Graham	0	0	1	0	1	0	4	4
	Sub-Total	*124*	*68*	*127*	*73*	*133*	*80*	*182*	*179*
Fairfield City Council									
1B	Cab Ck – Georges R to Eliz Dr.	23	17	26	20	26	24	41	39
TOTAL (both Councils)		**147**	**85**	**153**	**93**	**159**	**104**	**223**	**218**

TABLE 4.5
Inundation Depths for Homes in the 100 Year Flood

Location		Below Floor (Number of Houses)		Above Floor Flooding (Number of Houses)				
		-.5 to -.2	-.2 to 0	0 to 0.2	.2 to .5	.5 to 1	>1.0m	Total
Liverpool City Council Area								
1A	Cab Ck – Georges R to Eliz Dr	20	10	13	0	0	0	13
2	Cab Ck – Eliz Dr to Hoxton Pk Rd	1	0	0	0	0	0	0
3	Cab Ck – Hoxton Pk Rd to Jardine Dr	4	1	3	1	1	3	8
4	Cab Ck – Denham Court	4	4	1	2	3	2	8
5	Creek A – Cab Ck to Cowpasture Rd	1	0	0	0	0	0	0
6	Hinchinbrook Ck	3	1	3	1	3	5	12
7	Maxwells Ck	9	8	5	8	2	6	21
8	Brickmakers Ck – Cab Ck to Eliz Dr	36	20	2	0	0	1	3
9	Brickmakers Ck – Eliz Dr to HP Rd	40	16	7	0	0	0	7
10	Brickmakers Ck – HP Rd to Graham	14	6	1	0	0	1	2
	Sub-Total	*132*	*66*	*35*	*12*	*9*	*18*	*74*
Fairfield City Council								
1B	Cab Ck – Georges R to Eliz Dr.	44	50	15	13	12	10	50
TOTAL (both Councils)		**176**	**116**	**50**	**25**	**21**	**28**	**124**

TABLE 4.6
Inundation Depths for Commercial Buildings in the 100 Year Flood

Location		Below Floor (Number of Bldgs)		Above Floor Flooding (Number of Buildings)				
		-.5 to -.2	-.2 to 0	0 to 0.2	.2 to .5	.5 to 1	>1.0m	Total
Liverpool City Council Area								
1A	Cab Ck – Georges R to Eliz Dr	3	1	0	0	1	0	1
2	Cab Ck – Eliz Dr to Hoxton Pk Rd	0	0	0	1	0	1	2
3	Cab Ck – Hoxton Pk Rd to Jardine Dr	1	1	2	1	5	5	13
4	Cab Ck – Denham Court	0	0	0	0	0	0	0
5	Creek A – Cab Ck to Cowpasture Rd	0	0	0	1	2	1	4
6	Hinchinbrook Ck	1	1	0	1	1	1	3
7	Maxwells Ck	3	3	8	13	29	6	56
8	Brickmakers Ck – Cab Ck to Eliz Dr	0	0	0	0	1	0	1
9	Brickmakers Ck – Eliz Dr to HP Rd	0	0	0	0	0	0	0
10	Brickmakers Ck – HP Rd to Graham	0	0	0	0	0	0	0
	Sub-Total	*8*	*6*	*10*	*17*	*39*	*14*	*80*
Fairfield City Council								
1B	Cab Ck – Georges R to Eliz Dr.	0	0	0	4	5	15	24
TOTAL (both Councils)		**8**	**6**	**10**	**21**	**44**	**29**	**104**

5. CHANGES IN THE CATCHMENT THAT WILL AFFECT FLOODING

There are a number of changes in the Cabramatta Creek catchment which have occurred, or which could occur in the future, that will have an impact on flooding. These changes include:

- new development within the catchment, particularly in the new release areas;
- Liverpool Council's flood detention basin strategy;
- loss of floodplain storage through filling;
- the proposed Western Sydney Orbital highway;
- floodplain management options investigated as part of this study; and
- changes in flood behaviour due to greenhouse effects.

5.1 NEW RELEASE AREA DEVELOPMENT

In the early 1980s, much of the Cabramatta Creek catchment was predominantly rural, with only the lower one-third of the catchment developed. Since that time, however, there has been significant pressure for further urban expansion within this catchment. Major urban release areas have been identified within the catchment that are integral to the Metropolitan Planning Strategy for Sydney.

In 1982, the Minister of Environment and Planning designated an area of the catchment known as the Hinchinbrook/Green Valley (Stage 1) Release Area for urban development. The release area permitted the development of 340 ha of the Cabramatta Creek catchment, which represents 5% of the total catchment area. Residential development commenced in this area in 1985, and to date the majority of an estimated 4,800 residential lots has been developed.

A second area within the catchment was later identified for urban expansion, known as the Hoxton Park (Stage 2) Release Area. The Stage 2 Release Area will see the development of 2,300 ha of the Cabramatta Creek catchment, representing a further 31% of the total catchment area. Approximately 18,400 residential lots will be developed as part of this release area. Development commenced in 1989, and will continue for a number of years to come.

During 1997 the catchment produced approximately 23% of the Sydney and Central Coast lot production, and was forecast to average 19% of the total Sydney and Central Coast UDP production from 1998 to 2003.

In 2004, Master Plans were in preparation for the development of two precincts within the Hoxton Park Release Area. These were the Edmondson Park and Southern Hoxton Park Aerodrome precincts. The master plans will provide details of proposed drainage and flood mitigation measures, such as channel works, detention basins and water quality basins, throughout the two precincts.

The development that has occurred within the Cabramatta Creek catchment, and that will continue to occur over the coming years, will result in an increase in the impervious

areas within the catchment. Without compensatory flood mitigation measures, this would result in an increase in both the rate and volume of flood runoff.

Liverpool City Council has adopted a flood mitigation strategy to compensate for the development which is occurring within the catchment. The strategy involves the construction of compensatory detention basins to temporarily store flood runoff during flood events.

5.2 LIVERPOOL COUNCIL'S BASIN STRATEGY

Council's current basin strategy incorporates 16 detention basins in the Cabramatta Creek catchment. The objective of the strategy is to ensure that downstream peak flow rates are not increased as a result of the new release area development that is occurring within the catchment. The location of the detention basins is shown on **Figure 5.1**, with specific details provided in **Table 5.1**.

TABLE 5.1
Status of Detention Basins Included in Existing Basin Strategy

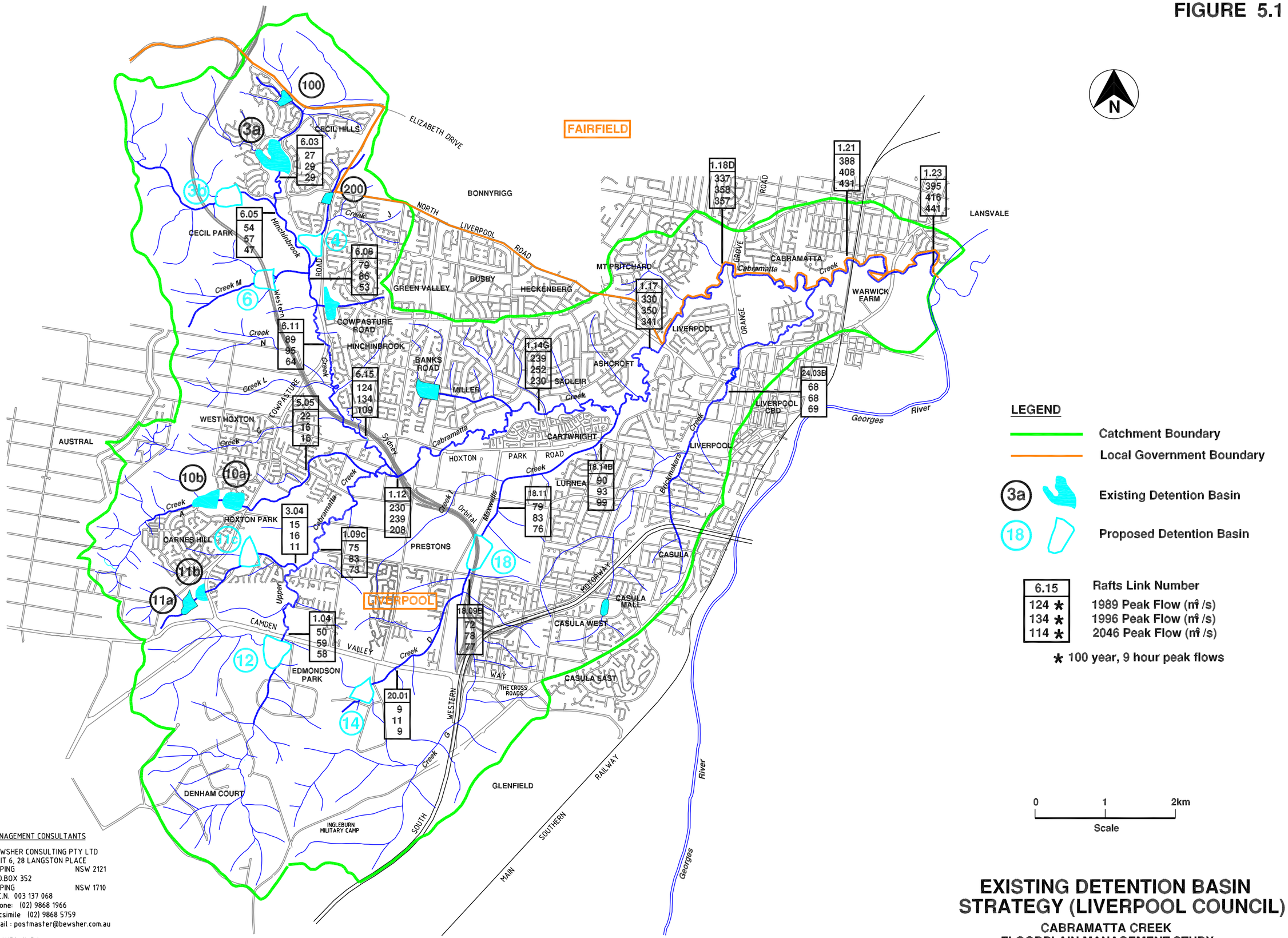
Basin	Location	Storage (m^3)	Status
Basin 100	Cecil Hills, Hinchinbrook Creek	35,500	Constructed
Basin 3A	Cecil Hills, Hinchinbrook Creek	179,500	Constructed
Basin 200	Cecil Hills, Hinchinbrook Creek	13,900	Constructed
Cowpasture Rd Basin	Green Valley, Hinchinbrook Creek	36,100	Constructed
Banks Road Basin	Hinchinbrook	40,500	Constructed
Basin 10A	Carnes Hill, Creek A (Upper Cab.)	54,000	Constructed
Basin 10B	Carnes Hill, Creek A (Upper Cab.)	91,800	Constructed
Basin 11A	Horningsea Park, Creek E (Upper Cab)	18,000	Constructed
Basin 11B	Horningsea Park, Creek E (Upper Cab.)	26,700	Constructed
Daruk Park*	Casula Mall, Brickmakers Creek	49,100	Constructed
Basin 3B	Farm dam, Creek E (Hinch. Ck)	84,000	Pending Review
Basin 6	West Cecil Hills, Creek M (Hinch. Ck)	170,000	Pending Review
Basin 4	South Cecil Hills, Creek J (Hinch. Ck)	183,000	Pending Review
Basin 11C	Horningsea Park, Creek E (Upper Cab.)	35,700	Pending Review
Basin 12	Camden Valley Way, Upper Cab. Ck	89,000	Pending Review
Basin 14	Croatia Ave (Maxwells Ck catchment)	50,000	Pending Review
Basin 18	Liverpool Showground, Maxwells Creek	170,000	Pending Review

* The Daruk Park detention basin is not part of the New Release Area basin strategy

Oblique aerial photo of Hinchinbrook Creek (November 1998), viewed looking downstream towards Cabramatta Creek. New release area development in Cecil Hills is evident, along with compensatory detention basins and smaller water quality basins.

