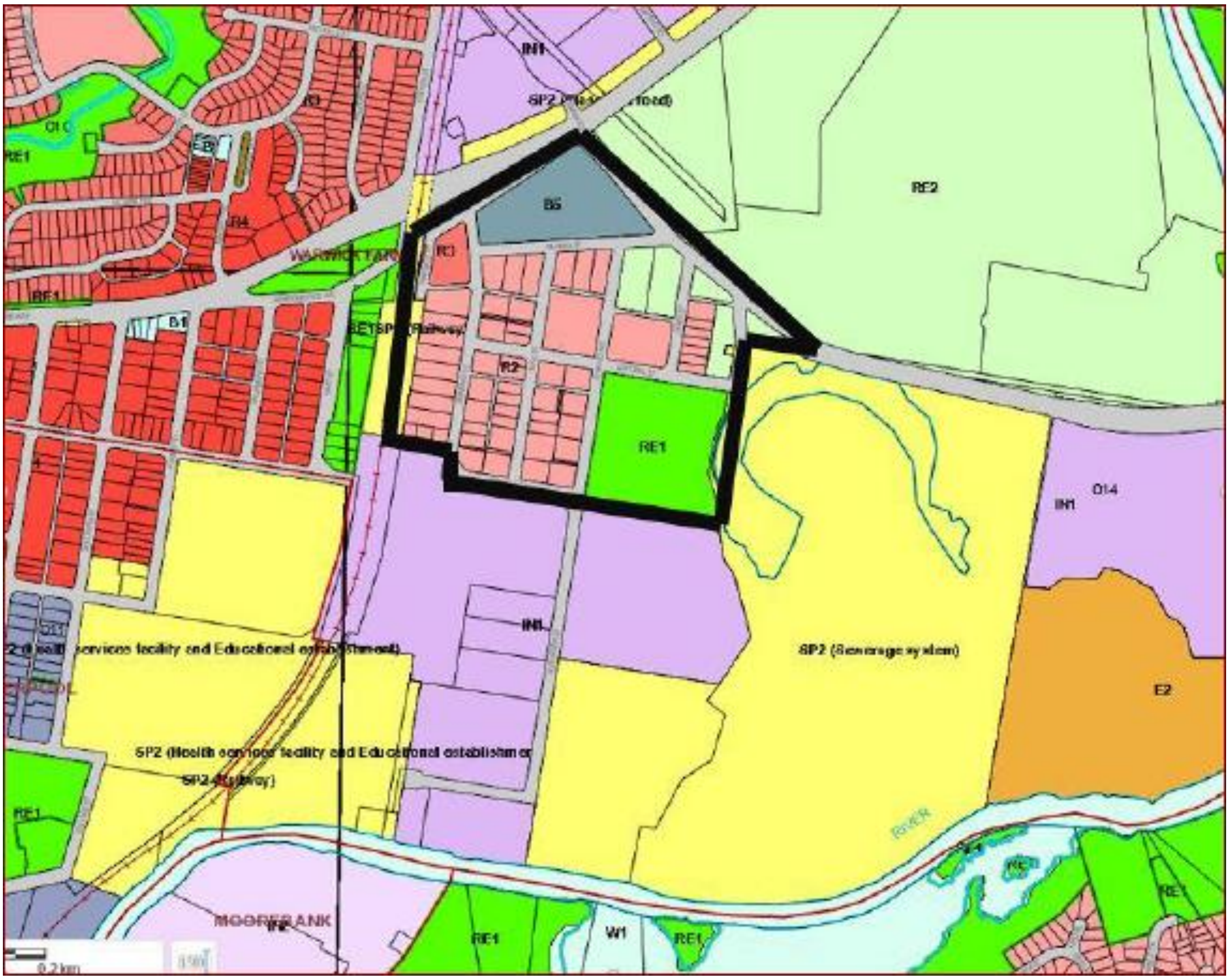
LIVERPOOL CITY COUNCIL

WARWICK FARM STRUCTURE PLAN AND PLANNING PROPOSAL FLOODING ASSESSMENT – FINAL REPORT



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Project **Warwick Farm Structure Plan and Planning Proposal Flooding Assessment – Final Report**			**Project Number** **120014**	
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AEP	Annual Exceedance Probability
AHD	Australian Height Datum
ARI	Average Recurrence Interval
ARR	Australian Rainfall and Runoff 1987 / 2019 editions
BoM	Bureau of Meteorology
DCP	Development Control Plan
EY	Exceedances per Year
FPL	Flood Planning Level
LEP	Local Environmental Plan
LGA	Local Government Area
LiDAR	Light Detection and Ranging or known as ALS (Airborne Laser Scanning)
mAHD	meters above Australian Height Datum
Mike-11	one-dimensional (1D) flood hydraulic computer model
PMF	Probable Maximum Flood
SES	State Emergency Services
TUFLOW	one-dimensional (1D) and two-dimensional (2D) flood hydraulic computer model

FOREWORD

The NSW State Government's Flood Policy provides a framework to ensure the sustainable use of floodplain environments. The Policy is specifically structured to provide solutions to existing flooding problems in rural and urban areas. In addition, the Policy provides a means of ensuring that any new development is compatible with the flood hazard and does not create additional flooding problems in other areas.

Under the Policy, the management of flood liable land remains the responsibility of local government. The State Government subsidises flood mitigation works to alleviate existing problems and provides specialist technical advice to assist councils in the discharge of their floodplain management responsibilities. The Federal Government may also provide subsidies in some circumstances.

The Policy provides for technical and financial support by the Government through four sequential stages:

1. Flood Study
- Determine the nature and extent of the flood problem.

2. Floodplain Risk Management Study
- Evaluates management options for the floodplain in respect of both existing and proposed development.

3. Floodplain Risk Management Plan
- Involves formal adoption by Council of a plan of management for the floodplain.

4. Implementation of the Plan
- Construction of flood mitigation works to protect existing development, use of Local Environmental Plans to ensure new development is compatible with the flood hazard.

A recently completed Georges River Flood Study (Reference 1) is in Draft stage in August 2021 and previously the Georges River Floodplain Risk Management Study and Plan was completed in May 2004 (Reference 2).

WMAwater was engaged to provide a flooding assessment of the Warwick Farm Structure Plan and Planning Proposal and has relied upon the above two references as well as guidelines provided in the 2005 NSW Government Floodplain Development Manual (Reference 3).

The work undertaken for this project was completed in two Stages. Stage 1 was completed in an initial report of June 2020. This initial report provided background to the flooding assessment but did not undertake any hydraulic modelling to assess the potential impacts of the Planning Proposal. Subsequently Stage 2 was undertaken which includes detailed hydraulic modelling. This current report is a combination of the Stage 1 and Stage 2 work.

TERMINOLOGY USED IN REPORT

Australian Rainfall and Runoff (ARR – Reference 4) have produced a set of guidelines for appropriate terminology when referring to the probability of floods. In the past, AEP has generally been used for those events with greater than 10% probability of occurring in any one year, and ARI used for events more frequent than this. However, the ARI terminology is to be replaced with a new term, EY.

Annual Exceedance Probability (AEP) is expressed using percentage probability. It expresses the probability that an event of a certain size or larger will occur in any one year, thus a 1% AEP event has a 1% chance of being equalled or exceeded in any one year. For events smaller than the 10% AEP event however, an annualised exceedance probability can be misleading, especially where strong seasonality is experienced. Consequently, events more frequent than the 10% AEP event are expressed as X Exceedances per Year (EY). Statistically a 0.5 EY event is not the same as a 50% AEP event, and likewise an event with a 20% AEP is not the same as a 0.2 EY event. For example, an event of 0.5 EY is an event which would, on average, occur every two years. A 2 EY event is equivalent to a design event with a 6-month average recurrence interval where there is no seasonality, or an event that is likely to occur twice in one year.

While AEP has long been used for larger events, the use of EY is to replace the use of ARI, which has previously been used in smaller magnitude events. The use of ARI, the Average Recurrence Interval, which indicates the long-term average number of years between events, is now discouraged. It can incorrectly lead people to believe that because a 100-year ARI (1% AEP) event occurred last year it will not happen for another 99 years. For example, there are several instances of 1% AEP events occurring within a short period, for example the 1949 and 1950 events at Kempsey.

Where the % AEP of an event becomes very small, for example in events greater than the 0.02 % AEP, the ARR draft terminology suggest the use of 1 in X AEP so a 0.02 % AEP event would be the same as a 1 in 5,000 AEP.

The PMF is a term also used in describing floods. This is the Probable Maximum Flood that is likely to occur. It is related to the PMP, the Probable Maximum Precipitation.

This report has adopted the approach of the ARR terminology guidelines and uses % AEP for all events the 50% AEP and greater and EY for all events smaller and more frequent than this. The image below provides the relationship between the various terminologies.

Frequency Descriptor	EY	AEP (%)	AEP (1 in x)	ARI
Very Frequent	12			
	6	99.75	1.002	0.17
	4	98.17	1.02	0.25
	3	95.02	1.05	0.33
	2	86.47	1.16	0.5
	1	63.21	1.58	1
Frequent	0.69	50	2	1.44
	0.5	39.35	2.54	2
	0.22	20	5	4.48
	0.2	18.13	5.52	5
	0.11	10	10	9.49
Rare	0.05	5	20	20
	0.02	2	50	50
	0.01	1	100	100
Very Rare	0.005	0.5	200	200
	0.002	0.2	500	500
	0.001	0.1	1000	1000
	0.0005	0.05	2000	2000
Extreme	0.0002	0.02	5000	5000
			↓	
			PMP/ PMPDF	

The blue shaded areas represent the terminology adopted in this report.

BRIEF OUTLINE OF HOW DESIGN FLOOD LEVELS ARE CALCULATED

There are two broad approaches for calculating design events (floods of a known probability of occurrence such as the old 100-year event now termed the 1% AEP). The first is to undertake statistical analysis (termed flood frequency analysis) of a long record of peak flood levels (such as recorded for over 100 years at Windsor). This approach is rarely used (but is possible for the Georges River) as there are few places where these accurate long-term records exist. The alternative method (termed rainfall runoff modelling) is to use computer models of the catchment which calculate peak flood levels (based on equations of flow) from design rainfall data provided by the Bureau of Meteorology (BoM). The BoM can calculate design rainfall depths across Australia based on an extensive and long-term record of historical rainfalls. The accuracy of the computer models is increased by "calibrating" them to historical flood height data using the actual rainfall records from that historical event. The models include detailed definition of the topography derived from laser aerial scanning of the ground (this data has a vertical accuracy of around +/- 150mm and is available at approximately 1m spacing).

EXECUTIVE SUMMARY

STUDY OBJECTIVE

The objective of this Report is to undertake a flooding assessment of the proposed Warwick Farm Structure Plan and Planning Proposal developed as part of the project. Given the relatively short timeframe for the project the Structure Plan / Planning Proposal can only be developed to Concept design stage. Consequently, the scope of the flooding assessment has been tailored accordingly.

