WEST KENSINGTON FLOODPLAIN RISK MANAGEMENT PLAN

FINAL – RANDWICK CITY COUNCIL

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FOREWORD

The State Government’s Flood Policy is directed at providing solutions to existing flooding problems in developed areas and to ensuring that 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 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.

The West Kensington Floodplain Risk Management Plan constitutes the third stage of the management process for the West Kensington catchment. WMAwater has been commissioned to undertake this study by Randwick City Council (RCC) and the City of Sydney (CoS). Funding assistance and specialist technical advice has also been provided by the NSW Department of Environment, Climate Change and Water (DECCW) (now Office of Environment and Heritage). The outcomes are to support the future management of flood liable lands in the West Kensington catchment.
EXECUTIVE SUMMARY

WEST KENSINGTON CATCHMENT
The West Kensington catchment covers approximately 0.9 km$^2$ and drains predominantly from east to west. It is bounded by Moore Park golf course to the north; The Australian golf course to the south, South Dowling Street to the west and is predominantly zoned for residential usage. The study area lies within the upper reaches of the broader (2.5 km$^2$) Green Square – West Kensington (GSWK) catchment.

Urbanisation has dramatically altered the nature of available drainage within the catchment. Flood problems typically result from ponding in trapped low-points such as those found in Milroy Avenue, McDougall Street and at the Lenthall Street underpass below the Eastern Distributor. Ponding also occurs at various locations along the eastern side of South Dowling Street. A number of the trapped low points in West Kensington are known to have experienced severe flooding during the November 1984 events.

The NSW Government's Flood Policy provides for:
- a framework to ensure the sustainable use of floodplain environments,
- solutions to flooding problems,
- a means of ensuring new development is compatible with the flood hazard.

Implementation of the Policy requires a four stage approach, the first of which is preparation of a Flood Study to determine the nature and extent of the flood problem. This is followed by a Floodplain Risk Management Study which examines management measures. The subsequent Floodplain Risk Management Plan details the adopted measures and ultimately the works are undertaken in the final stage. This report documents the Floodplain Risk Management Plan for the West Kensington catchment.

WEST KENSINGTON FLOOD STUDY
The GSWK catchment is known to have experienced flooding of roads, residential properties and commercial areas. The most recent significant floods occurred in November 1984.

The GSWK Flood Study (Reference 1) was jointly undertaken by both City Of Sydney (CoS) and Randwick City Council (RCC) to quantity existing flood behaviour and identify flood risk management issues within the area. As part of the subsequent GSWK Floodplain Risk Management Study (Reference 2), the models of the West Kensington area were refined to take advantage of more detailed topographic data made available by RCC. The specific objectives of the Flood Study components were to:
- define flood behaviour in the West Kensington catchment,
- prepare flood hazard and flood extent mapping,
- prepare suitable models of the catchment and floodplain for use in a subsequent Floodplain Risk Management Study and Plan.

Hydrologic and hydraulic investigations have been undertaken to determine the response of the
catchment and drainage system to 50% AEP (1 in 2 year), 20% (1 in 5 year), 5% AEP (1 in 20 year), 2% AEP (1 in 50 year), 1% AEP (1 in 100 year) and 0.2% AEP (1 in 500 year) events and the Probable Maximum Flood (PMF). The results of these investigations are documented in the two studies and included peak pipe capacities in addition to peak flood levels, flows and velocities within the floodplain.

EXISTING FLOOD PROBLEM
A flood damages assessment for existing development was undertaken for a range of design events. This assessment was based on a detailed survey of building floor levels in the West Kensington area. The estimated number of residential building floors which are likely to be inundated in the 5 year ARI is 25 and 55 in the 100 year ARI. In the PMF up to 154 building floors would be inundated. The annual average damages were estimated to be close to $0.5million. No consideration has been given for damages to public structures or utilities (bridges, roads, pumping stations) or for the complete collapse of structures due to flooding.

FUTURE DEVELOPMENT
The majority of the catchment has been developed for residential usage and there is limited pressure to re-develop existing properties on the floodplain.

WEST KENSINGTON CATCHMENT FLOODPLAIN RISK MANAGEMENT STUDY
The specific aims of this study were to:

- refine the existing Flood Study models of the West Kensington area to take advantage of more detailed topographic data,
- analyse the Flood Study results to determine flood damages and flood hazard for existing conditions,
- identify development and planning controls to regulate redevelopment in the flood affected properties and to ensure that future redevelopment does not significantly add to the overall potential damage,
- make recommendations to adopt Flood Planning Levels (FPL) appropriate for the catchment,
- investigate available floodplain risk management measures along with prioritisation, and staging of works.

FLOODPLAIN RISK MANAGEMENT MEASURES
A list of all possible floodplain risk management measures which could be applied in the study area were initially developed for consideration. The assessment extended to examination of potential future development and its possible adverse impacts on flows and water quality. The measures were then assessed in terms of their suitability and effectiveness for minimising social, ecological, environmental, cultural and economic impacts. As part of this process a number of measures were identified as not being worthy of further consideration.

A summary of the various floodplain management measures considered during the course of the Floodplain Risk Management Study is presented in Table i) and Figure A, including a brief assessment of their viability for implementation as part of the Floodplain Risk Management Plan for the West Kensington catchment.
### Table i): Review of Floodplain Management Measures