PHOTO 4
Hinchinbrook Creek

FIGURE 5.1



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Plot file name : J1150-fig5.1
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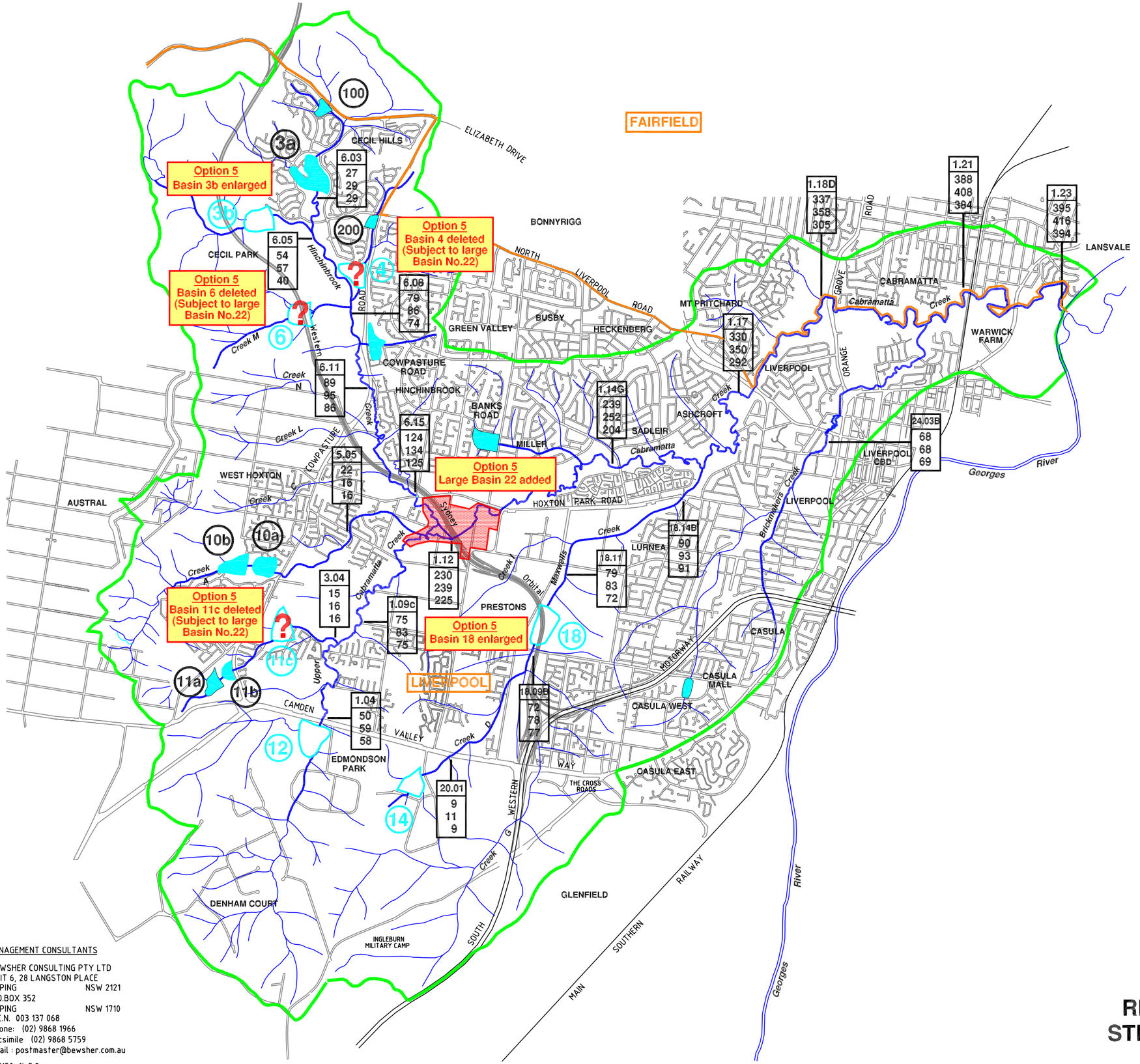
Date : May 2004

EXISTING DETENTION BASIN STRATEGY (LIVERPOOL COUNCIL)

CABRAMATTA CREEK FLOODPLAIN MANAGEMENT STUDY

FIGURE 5.2



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Plot file name : J1150-fig5.2
Plot scale 50 (=1:50000 @ a3)
Date : May 2004

REVISED DETENTION BASIN STRATEGY CONSIDERED IN 1999

CABRAMATTA CREEK
FLOODPLAIN MANAGEMENT STUDY

A total of 9 new release area detention basins have been constructed to date, in addition to the Daruk Park detention basin on Brickmakers Creek. The location and size of these basins have been largely based on the recommendations from previous reports [Sinclair Knight & Partners, 1983], [Kinhill, 1992].

Most of the detention basins that are included in the existing strategy are located on Hinchinbrook Creek. Four basins have already been constructed (Basins 100, 3A, 200, and Cowpasture Road), whilst another three from the original strategy are yet to be constructed.

Another basin that has been constructed near Hinchinbrook Creek is the Banks Road Basin. This basin drains through a stormwater drainage network direct to Cabramatta Creek, downstream of the confluence of Hinchinbrook Creek and Cabramatta Creek.

Four Basins have also been constructed in the Upper Cabramatta Creek area (Basins 10A, 10B, 11A, and 11B), with a further two basins from the original strategy yet to be constructed.

Two basins have been proposed as part of the original basin strategy in Maxwells Creek, but neither has been constructed to date.

The performance of the basin strategy, in mitigating the effects of new release area development, has been reviewed during this floodplain management study. Some deficiencies in the existing strategy were initially identified, mainly as a result of:

- increased development intensities than had previously been assumed;
- changes to the number and location of previously recommended basins; and
- the effects of other development other than Stage 2 Release Areas.

Several different options to improve the performance of the basin strategy for Cabramatta Creek were investigated, and are reported in a separate working paper titled “Review of Basin Strategy” [Bewsher Consulting, 1999a]. A revised strategy was proposed, as shown in **Figure 5.2**.

The revised strategy was based on the construction of a new detention basin, known as Basin 22, that was to be constructed downstream of the confluence of Cabramatta Creek and Hinchinbrook Creek. The proposed basin was considerably larger than any of the other basins already constructed or proposed to be constructed in Cabramatta Creek. The basin also had a number of components, benefiting new release area development, other ultimate catchment development, compensatory flood mitigation works for the proposed WSO highway, and providing a flood mitigation benefit for existing downstream development. The inclusion of Basin 22 in the strategy also provided the potential to remove Basins 4, 6 and 11C from the detention basin strategy.

The revised basin strategy, including Basin 22, was initially incorporated as a major component of the draft floodplain management plan for Cabramatta Creek. However, subsequent investigations undertaken for Council and the RTA have indicated that Basin 22 is likely to be much smaller than originally proposed. This is largely a result of

high land acquisition costs and a high, saline, water table that limits excavation depths in this vicinity.

The reduced storage volume available for Basin 22 means that it is unlikely to be able to act for anything other than a compensatory flood mitigation measure for the proposed WSO highway. As a result, the earlier proposal to remove Basins 4, 6 and 11C from Council's detention basin strategy will no longer be possible.

The proposed WSO highway also impacts on some of the remaining basins in Council's detention basin strategy. The most significant impact is the basin proposed on Maxwells Creek (Basin 18). The proposed route of the WSO highway was modified in November 2002 to minimise environmental impacts along Maxwells Creek. This moved the route of the highway through the middle of where Basin 18 was to be constructed.

Subsequently, the RTA agreed that a new basin would be incorporated in the design of the WSO highway that would provide for Council's detention basin strategy on Maxwells Creek and as a compensatory measure for the proposed highway. The revised basin is still referred to as Basin 18, but it is now located further upstream, just below the M5 motorway, and it is now larger than originally proposed.

Further discussion of proposed detention basins within the Cabramatta Creek catchment is presented in **Section 10.1**.

5.3 FILLING OF FLOODPLAINS

The detention basin strategy outlined above aims to mitigate the increase in catchment runoff that will occur due to an increase in the paved or impervious areas associated with new development. It does not allow for development that may be located within floodplain areas, which will result in a loss of floodplain storage volume.

The floodplains of Cabramatta Creek and its major tributaries are important for the natural temporary storage of floodwaters during flood events. When natural floodplain storage is reduced, flood peaks arrive at downstream locations more quickly and with a higher peak value.

Filling of low lying land, or floodplains, is sometimes considered to raise land above design flood levels so that it can be developed. This usually results in the natural flood storage of the site being lost or reduced, to the detriment of downstream flood behaviour.

Compensatory channel improvements are also often considered in conjunction with proposed filling activities, with the objective of maintaining existing flood levels at the site and upstream of the site. Whilst this objective may be achieved, it unfortunately overlooks the impact on downstream flood behaviour. In many cases the type of model used for the assessment (steady state models such as *HEC-2* or *HEC-RAS*) are not able to properly model the effects of loss of floodplain storage. More sophisticated dynamic models, such as *TUFLOW*, *MIKE-11* or *RMA-2V* are required to properly model these processes.