PAST FLOOD STUDIES

Several past studies have looked at flooding in the Georges River. These studies provide historical flood data as well as an assessment of design flood levels and flood mitigation measures. The latest being the Draft January 2020 Georges River Flood Study (Reference 1). This study established a computer model (TUFLOW) which was calibrated to historical flood data and used to determine design flood levels, depths and velocities for a range of design flood events. This study has not been adopted by Liverpool City Council and design flood levels are taken from the May 2004 Georges River Floodplain Risk Management Study and Plan (Reference 2) which adopted a Mike-11 computer model.

EXISTING FLOOD PROBLEM

Flooding has occurred in the past but there are few recorded flood marks within the study area. All relevant available historical flood information is provided in the Draft January 2020 Georges River Flood Study (Reference 1).

POSSIBLE FLOODPLAIN MANAGEMENT MEASURES

Management measures to manage the flood problem can be subdivided into flood modification (changes the nature of flooding), property modification (changes to the property) or response modification (changes the response of people) measures as summarised below.

Flood Modification	Property Modification	Response Modification
Levees	House raising	Flood warning
Temporary defences	Voluntary purchase	Flood emergency management
Channel construction	Flood proofing	Community awareness
Channel modification	Land use zoning	Improved evacuation access
Major structure modification	Flood planning levels	Flood plan / recovery plan
Drainage network modification	Flood planning area	
Drainage maintenance	Changes to planning policy	
Retarding basins	Modification to S10.7 Certificate	
	Flood Insurance	

The prior 2004 Floodplain Risk Management Study (Reference 2) evaluated possible flood mitigation measures but did not provide specific measures for the study area. However, Liverpool City Council has a LEP and DCP incorporating best practice flood planning guidelines which are to be followed for any development proposal on the floodplain.

FLOODING ASSESSMENT OUTCOMES

The Planning Proposal is at Concept design stage. The following are required to be undertaken at the detailed design stage:

1. Confirmation with Council regarding the design flood levels and the numerical modelling approach to be adopted.
2. The 2005 NSW Floodplain Development Manual requires a Merits based assessment to be undertaken which balances the social, economic, environmental and flood risk parameters to determine the appropriateness and sustainability of the proposed development.
3. A cut / fill balance to the 1% AEP level has been adopted to date based on hydraulic modelling. A further flood impact assessment using a Council approved numerical model is to be undertaken for the 1% AEP to the PMF design events to confirm that increases in flood level on adjacent lands are in accordance with Council's LEP and DCP controls. The final cut / fill balance at the 1% AEP flood level must be confirmed.
4. The potential implications of climate change are minor and OSD is not required. These conclusions should be confirmed.
5. Council should verify that the High / Medium Flood Risk categorisation as provided in the Draft January 2020 Georges River Flood Study (Reference 1) has adequately considered evacuation. This is a critical issue as if the study area is considered High Risk residential development is not permitted.
6. The proposed development must comply with Clause 6 Direction 4.3 which specifies that a planning proposal must not contain provisions that apply to flood planning areas which permit a significant increase in the development of that land or are likely to result in a substantially increased requirement for government spending on flood mitigation measures, infrastructure or services.
7. The proposed development must comply with all the guidelines provided in Council's DCP, notably: residential floors are to be 0.5m above the 1% AEP flood level, all material below the 0.5m + 1% AEP flood level is to be flood compatible, all structures must be structural sound up to the 0.5m + 1% AEP flood level, car parking and driveway access are to be as specified in the DCP.
8. A key issue with this development is the evacuation of residents during a flood. Shelter in place is not appropriate and therefore there must be appropriate access from every building in events larger than a 1% AEP. The key features of the evacuation approach are:
    - All floors to be at or above 9m AHD (1% AEP + 0.5m).
    - All floors must be at least 0.3m above the surrounding ground / road to allow for local drainage.
    - All internal roads to be at or above 8.5m AHD (1 % AEP).
    - All roads or pedestrian access used for evacuation must rise to the PMF.
    - There must be either pedestrian or vehicle access from all floors that is always at or above 8.5m AHD (1 % AEP) to above to the PMF.

    The exact details can only be determined once the design has progressed. In addition, an appropriate Flood Emergency Plan must be developed that does not rely upon external bodies (SES, Police etc.). This Plan must be reviewed by the SES.
9. Consideration of the issues described in Section 5.3.

1. BACKGROUND

This assessment is composed of two phases:

1. Background and investigation of the flooding problem; and
2. Provision of flooding assessment outcomes for the proposed development (Section 5).

1.1. Objectives of Floodplain Risk Management

The objective of floodplain risk management is to investigate a range of flood mitigation works and measures to address the future and continuing flood problems, in accordance with the NSW Government's Flood Prone Land Policy. As the existing flood problem will be removed with the proposed development the review of existing flooding issues in the study area has not been considered in this assessment. Key aspects of this assessment include:

- Not increase the flood risk to people and property in the surrounding community.
- Ensure future development is controlled in a manner consistent with the flood risk (taking into account the potential impacts of climate change).
- Reduce private and public losses due to flooding.
- Protect and where possible enhance the creek and floodplain environment.
- Be consistent with the objectives of, the NSW Government's Flood Prone Land Policy and gazetted 2005 NSW Government Floodplain Development Manual (Reference 3).
- Ensure that the floodplain strategy is fully in accordance with Council's existing corporate, business and strategic plans (LEP and DCP), existing and proposed planning proposals, meets Council's obligations under the Local Government Act 1993, and has the support of the local community.
- Ensure actions undertaken are sustainable in social, environmental, ecological and economic terms.
- Ensure that the floodplain risk management strategy is fully integrated with the local emergency management plan (flood plan) and other relevant catchment management plans.

1.2. Catchment Description Overview (taken from Reference 1)

The Georges River catchment is one of the most populated catchments in Australia, with a population of approximately 1.2 million people, spanning eleven local government areas (LGAs), with five Councils covering 90% of the catchment area including Wollondilly Shire Council, Campbelltown City Council, Liverpool City Council, Fairfield City Council, and Canterbury-Bankstown Council. Due to this, the Georges River and its tributaries represent Sydney's most immediate flood problem area in terms of both population and properties affected, and the potential rise in flood damaged areas as development continues to increase within the catchment.

Records of flooding in the Georges River catchment extend back to February 1873 where anecdotal evidence claims this is the largest flood to have occurred, approximately 2 metres higher than the February 1956 event, and 3 metres higher than the August 1986 and April 1988 floods. Recorded flooding events also occurred in March 1978, March 1983, April 2015 and June 2016.

Of the flooding events that have occurred in the Georges River catchment, the 1986 and 1988 events were the largest to have occurred in the last 30 years. Their significance is not only related to their magnitudes, but also to the extent of damage caused. As a result of the 1988 flood, over 1000 residential properties were affected and $18 million of damages caused. Thus, with population growth and resultant increases in development, especially in flood-prone areas, the forecasted damages of future flooding events in the Georges River catchment are vast.

1.3. Previous Studies (taken from Reference 1)

Flood behaviour of the Georges River has been investigated on several occasions. The key catchment-wide studies relevant to this study include the 1991 Georges River Flood Study (Reference 5), the 1999 Georges River Model Study (Reference 6) and the 2004 Georges River Floodplain Risk Management Study and Plan (Reference 2). Flood flows were estimated using several different synthetic hydrologic models as part of the 1991 Georges River Flood Study (Reference 5). The computed discharge hydrographs were then input into a physical model to establish flood levels. The physical model extended between Liverpool and Picnic Point, having a horizontal scale of 1:500 and a vertical scale of 1:70. The model could operate under steady-state flood conditions or dynamic conditions.

The design flood level estimates from the 1991 Georges River Flood Study (Reference 5) were adopted by Council and are still used today in some instances. The study, in conjunction with later site-specific flood studies, resulted in the development of a Georges River Floodplain Risk Management Study and Plan, completed in 2004 by Bewsher Consulting (Reference 2) for Bankstown City, Liverpool City and Fairfield City Councils and Sutherland Shire Council.

1.4. Draft Liverpool Collaboration Area Place Study – Floodplain Constraints Study (Reference 7)

This study was completed to Draft stage in March 2020. Collaboration Areas are areas that have been identified by the Greater Sydney Commission where significant future growth is anticipated to occur, and where a co-ordinated multi stakeholder approach to planning for this growth is required. Liverpool was identified as a Collaboration Area in 2017-18. The Liverpool Collaboration Area Place Strategy sets out a shared vision for the area and identifies projects and initiatives to deliver the above vision. This includes Action 24, which is to: *"Prepare a floodplain constraints categorisation study (led by Liverpool City Council) and a flood evacuation study (led by the State Emergency Service)"*. This study represents the first part of Action 24 and considers those flood constraints that apply to the Liverpool Collaboration Area as a whole, and more specific constraints that apply to the 11 different Place Areas that comprise the Collaboration Area.

The Collaboration Area includes major floodplain areas of the Georges River, Anzac Creek, Cabramatta Creek, and Brickmakers Creek catchments. Flooding is therefore an important consideration to ensure that future development is appropriately conditioned to the flood risk, and that existing flooding problems in other areas are not exacerbated. The Warwick Farm Structure Plan is included wholly within Area 7 – Munday Street and partially within Area 8 – Eco / Utility.

The report provides an assessment of flood constraints including.

i. A review of relevant legislative requirements and policies relevant to the area.
ii. A review of flood investigations that are relevant to the assessment.
iii. Identification of flooding constraints that apply to the region as a whole.
iv. Other flooding constraints that apply to each specific Place Area.

Whilst consideration has been given to evacuation and access associated with each Place Area, an evacuation capability assessment for the wider floodplain that addresses the capability of transport routes and community resources to safely evacuate the existing and future population of the area was beyond the scope of the study.

On site Detention (OSD) was investigated and the following was concluded:
"OSD is also unlikely to have any significant impact on flood behaviour in the Georges River due to timing differences between the local catchment area and the wider Georges River Valley. OSD facilities are likely to overflow long before peak flow conditions are experienced in the Georges River, and therefore will be largely ineffective."

This report considered the impacts of climate change and stated:
The impact of climate change on flood behaviour is a necessary consideration when assessing future development proposals. It has previously been demonstrated (FloodMit, 2012) that projected sea level rise will have negligible impact on design flood levels in the upper reaches of the Georges River, including within the Collaboration Area. Any impacts from increased rainfall intensities are also considered to be minor whilst more conservative (1987) rainfall estimates are adopted in studies undertaken within the Georges River.

1.5. Available Design Flood Information

The project was provided with all available reports on flooding and topographic data was available from current LiDAR. The TUFLOW hydraulic model used in the Draft January 2020 Georges River Flood Study (Reference 1) was supplied by Council to undertake the flood impact assessment.