<table>
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<tr>
<th>MEASURE</th>
<th>PURPOSE</th>
<th>COMMENTS</th>
<th>ECONOMIC ASSESSMENT</th>
<th>IMPLEMENTATION VIABILITY</th>
<th>ACTION</th>
<th>PRIORITY</th>
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<td><strong>FLOOD MODIFICATION MEASURES:</strong></td>
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<tr>
<td>FLOOD DAMS</td>
<td>Mitigation</td>
<td>Reduce flows from upper catchment areas, water storage.</td>
<td>Major dams are not practical. Many issues (cost, social, environmental) would need to be resolved in order to justify construction of major dams and any land acquisition process.</td>
<td>Generally not viable for small urban catchments.</td>
<td>Not viable. No further consideration to be given.</td>
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<tr>
<td>RETARDING (DETENTION) BASINS</td>
<td>Reduce flows from upper catchment areas. A number of basins already exist within the catchment. Opportunities for new basins within the catchment are constrained by land availability. Several locations currently being considered for larger basins include upstream of Joynton Avenue lowpoint (Precinct E) and the Moore Park golf course.</td>
<td>Generally not viable from a purely flooding perspective but more attractive if has water quality and stormwater harvesting benefits.</td>
<td>To be considered as a means of mitigating the effects of urban development.</td>
<td>Potential for detention basin / stormwater harvesting basin within Moore Park golf course to be further investigated. Council to discuss options with Moore Park golf club.</td>
<td>Medium</td>
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<tr>
<td>PIT/PIPE and TRUNK SYSTEM UPGRADE</td>
<td>To minimise overland flooding, particularly for smaller, more frequent events</td>
<td>Upgrades of trunk capacity are being considered at a number of locations, particularly where associated with re-development activities. Regional upgrades being considered as part of major urban renewal (e.g. Mid-Block and GSTC precincts), local improvements considered for established areas (e.g. Duke St).</td>
<td>Urban renewal activities provide opportunity to account for typically high costs as part of overall re-development. However, costs can be significant where there are conflicts with existing services infrastructure.</td>
<td>To be considered as part of any urban re-development activities. Must ensure that any improvements in upstream pipe capacity results in no adverse impacts downstream.</td>
<td>Upgrade pipe network in vicinity of Duke Street &amp; Balfour Road. Undertake discussions with City of Sydney (CoS) &amp; Sydney Water regarding potential upgrades to downstream trunk system as part of re-development activities within CoS LGA. Investigate options jointly with the RTA to manage impacts of the sound walls on South Dowling Street. Apart from these options no further consideration to be given to trunk drainage upgrades.</td>
<td>Medium</td>
</tr>
<tr>
<td>LEVEES, FLOOD</td>
<td>Prevents or reduces</td>
<td>No appropriate sites.</td>
<td>Not undertaken.</td>
<td>Not applicable.</td>
<td>No further consideration to be given.</td>
<td></td>
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<tr>
<td>GATES AND PUMPS</td>
<td>the frequency of inundation of protected areas, assists in reducing problems with local runoff issues.</td>
<td>to be given.</td>
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<tr>
<td>MANAGEMENT OF BLOCKAGE</td>
<td>Minimise opportunity for blockage to ensure that drainage system operates effectively during an event. Blockage of inlets and culverts is a major problem in urban catchments, can significantly affect local flood levels. Measures can include street sweeping, inlet works etc. Relatively low cost to implement although benefits are difficult to quantify due to uncertainties in blockage behaviour. Measures to manage blockage within the system are relatively easy to implement and should be actively supported.</td>
<td>Council to consider blockage protection works at major trapped low points and undertake works as appropriate.</td>
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<td>PROPERTY MODIFICATION MEASURES:</td>
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<td>HOUSE RAISING</td>
<td>Prevent flooding of existing buildings by raising habitable floor levels. No suitable buildings found within the study catchment. High cost per property. May introduce social problems. Not considered suitable.</td>
<td>No further consideration to be given.</td>
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<tr>
<td>VOLUNTARY HOUSE PURCHASE</td>
<td>To remove flood liable houses from the floodplain. May be limited opportunities within West Kensington catchment. Not financially viable due to the high cost of acquisition. Do nothing.</td>
<td>No further consideration to be given.</td>
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<tr>
<td>FLOOD PROOFING</td>
<td>Prevents inundation of floodwaters. Generally only suitable for non-residential buildings. Depends upon building. Not funded by the State Government. To be promoted where applicable.</td>
<td>Only suitable for retrofitting of existing development by property owner. No further consideration to be given for the use of flood proofing for new development.</td>
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<tr>
<td>FLOOD PLANNING LEVELS</td>
<td>To minimise flood damages to new developments. Existing controls have been reviewed for both Councils and potential improvements have been suggested. Negligible cost. Amendments and improvements to be prepared by Council.</td>
<td>Council to consider adoption of consistent FPLs. To be implemented via creation of appropriate planning instruments (see below).</td>
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<tr>
<td>DEVELOPMENT CONTROL PLANNING</td>
<td>To ensure new development reduces the flooding and drainage impacts on downstream properties, the pollutant loads and conserves potable water supplies. Existing guidelines have been reviewed and possible improvements have been suggested. All Development Applications in the floodplain must be supported by a Flood Study. Negligible cost. Amendments to be considered.</td>
<td>Council to implement suitable development controls through the creation of appropriate planning instruments. Provide appropriate flood-related information on planning certificates.</td>
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<tr>
<td>CLIMATE CHANGE</td>
<td>Assess possible impacts of climate change and include in Potential increases in rainfall intensity will affect the entire catchment. Unknown. To be considered.</td>
<td>Incorporate climate change risk into Flood Planning Levels.</td>
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## Flood Planning Level

**To minimise runoff volume, rate of runoff and to improve runoff quality.**

**Should be employed where opportunities arise.**

**Variable.**

**To be promoted.**

**Incorporate WSUD in planning controls and future Council works as appropriate.**

## RESPONSE MODIFICATION MEASURES:

### FLOOD WARNING

**Enable people to evacuate and take measures to reduce flood damages.**

**An effective flood warning system is not possible due to the short response time of the Green Square – West Kensington catchment.**

**Not applicable.**

**Not viable.**

**No further action by Council required.**

### EMERGENCY RESPONSE PLANNING

**To ensure that evacuation can be undertaken in a safe and efficient manner.**

**The SES should prepare a Local Flood Plan.**

**Relatively low cost.**

**Recommended.**

**Provide SES with flood information and work together to prepare Local Flood Plan.**

**High.**

### PUBLIC INFORMATION COMMUNITY AWARENESS AND RESPONSE

**Educate people on flood risk and community preparedness to minimise flood damages and reduce the flood risk.**

**A cheap and effective method but requires continued effort. Examples of methods are provided.**

**Benefits likely to be significant for relatively low cost. Effectiveness reduces with time since last flood.**

**Recommended.**

**Develop and implement suitable flood awareness program. Maintain flooding database. Provide access to flood studies, floodplain risk management studies and plans via Council’s website.**