It is also important that the possible cumulative effects of site filling and/or channelisation are considered when assessing such proposals. Whilst individual proposals may produce only marginal increases in downstream flood levels, the cumulative effect of many such proposals could have a significant impact.

There are a number of areas within the floodplain that have not yet been developed, but are currently zoned for urban development. This zoning is likely to give the land holder an expectation that the land can be developed. However, full development of these sites may be restricted, either as a result of flooding implications or other constraints which may be imposed by various departments. For example, application of the Threatened Species Act or the Rivers and Foreshores Act may preclude development of substantial areas of land in the vicinity of existing creek banks.

5.4 PROPOSED WESTERN SYDNEY ORBITAL

A major national highway has been proposed by the Government for western Sydney, known as the Western Sydney Orbital (WSO). The new highway would connect the M5 Motorway at Prestons to the M2 Motorway at West Baulkham Hills. The majority of this new highway would be located within the Cabramatta Creek catchment, with a large proportion of the route within the floodplains of Maxwells Creek, Cabramatta Creek and Hinchinbrook Creek.

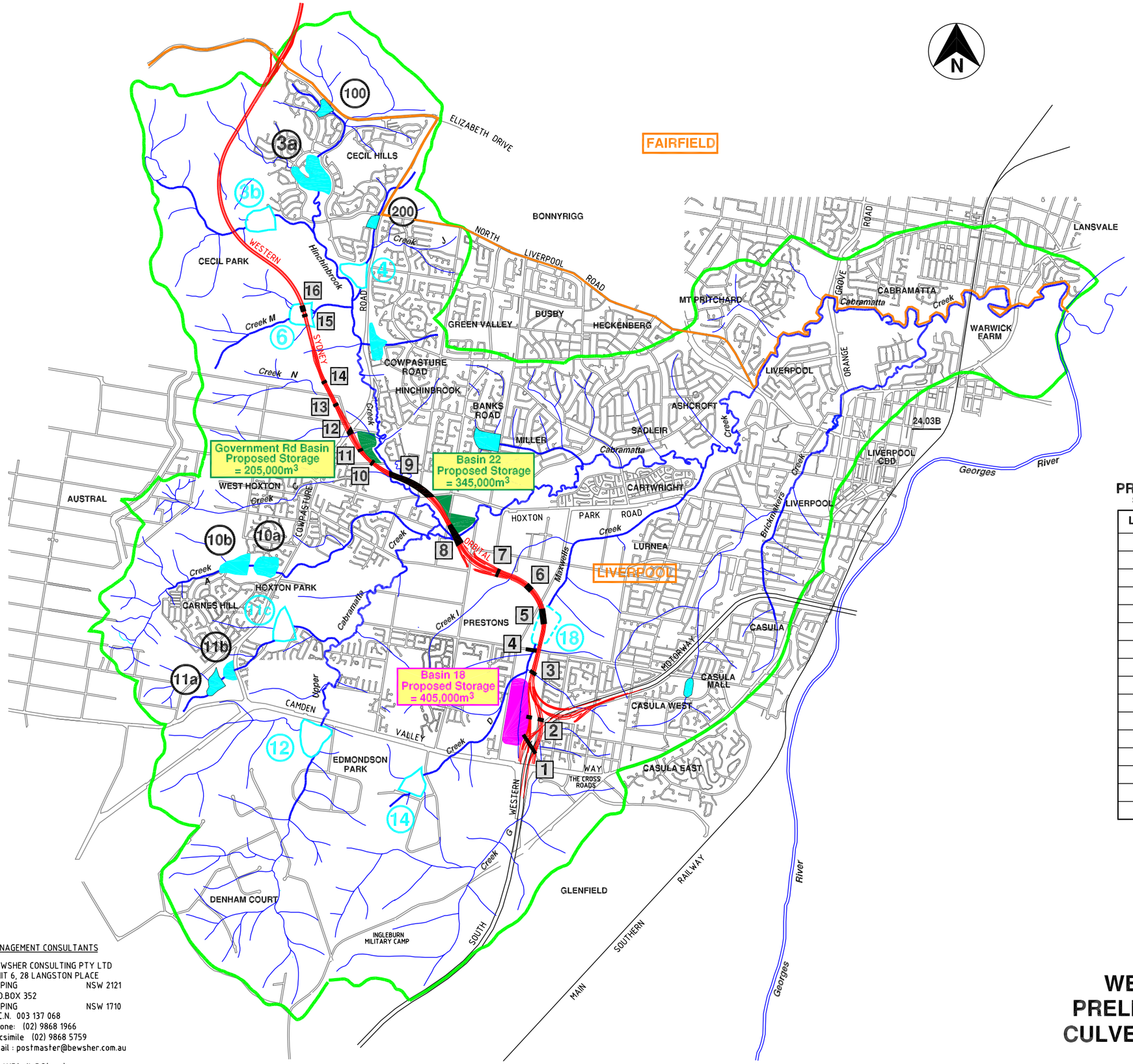
The proposed highway is a major development within the Cabramatta Creek catchment, which is likely to have a significant impact on flood behaviour unless compensatory flood mitigation measures are incorporated in the design. Potential impacts from the proposed highway arise from:

- a loss of floodplain storage in the three major creeks;
- a reduction in the capacity of these creeks to convey floodwaters;
- an increase in the impervious area of the catchment;
- local increases in flood levels at creek crossings; and
- the proposed route of the highway affecting the construction of several detention basins that are included in Liverpool Council's basin strategy.

Bewsher Consulting have been working with both Liverpool City Council and the RTA to determine an appropriate drainage management concept plan to ensure flooding conditions will not be exacerbated as a result of the proposed WSO Highway. This includes preliminary sizing of bridges and culverts, and the construction of a number of detention basins.

An initial water management plan was prepared in 1999, which is documented in a report titled "Western Sydney Orbital - Management of Cross Drainage and Road Stormwater" [Bewsher Consulting, 1999b]. Further investigations and detailed hydraulic modelling were undertaken in 2001-02 to determine preliminary sizes of bridges, culverts and detention basins [Bewsher Consulting and Oceanics Australia, 2002]. The recommended measures, shown on **Figure 5.3,** include detention basins located on Maxwells Creek, Cabramatta Creek and Hinchinbrook Creek.

FIGURE 5.3



LEGEND

- Catchment Boundary
- Local Government Boundary
- 3a — Existing Council Basin
- 12 — Proposed Council Basin
- Proposed Western Sydney Orbital/ Council Basin
- Proposed Western Sydney Orbital Basin
- 3 — Preliminary Western Sydney Orbital Bridge/Culvert location - See Table below

PRELIMINARY BRIDGE AND CULVERT SIZES

Source : Bewsher Consulting & WBM Oceanics Australia - 2002

Location No.	Description of Structure
1	Extend 9 x 3.0 x 1.8 RC Box Culverts
2	2 x 35m Bridge Structures
3	1 x 20m Bridge Structure
4	1 x 70m Bridge Structure
5	1 x 165m Bridge Structure
6	1 x 56m Bridge Structure
7	1 x 20m Bridge Structure
8	1 x 275m Bridge Structure
9	1 x 600m Bridge Structure
10	1 x 2.1m x 1.2m RC Box Culvert
11	2 x Ø1500 Pipe Culverts
12	1 x 62m Bridge Structure
13	1 x 20m Bridge Structure
14	1 x 20m Bridge Structure
15	2 x Ø2100 Pipe Culverts
16	1 x 30m Bridge Structure

0 1 2km
Scale

WESTERN SYDNEY ORBITAL PRELIMINARY SIZING OF BRIDGES, CULVERTS AND DETENTION BASINS

CABRAMATTA CREEK
FLOODPLAIN MANAGEMENT STUDY

FLOODPLAIN MANAGEMENT CONSULTANTS

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The basin on Maxwells Creek (Basin 18) is an amended form of the basin originally proposed for Liverpool Council's detention basin strategy in this vicinity. It has been located further upstream on Maxwells Creek and has been expanded to provide additional flood storage to mitigate any adverse impacts from the WSO in Maxwells Creek.

The basin on Cabramatta Creek (Basin 22) was originally intended to be another joint Council/WSO basin. However, its reduced size is such that it is only able to mitigate adverse impacts from the WSO.

The basin on Hinchinbrook Creek (Government Drive Basin) is a new basin with the objective of mitigating any adverse impacts from the WSO in both Hinchinbrook Creek and Cabramatta Creek.

The measures shown on Figure 5.3 are preliminary, and subject to detailed design considerations currently being formulated as part of the design of the WSO Highway by the Abigroup-Leighton Joint Venture Group.

5.5 FLOODPLAIN MANAGEMENT OPTIONS

Floodplain management options are often considered to compensate for development or other activity within the catchment that may otherwise have a detrimental impact on flood behaviour. Examples of such options are Liverpool City Council's detention basin strategy, which compensates for the new release area development. Another example is the concept water management plan developed for the proposed WSO Highway. The objective of these options is to ensure that flooding is not exacerbated as a result of future development.

Floodplain management options also have the potential to reduce existing flooding problems within the catchment. Options such as additional detention basin storage or channel improvements might be considered to lower existing flood levels, whilst other options such as levee banks might be considered to keep floodwater away from property.

The assessment of floodplain management options should be based on consideration of the whole catchment, not just a specific site or problem area. Some options by themselves, such as channel improvements, can reduce flooding at their location and further upstream at the expense of downstream flood behaviour. Other options, such as levees, can increase flooding that may be experienced in upstream areas.

Floodplain management options are further discussed in **Sections 9** and **Section 10**, with recommended options included in the draft floodplain management plan presented in **Section 11**.

5.6 GREENHOUSE EFFECTS

The term “greenhouse effect” is used to describe the build up of gases in the earth’s atmosphere, known as greenhouse gases, which restrict the radiation of heat from the earth’s atmosphere. This build-up of gasses can potentially lead to long term changes in the earth’s climatic patterns, with implications for flood behaviour.

Various scenarios for climate change due to the greenhouse effect have been presented by research organisations such as CSIRO and the Intergovernmental Panel on Climate Change (IPCC). The impacts of the greenhouse effect are likely to include an increase in sea level and more frequent heavy rainfall events. Both these impacts can potentially affect flood behaviour in Cabramatta Creek.

Although there is still considerable debate on the magnitude of potential sea level increases, it has been predicted on a global scale to be about 220 mm in 50 years time, and 440mm in 100 years time [IPCC, 1995]. This is reasonably consistent with more specific predictions by CSIRO for NSW, with estimates varying between 50 to 350mm over the next 35 years.