Liverpool City Council has advised that the TUFLOW hydraulic model from the Draft January 2020 Georges River Flood Study (Reference 1) is provided to developers for flood assessments but Council still adopts the design flood levels taken from the 2004 Georges River Floodplain Risk Management Study and Plan (Reference 2). Consequently the 1% AEP and PMF flood maps from Reference 2 were provided for use in the project. From these flood maps a 1% AEP flood level of 8.5m AHD (Diagram 2) and a PMF flood level of 10.8m AHD (Diagram 3) was adopted for the study area. However, it should be noted that the PMF level from the January 2020 Draft Georges River Flood Study (Reference 1) is approximately 12m AHD.

The 2004 Georges River Floodplain Risk Management Study and Plan (Reference 2) adopted a

Mike-11 hydraulic model to determine design flood levels (compared to the TUFLOW model adopted in Reference 1). The project was not provided with the Mike-11 model and thus could not run this model.

Unfortunately, the use of design flood results from Reference 2 and unavailability of the Mike-11 model means that updated hazard figures, flood risk figures etc. cannot be provided from this model. The project has therefore relied upon the figures taken from the TUFLOW results in the Reference 1 report (i.e., scan of results and not digitally derived). This approach is unorthodox and should be re-worked once the results from the January 2020 Draft Georges River Flood Study (Reference 1) are adopted by Council.

1.6. Australian Rainfall and Runoff 2019

1.6.1. Overview

The ARR guidelines published in 1987 (Reference 8) were updated in 2019 (Reference 4) due to the availability of numerous technological developments, a significantly larger rainfall dataset since 1987 and development of updated methodologies. The rainfall dataset includes a larger number of rainfall gauges which continuously recorded rainfall (pluviometers) and a longer record of storms (events from 1985 to 2015 are included).

Three major changes have been made to the approach adopted in ARR 1987 (Reference 8) in ARR 2019 (Reference 4).

1. The recommended Intensity, Frequency and Duration (IFD) rainfall data and initial and continuing loss values across Australia have been updated based on analysis of available records (available on the Bureau of Meteorology (BoM) website).
2. ARR 2019 recommends the analysis of 10 temporal patterns for each storm duration to determine the critical storm event. The critical storm event for a duration corresponds to the temporal pattern which produces the maximum average peak value from the 10 storms.
3. The inclusion of Areal Reduction Factors (ARFs) based on Australian data for short (12 hours and less) and long durations (larger than 12 hours). ARFs are an estimate of how design rainfall intensity varies over a catchment, based on the assumption that large catchments will not have a uniform depth of rainfall across their entire area.

1.6.2. Accuracy of the 2019 IFD Data

The 2019 IFD data (released in 2016 and thus referred to by the BoM below as 2016 IFD) can vary significantly from the previous 1987 IFD data. This issue is addressed by the text below taken from the BoM's web site (May 2019).

> The 2016 IFDs are based on a greatly expanded rainfall database and use contemporary methods for analysis of the rainfall data. In addition, the length of record available for each station has been maximised through quality control processes and Region of

Influence methods. The 2016 IFDs provide a better overall fit to the current rainfall database than the old IFDs.

As with all statistical methods, there is a level of uncertainty in the derived results due to the variability inherent in the data sample. In the 2016 IFDs this uncertainty has been reduced through the increased sample size afforded by the additional years of recorded data and inclusion of significant amounts of rainfall data from water agencies around the country.

The process of developing the new IFDs was guided and reviewed by a panel of experts set up by Engineers Australia. The differences in methods between the new IFDs and the ARR87 IFDs are summarised in Table 1 below:

Table 1: Comparison of New (2019) and Old (1987) IFD Data

Method	New IFDs	ARR87 IFDs
Number of rainfall stations	Daily read - 8074 Continuous – 2280	Daily read - 7500 Continuous - 600
Period of record	All available records up to 2012	All available records to up ~ 1983
Length of record used in analyses	Daily read >= 30 years Continuous > 8 years	Daily read >= 30 years Continuous > 6 years
Source of data	Bureau of Meteorology & other organisations collecting rainfall data	Primarily Bureau of Meteorology
Extreme value series	Annual Maximum Series (AMS)	Annual Maximum Series (AMS)
Frequency analysis	Generalised Extreme Value (GEV) distribution fitted using L-moments	Log-Pearson Type III (LPIII) distribution fitted using method of moments
Extension of sub-daily rainfall statistics to daily read stations	Bayesian Generalised Least Squares Regression (BGLSR)	Principal Component Analysis
Gridding	Regionalised at-site distribution parameters gridded using ANUSPLIN	Maps hand-drawn to at-site distribution parameters, digitised and gridded using an early version of ANUSPLIN

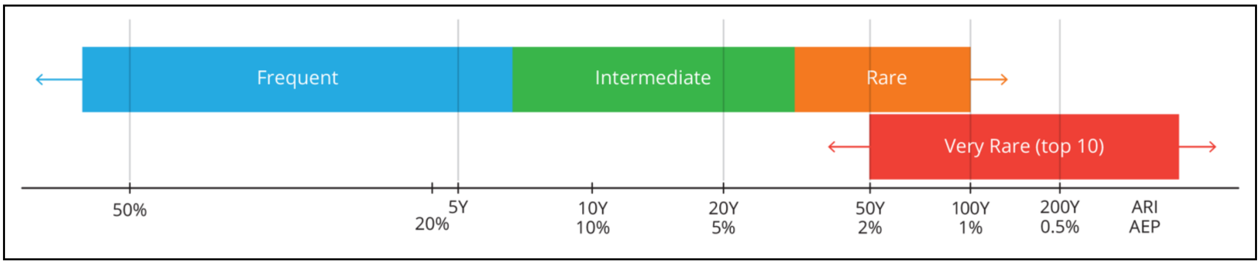
1.6.3. Storm Temporal Patterns

ARR 1987 provided a single temporal pattern for each storm duration for:

- events less than a 30-year ARI; and
- for events greater than a 30-year ARI.

ARR 2019 provides several patterns for each storm duration. The temporal patterns were extracted from storms occurring across Australia and are different for each region. The data hub provides a table with all the temporal patterns that could be used at a given location. The temporal patterns are grouped in bins based on the intensity of the recorded storms as shown in Diagram 1.

Diagram 1: Temporal Pattern Bins



ARR 2019 recommends the use of 10 temporal patterns for design storm analysis. The 10 patterns have the same total rainfall depth, but there are differences in rainfall distribution across the storm duration. Some patterns may represent storms with intense bursts at the start, middle or end of the storm duration, others represent storms with multiple bursts, and some may represent storms with constant rainfall. Different patterns can produce different peak flood levels for the same catchment area depending on the catchment topography and response.

The representative temporal pattern (used as part of the critical duration analysis) is the pattern which produces peak flood levels just greater than the average of the 10 temporal patterns (not the temporal pattern which produces the largest peak level) for each storm duration. This can be determined by running each of the 10 temporal patterns through the hydrologic and hydraulic models and obtaining the average flood level or peak flow produced. The critical storm duration is the duration whose representative temporal pattern produces the maximum flow or level (i.e the highest of the average values for all storm durations).

1.6.4. Summary

The 2019 revision of ARR includes a range of up-to-date methodologies and data for the determination of design flood levels and is therefore to be adopted rather than the 1987 version of ARR.

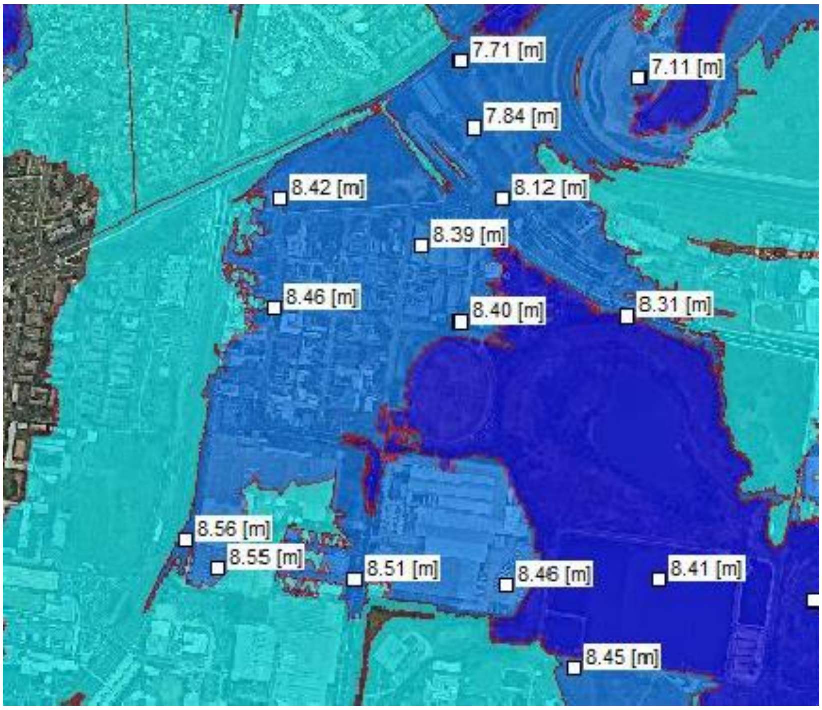
The recently completed Draft 2020 Georges River Flood Study (Reference 1) compared a variety of hydrologic approaches using both ARR 2019 and ARR 1987 data. The results are based on ARR 1987 data, as is the prior 2004 Georges River Floodplain Risk Management Study and Plan (Reference 2). However, the two studies are not directly comparable as different hydrologic approaches have been adopted. It should be noted that as this project has adopted peak levels from the latter (ARR 1987) study these may change if the ARR 2019 data and approaches are adopted.

2. EXISTING FLOOD BEHAVIOUR

2.1. Existing Flood Depths and Extents

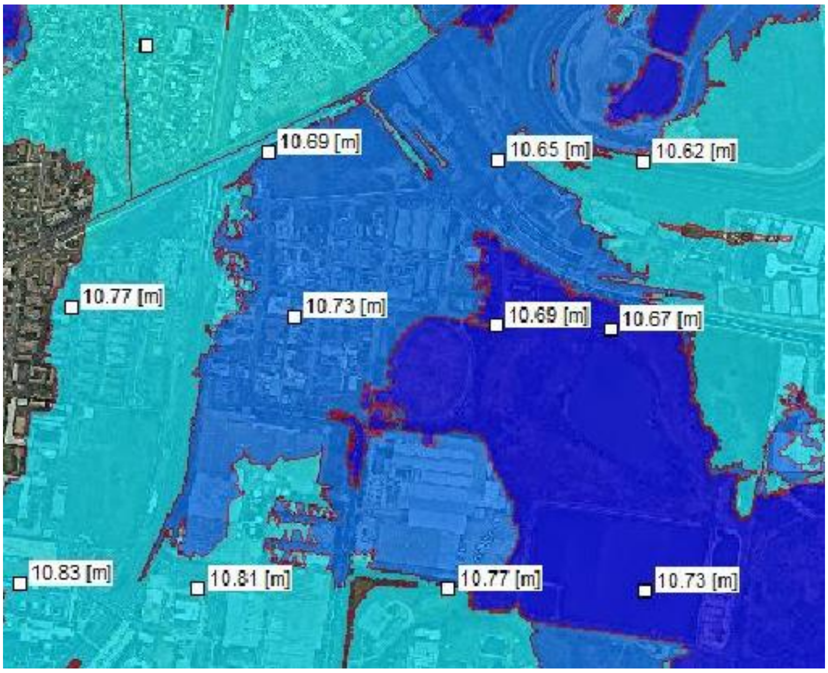
The existing peak flood depths and extents within the study area provided by Liverpool City Council taken from the 2004 Georges River Floodplain Risk Management Study and Plan (Reference 2) are shown in Diagram 2 and Diagram 3 below.