**High.**
FIGURE A
OVERVIEW OF WEST KENSINGTON FLOODPLAIN RISK MANAGEMENT PLAN

OUTCOMES FOR SITE SPECIFIC WORKS IN WEST KENSINGTON AREA
(refer to Adjacent Map)

HIGH PRIORITY ACTIONS:
Management of Blockage
  - Consider works to minimise blockage at major trapped low points and undertake works as appropriate

MEDIUM PRIORITY ACTIONS:
Pit/Pipe and Trunk System Upgrades
  - Upgrade pipe network in vicinity of Duke Street and Balfour Road.
  - Undertake discussions with City of Sydney (CoS) & Sydney Water regarding potential upgrades to downstream trunk system as part of re-development activities within CoS LGA.
  - Apart from these options no further consideration to be given to trunk drainage upgrades.
Detention Basins
  - Potential for detention basin/stormwater harvesting basin within Moore Park Golf Course to be further investigated.
  - Council to discuss options with Moore Park Golf Club.

OUTCOMES FOR BROADER WEST KENSINGTON AREA

HIGH PRIORITY ACTIONS:
Planning Instruments and Development Controls
  - Implement suitable development controls through creation of appropriate planning instruments.
  - Provide appropriate flood-related information on planning certificates.
Flood Planning Levels (FPLs)
  - Consider adoption of consistent Flood Planning Levels.
  - FPLs to be implemented via creation of appropriate planning instruments.
Public Information, Community Flood Awareness and Response
  - Develop and implement flood awareness program.
  - Formalise and maintain flooding database.
  - Provide free access to flood related information such as flood studies, floodplain risk management studies and plans (e.g. via Council web-site).
Emergency Response Planning
  - Council to provide SES with flood information and work together to prepare Local Flood Plan.

MEDIUM PRIORITY ACTIONS:
Climate Change
  - Incorporate climate change risk into Flood Planning Levels.
  - Monitor future scientific research and review management measures.
Water Sensitive Urban Design
  - Incorporate Water Sensitive Urban Design into planning controls and future Council works as appropriate.

LOW PRIORITY ACTIONS:
Flood Proofing
  - Only suitable for retrofitting of existing development by property owner.
  - No further consideration to be given for the use of flood proofing for new development.
1. INTRODUCTION

1.1. Background

The West Kensington study catchment has an area of approximately 0.9 km$^2$ and drains predominantly from east to west (refer Figure 1). The study area lies within the upper reaches of the broader (2.5km$^2$) Green Square – West Kensington (GSWK) catchment. The area is predominantly located within the Randwick City Council (RCC) Local Government Area (LGA), although portions of the contributing catchment also lie within the City of Sydney (CoS) LGA.

Flooding problems have been experienced at a number of locations within the West Kensington area during periods of heavy rainfall. The catchment is fully urbanised and consists predominantly of established residential areas together with some open space. Drainage within the catchment is mainly by pit and pipe networks with surcharging flows conveyed overland along streets. Flood problems typically result from ponding in trapped low-points such as those found in Milroy Avenue, McDougall Street and at the Lenthall Street underpass below the Eastern Distributor. Ponding also occurs at various locations along the eastern side of South Dowling Street. A number of the trapped low points in West Kensington are known to have experienced severe flooding during the November 1984 events.

Recognising the importance of having a consistent approach across the catchment RCC and the CoS have initiated a floodplain risk management program for the broader GSWK catchment. This current document has been prepared based on the results of the previous catchment-wide studies prepared as part of the overall GSWK floodplain risk management process.

1.2. Floodplain Risk Management Process

As described in the Floodplain Development Manual (Reference 3), the Floodplain Risk Management Process entails four sequential stages:

- **Stage 1:** Flood Study.
- **Stage 2:** Floodplain Risk Management Study.
- **Stage 3:** Floodplain Risk Management Plan.
- **Stage 4:** Implementation of the Plan.

The West Kensington Floodplain Risk Management Plan constitutes the third stage of the management process for the West Kensington catchment. The Flood Study stage was completed in April 2010 with the draft publication of the West Kensington Flood Study (Reference 4). (Note that the latter document has since being incorporated as an Appendix to Reference 2). A combination of hydrologic and hydraulic models was used in the Flood Study to determine design flood levels for the West Kensington catchment. This study made use of more recent information and superseded a previous Flood Study completed in April 2008 (Reference 5). The Floodplain Risk Management Study was completed in November 2011 (Reference 2).
2. STUDY AREA

2.1. Catchment Description

The land use within the study area is predominantly urban residential development, comprising mainly free standing dwellings although there is a limited amount of medium and high density complexes. There are no significant industrial developments and few major commercial developments.

The upper reaches of the catchment are flanked by open space areas within the Moore Park and The Australian golf courses. There are also a number of smaller parks and private open space areas throughout the catchment.

Drainage throughout much of the catchment is characterised by underground pipe systems and overland flow conveyed along the roads, which are nearly entirely formed with kerbs and gutters. An overland flowpath also forms along the property easement between Ingram Street and Lenthall Street (refer to Photo 1).

much of the West Kensington catchment was developed between 1912-1920 and was fully developed by the 1940’s with most of the subsurface drainage system in the West Kensington area estimated to have been constructed prior to the 1930s (Reference 5). Major changes since 1980 have included the re-development of industrial premises at Raleigh Park into medium density residential estate and drainage works associated with the Eastern Distributor (refer to Photo 2).
2.2. Existing Flood Environment

Flooding in the catchment typically occurs due to intense rainfall that may be experienced during thunderstorms (as occurred in all previous events in the 1980’s and 1990’s). As discussed in Reference 1, urbanisation has dramatically altered the nature of available drainage within the catchment and has led to:

• a major increase in the proportion of paved area and consequent reduction in pervious areas, resulting in corresponding increases in runoff (in terms of both peak flows and volumes), and
• development within the trapped depressions that were once swamps or dams, resulting in flood problems in these areas. Examples within the West Kensington catchment include Milroy Avenue and McDougall Street. Damages have been incurred at these locations during past floods such as the November 1984 events.