An increase in sea level of the magnitude predicted would affect flooding in the lower reaches of the Georges River. It has previously been shown [PWD, 1991] that a 600 mm increase in levels for Botany Bay would have less than a 100 mm influence on the 100 year ARI flood level for East Hills. In the vicinity of Cabramatta Creek this influence would be negligible.

The impact of more frequent heavy rainfall events is likely to have a more significant impact on design flood levels for Cabramatta Creek. Any future increase in design storm intensities would lead to higher flood levels, both within the Georges River and Cabramatta Creek. Unfortunately, intense rainfall associated with local storms cannot be simulated reliably with current global climatic models. As there is no current indication on how design storm intensities may vary in the future, the potential impact on flood levels in Cabramatta Creek can not be determined.

Both Liverpool and Fairfield Councils include a 0.5m freeboard allowance, above design flood levels, when specifying minimum floor level controls. This freeboard allowance largely caters for uncertainties in the estimation method, one of which can be considered to be climatic changes due to greenhouse effects. Until more definitive information becomes available on these likely changes, further allowance for these effects is not warranted.

6. COMMUNITY CONSULTATION

6.1 CONSULTATION PROCESS

The success of any floodplain management plan hinges on community acceptance of the proposal. This can be achieved by involving the local community at all stages of the decision-making process. This includes the collection of their ideas and information, together with discussing the issues and outcomes of the study with them.

The key elements of the community consultation process for this study were as follows:

- floodplain management committees
- community newsletters and questionnaires
- liaison with agencies and authorities; and
- exhibition of the draft report.

A full report on the community consultation process has been prepared as a separate working paper [Bewsher Consulting, 1998h]. A brief description of the findings from this process is included in the remainder of this Section.

6.2 FLOODPLAIN MANAGEMENT COMMITTEES

This study has been overseen by floodplain management committees established by both Liverpool and Fairfield Councils. Both committees have met separately on a number of occasions, as well as meeting together to discuss joint issues. The committees have formed a vital link between the Consultant, the two Councils, relevant Departments and interested agencies, and the local community.

The floodplain management committees have included representation from:

- Liverpool and Fairfield Councils;
- DLWC (now part of DIPNR);
- Department of Urban Affairs and Planning (now part of DIPNR);
- State Emergency Services; and
- community groups with an interest in the study, including the Elouera Nature Reserve Management Committee, Georges River Catchment Management Committee, Residents Association of Mt Pritchard, and East Fairfield Progress Association.

6.3 NEWSLETTERS AND QUESTIONNAIRES

During the course of this study, two community newsletters and questionnaires were distributed to residents and businesses in the vicinity of Cabramatta Creek and its tributaries. The objective of the newsletters was to inform the community of the floodplain management study and progress being made on the study. The objective of the questionnaire was to provide a mechanism where the concerns and views of the community could be gathered.

Nearly 5,000 questionnaires were distributed within the Cabramatta Creek catchment. Approximately 20% of residential questionnaires were completed and returned. This is considered to be quite a good response rate, given it has been almost ten years since a large flood was experienced in the catchment and nearly 1/3 of respondents have lived in their current dwelling for less than 5 years.

A detailed analysis of the results from the questionnaires is presented in the *Community Consultation* working paper [Bewsher Consulting, 1998h], with key findings represented below.

Overall, flood experience and the information obtained by residents about flooding were found to be quite low in the Cabramatta Creek catchment. The results show that:

- generally, only about 30% of respondents have experienced a flood:
  - the most flood experience was found to be from Maxwells Creek residents (54%);
  - the least flood experience was found to be from Hinchinbrook Creek residents, where only one respondent has experienced a flood;
- about one-third of respondents thought their property could not be flooded in the future, while another one-third were not sure;
- more than one-third of respondents have received no information at all about flooding, and of those who had, the most common source of information has come from 'unofficial' sources such as neighbours, relatives and friends. Only very few people have obtained information from Council, the DLWC or their Section 149 Planning Certificate; and
- of those people who have experienced a flood in the Cabramatta Creek catchment, very few people received official warning of the approaching flood from the SES, police or on the radio;

The main environmental concerns of the community were found to be:

- a need for more maintenance along the creek corridor (78%);
- a need to restore the creek to a more natural condition (72%);
- the problem of dumping of litter in the creek (72%); and
- a need for more educational programs centred around the creek (71%).

The most favoured floodplain management measures that the community thought 'could prevent damage' are listed in **Table 6.1**. The most favoured measures generally included those actions that would improve flood awareness, such as issuing flood certificates, flood markers, better public education, and improved flood warning. Other favoured measures included restoring the creek and clearing the creek of rubbish, as well as the implementation of an urban bush management plan for the creek corridor.

TABLE 6.1
Residents Most Favoured Opinion on Floodplain Management Options That Could Prevent Damage
(in order of popularity over the total catchment)

OPTION	FLOODPLAIN MANAGEMENT OPTIONS THAT COULD PREVENT DAMAGE	TOTAL CABRAMATTA CREEK
v	Ensuring that all information about the risks of flooding is available to all residents and business owners	75%
x	Ensuring that all residents and business owners have Flood Action Plans in the event of a flood	72%
w	Providing certificates to all residents stating whether or not their property is flood affected	71%
c	Restoration of the creek to a more natural looking condition	70%
a	Clearing the creek of rubbish, debris and exotic vegetation	69%
g	Investigation of works in the Georges River to help prevent floodwaters backing up into Cabramatta Creek	66%
t	Improve flood warning both before and during floods	66%
y	Install flood markers to act as constant reminders of heights of previous floods	66%
b	Develop and implement an urban bush management program for the creek corridor	60%

6.4 LIAISON WITH COMMUNITY GROUPS, AGENCIES & AUTHORITIES

Ten resident groups with an interest in the Cabramatta Creek catchment were contacted through the course of this study. Specific questionnaires were designed for these groups, seeking information on the Group's interest, any concerns that they may have for the catchment, and opinions on environmental issues and floodplain management measures.

Responses were received from:

- Elouera Nature Reserve Management Committee — Bewsher Consulting met with this group at their meeting in February 1997. Most of the discussions revolved around the proposed works in Cabramatta Creek in the vicinity of Elizabeth Drive. An inspection of parts of the reserve with members of the Committee was also undertaken.
- Orange Grove Precinct Committee — a creek walk was undertaken with a representative of this group in February 1997. The walk took place along Cabramatta Creek between Elizabeth Drive and Orange Grove Road. The Group expressed concern about illegal or unauthorised filling of the floodplain, particularly in the vicinity of the Orange Grove Golf Course.
- Liverpool (incorporating Lurnea) Precinct Committee — Bewsher Consulting met with the group at their meeting in March 1997. Most of these residents live near Brickmakers Creek. Their concerns relate mainly to lack of maintenance of the

creek and lack of community consultation about those works that have been carried out in the past.

- Georges River Catchment Management Committee — a completed questionnaire was returned.

More than twenty government agencies and authorities were also contacted and requested to provide advice on:

- the appropriate contact person in that organisation;
- the potential damage that could occur to their asset/property/service should it be inundated by floodwaters;
- whether their organisation had any planned future works that would be located close to the creeks within the catchment; and
- any other flood related issues that their organisation felt should be addressed.

6.5 PUBLIC MEETINGS AND PUBLIC EXHIBITION

Two public meetings were held during the course of the study, to advise the community of the study and to gain feedback on community concerns and opinions.

The first of these meetings was held in Ashcroft High School Hall in 26 February 1997, to discuss flooding issues in the Elizabeth Drive/Tresalam Street/ Florence Street area, and possible flood mitigation options to reduce flooding in this area.

The second meeting was a more general meeting concerning the overall study, which was held at Liverpool Catholic Club on 20 May 1997. The meeting was attended by representatives of both Councils, government agencies and about 30 residents.

The main issues raised by the public included:

- how residents can be made aware of flood-affectation on their properties, and limitations with the existing use of Section 149 certificates;
- that flooding would be made worse in the lower sections of Cabramatta Creek due to the large scale urban development that is currently taking place in the upstream areas; and
- flood markers on telegraph poles were thought to be a good idea to remind people of historical floods.

The final stage of community consultation for this study is the public exhibition of the draft floodplain management study and plan for Cabramatta Creek. Both Liverpool and Fairfield Councils exhibited the document over an 8 week period from July to September 2004. A copy of the submissions received, and a response to these submissions, is included in Appendix E.

7. ENVIRONMENTAL AND ECOLOGICAL CONSIDERATIONS

7.1 WATER QUALITY ISSUES

It has been noted that Cabramatta Creek, together with the upper estuarine section of the Georges River and Prospect Creek, has the poorest water quality in the Georges River system (Mackay and Swan, 1990). Major sources of pollution include urban runoff quality and sewage effluent quality.

Dry weather water quality monitoring during 1990-1991 found that water quality was generally poor throughout Cabramatta Creek and Maxwells Creek, although water quality improved in Cabramatta Creek downstream of the confluence with Maxwells Creek. A small tributary off Hoxton Park Road was found to be the most polluted, probably due to seepage and overflows from septic tanks. Water quality in the headwaters of Hinchinbrook Creek (which until recently was largely undeveloped), was found to be satisfactory [Mackay 1991].

Wet and dry weather monitoring in the Cabramatta Creek catchment was carried out by Australian Water Technologies [O'Connell, 1992] during 1990-1992. Adverse impacts on water quality of urbanisation/agricultural activities were apparent from the data, with the impacts of rural and market garden activities thought to be greater than water quality impacts associated with urban development [Kinhill, 1992]. It was also apparent that natural areas adjacent to creeks were effective in "treating" pollutants and reducing pollutant concentrations. Large amounts of urban litter were also present in the creek system, both in the urban areas and the rural areas, and the creeks have often been used as dumping grounds for car bodies, building materials and household waste, etc.

Data and monitoring by Sydney Water from 1993 to 1996 [Sinclair Knight Merz, 1998] in Chipping Norton Lakes at the confluence of Cabramatta Creek and the Georges River found that the majority of nutrients were contributed by stormwater, with the majority of faecal coliforms contributed by sewage overflows.

Water quality monitoring in Cabramatta Creek by Fairfield and Liverpool Councils during 1996-1998 showed elevated levels of nutrients and faecal coliforms in relation to ANZECC guidelines for recreational use and protection of aquatic ecosystems. Although mean results for dissolved oxygen (DO) were generally above the minimum guideline level, concentrations were lower than the guideline during dry weather sampling and up to about 9.6 mg/L during wet weather sampling. Turbidity levels were found to be medium.