Diagram 2: 1% AEP Peak Flood Levels and Extents (Reference 2)



Note in both diagrams: Light blue = PMF extent, mid blue = 1% AEP extent

Diagram 3: PMF Peak Flood Levels and Extents (Reference 2)



2.2. Flood Hazard Categorisation

Provisional hazards in accordance with the NSW Floodplain Development Manual (Reference 3) only take account of the hydraulic aspects of flood hazard; depth and velocity (Diagram 4), while true hazard takes into account additional factors such as size of flood, effective warning time, flood readiness, rate of rise of floodwaters, duration of flooding, evacuation problems, effective flood access, type of development within the floodplain, complexity of the stream network and the inter-relationship between flows.

Diagram 4: Hazard Hydraulic Hazard Categories

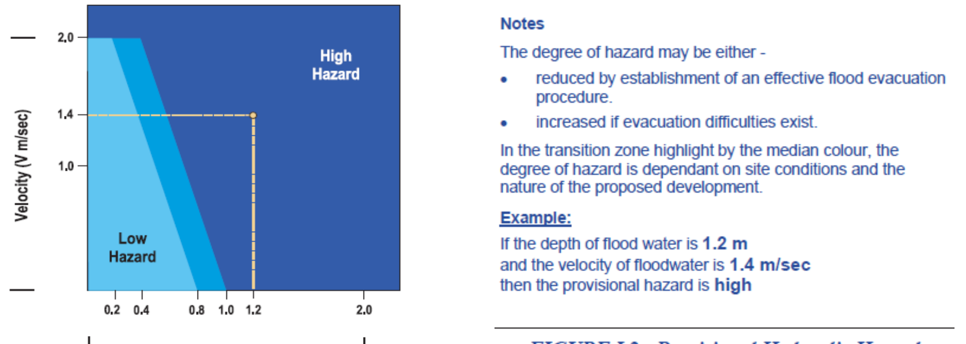


FIGURE L2 - Provisional Hydraulic Hazard Categories

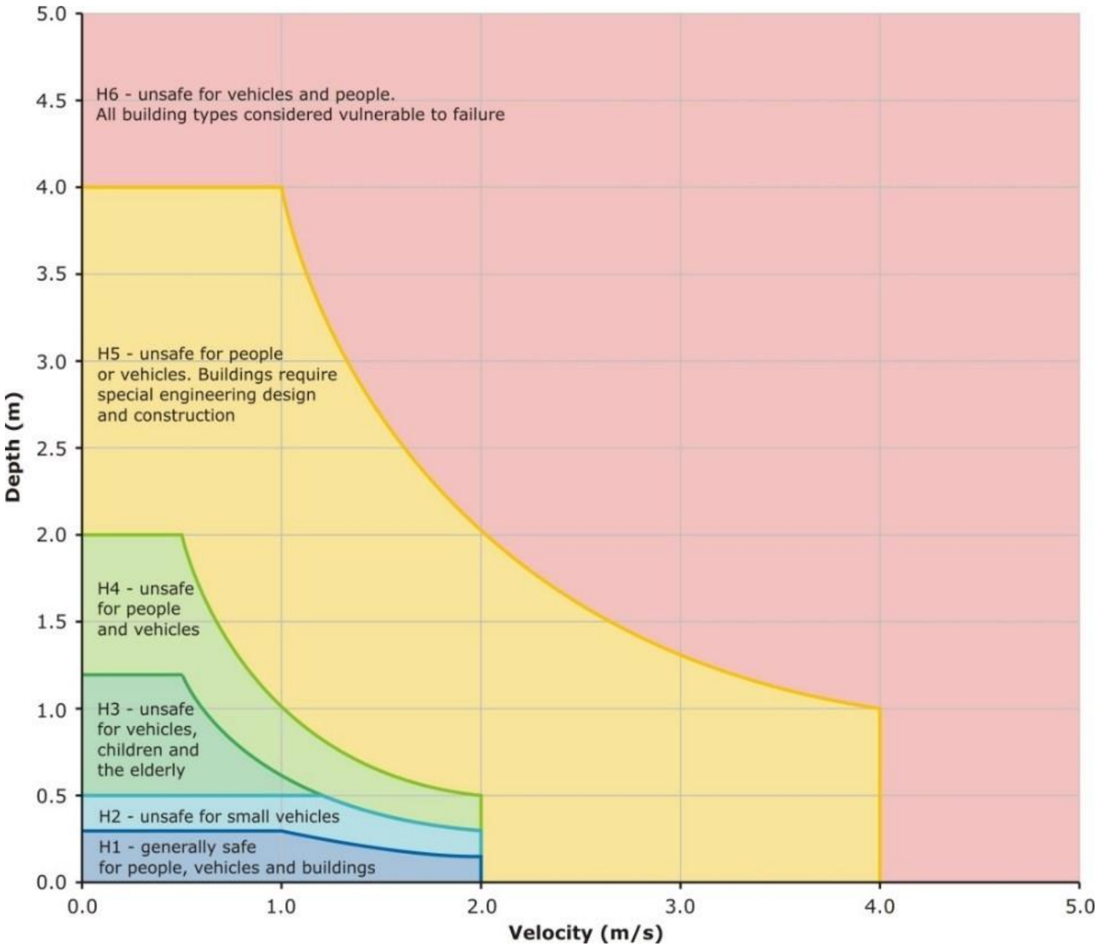
Extracted from The Floodplain Development Manual (Reference 3)

The 2004 Georges River Floodplain Risk Management Study and Plan (Reference 2) established high and low provisional hazard areas in accordance with the NSW Floodplain Development Manual (Reference 3).

In recent years there has been several developments in the classification of hazard. *Managing the floodplain: a guide to best practice in flood risk management in Australia* (Reference 9) provides revised hazard classifications. These add clarity to the description of hazard categories and what they mean in practice. The hazard classifications are divided into six categories (Diagram 5) which indicate the restrictions on people, buildings and vehicles:

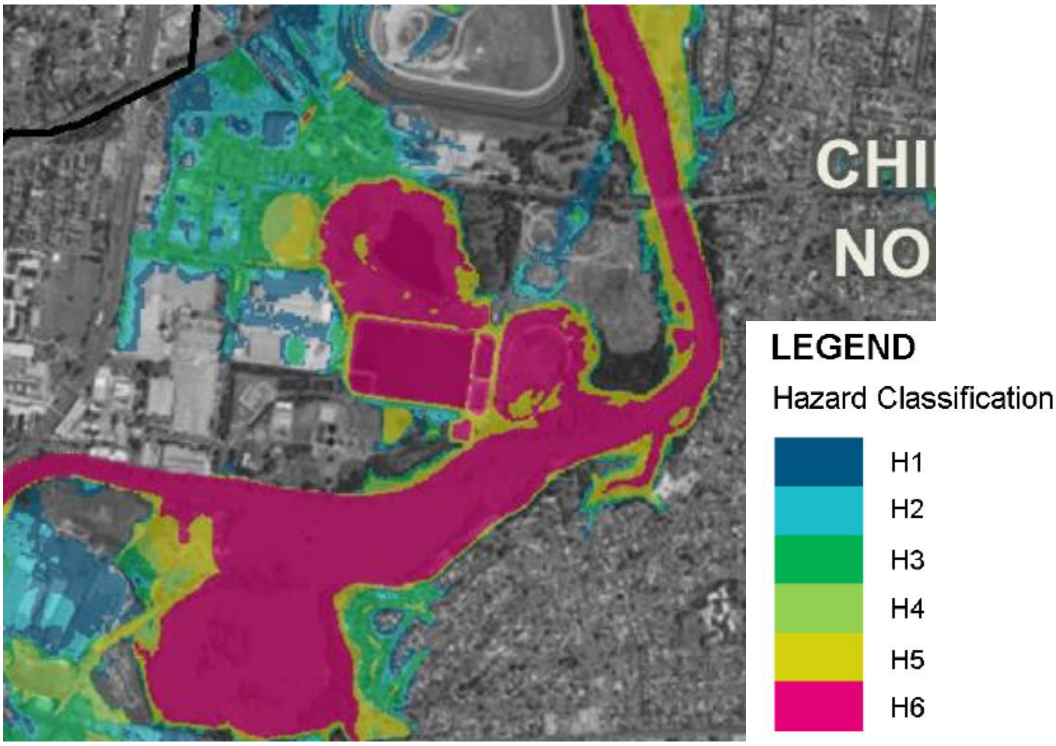
- H1 - Generally safe for vehicles, people and buildings,
- H2 - Unsafe for small vehicles,
- H3 - Unsafe for vehicles, children and the elderly,
- H4 - Unsafe for people and vehicles,
- H5 - Unsafe for people or vehicles. Buildings require special engineering design and construction, and
- H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure.

Diagram 5: Hazard Classifications (Reference 9)



Flood hazard classification was in the undertaken in the Draft 2020 Georges River Flood Study (Reference 1) in accordance with Diagram 5 as shown in Diagram 6.

Diagram 6: Hazard Classifications (Reference 1)



2.3. Hydraulic Categorisation

The NSW Government's Floodplain Development Manual 2005 (Reference 3) defines three hydraulic categories which could be applied to the study area, namely floodway, flood storage or flood fringe.

Floodways
"those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood levels."

***Flood storage* areas**
"*those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. Hence, it is necessary to investigate a range of flood sizes before defining flood storage areas.*"

Flood fringe
"the remaining area of flood prone land after floodway and flood storage areas have been defined"

Hydraulic categorisation was in the undertaken in the Draft 2020 Georges River Flood Study (Reference 1) but these figures have not been provided by Liverpool City Council.