In view of the above, flood problems within the catchment are generally the result of insufficient capacity within the trunk drainage system and the general lack of a formal overland flow system to provide controlled capacity in large events. Based on evidence from past floods flooding can be exacerbated by blocked local drainage and restricted overland flow paths (Reference 4).

Given the natural topography of this area most of the flood problems occur in the known low points where there is insufficient drainage capacity to convey runoff during periods of intense rainfall. This includes locations such as Milroy Avenue, Balfour Road, McDougall Street and Duke Street (refer to Photos 3 and 4). Results from the Flood Study for the smaller design events are consistent with local observations that ponding within the roadway for these areas occurs relatively frequently. For larger events the design flood levels compare well with observed levels from the event of 8-9 November 1984. This outcome lends confidence to the modelling results and highlights the severity of the flood problem in these areas.
A number of major trapped lowpoints such as the one shown above exist throughout the West Kensington catchment.

In addition to the above locations the modelling results indicate that ponding will occur at the western (downstream) end of Ingram Street again due to insufficient drainage capacity. Ponding depths in this area exceed 1 m for the 1% AEP (1 in 100 year) event. For the area of South Dowling Street between Myrtle Street and Todman Avenue, peak depths along the roadway are typically within 0.2 m. A minor area of ponding occurs along this street between Cooper Place and Winkurra Street where peak depths exceed 0.5 m for the 1% AEP (1 in 100 year) event. This minor low point is due to the natural topography of the area.

2.3. Preliminary Environmental Assessment

The current LEP zoning for the catchment is provided on Figure 2 and a preliminary environmental assessment of the catchment is included within the Floodplain Risk Management Study (Reference 2). Water quality studies of the broader Sheas Creek catchment (of which the West Kensington catchment is part of) have been undertaken previously, although there is little detailed information relating specifically to the local area. These studies suggest that the water quality exhibits pollutants which are typical of most urban catchments in Sydney. As most of the natural drainage system has effectively been replaced by either pipes or modified flowpaths there is little opportunity for the development of flora/fauna habitats. The visual amenity of most of the drainage system would generally be described as of low quality compared to a natural system. The drainage system within the series of major trapped low points offers no particular visual amenity as it generally blends in as part of the urban landscape. Drainage features within the Moore Park and The Australian golf courses mitigate this to some degree whilst, landscaping of some constructed features (e.g. the Raleigh Park detention basin) also addresses this aspect.

At present much of the formal drainage system has no legal recreational amenity. However,
there are exceptions to this including parts of the floodplain that lie within public parklands and several golf courses (e.g. portions of Moore Park and The Australian golf courses). Providing due consideration is given to personal safety and risk to life then the use of the floodplain for these activities are an excellent use of flood prone lands.

A number of previous flood related studies have been undertaken in the catchment and these are discussed in Reference 1.
3. KEY DATASETS

3.1. Historical Flood Data

A detailed analysis of rainfall records and flood records was undertaken as part of Reference 1. Although a survey questionnaire was distributed to the local community as part of that study, much of the information on past flooding within the catchment was sourced from existing reports and references.

Most records relate to the significant flooding that occurred during the November 1984 events and document extensive flooding within trapped low points. This includes the inundation of 56 properties (including 27 houses) within West Kensington (Reference 5).

When flooding occurs within the catchment in future, it is recommended that Council undertake to collect any available information (photos, rainfall data, flood heights, extent of inundation and damages to private property etc.) as soon as practicable after the event including after smaller, more frequent flooding such as would be expected in the 50% AEP (1 in 2 year) event.

3.2. Design Flood Data

3.2.1. Peak Flows and Flood Levels

The West Kensington Flood Study (Reference 4) reported design flood data for current catchment conditions. The Study recommended that the full range of storm durations should be considered if undertaking detailed investigations for drainage augmentation within the catchment. This is due to the potential redistribution of catchment flows if the drainage networks locally are upgraded.

Maps of peak depths together with peak flood levels in each of the major trapped low points for the 1% AEP (1 in 100 year) and Probable Maximum Flood (PMF) events are provided in Figure 3 and Figure 4 respectively. A summary of peak flood levels and depths at major trapped low points within the West Kensington area is shown in Table 1. Further details regarding peak flows in the pipe network and in terms of overland flows can be found in Reference 4.

Table 1: Peak Flood Levels and Depths – Major Trapped Low Points West Kensington

<table>
<thead>
<tr>
<th>Location</th>
<th>Minimum Level At Low Point (mAHD)</th>
<th>50% AEP Design Flood</th>
<th>20% AEP Design Flood</th>
<th>10% AEP Design Flood</th>
<th>5% AEP Design Flood</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Level (mAHD)</td>
<td>Depth (m)</td>
<td>Level (mAHD)</td>
<td>Depth (m)</td>
<td>Level (mAHD)</td>
</tr>
<tr>
<td>Balfour Road</td>
<td>24.0</td>
<td>24.7</td>
<td>24.9</td>
<td>0.9</td>
<td>25.0</td>
</tr>
<tr>
<td>McDougall Street</td>
<td>23.2</td>
<td>23.9</td>
<td>24.0</td>
<td>0.8</td>
<td>24.2</td>
</tr>
<tr>
<td>Milroy Avenue</td>
<td>24.3</td>
<td>24.7</td>
<td>24.9</td>
<td>0.6</td>
<td>24.9</td>
</tr>
<tr>
<td>Virginia Street</td>
<td>23.8</td>
<td>24.0</td>
<td>24.1</td>
<td>0.3</td>
<td>24.1</td>
</tr>
<tr>
<td>Lenthall Street</td>
<td>20.4</td>
<td>21.9</td>
<td>22.0</td>
<td>1.6</td>
<td>22.0</td>
</tr>
</tbody>
</table>

Note: Estimated ponding depths are approximate only (based on ALS data)
### 3.2.2. Hydraulic Classification

Hydraulic classification of the floodplain was undertaken as part of Reference 2. A number of roadways within the West Kensington area act as overland flow paths. Hence, these are to be considered as floodway given that a significant portion of flow is conveyed via the road network. Within each of the major trapped low points (including the Lenthall Street lowpoint at the underpass), the areas contained by road reserve are considered to be floodways as floodwaters typically enter these low points via the road network. The remaining inundated area adjacent to each of the low points is regarded as being flood storage.