It has also been found that stormwater entering Cabramatta and Maxwells creeks contained elevated levels of nutrients, up to one order of magnitude higher than ANZECC guidelines [Osborne at al, 1995].

7.2 RIVERINE ECOLOGY

There is little information on aquatic fauna in Cabramatta Creek. The *Urban Bushland Biodiversity Study* [NPWS, 1997] lists 21 frog species as occurring or potentially occurring in the Liverpool LGA, and nine frog species occurring or potentially occurring in the Fairfield LGA. Fifty-three reptile species have been recorded for western Sydney comprising two tortoises, four geckos, two legless lizards, four dragons, two goannas, 20 skinks and 19 snakes.

NPWS (1997) lists a total of 76 bird species for Cabramatta Creek from the RAOU Australian Bird Count, including eight introduced species, 12 migratory species and 18 regionally significant species. Similarly, Sainty and Associates (1997) recorded a total of 76 native bird species in the lower reaches of Cabramatta Creek and nine introduced species. LesryK Environmental Consultants (1996) recorded 50 native bird species at Hinchinbrook Creek and 36 in Elouera Nature Reserve.

LesryK Environmental Consultants (1996) recorded three native mammal species at both Hinchinbrook Creek and Elouera Nature Reserve. These species included Ringtail and Bushtail possums in Hinchinbrook Creek and the Common Bentwing-bat at Elouera Nature Reserve.

One of two major metropolitan Sydney maternity colonies of the Grey Headed Flying-fox is located adjacent to Cabramatta Creek in the Fairfield LGA [FCC, 1996].

7.3 AREAS OF SIGNIFICANT VEGETATION

Native vegetation communities along the Hinchinbrook and Cabramatta Creek corridors comprise Red Gum-Cabbage Gum River-flat Forest and Swamp Oak Forest. Over 50 native plant species have been recorded for the Cabramatta Creek corridor, including over 30 species in the upper catchment, upstream of Hoxton Park Road. Of these, Blue Box is considered to be of particular regional significance and Cabbage Gum and Prickly Beard-heath are considered to be vulnerable in Western Sydney. Over 50 species have been recorded for the Hinchinbrook Creek corridor. In addition to Blue Box and Cabbage Gum, Smooth Willow-herb, Native Flax and *Polymeria calycina* are considered vulnerable in Western Sydney [NPWS, 1997].

Significant areas of remnant bushland along Cabramatta Creek and tributaries are described in **Table 7.1**.

The Elouera Nature Reserve is also recognised as being of significant conservation potential [Greening Australia, 1991].

TABLE 7.1
Remnant Bushland of Conservation Significance
(Source : NPWS, 1997)

Location	Vegetation Community	Comments
Denham Court (east of Forest Lawn Memorial Park at head of tributary to Cabramatta Ck	Grey Box Woodland	Grey Box Woodland endangered at National, State and regional level Over 70 plant species recorded 10 species vulnerable in western Sydney
Hoxton Park Aerodrome (bushland to north-west of aerodrome)	Spotted Gum Forest	Spotted Gum Forest endangered at National, State and regional levels Over 60 species recorded 12 Species vulnerable in western Sydney low to moderate weed invasion
Prestons (bushland bordered by Jedda, Wonga, Bernera and Kurrajong Roads)	Grey Box Woodland (west of Maxwells Creek) Shale/Gravel Transition Forest (east of Maxwells Creek)	Both vegetation communities are of National, State and regional significance Over 200 species recorded One rare or Threatened Australian Plant (ROTAP) species found at site 11 species considered of particular regional significance 70 species considered vulnerable in western Sydney
Prout Park	Spotted Gum Forest	Spotted Gum Forest endangered at National, State and regional levels 53 species recorded high weed invasion
Bat Colony (north east of Jacqui Osmond Softball Centre)	River-Flat Forest including Swamp Oak Forest and Red Gum-Cabbage Gum Forrest	River-flat endangered at regional level 44 species recorded Two regionally significant species 12 species considered vulnerable in western Sydney important fauna habitat severe weed invasion
Chipping Norton Lakes (including Irelands Bridge Reserve and Cherrybrook Park)	River-flat Forest including Swamp Oak Forest and Red Gum-Cabbage Gum Forest	River-flat Forest wetland communities of regional significance Over 250 species recorded for the Lakes 40 species considered vulnerable in western Sydney Large number of significant species including 8 of particular regional significance Irelands Bridge Reserve contains locally rare rainforest species

7.4 AREAS OF ARCHAEOLOGICAL SIGNIFICANCE

Smith (1989) identified 21 previously unrecorded Aboriginal sites for the Liverpool Release Areas. Sites comprised 19 artefact scatters (generally containing between two and seven artefacts) and two scarred trees. In addition, five isolated artefacts were recorded, which were considered to be the remnants of destroyed sites. The occurrence of scarred trees is significant, as very few such trees have been recorded on the Cumberland Plain. The trees are located along Cabramatta Creek, one upstream of Hoxton Park Road and the other just downstream of Camden Valley Way.

Smith ranked sites in terms of disturbance, from excellent (no disturbance) to very poor (all but destroyed). Of the artefact scatters, eight were found to be in very poor condition, five in poor condition, four in fair condition and two in good condition. Both of the scarred trees were in excellent condition.

Most archaeological sites were found on creek banks and flats, with 89% found within 100 m of water. Artefact scatters were generally associated with permanent water. Accordingly, areas of high archaeological potential are permanent creek lines and swamps, as most sites would be expected to be found within 50 to 100 m of these water sources. Relatively undisturbed areas along Maxwells Creek also have high archaeological potential, as they are likely to contain relatively more sites and sites of high archaeological significance due to lack of disturbance. Although not surveyed due to access restrictions, the headwaters of permanent tributary creeks were also considered to be of high archaeological potential.

A survey undertaken for Maxwells Creek, between Kurrajong Road and Camden Valley Way, recorded six artefact scatter sites [McDonald, 1998]. Two artefacts and four open areas of potential archaeological deposits were also recorded. Only two of the artefact scatter sites were considered to be of some scientific significance with all the open sites assessed as having moderate to good potential for intact archaeological deposits.

7.5 VALUE OF CREEK CORRIDORS

Values of the Cabramatta Creek Corridor and other creek corridors within the catchment include:

- the conservation of remnant vegetation, including threatened or rare species;
- provision of habitat for the flying fox colony in the Fairfield LGA and habitat for numerous bird species;
- for sections of the creek which are in a relatively natural state, benefits to water quality through natural treatment processes;
- in urban areas, visual relief from surrounding development;
- provision of a variety of structured recreational opportunities (sports fields etc) and the potential for improved casual recreational opportunities (eg. nature trails);
- opportunities for environmental education and scientific research (eg. bush regeneration by volunteer groups, streamwatch activities by local schools and bird watching).

8. PLANNING AND FLOOD POLICY ISSUES

8.1 LOCAL ENVIRONMENTAL PLANS AND ZONING CONTROLS

A Local Environmental Plan (LEP) is a Plan prepared in accordance with the EP&A Act, which defines zones, permissible uses within those zones and specific development standards and other special matters for consideration with regard to the use or development of land. The relevant LEPs for consideration in the context of this Study are the Liverpool LEP 1997 and the Fairfield LEP 1994.

The Liverpool LEP maps which cover the study area have a broad range of zonings including Rural, Residential, Industrial, Future Urban, Special Uses and Open Space. There are no specific flood related zones.

It is noted that the previous Liverpool zoning instruments contained a Residential 2(f) Zone (Flood Liable Land Zone) which is not incorporated in the Liverpool LEP 1997. This Residential 2(f) zone basically affected pockets of land along the creek and drainage corridors which were affected by the designated flood and could not be developed for residential purposes without ameliorative works such as land filling.

The Cabramatta Creek and the majority of major drainage channels within the Liverpool urban areas, are contained in a Special Uses 5(a) Drainage zone. These drainage corridors are also often flanked by open space areas zoned 6(a) Recreation - Public. There are also a number of other zones and uses within the creek and drainage corridors such as Special Uses 5(a) TAFE College and Schools within that section of Cabramatta Creek between Hoxton Park Road and Elizabeth Drive. The majority of the creek and drainage corridors within the Future Urban zoned areas are not separately zoned and it is anticipated that this would be formalised within any future zonings which initiate the urban release.

The Fairfield LEP map which covers the Fairfield LGA part of the study area has a broad range of zonings including recreation, residential, industrial and special uses. The majority of flood affected areas are zoned either 6(a) Existing and Proposed Recreation of 6(b) Private Recreation.

Whilst the written provisions of both the Liverpool and Fairfield LEPs differ in relation to flooding, they both have the objective to minimise risk to persons and property within flood affected lands. A detailed analysis of these provisions is provided in the "Review of Planning Controls" working paper [Bewsher Consulting and Don Fox Planning, 1998b], and certain recommendations are given in **Section 8.3.4**.

8.2 OTHER FLOOD RELATED PLANNING CONTROLS

There is various legislation and other related non-statutory documents which have direct or indirect implications in regard to planning in the floodplain. This body of legislation and controls vary from state based statutes and planning documents which have indirect implications to floodplain planning in the Cabramatta Creek Catchment to site specific planning controls prepared by the Councils to provide detailed control of

development having regard to the flood hazard in the Study Area. These planning controls include:

- Environmental Planning & Assessment Act, 1979 and Regulations

  Development applications for proposals which are permissible with consent must have regard to the relevant "matters for consideration" contained in Section 79C of the Environmental Planning and Assessment Act, 1979. Of particular relevance are the Liverpool and Fairfield Local Environmental Plans, and any relevant Development Control Plan (DCP). While no DCP is presently in force which deals with the issue of flooding, such an instrument would provide a desirable mechanism for both Councils to comprehensively assess development applications with respect to the issue of flooding.

- State Environmental Planning Instruments

  A State Environmental Planning Policy (SEPP) is a planning document prepared in accordance with the EP&A Act by the Department of Infrastructure, Planning and Natural Resources (formerly Planning NSW) and eventually approved by the Minister, which deals with matters of significance for environmental planning for the State. The existing SEPPs which have some implications in regard to development within the Study Area include SEPP No.5 (Housing for the Aged or Disabled Persons), SEPP No. 19 (Bushland in Urban Areas), and SEPP No.21 (Caravan Parks).