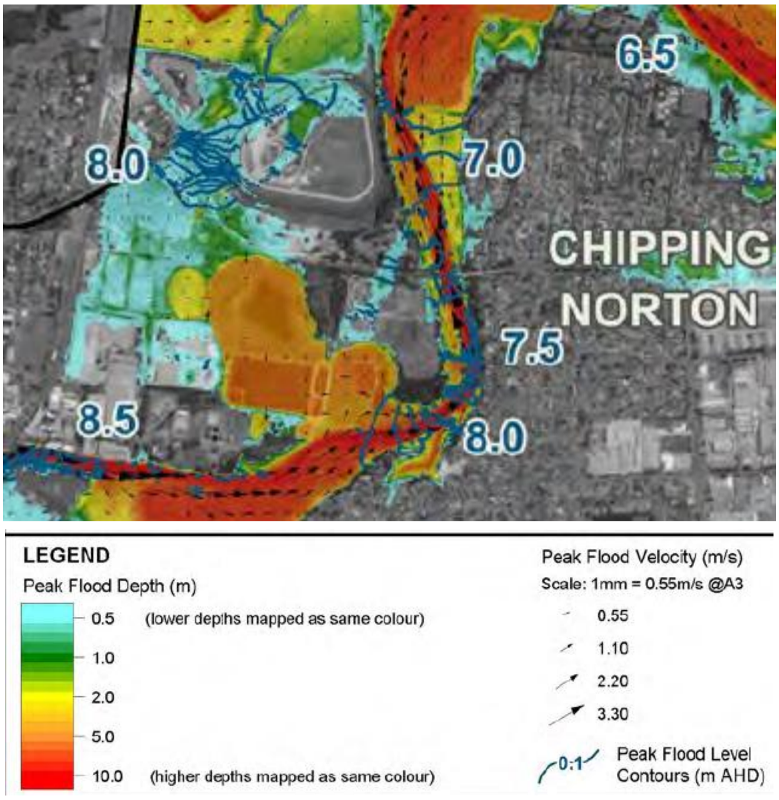
2.4. Emergency Response Planning Classifications

Emergency Response Planning (ERP) mapping has not been undertaken as part of the 2020 Draft Georges River Flood Study (Reference 1).

2.5. Road Inundation and Access

Understanding flood access issues is critical to effective evacuation and flood response planning. The Draft 2020 Georges River Flood Study (Reference 1) modelled peak flood depths and peak velocities and these are shown in Diagram 7 for the 1% AEP event (note a higher quality figure was not provided).

Diagram 7: 1% AEP Peak Depth and Peak Velocity (Reference 1)



Research undertaken for the revision of ARR 2019 indicates that if velocities approach 3 m/s, vehicles can become unstable in shallow depths of floodwaters (~0.1 m) and small cars can float in still water depths of only 0.3 m (Reference 10).

Information about the depths and velocities of road inundation and likely timing of road closures can aid flood response planning and ensure that evacuation and or emergency access occurs in a timely fashion. Additionally, early warning can allow motorists to better plan their route, make informed choices and thus avoid flood affected areas and road crossings. In many rural catchments flood depth indicator boards are located at frequently inundated crossings to warn motorists of the depth of flood waters. However, the SES advises that driving or walking through any depth of floodwaters should not be undertaken. In the Sydney basin these flood depth indicator boards are frequently found in rail or road bridge underpass areas where significant depths of floodwaters occur or in high-risk areas where motorists have had to be rescued in the past. The installation of flood depth indicator boards should be considered for frequently inundated crossings.

2.6. Flood Risk Precincts

(Text in italics taken from Reference 1) *Flood risk, or hazard, is a measure of the overall potential adverse impact of flooding that considers threat to life, danger and difficulty in evacuating people and possessions, and the potential for damage, social disruption and loss of production. The degree of flood risk varies across a catchment. The following categorisation is adopted by Liverpool City Council and has been applied in this study to identify relative risk within the catchment and to guide planning controls appropriate for the different flood risk categories:*

- *High Flood Risk – land below the 1% AEP flood level that is subject to a high hydraulic hazard (as defined in Figure L2 of the Floodplain Development Manual) or where there are significant evacuation difficulties.*
- *Medium Flood Risk – Land below the 1% AEP 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 (i.e. within the Extreme Flood extent) but not identified as either in a high 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.*

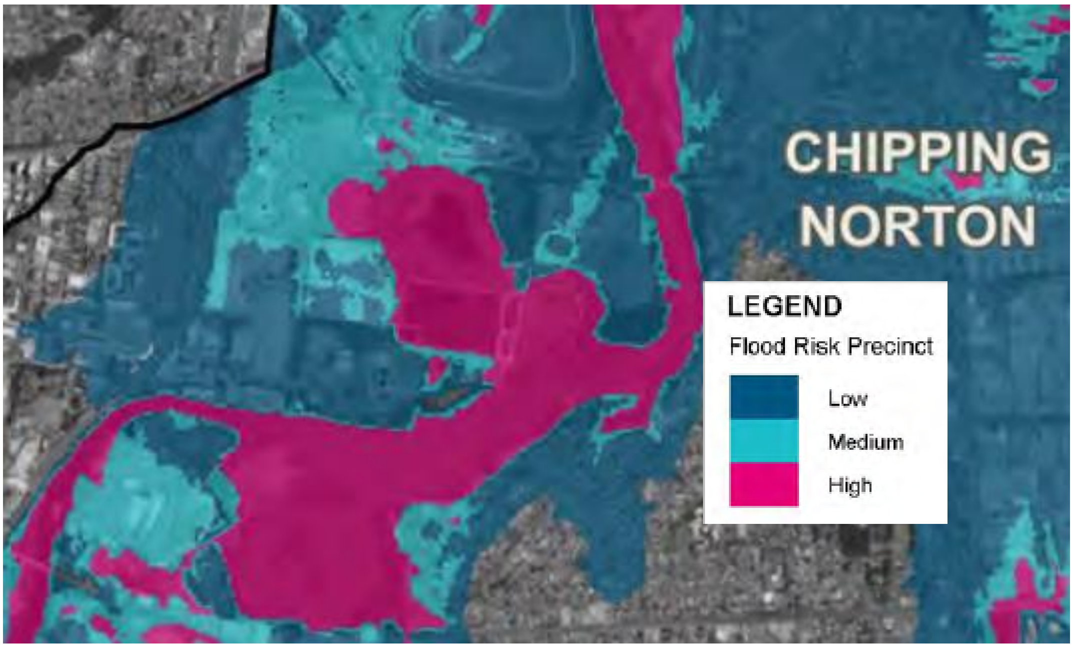
The ***medium flood risk*** *area is where there is still significant risk of flood damage, but where these damages can be minimised by the application of appropriate development controls.*

The ***low flood risk*** *area is that area above the 1% AEP flood, where the risk of damage is low based on the likelihood of flooding alone. Most land uses would be permitted within this area.*

The adopted flood risk precincts for the study area are shown in Diagram 8 (note a higher quality figure was not provided). Much of the inundated area at the 1% AEP design event is classed as high flood risk precinct.

A key issue is the separation of land inundated in the 1% AEP event into either a High or Medium flood risk precinct. The difference being that in a High flood risk precinct there are high flood damages, potential risk to life, or evacuation problems. It is unclear if and how these factors have been taken into account in the assessment provided in Diagram 8. Preliminary investigation suggests that the extent of the High flood risk precinct is H4 Hazard and greater and appears to ignore the effect of evacuation problems. This is a crucial issue as in a High flood risk precinct new residential development is not permitted (Reference 11).

Diagram 8: Flood Risk Precincts (Reference 1)



2.7. Existing Flood Mitigation Works in the Catchment

There are no flood modification works in the catchment which provide any significant reduction in flood level in the study area.

2.8. Flood Awareness

The flood awareness of the community and the available flood warning time are important factors in reducing the likely flood damages. Whilst some residents will have experienced small floods many of the affected properties in large floods will not have. People generally become aware of certain types of flooding and flood behaviour and are therefore less likely to be prepared for the impacts of a different magnitude flood such as the 1% AEP event as they are so familiar with smaller events.

A low level of awareness combined with a relatively short warning time are typical in urbanised areas such as the study area.

2.9. Flood Warning

A specific warning for the Georges River will be issued by the BoM. Severe Weather Warnings, Flood Watches and Warnings are issued by the BoM and evacuation warnings and orders are issued by the SES. The SES is the legislated combat agency for floods in NSW and is responsible for the control of flood response operations. It maintains a flood intelligence system for key flood warning gauges in NSW and develops specific flood emergency plans for LGAs which are subject to flooding.

2.10. Implications of Future Development

Future development can cause hydrological impacts, such as increased runoff due to increased area of impermeable land cover, as well as diversions of flows by blocking floodways or displacement of water in flood storage areas. Appropriate land zoning, planning and development controls such as OSD or retarding basins can reduce these impacts. Good planning controls will mean that as existing flood liable areas are redeveloped, they may become more flood compatible as developers are required to consider runoff from sites and impacts on overland flow paths and flood storage areas.

The other means by which future development can affect flood levels is through changes to infrastructure (construction of buildings or raising roads). This can be addressed by undertaking appropriate flood modelling to assess and mitigate any potential impacts.

2.11. Economic Impacts of Flooding

The impact of flooding can be quantified through the calculation of flood damages. Flood damage calculations do not include all impacts associated with flooding (for example it does not include worry, risk to life or injury). They do, however, provide a basis for assessing the economic loss of flooding and a non-subjective means of assessing the merit of flood mitigation works such as retarding basins, levees, drainage enhancement etc.

The quantification of flood damages is an important part of the floodplain risk management process. By quantifying flood damage for a range of design events, appropriate cost-effective management measures can be analysed in terms of their benefits (reduction in damages) versus the cost of implementation.

The cost of damage and the degree of disruption to the community caused by flooding depends upon many factors including the following.

- the magnitude (depth, velocity and duration) of the flood.
- land use and susceptibility to damages.
- awareness of the community to flooding.
- effective warning time.
- the availability of an evacuation plan or damage minimisation program.
- physical factors such as failure of services (sewerage), flood borne debris, sedimentation; and
- the types of assets and infrastructure affected.

The estimation of flood damages tends to focus on the physical impact of damages on the human environment but there is also a need to consider the ecological cost and benefits associated with flooding. Flood damages can be defined as being tangible or intangible. Tangible damages are those for which a monetary value can be easily assigned, while intangible damages are those to which a monetary value cannot easily be attributed. No current detailed flood damages assessment for the study area is available.

3. CURRENT PLANNING INSTRUMENTS AND LEGISLATION

3.1. National Provisions – Building Code of Australia

The Building Code of Australia (BCA) is a uniform set of technical provisions for the design and construction of buildings and other structures throughout Australia. The goals of the BCA are to enable the achievement and maintenance of acceptable standards of structural sufficiency, safety, health and amenity for the benefit of the community now and in the future.

The BCA contains requirements to ensure new buildings and structures and, subject to State and Territory legislation, alterations and additions to existing buildings located in flood hazard areas do not collapse during a flood when subjected to flood actions resulting from the defined flood event. The Standard provides additional requirements for buildings in flood hazard areas consistent with the objectives of the BCA which primarily aim to protect the lives of occupants of those buildings in events up to and including the defined flood event. Flood hazard areas are identified by the relevant State/Territory or Local Government authority.