The easement between Lenthall Street and Ingram Street in West Kensington conveys overland flow from the Virginia Street trapped low point and is classified as floodway.

Hydraulic categories for the West Kensington area as determined from this study are shown in Figure 5.

### 3.2.3. Flood Hazard Classification

The hazard categorisation for the catchment was quantitatively determined using depth and velocity for each design event in accordance with the provisional hydraulic hazard categorisation. The provisional hazards were then refined to consider other factors such as rate of rise of floodwaters, duration, threat to life, danger and difficulty in evacuating people and possessions and the potential for damage, social disruption and loss of production. For the West Kensington catchment these factors do not significantly alter the provisional hazard classifications for the 100 year ARI and PMF events although some allowance was made to identify key flowpaths likely to act as floodways (e.g. along the easement between Ingram Street and Lenthall Street).

Flood hazard categories for the West Kensington area as determined from this study are shown in Figure 6 and Figure 7 for the 1% AEP (1 in 100 year) and PMF events respectively.
3.2.4. Flood Damages

The cost of flood damages and the extent of the disruption to the community depend upon many factors including:

- the magnitude (depth, velocity and duration) of the flood,
- land usage and susceptibility to damage,
- awareness of the community to flooding,
- effective warning time,
- the availability of an evacuation plan or damage minimisation program,
- physical factors such as erosion of the river bank, flood borne debris, sedimentation.

Flood damages can be defined as being “tangible” or “intangible”. Tangible damages are those for which a monetary value can be assigned, in contrast to intangible damages, which cannot easily be attributed a monetary value (stress, injury, loss to life, etc.).

A flood damages assessment was undertaken for existing residential properties within the West Kensington catchment (refer to Table 2 and Figure 8). The assessment was based on a detailed floor level survey and results from the Flood Study (Reference 4).

Table 2: Summary of Flood Damage Estimates for West Kensington Catchment

<table>
<thead>
<tr>
<th>Event</th>
<th>Virginia Street</th>
<th>Milroy Avenue</th>
<th>McDougall Street</th>
<th>Balfour Road</th>
<th>All Properties Within RCC LGA</th>
</tr>
</thead>
<tbody>
<tr>
<td>50% AEP (1 in 2y)*</td>
<td>$7K</td>
<td>$14K</td>
<td>$1K</td>
<td>$26K</td>
<td>$320K</td>
</tr>
<tr>
<td>20% AEP (1 in 5y)*</td>
<td>$10K</td>
<td>$59K</td>
<td>$2K</td>
<td>$134K</td>
<td>$840K</td>
</tr>
<tr>
<td>10% AEP (1 in 10y)*</td>
<td>$10K</td>
<td>$59K</td>
<td>$10K</td>
<td>$220K</td>
<td>$1,000K</td>
</tr>
<tr>
<td>5% AEP (1 in 20y)*</td>
<td>$10K</td>
<td>$80K</td>
<td>$20K</td>
<td>$340K</td>
<td>$1,200K</td>
</tr>
<tr>
<td>2% AEP (1 in 50y)*</td>
<td>$10K</td>
<td>$81K</td>
<td>$80K</td>
<td>$640K</td>
<td>$1,620K</td>
</tr>
<tr>
<td>1% AEP (1 in 100y)*</td>
<td>$10K</td>
<td>$120K</td>
<td>$150K</td>
<td>$1,030K</td>
<td>$2,160K</td>
</tr>
<tr>
<td>0.2% AEP (1 in 500y)*</td>
<td>$23K</td>
<td>$120K</td>
<td>$150K</td>
<td>$1,870K</td>
<td>$3,100K</td>
</tr>
<tr>
<td>PMF*</td>
<td>$72K</td>
<td>$696K</td>
<td>$669K</td>
<td>$4,250K</td>
<td>$7,900K</td>
</tr>
<tr>
<td>Avg. Annual Damages</td>
<td>$6K</td>
<td>$29K</td>
<td>$6K</td>
<td>$103K</td>
<td>$496K</td>
</tr>
</tbody>
</table>

*Tangible Damages.

^Average Annual Damages are Tangible Damages weighted according to probability of occurrence.
3.3. Previous Flood Mitigation Measures Considered

Flood mitigation measures for the catchment have been considered previously as part of investigations undertaken following the November 1984 floods (Reference 5). Due to a number of physical constraints (including the amount of existing development within the catchment) the sub-surface drainage options considered were based on the amplification of existing drainage lines and/or the installation of new pipes as part of a bypass system. The potential to amplify existing drainage infrastructure was noted as being complicated for those reaches not located within existing drainage easements or road reserves.

These potential options are also subject to downstream capacity constraints. Any increase in system capacity to alleviate flooding in the West Kensington catchment has the potential to exacerbate flooding in the lower reaches due to the additional loading on the downstream system.

The key components of the preferred scheme are shown in Figure 9 and included:

- amplification of existing local drainage within West Kensington (although the inlet capacity was initially limited so as not to exceed the current capacity of downstream infrastructure),
- provision of detention capacity in Raleigh Park and on the grounds of The Australian golf course (the detention capacity within the golf course also included improved sub-surface drainage to this area from the Balfour Road trapped low point), and
- amplification of the Sydney Water (then known as the Metropolitan Water, Sewer and Drainage Board (MWS&DB)) channel downstream to provide additional downstream capacity.

Information provided by Randwick City Council confirms that the scheme has been partially implemented including:

- provision of detention capacity at Raleigh Park (refer to Figure 9),
- drainage upgrade works completed in the 1990’s along Baker Street (new system
along the northern side) and the Balfour Road system (increased pipe capacity through amplification and duplication).

From the available survey it appears that the new Baker Road system drains directly west to South Dowling Street rather than Virginia Street as was originally intended. RCC has also indicated that the pipe sizes nominated in the 1985 study could not be achieved in some portions of the system due to utility services constraints.

3.4. Community Consultation

The Draft Green Square - West Kensington Floodplain Risk Management Study and the Draft West Kensington Catchment Floodplain Risk Management Plan were placed on public exhibition from Monday 16th May 2011 to Friday 24th June 2011.