- Local Government Act 1993

  The Local Government Act will have implications primarily in regard to the use of public lands for flood mitigation works. Part 2 of the Local Government Act 1993 requires that all land vested in a Council (except a road or land to which the Crown Lands Act 1989 applies) must be classified as either "community" or "operational". The purpose of the classification to clearly identify that land which should be kept for the use by the general public (community) and that land which need not (operational). The majority of the open space and drainage zoned lands in the ownership of Council will likely be classified as "community". The implication is that the development of these lands for flood mitigation works will need to be in accordance with a Plan of Management, or reclassified to operational.

- Advisory Circulars

  The Department of Infrastructure, Planning and Natural Resources is responsible for providing advice to local Councils to ensure that best practice is maintained in the planning process. Circular No. C9 was issued to assist Councils to relate the flood policy of the State Government and the *Floodplain Development Manual* (now superseded by the *Floodplain Management Manual*) to the requirements of the EPA Act and the Department's general approach to floodplain planning. The Circular states that in accordance with the *Manual*, Councils should prepare single comprehensive LEPs to implement their floodplain management plans and so avoid ad hoc, piecemeal approach to planning within the floodplains.

- Section 117 Directions

  Ministerial directions pursuant to Section 117(2) of the EPA Act specify matters which local Councils must take into consideration in the preparation of LEP's. Section 117(2) Direction No. G25 (in regard to 'flood liable land') applies. The

direction is aimed specifically at enforcing the principles contained within the *Floodplain Management Manual*.

- Other Statutory Considerations

  In addition to the above, there may be other statutory matters which have an implication in regard to planning in the floodplain. These matters would include requirements in regard to the rezoning of the land (preparation of LEPs, sometimes REPs and SEPPs), Section 94 Contributions Plans and general policies of Council.

8.3 REVIEW OF LOCAL FLOODPLAIN MANAGEMENT POLICIES

One important component of any floodplain management plan is land use planning and development controls.

A review of the local floodplain management policies for both Liverpool and Fairfield Councils was undertaken during 1998-99. At this time, both Councils had in existence a combination of interim flood policies and floodplain management plans for various catchments within their area of responsibility. The discussion in Section 8.3 and 8.4 below relates to the policies in existence at that time, and recommends the adoption of a single flood risk management DCP with provision for specific controls in different catchments as separate schedules (or planning matrices) attached to the DCP.

Since this review was undertaken, further consideration of planning issues and liaison with Council officers has been undertaken as part of the Georges River Floodplain Management Study, which has been prepared for Liverpool, Fairfield, Bankstown and Sutherland Councils. A draft flood risk management DCP has been prepared for each of the four Councils as part of that study. The draft DCP prepared for Liverpool and Fairfield Councils is consistent with the recommendations that were provided from the initial Cabramatta Creek Floodplain Management Study, which are provided below.

8.3.1 Liverpool City Council

There is at present substantial inconsistency between three primary documents relating to floodplain planning in the Liverpool LGA, being:

- *Council's Interim Flood Policy* - prepared in accordance with the requirements of the State Government's Flood Policy expected to be superseded by more detailed floodplain management studies and plans in the future. This interim policy places controls on development primarily based on the 100 year ARI flood.

- *The recommendations of the Floodplain Management Committee and Council's resolution of September 25, 1995* - which adopts the PMF as the designated flood, and the 100 year ARI flood extent as the floodway for development control, for the Austral Floodplain.

- *Council's recently adopted LEP 1997* - which defines "flood liable land" for the whole of the Liverpool LGA as that area potentially affected by the 100 year ARI flood (irrespective of the requirements of the *Floodplain Management Manual* for this to be based on consideration of all floods up to the PMF).

In addition to the individual requirements of each of the above documents, when assessing applications for development, there are other statutes which refer to these documents which compound the problems arising from inconsistencies. This has implications in regard to Council's liability indemnity provided by Section 733 of the Local Government Act.

In order to resolve this situation, and to provide for long term floodplain planning direction for Council, it is recommended that an updated Floodplain Management Policy be adopted for the Liverpool LGA (in addition to associated changes to LEP 1997. This policy will need to embrace the recommendations from the current floodplain management plan for Cabramatta Creek, and should also take the opportunity to address associated floodplain management issues relevant to the whole of the Liverpool LGA.

8.3.2 Fairfield City Council

Similar to Liverpool City Council, Fairfield City Council has undertaken a number of floodplain management studies and plans. Whilst a number of these studies and plans refer to land use planning and development controls as a mechanism for flood mitigation, no specific recommendations have emanated from these documents.

Fairfield City Council currently has an Interim Floodplain Management Policy, and the adoption of a revised and updated policy for the whole of the LGA is desirable, as opposed to the piecemeal adoption of a policy relating only to Cabramatta Creek. Accordingly, it is also recommended that an updated floodplain management policy be prepared for Fairfield. This should also provide for consistent policies within both Council areas of the Cabramatta Creek catchment.

8.3.3 Recommended Floodplain Management Policies

The Environmental Planning and Assessment (EP&A) Act provides the appropriate platform for the implementation of land use planning and development controls in NSW. The most appropriate mechanism available within the EP&A Act to implement the bulk of land use and development controls that may emanate from an interim flood policy or floodplain management plan is through a Development Control Plan (DCP). Additionally, there may be a number of associated changes to both Council's Local Environmental Plans, other flood related Council policies and other DCPs, to ensure consistency between all documents.

The Floodplain Management Policies recommended for Liverpool and Fairfield City Councils have been based on the Draft Liverpool Floodprone Land Policy (prepared by Bewsher Consulting and Don Fox Planning, for Liverpool City Council in April 1998) which has been widely distributed and advocated to various Councils within the Sydney area as an appropriate basis for the formulation of a regionally consistent Policy document for the management of floodplains.

The main attributes of the recommended floodplain management policies for both Councils are as follows:

- it provides a plain English presentation so as to be effectively more accessible to the general population;
- it is structured to provide both general policies (eg. criteria for rezoning proposal) and to be adopted as a development control plan which provides detailed guidelines in regard to proposed development;
- disbands the use of a singular flood planning level (FPL) to control development. This is considered to result in a more substantial and effective means of satisfying the requirements of the *Floodplain Management Manual*;
- the document is structured to deal with both general and individual floodplain issues. The front section of the document provides general policies and objectives, and other necessary provisions required to bring the document into force as a DCP. The detailed controls are referenced through "planning matrices" attached as schedules to the document, which effectively summarise the planning controls emanating from individual floodplain management studies and plans for specific floodplains where they have been prepared, or to act as interim policies where they are yet to be prepared; and
- the structure of the document allows updating as floodplain management studies and plans are prepared, principally by amending or providing additional planning matrices for floodplains or subcatchments of floodplains.

The proposed floodplain management policy for Liverpool Council and Fairfield Council is included in the "Review of Local Flood Policies" working paper [Bewsher Consulting and Don Fox Planning, 1998f].

8.3.4 Other Associated Changes

In addition to the adoption of the above principal policy/DCP documents, there are a number of associated changes which are required to be implemented to ensure consistency and to remove any statutory constraints in the implementation of the recommended policies. These changes relate primarily to the amendment of the Councils' current DCPs, as relevant, and modification to the Liverpool and Fairfield LEPs.

Amendments to the Councils' existing DCPs primarily relate to ensuring that any reference to terms such as "flood liable land" or specific controls on development associated with the flood hazard be amended to be consistent with the proposed Floodplain Management Policy/DCP or preferably deleted and substituted with a cross-reference to the principle Floodplain Management Policy/DCP. Recommendations for standard inclusions for LEPs to deal with flood related issues and to ensure consistency with the proposed floodplain management policy, are provided in the "Review of Local Flood Policies" working paper [Bewsher Consulting and Don Fox Planning, 1998f].

8.4 THE PLANNING MATRIX APPROACH

The Planning Matrix approach is central to the proposed floodplain management policies. The Planning Matrix considers the flood hazard across the whole floodplain (i.e. up to the PMF) and manages the floodplain by the application of a graded set of planning controls which vary with the flood hazard and land use.

This approach was primarily developed as the flood hazard within floodplains is often poorly understood and appreciated by the community. Often the community considers there to be a flood hazard only on land below the FPL, which is the level below which councils place restrictions on development. This FPL is commonly the 100 year ARI flood, which is the FPL adopted for most of the Liverpool and Fairfield LGAs.

For that part of the floodplain which is situated above the FPL, where there is no flood related planning controls, the community often misinterprets this as a statement that there is no flood hazard. In reality, the flood hazard may be significant in dimension, albeit rarer in occurrence.

Traditional floodplain planning has relied almost entirely on the definition of a singular FPL, which has usually been the 100 year ARI flood level. While such an approach has often been adequate, the approach has not worked well everywhere and has led to a number of problems including:

- creation of a 'hard edge' to development at the FPL;
- distribution of development within the floodplain in a manner which does not recognise the risks to life or the economic costs of flood damage;
- unnecessary restriction of some land uses from occurring below the FPL, while allowing other inappropriate land uses to occur immediately above the FPL;
- polarisation of the floodplain into perceived 'flood prone' and 'flood free' areas;
- lack of recognition of the significant flood hazard that may exist above the FPL (and as a result, there are very few measures in place to manage the consequences of flooding above the FPL);
- creation of a political climate where the redefinition of the FPL (due to the availability of more accurate flood data, or other reasons) is fiercely opposed by some parts of the community, due to concern about significant impacts on land values — i.e. land which was previously perceived to be 'flood free' will now be made 'flood prone' — despite the likelihood that such impacts may be short term.

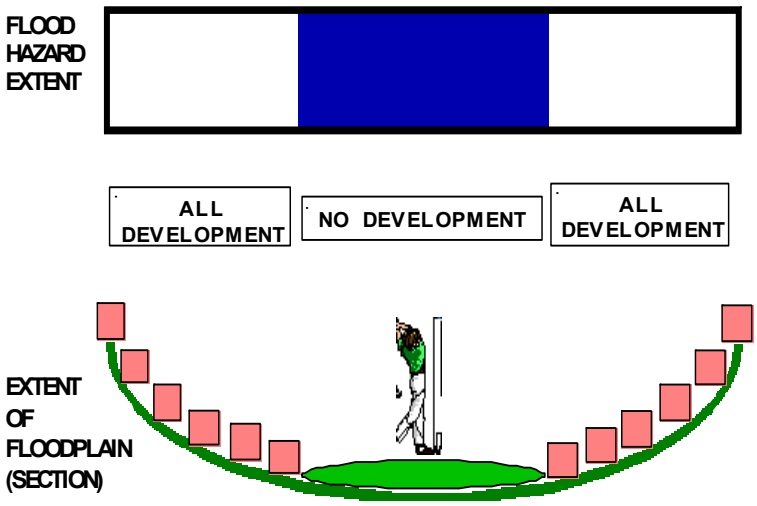
Accordingly, continuation of the sole reliance on the 100 year ARI FPL is considered inappropriate — specifically in regard to the Liverpool and Fairfield LGAs.