The BCA is produced and maintained by the Australian Building Codes Board, and given legal effect through the *Building Act 1975,* which in turn is given legal effect by building regulatory legislation in each State and Territory. Any provision of the BCA may be overridden by, or subject to, State or Territory legislation. The BCA must therefore be read in conjunction with that legislation.

3.2. State Provisions

3.2.1. EP&A Act 1979

The NSW Environmental Planning and Assessment Act 1979 (EP&A Act) provides the framework for regulating and protecting the environment and controlling development.

3.2.2. Ministerial Direction 4.3

Pursuant to Section 117(2) of the EP&A Act, the Minister has directed that Councils have the responsibility to facilitate the implementation of the NSW Government's Flood Prone Land Policy. The objectives of Direction 4.3 are:

(a) to ensure that development of flood prone land is consistent with the NSW Government's Flood Prone Land Policy and the principles of the Floodplain Development Manual 2005, and

(b) to ensure that the provisions of an LEP on flood prone land is commensurate with flood hazard and includes consideration of the potential flood impacts both on and off the subject land.

Various clauses within Direction 4.3 provide additional legislation in regard to development on the floodplain. Clause 6 specifies that a planning proposal must not contain provisions that apply to flood planning areas which permit a significant increase in the development of that land or are likely to result in a substantially increased requirement for government spending on flood mitigation measures, infrastructure, or services.

3.2.3. NSW Flood Prone Land Policy

The primary objectives of the NSW Government's Flood Prone Land Policy are:

- to reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone land, and
- to reduce public and private losses resulting from floods whilst utilising ecologically positive methods wherever possible.

The NSW Floodplain Development Manual 2005 (Reference 3) relates to the development of flood prone land for the purposes of Section 733 of the Local Government Act 1993 and incorporates the NSW Flood Prone Land Policy.

The Manual outlines a merits approach based on floodplain management. At the strategic level, this allows for the consideration of social, economic, cultural, ecological and flooding issues to determine strategies for the management of flood risk.

The Manual recognises differences between urban and rural floodplain issues. Although it maintains that the same overall floodplain management approach should apply to both, it recognises that a different emphasis is required to address issues particular to a rural floodplain.

3.2.4. Planning Circular PS 07-003

Planning Circular PS 07-003 provides advice on a package of changes concerning flood-related development controls for land above the 1% AEP flood and up to the PMF.

Councils can make an application to the Department of Planning for exceptional circumstances for the inclusion of a Floodplain Risk Management Clause in the LEP, as per Planning Circular PS 07-003. This can be useful for areas where there are significant increases in flood risk associated with increased flood magnitude above the 1% AEP event. Some Councils, where this is an issue, choose to prohibit sensitive land uses below the PMF.

3.2.5. Section 10.7 (formerly Section 149) Planning Certificates

Section 10.7 Planning Certificates are issued in accordance with the EP&A Act 1979. They contain information on how a property may be used and the restrictions on development. A person may request a Section 10.7 certificate to obtain information about his or her own property but generally a Section 10.7 certificate will be requested when a property is to be redeveloped or sold. When land is bought or sold the Conveyancing Act 1919, requires that a Section 10.7 Planning Certificate be attached to the Contract for Sale.

3.3. Local Provisions

Appropriate planning restrictions, ensuring that development is compatible with flood risk, can significantly reduce flood damages. Planning instruments are used as tools to guide new development away from high flood risk locations and ensure that new development does not increase flood risk elsewhere. They can also be used to develop appropriate evacuation and disaster management plans to better reduce flood risks to the existing population. Councils use LEPs and DCPs to control development on flood prone land.

A LEP guides land use and development by zoning all land, identifying appropriate land uses that are allowed in each zone, and controlling development through other planning standards and DCPs. LEPs are made under the EP&A Act 1979 which contains mandatory provisions on what they must contain and the steps a Council must go through to prepare them. In 2006 the NSW Government initiated the Standard Instrument LEP program and produced a new standard format which all LEPs should conform to. Liverpool City Council's LEP 2008 was last updated on 15 January 2020.

The DCP is supplementary to the LEP and State Environmental Planning Policies (SEPPs). If there is any inconsistency between the DCP and the LEP, the LEP will prevail to the extent of the inconsistency.

A DCP specifies detailed guidelines and environmental standards for new development, which need to be considered in preparing a Development Application. The DCP provides a layered approach – some parts are relevant to all development, some to specific types of development, and some to specific land.

3.3.1. LEP 2008

Section 7.8 Flood Planning states.

(1) The objectives of this clause are as follows

(a) to minimise the flood risk to life and property associated with the use of land,

(b) to allow development on land that is compatible with the land's flood hazard, taking into account floodplain risk management studies and plans adopted by the Council and projected changes as a result of climate change, including sea level rise and rainfall intensity,

(c) to avoid significant adverse impacts, including cumulative impacts, on flood behaviour and the environment.

(2) This clause applies to land at or below the flood planning level.

(3) Development consent must not be granted to development on land to which this clause applies unless the consent authority is satisfied that the development

(a) is compatible with the flood hazard of the land, and

(b) will not significantly adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties, and

(c) incorporates appropriate measures to manage risk to life from flood, and

(d) will not significantly adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses, and

(e) is not likely to result in unsustainable social and economic costs to the community as a consequence of flooding, and

(f) is consistent with any relevant floodplain risk management plan adopted by the Council in accordance with the Floodplain Development Manual.

(4) A word or expression used in this clause has the same meaning as it has in the Floodplain Development Manual, unless it is otherwise defined in this Plan.

Section 7.8A Floodplain Risk Management states:

(1) The objectives of this clause are as follows

(a) in relation to development with particular evacuation or emergency response issues, to enable evacuation of land subject to flooding in events exceeding the flood planning level,

(b) to protect the operational capacity of emergency response facilities and critical infrastructure during extreme flood events.

(2) This clause applies to land between the flood planning level and the level of a probable maximum flood, but does not apply to land at or below the flood planning level.

(3) Development consent must not be granted to development for any of the following purposes on land to which this clause applies unless the consent authority is satisfied that the development is consistent with any relevant floodplain risk management plan adopted by the Council in accordance with the Floodplain Development Manual, and will not, in flood events exceeding the flood planning level, affect the safe occupation of, and evacuation from, the land

(a) caravan parks,

(b) centre-based child care facilities,

(c) correctional centres,

(d) emergency services facilities,

(e) group homes,

(f) hospitals,

(g) residential care facilities,

(h) respite day care centres,

(i) tourist and visitor accommodation.

(4) In this clause probable maximum flood has the same meaning as it has in the Floodplain Development Manual.

3.3.2. Liverpool Development Control Plan 2008, Section 9 Flooding Risk (Reference 11)

The objectives are:

a) To minimise the potential impact of development and other activity upon the aesthetic, recreational and ecological value of the waterway corridors.

b) To ensure essential services and land uses are planned in recognition of all potential floods.

c) To reduce the risk to human life and damage to property caused by flooding through controlling development on land affected by potential floods.

d) To ensure that the economic and social costs which may arise from damage to property due to flooding is minimised and is not greater than that which can be reasonably managed by the property owner and general community.

e) To limit developments with high sensitivity to flood risk (e.g. critical public utilities) to land with minimal risk from flooding.

f) To prevent intensification of inappropriate use of land within high flood risk areas or floodways.

g) To permit development with a lower sensitivity to the flood hazard to be located within the floodplain, subject to appropriate design and siting controls.

h) To ensure that development should not detrimentally increase the potential flood affectation on other development or properties either individually or in combination with the cumulative impact of development that is likely to occur in the same floodplain.

i) To ensure that development does not prejudice the economic viability of any Voluntary Acquisition Scheme.

4. FLOODPLAIN RISK MANAGEMENT MEASURES

A range of floodplain management measures have been considered to determine the effectiveness in managing future flood risks in the study area. The 2005 NSW Government's Floodplain Development Manual (Reference 3) separates risk management measures into three broad categories.

- **Flood modification measures** modify the physical behaviour of a flood including depth, velocity and redirection of flow paths. Typical measures include flood mitigation dams, retarding basins, channel improvement, levees or defined floodways.

- **Response modification measures** modify the response of the community to flood hazard by educating flood affected property owners about the nature of flooding so that they can make better informed decisions. Examples of such measures include provision of flood warning and emergency services, improved information, awareness and education of the community, and provision of flood insurance.

- **Property modification measures** modify the existing land use and development controls for future development. This is generally accomplished through such means as flood proofing, house raising or sealing entrances, strategic planning such as land use zoning, building regulations such as flood-related development controls, or voluntary purchase / voluntary house raising.

Table 2 provides a summary of typical floodplain risk management measures that are available. It should be noted that many of these management measures are not appropriate for the study area.

Table 2: Floodplain Risk Management Measures

Flood Modification	Property Modification	Response Modification
Levees	House raising	Flood warning
Temporary defences	Voluntary purchase	Flood emergency management
Channel construction	Flood proofing	Community awareness
Channel modification	Land use zoning	Improved evacuation access
Major structure modification	Flood planning levels	Flood plan / recovery plan
Drainage network modification	Flood planning area	
Drainage maintenance	Changes to planning policy	
Retarding basins	Modification to S10.7 Certificate	
	Flood Insurance	

A detailed assessment of the available floodplain management measures was undertaken in the 2004 Georges River Floodplain Risk Management Study and Plan (Reference 2). No measures were proposed which would significantly reduce flood levels within the study area. As part of the present study an overview of the above measures has been undertaken and have concluded that there are no applicable measures which can reduce the adopted design flood levels (refer Section 2.1).

5. FLOOD IMPACT ASSESSMENT

Stage 1 of the work completed in June 2020 did not include hydraulic modelling of the potential impacts of the Planning Proposal. This work was undertaken in Stage 2 and is described below.

5.1. Review of the January 2020 Draft Georges River Flood Study (Reference 1) TUFLOW model

5.1.1. Background

The modelling of floodplains to determine flood extents, depths and velocities is undertaken using a computer model. The most widely used model is called TUFLOW. The January 2020 Draft Georges River Flood Study undertaken by BMT used a 2017 model version termed TUFLOW HPC. This version was introduced in 2017 and includes a completely different mathematical scheme to solve the equations of flow compared to the TUFLOW Classic version.

A significant advantage of TUFLOW HPC is that it significantly reduces model run times. The Georges River model takes approximately 30 minutes to model the 1% AEP event using a 10m-by-10m grid (i.e., this is the smallest area that can be represented in the model). This grid size is reasonable for a large river system such as the Georges River but to model more precise detail of the Planning Proposal (e.g., flow between buildings such as in the Warwick Farm precinct) a smaller grid size is preferred.

The TUFLOW model was updated to include a building layer as there was none previously. It was also hoped that the grid size could be reduced and / or the model updated to the 2020 version of TUFLOW HPC. These updates are typically undertaken when detailed modelling of a small area within a larger model is required. However, sometimes these changes produce significant (say > 0.1m) changes in peak flood levels across the model area. A decision then needs to be made if these changes in flood level are acceptable or these upgrades should not be undertaken.