Public displays were placed at the following locations:
- Bowen Library, 669-673 Anzac Parade, Maroubra,
- Randwick Library, Level 1 Royal Randwick Shopping Centre, Randwick,
- Council’s administration centre, 30 Frances Street, Randwick.

Exhibition material at the public displays included:
- Copies of the draft reports,
- Poster,
- Fact sheets,
- Comment sheets,
- Comment box.

Newspaper advertisements were placed in the Southern Courier on 17th May and 7th June providing details of the public exhibition.

The public exhibition was also advertised on Council’s website. Information was placed on the website as follows:
- Copies of the draft reports,
- Details of the public exhibition,
- Fact sheet,
- Comment sheet.

A community drop in session was held at Bowen Library, 669-673 Anzac Parade, Maroubra on Wednesday 8th June between 4pm and 7pm. Staff from Council, WMAwater and the Office of Environment and Heritage were available for the community to come along and find out about the study or ask questions. A letter was sent to all property owners, within Randwick City Council’s portion of the catchment, identified as being below the 1% AEP flood plus freeboard or below the Probable Maximum Flood. A total of 1049 letters were sent to property owners providing details of the public exhibition and the community drop in session.
4. FLOODPLAIN RISK MANAGEMENT PLAN

4.1. Introduction

The West Kensington Floodplain Risk Management Plan has been prepared in accordance with the NSW Floodplain Development Manual (Reference 3) and:

- *Is based on a comprehensive and detailed evaluation of all factors that affect and are affected by the use of flood prone land*;
- *Represents the considered opinion of the local community on how to best manage its flood risk and its flood prone land*;
- *Provides a long-term path for the future development of the community*.

4.2. Floodplain Risk Management Measures Considered

All possible management measures were evaluated in the Floodplain Risk Management Study (Reference 2) taking into account a range of parameters. This process eliminated a number of measures including:

- Flood mitigation dams (no available space in catchment),
- Channel modification works (dredging, straightening, concrete lining, removal of vegetation etc are not possible),
- Levees, flood gates and pumps,
- Flood warning (available warning time too short),
- House raising (no suitable buildings),
- Flood proofing of buildings (not suitable for residential buildings).

The evaluation process for assessing each measure involved interaction with the Floodplain Management Committee technical committee, the Floodplain Management Committee itself and meetings with Council officers. The proposed measures identified as part of the present study are described in Sections 4.3 to 4.5. Note that the various measures are presented in no particular order within each priority group.

4.3. HIGH Priority Floodplain Management Measures

4.3.1. Maintain Flood and Drainage Database

- **Cost:** minimal,
- **Responsibility:** Council,
- **Timeframe:** ongoing.

**OUTCOMES**

Local drainage issues will arise from time to time and it is important that Council record all such instances. In order to assess their importance and determine whether a permanent solution is available the local drainage database which Council has used in the past must be maintained.
and where possible enhanced (e.g. photographs and data on future events).

**ACTIONS**
Council should maintain and where possible improve the existing database of reported local drainage issues and review the required actions following each major rainfall event (say an event of magnitude occurring once or twice a year). It is also important to obtain rainfall records to estimate the magnitude of the rainfall event. This can generally only be done using the pluviometer records as daily records do not identify a peak rainfall burst within a period of say 24 hours of rain.

**4.3.2. Public Information, Community Awareness and Response**

- **Cost:** depends on extent of program,
- **Responsibility:** Council, SES,
- **Timeframe:** ongoing.

**OUTCOMES**
Based on feedback received from earlier public consultation phases and general discussions, the residents within the West Kensington catchment generally have a low to moderate level of flood awareness and it is expected that there is a correspondingly low level of preparedness and ability to effectively respond to flooding impacts. This can be attributed to the quick onset of flooding, the influx/turnover of residents (particularly since the last major flooding that occurred in November 1984) within the area, a general low awareness of flooding in an urban area (as opposed to say a rural area such as Maitland) and the possibility of flooding occurring at night.

A suitable Council wide flood awareness and response program should be implemented by Council using appropriate elements (as outlined in Reference 2). The details of the program and necessary follow up should be properly documented to ensure that they do not lapse with time and to ensure the most cost effective means of communication.

Council should also consider making flood related information such as flood studies, floodplain risk management studies and plans freely available (e.g. via Council’s website). These studies provide information regarding the nature of flooding in the catchment, flood issues and form the basis for Council’s actions in managing the floodplain.

**ACTIONS**
The SES in conjunction with Council should implement a public information program to raise the level of flood awareness and preparedness within the community.

Council should make flood-related information such as flood studies, floodplain risk management studies and plans freely available via the Council website.
4.3.3. Planning Instruments and Development Control Planning

- **Cost:** negligible,
- **Responsibility:** Council,
- **Timeframe:** ongoing.

**OUTCOMES**

The Randwick LEP 1998 contains several clauses relating to drainage and water management issues. These conditions are broadly defined covering drainage and environmental management. There are no references to specific floodplain risk management objectives (e.g. risk to life and property) within the LEP.

Council has a number Development Control Plans (DCPs) that contain flood-related conditions, although there are no site specific DCPs relevant to the West Kensington area. The two applicable LGA-wide DCPs contain general references to stormwater management and do not contain specific details regarding flooding and/or floodplain risk management.

**ACTIONS**

Council should consider including a reference to the Floodplain Development Manual (Reference 3) and/or relevant floodplain risk management principles in the LEP with regards to development on flood prone land.

It is recommended that Council review and consolidate existing flood-related DCPs incorporating specific floodplain risk management provisions, and in time formally adopt a Flood Risk Management DCP applicable for the broader LGA. This would enable Council to implement sound floodplain management and drainage strategies across all catchments in a consistent manner. Note that this does not preclude the use of more refined, site specific control conditions where needed.