The current approach to floodplain planning discussed above may be typified by the example shown at the top of **Figure 8.1**. No development is permitted below the FPL (ie. 100 year ARI flood) because of an acknowledgement of the flood hazard. Above the FPL, no flood hazard is perceived and therefore there are no flood related controls on development. Thus an abrupt change in development control occurs at the FPL. In contrast, the Planning Matrix approach distributes land uses within the floodplain and controls development to minimise the consequences of flooding, as depicted at the bottom of **Figure 8.1**.

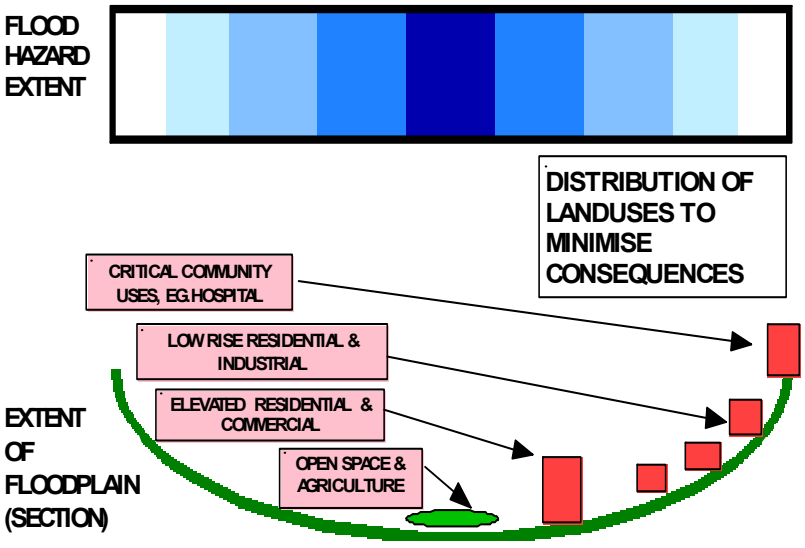
Using this approach, a matrix of development controls, based on the flood hazard and the land use, can be developed which balances the risk exposure across the floodplain. This approach has been adopted as part of the recent Hawkesbury-Nepean Flood Management Strategy and has also been previously applied within the Blacktown, Narrabri, Boundary Creek (Strathfield LGA), North Wentworthville (Parramatta LGA) and Molong Floodplain Management Plans.

The approach, summarised in **Figure 8.2**, is consistent with the principles of the *Floodplain Management Manual*.

The outcome of this approach is centred on a matrix of controls embodied within the recommended local flood policies for Liverpool and Fairfield Councils.

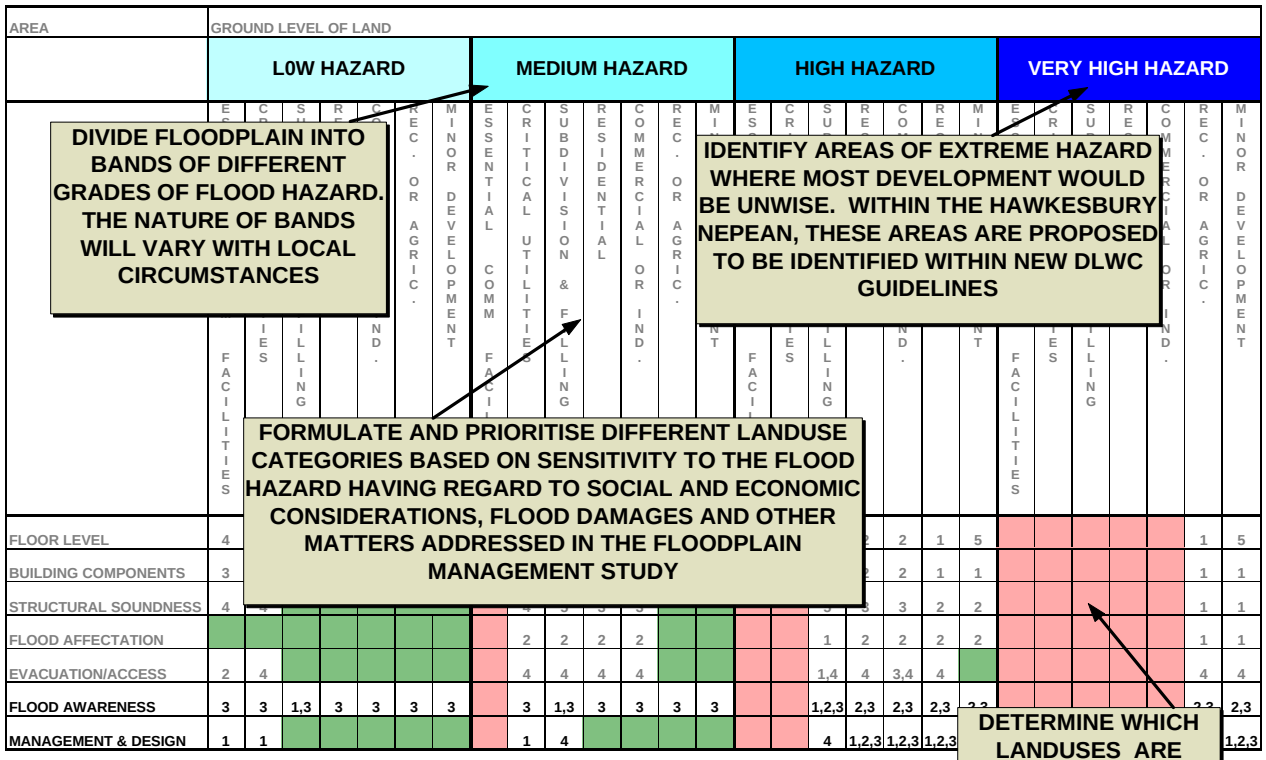


Current Floodplain Planning Approach
Derived from an inappropriate view of flood hazard and the use of a singular flood planning level



Distributing Land Uses under the Planning Matrix Approach
Using this approach, a matrix of development controls, based on the flood hazard and the land use, can be developed which balances the risk exposure across the floodplain

FIGURE 8.1
Land Use Distribution under Current and Proposed Planning Approaches



FLOOR LEVEL	4								2	2	2	2			2	2	1	5						1	5					
BUILDING COMPONENTS	3								2	2	2	2			2	2	1	1						1	1					
STRUCTURAL SOUNDNESS	4								4	5	5	5			5	5	3	2						1	1					
FLOOD AFFECTATION									2	2	2	2			1	2	2	2	2					1	1					
EVACUATION/ACCESS	2	4							4	4	4	4			1,4	4	3,4	4						4	4					
FLOOD AWARENESS	3	3	1,3	3	3	3	3		3	1,3	3	3	3	3	1,2,3	2,3	2,3	2,3	2,3					2,3	2,3					
MANAGEMENT & DESIGN	1	1							1	4					4	1,2,3	1,2,3	1,2,3						1,2,3						

NOTES

NOT RELEVANT

UNSUITABLE LAND USE

HHF — REFERS TO THE HIGHEST HISTORICAL FLOOD AS DEFINED IN THE GLOSSARY

PMF — REFERS TO THE PROBABLE MAXIMUM FLOOD AS DEFINED IN THE GLOSSARY

FLOOR LEVEL

1 ALL FLOOR LEVELS TO BE EQUAL TO OR GREATER THAN THE 1 IN 5 YEAR FLOOD PLUS 0.5M (FREEBOARD)

2 HABITABLE FLOOR LEVELS TO BE EQUAL TO OR GREATER THAN THE 1IN 100YR FLOOD PLUS 0.8M (FREEBOARD)

AND OTHER FLOOR LEVELS TO BE EQ

3 ALL FLOOR LEVELS TO BE EQUAL TO O

4 ALL FLOOR LEVELS TO BE EQUAL TO O

5 FLOOR LEVELS TO BE AS CLOSE TO THI LOOR LEVEL WHEN AN ADDITION TO AN EXISTING BUILDING

FLOOD COMPATIBLE BUILDIN

1 ALL STRUCTURES TO HAVE FLOOD COM D LEVEL

2 ALL STRUCTURES TO HAVE FLOOD CO

3 ALL STRUCTURES TO BE CONSTRUCTED OF FLOOD COMPATIBLE MATERIALS BELOW OR AT THE PMF LEVEL

STRUCTURAL SOUNDNESS

1 ENGINEERS REPORT TO PROVE ANY STRUCTURE SUBJECT TO A FLOOD UP TO & INCL. THE 1 IN 100 YR LEVEL CAN WITHSTAND THE FORCE OF FLOODWATER, DEBRIS & BUOYANCY

2 ANY STRUCTURE SUBJECT TO A FLOOD UP TO & INCL. THE 1 IN 100 YEAR SHOULD WITHSTAND THE FORCE OF FLOODWATER, DEBRIS & BUOYANCY

3 ANY STRUCTURE SUBJECT TO A FLOOD UP TO & INCL. THE HHF SHOULD WITHSTAND THE FORCE OF FLOODWATER, DEBRIS & BUOYANCY

4 ANY STRUCTURE SUBJECT TO A FLOOD UP TO & INCLUDING THE PMF LEVEL SHOULD WITHSTAND THE FORCE OF FLOODWATER, DEBRIS & BUOYANCY

5 GEOTECHNICAL ENGINEERS REPORT REQUIRED TO SPECIFY APPROPRIATE FILLING/EARTHWORKS & THE MEANS OF RETENTION OF BATTERS AGAINST SCOURING/EROSION

FLOOD EFFECT ON OTHERS

1 ENGINEERS REPORT REQUIRED TO PROVE THAT THE DEVELOPMENT OF AN EXISTING ALLOTMENT WILL NOT INCREASE FLOOD AFFECTATION ELSEWHERE

2 THE IMPACT OF THE DEVELOPMENT ON FLOOD AFFECTATION ELSEWHERE TO BE CONSIDERED

EVACUATION/ACCESS

1 RELIABLE ACCESS FOR PEDESTRIANS REQUIRED DURIN

2 RELIABLE ACCESS FOR PEDESTRIANS & VEHICLES REQ

3 ELECTRONIC FLOOD WARNING DEVICES TO INSTALLED C

4 CONSIDERATION REQUIRED REGARDING AN APPROPRIAT

FLOOD AWARENESS

1 RESTRICTIONS TO BE PLACED ON TITLE ADVISING OF MINIMUM FLOOR LEVELS REQUIRED RELATIVE TO THE FLOOD LEVEL

2 S149(2) CERTIFICATES TO NOTIFY AFFECTATION BY THE 1 IN 100 YEAR FLOOD

3 S149(2) CERTIFICATES TO NOTIFY AFFECTATION BY THE PMF FLOOD

MANAGEMENT & DESIGN

1 FLOOD PLAN REQUIRED WHERE FLOOR LEVELS ARE BELOW THE DESIGN FLOOR LEVEL

2 APPLICANT TO DEMONSTRATE THAT THERE IS AN AREA WHERE GOODS MAY BE STORED ABOVE THE 1 IN 100 YEAR FLOOD LEVEL PLUS 0,5M(FREEBOARD) DURING FLOODS.