5.1.2. Investigation of Potential Changes to TUFLOW Grid Size and Model Version

WMAwater undertook various modelling scenarios for the 1% AEP event to determine if the grid size and model version changes could be adopted for use in this assessment. The key modelling scenarios (other scenarios were also undertaken) are described below.

Scenario 1: Comparison of a 10m-by-10m grid using the 2017 TUFLOW and the 2020 TUFLOW versions. Results indicate that the 1% AEP flood levels would rise by up to 0.3m at the site and further upstream if the 2020 TUFLOW version was adopted.
Scenario 2: Comparison of 10m-by-10m grid and 3m-by-3m grids using the 2017 TUFLOW version. Results indicate that the 1% AEP flood levels would reduce by up to -0.1m at the site and by over -0.4m upstream if the 3m-by-3m grid was adopted using the 2017 TUFLOW version. There are also significant changes in peak level downstream of the site.

Scenario 3: Comparison of 10m-by-10m grid and 3m-by-3m grids using the 2020 TUFLOW version. Results indicate that the 1% AEP flood levels would increase by up to +0.1m at the site and by over +0.2m upstream if the 3m-by-3m grid was adopted using the 2020 TUFLOW version. The 2020 TUFLOW version does not produce the significant changes in peak level downstream of the site as shown with the 2017 TUFLOW version.

The results from the above three scenarios are extremely variable and considerable effort would be required to resolve them. In consultation with Council Officers, the 10m-by-10m grid using the 2017 TUFLOW version (as used in Reference 1 with a building layer included and updated topography across the Warwick Farm precinct) has been adopted for the assessment of this Planning Proposal.

5.2. Hydraulic Modelling

Hydraulic modelling was undertaken for two reasons. Firstly, to ensure that the there is a cut / fill balance at the 1% AEP flood level of 8.5m AHD. Thus, the temporary floodplain storage capacity within the Precinct will be the same for design conditions as under existing conditions. Secondly, TUFLOW modelling was undertaken to determine the potential impacts of the Planning Proposal in terms of change in the 1% AEP flood level.

The results are provided on Table 3 and Figure 1.

Table 3: Comparison of Existing and Planning Proposal Design Temporary Floodplain Storage

Level (m AHD)	Existing (m3)	Planning Proposal (m3)	Difference (m3)
8	107,090	129,062	21,971
8.1	125,326	144,279	18,953
8.2	144,914	159,973	15,059
8.3	165,546	176,052	10,505
8.4	187,118	192,481	5,363
8.5	209,384	209,236	-148

Table 3 indicates that there is an increase in temporary floodplain storage within the precinct with the Planning Proposal compared to the existing scenario. This is because of the lowering of the ground within the three open space areas. At this concept stage there is not an exact match at the 1% AEP peak level, however the analysis will be redone at the detail design stage to ensure full compliance at the 1% AEP peak level.

Figure 1 indicates the change in the peak 1% AEP flood level with the Planning Proposal, compared to the existing building layouts and topography within the precinct. Within the precinct some areas are now raised and become not inundated whilst other areas are lowered and become inundated. Within the precinct the change in the 1% AEP peak flood level is within +/- 0.01m. Immediately downstream of the precinct in a north easterly direction there is a slight reduction in peak level of generally less than 0.05m. This occurs as the passage of flood waters through the site is constricted due to the raised ground surfaces (podiums) and road network. There is no change in peak 1% AEP flood level upstream of the precinct.

5.3. Other Flood Related Issues to be Considered

Council should be aware that the following risks are to be carefully managed at the detailed design stage.

- Construction of a basin with a water depth of over 2m represents a potential risk to residents in times of flood – appropriate design solutions (i.e., fencing, warning signs etc.) are to be carefully considered in the detailed design stage to minimise the risk to users of the open spaces and prevention of objects being drawn into the open space by flood waters.
- The basins will potentially drain slowly with the result being the ground surface being poorly drained. Therefore, the basins should be designed in a way to mitigate this with adequate distributed drainage.
- Design of the outlets from the basins will need to have non return valves to prevent inflow from the Georges River.
- Design of the outlets from the basins will need to be designed with adequate distributed drainage to minimise the risk of blockage or the potential risk of objects or people being drawn into them.

It should also be noted that:

- The temporary floodplain storage capacity at the 1% AEP peak flood level is maintained for design but the distribution of temporary storage at various depths is different to existing.
- The current design is planning for the 1% AEP level. In larger floods than the 1% AEP the design scenario will raise flood levels compared to existing conditions.

5.4. Outcomes

The Planning Proposal is at Concept design stage. The following are required to be undertaken at the detailed design stage:

1. Confirmation with Council regarding the design flood levels and the numerical modelling approach to be adopted.
2. The 2005 NSW Floodplain Development Manual requires a Merits based assessment to be undertaken which balances the social, economic, environmental and flood risk parameters to determine the appropriateness and sustainability of the proposed development.
3. A cut / fill balance to the 1% AEP level has been adopted to date based on hydraulic modelling. A further flood impact assessment using a Council approved numerical model is to be undertaken for the 1% AEP to the PMF design events to confirm that increases in flood level on adjacent lands are in accordance with Council's LEP and DCP controls. The final cut / fill balance at the 1% AEP flood level must be confirmed.

4. The potential implications of climate change are minor and OSD is not required. These conclusions should be confirmed.
5. Council should verify that the High / Medium Flood Risk categorisation as provided in the Draft January 2020 Georges River Flood Study has adequately considered evacuation. This is a critical issue as if the study area is considered High Risk residential development is not permitted.
6. The proposed development must comply with Clause 6 Direction 4.3 which specifies that a planning proposal must not contain provisions that apply to flood planning areas which permit a significant increase in the development of that land or are likely to result in a substantially increased requirement for government spending on flood mitigation measures, infrastructure or services.
7. The proposed development must comply with all the guidelines provided in Council's DCP, notably: residential floors are to be 0.5m above the 1% AEP flood level, all material below the 0.5m + 1% AEP flood level is to be flood compatible, all structures must be structural sound up to the 0.5m + 1% AEP flood level, car parking and driveway access are to be as specified in the DCP.
8. A key issue with this development is the evacuation of residents during a flood. Shelter in place is not appropriate and therefore there must be appropriate access from every building in events larger than a 1% AEP. The key features of the evacuation approach are:

   - All floors to be at or above 9m AHD (1% AEP + 0.5m).
   - All floors must be at least 0.3m above the surrounding ground / road to allow for local drainage.
   - All internal roads to be at or above 8.5m AHD (1 % AEP).
   - All roads or pedestrian access used for evacuation must rise to the PMF.
   - There must be either pedestrian or vehicle access from all floors that is always at or above 8.5m AHD (1 % AEP) to above to the PMF.

   The exact details can only be determined once the design has progressed. In addition, an appropriate Flood Emergency Plan must be developed that does not rely upon external bodies (SES, Police etc.). This Plan must be reviewed by the SES.
9. Consideration of the issues described in Section 5.3.

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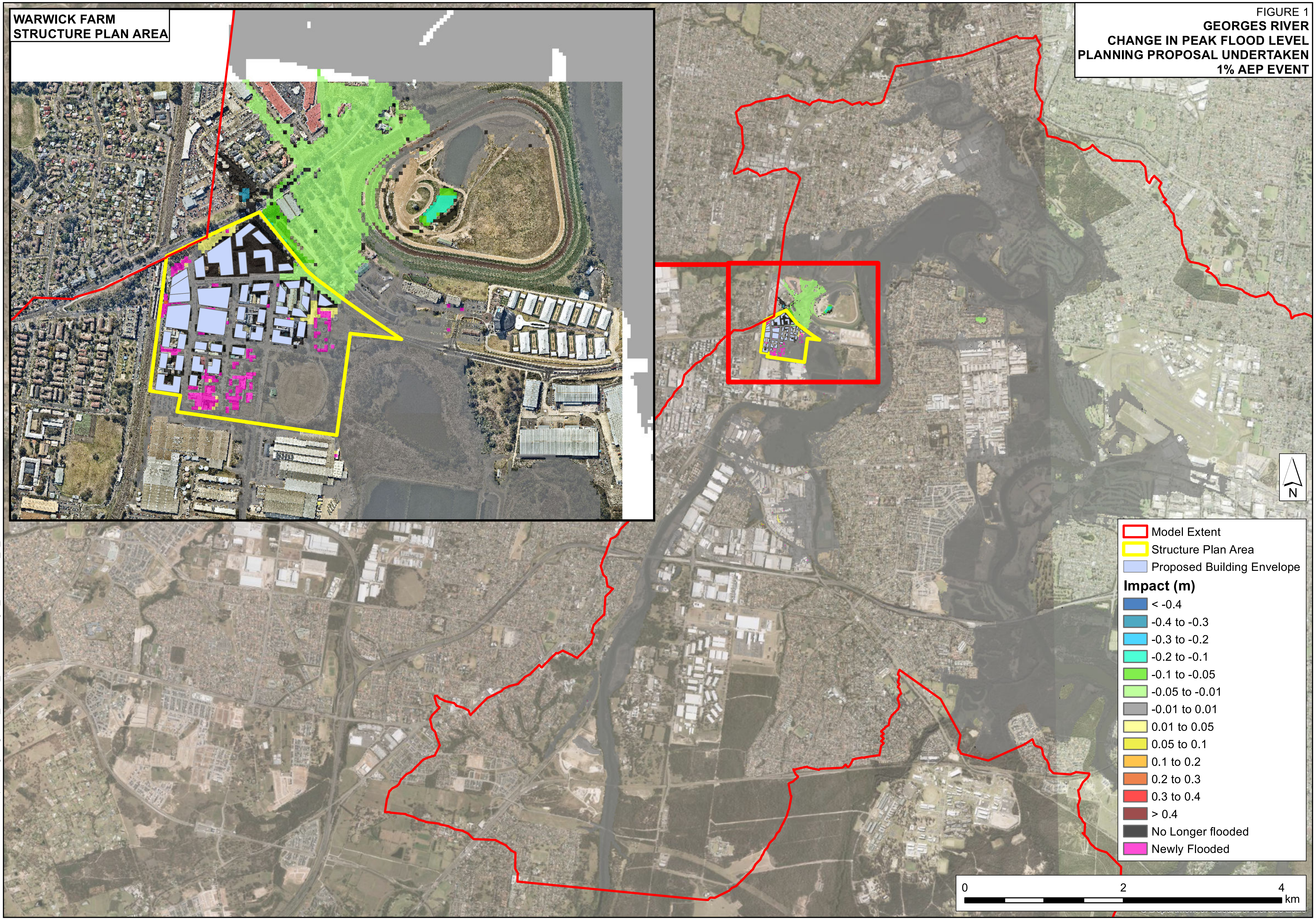
Figures



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Appendix A: Glossary of Terms