Flooding related development controls should ensure that the following principles are incorporated into new developments:

- use of appropriate flood planning levels,
- no adverse impact on flooding including conveyance of flood waters and floodplain storage volume for floods up to and including the 1% AEP flood,
- ensure that there is no adverse cumulative impact of permitting similar types of development within the floodplain,
- ensure the safety of persons and emergency access during flooding for all floods up to and including the PMF,
- ensure appropriate protection, warning and safe evacuation from basement car parking,
- ensure structural soundness and flood compatibility of building components up to the applicable flood planning level,
- minimise the likelihood of cars or other objects becoming floating debris during a flood,
- ensure that adequate flood protection is provided for materials sensitive to flood...
damage, materials that may cause pollution or be potentially hazardous during a flood,

- ensure that fencing does not obstruct the flow of flood waters, become unsafe during times of flood or become moving debris, and
- ensure that existing inappropriate structures and uses are redeveloped with no increase in floor area and in a manner that reduces the risk to human life and property damage.

4.3.4. Flood Planning Levels

- **Cost:** negligible,
- **Responsibility:** Council,
- **Timeframe:** ongoing.

**OUTCOMES**

Although site-specific DCPs for other areas within the RCC LGA define a range of Flood Planning Levels, there is no existing documentation of FPLs that are directly applicable to the West Kensington catchment. Hence, it is recommended that RCC review existing practice and develop appropriate FPLs for use in West Kensington. These FPLs should be developed in accordance with the principles of the Floodplain Development Manual (Reference 3) and should be applicable across the RCC LGA.

**ACTIONS**

It is recommended that Council undertake to review existing site-specific Flood Planning Level conditions in combination with the Floodplain Development Manual to produce a consistent set of Flood Planning Levels applicable across the RCC LGA. Note that this does not preclude the use of more refined, site specific controls as needed.

4.3.5. Notations to the Section 149 Certificate

- **Cost:** internally within Council,
- **Responsibility:** Council,
- **Timeframe:** proposed commencement in 2011–2012.

**OUTCOMES**

A Section 149 certificate is a planning tool to notify that land is affected by a Council Policy with development controls. It provides an important source of information for a prospective property purchaser in determining the flood risk. Thus it is essential that this information is as accurate and up-to-date as possible. Property owners may also wish to use this information to obtain (or not to obtain) flood insurance which has recently been introduced by major insurance companies.

**ACTIONS**

RCC currently has no formal Flood Policy or requirements regarding flood-risk notations on the
s149 certificate. To address it is recommended that Council give consideration to:

- the development of a formal RCC Flood Policy,
- providing flood related s149(2) notations that comply with current planning regulations,
- providing additional flood related information for s149(5) notations. Such information could include flood levels (say for the 5% and 1% AEP and the PMF events) and/or provide corresponding depths for shallower overland flowpaths. Information for smaller events (e.g. <20% AEP) is not required as these small floods can potentially be impacted by localised features, and
- Council’s internal processes used to manage the provision of s149 notations.

4.3.6. Management of Blockage

- **Cost**: internally within Council,
- **Responsibility**: Council,
- **Timeframe**: on-going.

**OUTCOMES**

It is recommended that Council:

- regularly assess the effectiveness of current street sweeping programs and in light of the outcomes refine/improve the adopted approach,
- investigate options for blockage protection works at key trapped low points including Milroy Avenue, McDougall Street, Virginia Street and Balfour Road,
- review current configuration of pit inlets and consider potential options to minimise risk of blockage,
- consider adopting parking controls at locations where the flow is large and regularly inundates adjacent properties,
- adopt a maintenance program to inspect and rectify sedimentation in pipes, this may mean CCTV inspection of pipes in critical locations.

**ACTIONS**

The management of blockage in the drainage system will provide a cost effective management measure and should be pursued.

4.3.7. Local Flood Plan and Emergency Response Planning

- **Cost**: minimal,
- **Responsibility**: Council, SES,
- **Timeframe**: ongoing.

**OUTCOMES**

A Local Flood Plan of the overall catchment (which includes Green Square and West Kensington areas) should be prepared. The SES’s role in flooding in the West Kensington catchment is likely to occur before (awareness program) and after the event (clean up) due to
the limited response time available and likely demand on resources from other areas flooding concurrently. The response of the community during an event is critical in reducing the flood damages and risk to life and thus, even if emphasised as a ‘self help’ approach, should be formulated in conjunction with/by the SES.

**ACTIONS**

It is recommended that Council provide flood related information to the SES and work with the SES to develop and adopt a Local Flood Plan.

**4.4. MEDIUM Priority Floodplain Management Measures**

**4.4.1. Pipe/Pipe and Trunk Drainage Upgrades**

- **Cost:** Significant - typically in the order of $0.5M to > $1.0M (subject to extent of works and site constraints (e.g. conflicts with existing services)),
- **Responsibility:** Council,
- **Timeframe:** Ongoing, to be incorporated as funding opportunities arise.

**OUTCOMES**

Opportunities to implement pit/pipe and trunk drainage upgrades to address major flooding within the West Kensington area were found to be limited as:

- a number of extensive upgrades proposed following the November 1984 floods have been implemented,
- a number of branches are limited by downstream capacity constraints. For example, the existing Sydney Water stormwater channel that services much of the southern portion of the upper West Kensington catchment is of limited capacity and acts as a constraint for any proposed drainage augmentation in the upper catchment, and
- there are significant physical constraints associated with major transport infrastructure along South Dowling Street (e.g. sound walls).

To mitigate localised flood problems in Duke Street, the impact of upgrading local drainage in the vicinity of Duke Street was examined and showed that:

- upgrading the local system resulted in minimal reductions in flood levels for design events in Duke Street and,
- such upgrades would result in negligible adverse impacts in downstream areas.

These outcomes reflect the fact that the local system reaches capacity even in smaller events and is affected by flooding within the Balfour Road system during larger events. However, given the condition of the existing kerb and gutter system in Duke Street, the planned upgrade will result in localised improvements for minor rainfall events and hence reduce the occurrence of nuisance flooding.

In terms of flooding along South Dowling Street adjacent to the existing sound walls, the potential options in terms of feasible physical drainage works are limited. There are significant
complications posed by the presence of infrastructure associated with South Dowling Street and the Eastern Distributor. Joint investigations between Council and the Roads and Traffic Authority (RTA) would be needed to further assess this aspect.