3 NO EXTERNAL STORAGE OF MATERIALS BELOW THE 1 IN 100 YEAR LEVEL PLUS 0.5M(FREEBOARD) WHICH MAY BE POTENTIALLY HAZARDOUS DURING FLOODS

4 APPLICANT TO DEMONSTRATE THAT POTENTIAL DEVELOPMENT AS A CONSEQUENCE OF A SUBDIVISION PROPOSAL CAN BE UNDERTAKEN IN ACCORDANCE WITH THIS POLICY

FIGURE 8.2

Example Planning Matrix and Explanation

8.5 POLICY FOR THE RELEASE OF FLOOD DATA

8.5.1 Legal Issues

The State Government Flood Policy and the *Floodplain Management Manual* establish a basis for ensuring exemption from liability as provided for by Section 733 of the Local Government Act, 1993. Section 733 of the Act provides that Councils do not incur any liability in respect of advice furnished or anything done or omitted to be done in good faith by Council which relates to the nature and extent of flooding provided that Council acts in good faith. Unless the contrary is proved, Council is taken to have acted in good faith if it has acted substantially in accordance with the *Manual*.

Section 3.2 of the *Manual* outlines the specific areas of responsibility of Councils in regard to floodplain management and flood awareness.

The release of accurate, comprehensive and consistent flood data, between different Council officers, to other government authorities, to the general public and to consultants and developers, is essential in exercising Council's duties as specified by the *Manual* in a manner which limits liability.

In a recent court case involving *Mid Density Development Pty Ltd -v- Rockdale MC (1993) 81 LGERA 104*, the concept of acting in good faith when releasing flood data was examined in detail. The responsible officer, in completing Section 149 Certificates had relied on his own knowledge and had not searched Council's records which would have revealed that the property was subject to the risk of flooding. The Court concluded that the lack of personal dishonesty was not determinative of action "in good faith" as provided for by Section 733 of the LG Act. The Court also held that in the circumstances, the disclaimer on the Certificate was not sufficient to absolve the Council of liability for its negligence. As a result Council was found liable for damages exceeding $1 million.

Recent legal advice provided in association with the preparation of other floodplain management plans revealed two important considerations:

- before Council can rely on a good faith defence, it must conscientiously apply itself in the exercise of its duties; and
- Council should disclose the possibility that a land may be subject to a flood in a PMF event upon a Section 149(2) Certificate, and presumably when providing flood data by any other means.

8.5.2 Policy Development

The comprehensive and orderly dissemination of accurate flood data, is important both because of its implications for Council's legal liability, and as an important flood awareness tool to mitigate the impacts of flooding. Accordingly, there are clear benefits in seeking to streamline and safeguard the release of flood data to the public.

Bewsher Consulting and Don Fox Planning were commissioned by Liverpool City Council during 1998 to review existing procedures and recommend a framework and

policy for the use and release of flood information. This was undertaken and a report was prepared providing relevant recommendations, entitled “Policy for Release of Flood Data” [Bewsher Consulting and Don Fox Planning, 1998j]. Whilst the policy was developed specifically for Liverpool, it has a generic framework and could be applied within Fairfield with only minor modifications.

The abovementioned document identified relevant issues and recommended strategies for dealing with these issues, as well as providing a general policy for the collection and dissemination of flood related information.

The main objectives of the Policy are as follows:

1. To ensure that those handling or receiving flood information understand the distinction between risks associated with flooding and controls imposed by Council to mitigate against the consequences of select flood events.
2. To maximise the potential to increase flood awareness amongst the general community and Council personnel involved in the land management and development processes.
3. To ensure that flood related information released is consistent.
4. To ensure that flood related information is released in an orderly and efficient manner.
5. To advise the public of restrictions that may be imposed by Council on development due to flood affection.
6. To provide a flood related information service to all relevant sections of Council
7. To provide a mechanism to increase public awareness of flood risks, to minimise consequences of flooding, by increasing the preparedness of the community and to increase the capacity of the community to recover subsequent to being flooded.
8. To ensure that Council meets its statutory obligations in regard to the dissemination of flood-related information.

8.5.3 Components of the Policy for Liverpool

The major components of the Policy for Release of Flood Data are summarised within **Figure 8.3**. The Policy provides for two levels of flood related information to be made available, being:

- Standardised flood data — which refers to documented information prepared by Flood Investigation Engineers and may include a flood information brochure, flood reports, flood certificates, attachments to S. 149 Certificates, flood policies and floodplain management plans, flood studies, and standard conditions of consent.

- Non Standardised flood data — this refers to information requests which are not able to be satisfied by reference to documented data (standardised flood data) and will require a specialised response by the flood investigation engineers.

The Policy also provides a basis for establishing Council's position in regard to the following:

- who should have ownership of data?
- what is the process for updating the information? and
- who is to have access to and be able to use the information?

The overall responsibility for the compilation, management and release of flood data will be vested with the Flood Investigation Engineers. Flood Investigation Engineers will be responsible for setting up various mechanisms to allow release of standardised information without their involvement, which would include:

- flood brochure;
- standard question and answers booklet for staff;
- flood certificates;
- flood reports;
- attachments for Section 149 Certificates;
- input into the LIS and Corporate data base;
- specifications for site/development specific flood studies and management, control and acceptance of the study;
- catchment wide flood studies, floodplain management studies and floodplain management plans prepared in accordance with the FPDM; and
- standard conditions of consent.

The availability of standardised information will increase efficiencies and consistency of data released and should be continually monitored and reviewed in the objective of minimising the involvement required of flood investigation engineers in satisfying individual flood related information requests. However, where limited information outputs are not sufficient to handle the specific nature of a flood related question, then this question must be referred onto the Flood Investigation Engineers.

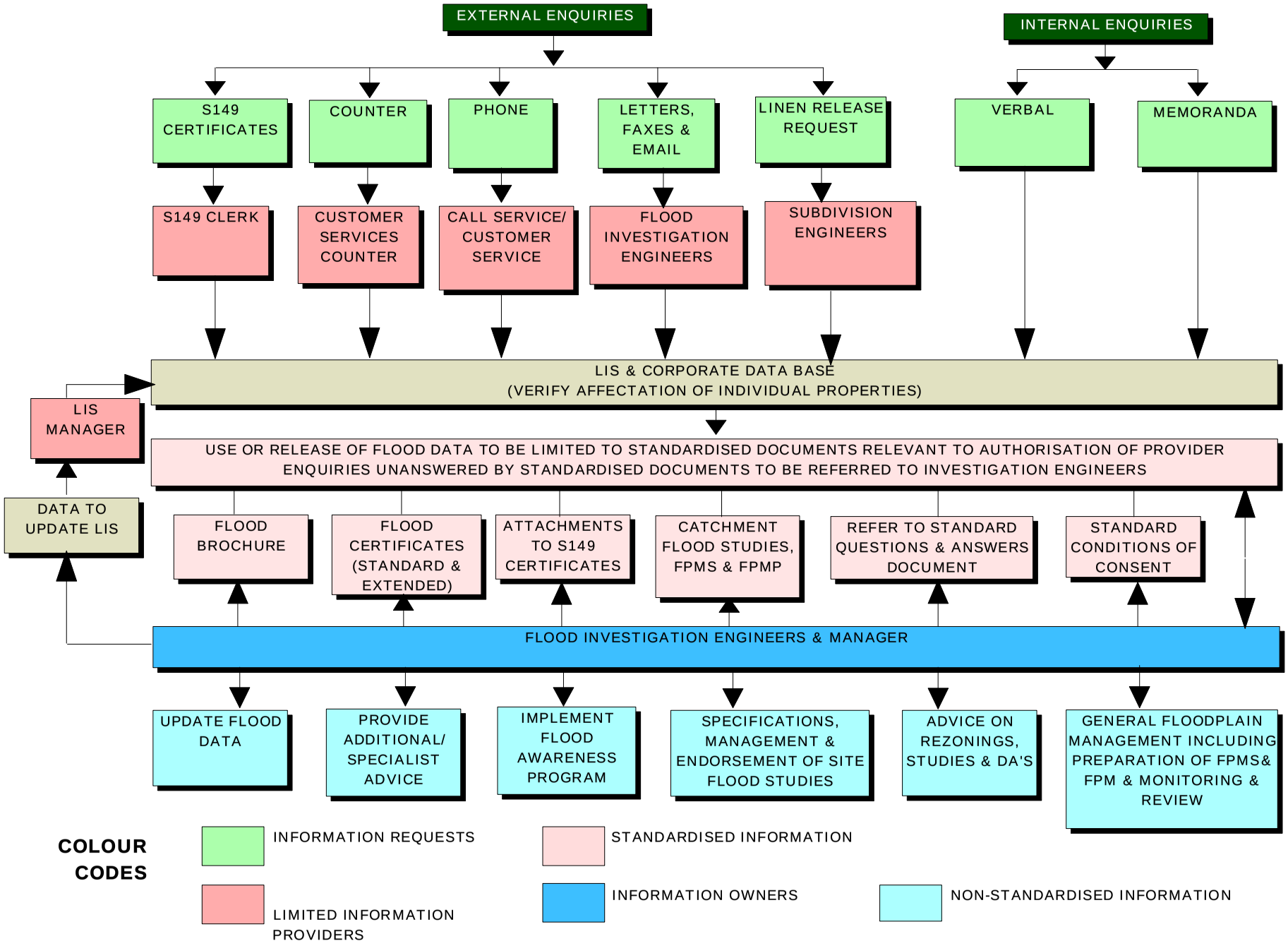


FIGURE 8.3
Processing Requests for Flood Data