Appendix A

APPENDIX A: GLOSSARY OF TERMS

Taken from the Floodplain Development Manual (April 2005 edition)

acid sulfate soils	Are sediments which contain sulfidic mineral pyrite which may become extremely acid following disturbance or drainage as sulfur compounds react when exposed to oxygen to form sulfuric acid. More detailed explanation and definition can be found in the NSW Government Acid Sulfate Soil Manual published by Acid Sulfate Soil Management Advisory Committee.
Annual Exceedance Probability (AEP)	The chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage. For example, if a peak flood discharge of 500 m^3/s has an AEP of 5%, it means that there is a 5% chance (that is one-in-20 chance) of a 500 m^3/s or larger event occurring in any one year (see ARI).
Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level.
Average Annual Damage (AAD)	Depending on its size (or severity), each flood will cause a different amount of flood damage to a flood prone area. AAD is the average damage per year that would occur in a nominated development situation from flooding over a very long period of time.
Average Recurrence Interval (ARI)	The long term average number of years between the occurrence of a flood as big as, or larger than, the selected event. For example, floods with a discharge as great as, or greater than, the 20 year ARI flood event will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event.
caravan and moveable home parks	Caravans and moveable dwellings are being increasingly used for long-term and permanent accommodation purposes. Standards relating to their siting, design, construction and management can be found in the Regulations under the LG Act.
catchment	The land area draining through the main stream, as well as tributary streams, to a particular site. It always relates to an area above a specific location.
consent authority	The Council, Government agency or person having the function to determine a development application for land use under the EP&A Act. The consent authority is most often the Council, however legislation or an EPI may specify a Minister or public authority (other than a Council), or the Director General of DIPNR, as having the function to determine an application.
development	Is defined in Part 4 of the Environmental Planning and Assessment Act (EP&A Act). **infill development:** refers to the development of vacant blocks of land that are generally surrounded by developed properties and is permissible under the current zoning of the land. Conditions such as minimum floor levels may be imposed on infill development. **new development:** refers to development of a completely different nature to that associated with the former land use. For example, the urban subdivision of an area previously used for rural purposes. New developments involve rezoning and typically require major extensions of existing urban services, such as roads, water supply, sewerage and electric power. **redevelopment:** refers to rebuilding in an area. For example, as urban areas age, it may become necessary to demolish and reconstruct buildings on a relatively large scale. Redevelopment generally does not require either rezoning or major extensions to urban services.
disaster plan (DISPLAN)	A step by step sequence of previously agreed roles, responsibilities, functions, actions and management arrangements for the conduct of a single or series of connected emergency operations, with the object of ensuring the coordinated response by all agencies having responsibilities and functions in emergencies.

discharge	The rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second (m^3/s). Discharge is different from the speed or velocity of flow, which is a measure of how fast the water is moving for example, metres per second (m/s).
ecologically sustainable development (ESD)	Using, conserving and enhancing natural resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be maintained or increased. A more detailed definition is included in the Local Government Act 1993. The use of sustainability and sustainable in this manual relate to ESD.
effective warning time	The time available after receiving advice of an impending flood and before the floodwaters prevent appropriate flood response actions being undertaken. The effective warning time is typically used to move farm equipment, move stock, raise furniture, evacuate people and transport their possessions.
emergency management	A range of measures to manage risks to communities and the environment. In the flood context it may include measures to prevent, prepare for, respond to and recover from flooding.
flash flooding	Flooding which is sudden and unexpected. It is often caused by sudden local or nearby heavy rainfall. Often defined as flooding which peaks within six hours of the causative rain.
flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami.
flood awareness	Flood awareness is an appreciation of the likely effects of flooding and a knowledge of the relevant flood warning, response and evacuation procedures.
flood education	Flood education seeks to provide information to raise awareness of the flood problem so as to enable individuals to understand how to manage themselves and their property in response to flood warnings and in a flood event. It invokes a state of flood readiness.
flood fringe areas	The remaining area of flood prone land after floodway and flood storage areas have been defined.
flood liable land	Is synonymous with flood prone land (i.e. land susceptible to flooding by the probable maximum flood (PMF) event). Note that the term flood liable land covers the whole of the floodplain, not just that part below the flood planning level (see flood planning area).
flood mitigation standard	The average recurrence interval of the flood, selected as part of the floodplain risk management process that forms the basis for physical works to modify the impacts of flooding.
floodplain	Area of land which is subject to inundation by floods up to and including the probable maximum flood event, that is, flood prone land.
floodplain risk management options	The measures that might be feasible for the management of a particular area of the floodplain. Preparation of a floodplain risk management plan requires a detailed evaluation of floodplain risk management options.
floodplain risk management plan	A management plan developed in accordance with the principles and guidelines in this manual. Usually includes both written and diagrammatic information describing how particular areas of flood prone land are to be used and managed to achieve defined objectives.

flood plan (local)	A sub-plan of a disaster plan that deals specifically with flooding. They can exist at State, Division and local levels. Local flood plans are prepared under the leadership of the State Emergency Service.
flood planning area	The area of land below the flood planning level and thus subject to flood related development controls. The concept of flood planning area generally supersedes the flood liable land concept in the 1986 Manual.
Flood Planning Levels (FPLs)	FPLs are the combinations of flood levels (derived from significant historical flood events or floods of specific AEPs) and freeboards selected for floodplain risk management purposes, as determined in management studies and incorporated in management plans. FPLs supersede the standard flood event in the 1986 manual.
flood proofing	A combination of measures incorporated in the design, construction and alteration of individual buildings or structures subject to flooding, to reduce or eliminate flood damages.
flood prone land	Is land susceptible to flooding by the Probable Maximum Flood (PMF) event. Flood prone land is synonymous with flood liable land.
flood readiness	Flood readiness is an ability to react within the effective warning time.
flood risk	Potential danger to personal safety and potential damage to property resulting from flooding. The degree of risk varies with circumstances across the full range of floods. Flood risk in this manual is divided into 3 types, existing, future and continuing risks. They are described below. **existing flood risk:** the risk a community is exposed to as a result of its location on the floodplain. **future flood risk:** the risk a community may be exposed to as a result of new development on the floodplain. **continuing flood risk:** the risk a community is exposed to after floodplain risk management measures have been implemented. For a town protected by levees, the continuing flood risk is the consequences of the levees being overtopped. For an area without any floodplain risk management measures, the continuing flood risk is simply the existence of its flood exposure.
flood storage areas	Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. Hence, it is necessary to investigate a range of flood sizes before defining flood storage areas.
floodway areas	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flows, or a significant increase in flood levels.
freeboard	Freeboard provides reasonable certainty that the risk exposure selected in deciding on a particular flood chosen as the basis for the FPL is actually provided. It is a factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. Freeboard is included in the flood planning level.
habitable room	**in a residential situation:** a living or working area, such as a lounge room, dining room, rumpus room, kitchen, bedroom or workroom. **in an industrial or commercial situation:** an area used for offices or to store valuable possessions susceptible to flood damage in the event of a flood.
hazard	A source of potential harm or a situation with a potential to cause loss. In relation to this manual the hazard is flooding which has the potential to cause damage to

	the community. Definitions of high and low hazard categories are provided in the Manual.
hydraulics	Term given to the study of water flow in waterways; in particular, the evaluation of flow parameters such as water level and velocity.
hydrograph	A graph which shows how the discharge or stage/flood level at any particular location varies with time during a flood.
hydrology	Term given to the study of the rainfall and runoff process; in particular, the evaluation of peak flows, flow volumes and the derivation of hydrographs for a range of floods.
local overland flooding	Inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.
local drainage	Are smaller scale problems in urban areas. They are outside the definition of major drainage in this glossary.
mainstream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.
major drainage	Councils have discretion in determining whether urban drainage problems are associated with major or local drainage. For the purpose of this manual major drainage involves: • the floodplains of original watercourses (which may now be piped, channelised or diverted), or sloping areas where overland flows develop along alternative paths once system capacity is exceeded; and/or • water depths generally in excess of 0.3 m (in the major system design storm as defined in the current version of Australian Rainfall and Runoff). These conditions may result in danger to personal safety and property damage to both premises and vehicles; and/or • major overland flow paths through developed areas outside of defined drainage reserves; and/or • the potential to affect a number of buildings along the major flow path.
mathematical/computer models	The mathematical representation of the physical processes involved in runoff generation and stream flow. These models are often run on computers due to the complexity of the mathematical relationships between runoff, stream flow and the distribution of flows across the floodplain.
merit approach	The merit approach weighs social, economic, ecological and cultural impacts of land use options for different flood prone areas together with flood damage, hazard and behaviour implications, and environmental protection and well being of the State's rivers and floodplains. The merit approach operates at two levels. At the strategic level it allows for the consideration of social, economic, ecological, cultural and flooding issues to determine strategies for the management of future flood risk which are formulated into Council plans, policy and EPIs. At a site specific level, it involves consideration of the best way of conditioning development allowable under the floodplain risk management plan, local floodplain risk management policy and EPIs.
minor, moderate and major flooding	Both the State Emergency Service and the Bureau of Meteorology use the following definitions in flood warnings to give a general indication of the types of problems expected with a flood: **minor flooding:** causes inconvenience such as closing of minor roads and the submergence of low level bridges. The lower limit of this class of flooding on the reference gauge is the initial flood level at which landholders and townspeople begin to be flooded.

	moderate flooding: low-lying areas are inundated requiring removal of stock and/or evacuation of some houses. Main traffic routes may be covered. **major flooding:** appreciable urban areas are flooded and/or extensive rural areas are flooded. Properties, villages and towns can be isolated.
modification measures	Measures that modify either the flood, the property or the response to flooding. Examples are indicated in Table 2.1 with further discussion in the Manual.
peak discharge	The maximum discharge occurring during a flood event.
Probable Maximum Flood (PMF)	The PMF is the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation, and where applicable, snow melt, coupled with the worst flood producing catchment conditions. Generally, it is not physically or economically possible to provide complete protection against this event. The PMF defines the extent of flood prone land, that is, the floodplain. The extent, nature and potential consequences of flooding associated with a range of events rarer than the flood used for designing mitigation works and controlling development, up to and including the PMF event should be addressed in a floodplain risk management study.
Probable Maximum Precipitation (PMP)	The PMP is the greatest depth of precipitation for a given duration meteorologically possible over a given size storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends (World Meteorological Organisation, 1986). It is the primary input to PMF estimation.
probability	A statistical measure of the expected chance of flooding (see AEP).
risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of the manual it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
runoff	The amount of rainfall which actually ends up as streamflow, also known as rainfall excess.
stage	Equivalent to water level. Both are measured with reference to a specified datum.
stage hydrograph	A graph that shows how the water level at a particular location changes with time during a flood. It must be referenced to a particular datum.
survey plan	A plan prepared by a registered surveyor.
water surface profile	A graph showing the flood stage at any given location along a watercourse at a particular time.
wind fetch	The horizontal distance in the direction of wind over which wind waves are generated.