ACTIONS
Although the works proposed for the Duke Street area are unlikely to reduce flood damages, there is the potential to improve the local flood behaviour and in view of this these works are recommended.

It is recommended that Council investigate options jointly with the RTA to manage impacts of the sound walls on South Dowling Street.

4.4.2. Implement Climate Change Policy

- **Cost:** minimal for Council but will add to developer costs,
- **Responsibility:** Council, Office of Environment and Heritage, property owners,
- **Timeframe:** ongoing.

OUTCOMES
The potential impact of increased design flood levels in the catchment due to climate change has been examined for the 1% AEP (1 in 100 year) event for existing conditions as part of the GSWK Floodplain Risk Management Study (Reference 2). As the lowest elevation within the West Kensington area is in the order of 20 mAHD, flood levels within the study catchment are not affected by potential changes in sea-level rise.

Within West Kensington, the potential increase in peak flood level resulting from a +30% increase in rainfall was generally found to be less than 0.25 m although localised increases of between 0.4 m to 0.6 m do occur. The largest increases were found to occur in trapped low points and in areas where flow was concentrated, such as the Raleigh Park detention basin, the Balfour Road trapped lowpoint and The Australian golf course detention basin. Corresponding increases along unobstructed overland flowpaths (e.g. within roadways and through property) were typically less than 0.15 m. Impacts of this magnitude can be readily accommodated through the use of appropriate freeboards in excess of the Flood Planning Level, particularly for residential development and critical infrastructure. For other areas where significant impacts were noted, these may be addressed through this or other means. It is expected that these aspects would be confirmed as part of Council’s review of Flood Planning Levels (refer to Section 4.3.4).

ACTIONS
For existing conditions the potential impacts of increased rainfall due to climate change can be accommodated through the use of appropriate freeboards specified as part of Flood Planning Level conditions yet to be determined by Council.

For any future development that involves the modification of flood behaviour, the resulting impacts due to climate change should be accounted for as part of a site specific flood
assessment.

Council should continue to monitor the available literature and reassess Council’s flood-related DCPs as appropriate. At a minimum Council should obtain the most current information available from the Bureau of Meteorology, CSIRO and OEH every two years.

4.4.3. Detention Basins

- **Cost:** Significant - typically in the order of $0.4M (subject to capacity and site constraints),
- **Responsibility:** Council, property owners,
- **Timeframe:** Ongoing, subject to future negotiation with property owners,

**OUTCOMES**

Within the West Kensington portion of the catchment a number of detention basins have already been constructed and opportunities for new basins are limited by a lack of suitable sites (these aspects are discussed in further detail in Reference 2). However, there is the potential to construct some form of detention capacity within the Moore Park golf course site. Hydraulic assessments indicated that approximately 16,100m$^3$ of storage would be sufficient to contain runoff from the area in the 1% AEP (1 in 100 year) event. The provision of such capacity would result in localised reductions in flood levels of between 0.1 m to 0.2 m in Todman Avenue, adjacent to the Supacentre and Raleigh Park sites.

The layout of this option is flexible and it may involve the construction of several smaller basins serving local catchments within the Moore Park golf course site. These basins would also provide stormwater harvesting opportunities for the golf course operators.

**ACTIONS**

Retarding basins in Moore Park golf course would provide localised reductions in flood levels within the West Kensington catchment and may also provide some water quality and re-use potential.

The construction of basins in these locations is supported and it is recommended that Council liaise with the Moore Park (public course) golf club.

4.4.4. Water Sensitive Urban Design (WSUD)

- **Cost:** minimal for Council but will add to developer costs,
- **Responsibility:** Council, property owner,
- **Timeframe:** ongoing.

**OUTCOMES**

Whilst the floodplain risk management process supports the general objectives of WSUD it is not possible to address every aspect (e.g. water saving devices, grey water reuse, etc.) within
the scope of the overall process. However there are specific WSUD aspects that are relevant to
the scope of the NSW Government’s Floodplain Development Manual (Reference 3) including:

- Opportunities to maximise the pervious area in developments (as part of BASIX
  requirements) should be encouraged to reduce potable water demand. These
  principles can also be applied to other current measures (e.g. on-site detention) or
  land use activities (commercial and industrial developments and/or to existing Council
  or government structures and facilities, particularly in open space areas),
- Treatment of urban stormwater through the installation of gross pollutant traps and/or
  maximising opportunities for the absorption of runoff (e.g. shedding of local runoff onto
  swales or grassed areas before entering the formal stormwater drainage system). In
  all cases, care should be taken to ensure no adverse hydraulic impacts are created
  and that costs associated with ongoing maintenance are accounted for.

**ACTIONS**
The implementation of WSUD should be generally encouraged. WSUD opportunities that also
provide flood amenity should be actively pursued.

**4.5. LOW Priority Floodplain Management Measures**

**4.5.1. Flood Proofing**

- **Cost:** Site specific, to be borne by property owner,
- **Responsibility:** Council, individual property owner,
- **Timeframe:** ongoing.

**OUTCOMES**
Flood proofing for the existing flood affected non-residential buildings would assist in reducing
the tangible damages associated with flooding in the catchment. This measure is unlikely to
receive state or federal government funding however it should still be pursued by Council.
Potential owners should be advised that it is an available option.

Flood proofing of existing residential properties in low hazard areas on a property by property
basis could alleviate local inundation issues however consideration would have to be given to
the (possible) redistribution of flows to downstream properties and safety issue of isolating
residents behind such protection measures. This option would not be considered for
government funding however could be pursued by individual property owners.

**ACTIONS**
Flood proofing should be promoted as a means available to reduce flood damages for existing
non-residential buildings. It is not recommended for use as part of any new development (or re-
development).
5. ACKNOWLEDGEMENTS

This study was carried out by WMAwater and funded by Randwick City Council, City of Sydney and the Department of Environment, Climate Change and Water (now Office of Environment and Heritage). The assistance of the following in providing data and guidance to the study is gratefully acknowledged:

- Randwick City Council,
- City of Sydney,
- Department of Environment, Climate Change and Water (now Office of Environment and Heritage),
- members of the Green Square - West Kensington Floodplain Management Committee,
- residents of the West Kensington catchment.
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