# GREEN SQUARE CATCHMENT
# FLOODPLAIN RISK MANAGEMENT PLAN
# JULY 2013

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# GREEN SQUARE FLOODPLAIN RISK MANAGEMENT PLAN

**JULY, 2013**

| **Project**<br>**Green Square Floodplain Risk Management Plan** | **Project Number**<br>**28041-01** |
|---|---|
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# GREEN SQUARE FLOODPLAIN RISK MANAGEMENT PLAN

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| | |
|---|---|
| AEP | Annual Exceedance Probability |
| AHD | Australian Height Datum |
| ARI | Average Recurrence Interval |
| BASIX | Building Sustainability Index |
| CoS | City of Sydney |
| CSIRO | Commonwealth Scientific and Industrial Research Organisation |
| DCP | Development Control Plan |
| DECCW | Department of Environment, Climate Change and Water (now OEH) |
| FPL | Flood Planning Level |
| GSTC | Green Square Town Centre |
| GSWK | Green Square-West Kensington |
| LEP | Local Environmental Plan |
| LGA | Local Government Area |
| OEH | Office of Environment and Heritage (was DECCW) |
| PMF | Probable Maximum Flood |
| RCC | Randwick City Council |
| SES | State Emergency Service |
| SSLEP | South Sydney Local Environment Plan |
| WSUD | Water Sensitive Urban Design |

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

# EXECUTIVE SUMMARY

## GREEN SQUARE CATCHMENT

The Green Square and West Kensington study catchment has an area of approximately 2.5 $km^2$ and drains predominantly from east to west (refer Figure 1). South Dowling Street runs north-south through the middle of the catchment dividing the City of Sydney and Randwick City Local Government Areas (LGAs). 57% of the study catchment lies within the City of Sydney LGA, with 43% being within the Randwick City Council LGA. The City of Sydney portion of the catchment includes parts of the suburbs of Zetland, Waterloo, Alexandria and Rosebery.

Urbanisation has dramatically altered the nature of available drainage within the catchment. Flood problems typically result from insufficient capacity in the formal drainage system and ponding in trapped low-points such as those found in Joynton Avenue, Lachlan Street, South Dowling Street and Botany Road. A number of these locations are known to have experienced severe flooding in the past.

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 Green Square catchment.

## GREEN SQUARE WEST KENSINGTON FLOOD STUDY

The Green Square-West Kensington (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 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. The specific aims of the Green Square-West Kensington Flood Study were to:

- define flood behaviour in the Green Square-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% AEP (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 were quantified as 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 Green Square area. The estimated number of residential building floors which are likely to be inundated in the 20% AEP is 8 and 17 in the 1% AEP. The corresponding number of commercial properties inundated is 27 and 56 for the 20% AEP and 1% AEP events respectively. In the PMF a total of 130 building floors would be inundated. The annual average damages were estimated to be close to $1.03million. 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 area of the catchment immediately west of South Dowling Street was once dominated by industrial premises. Re-development of this area in the form of medium and high density housing/mixed use premises has been undertaken in recent years, including ongoing development within the Victoria Park precinct. Significant re-development has commenced (or is planned to commence within the next five to ten years) for other areas within the catchment including the Green Square Town Centre (GSTC) precinct, the Mid-block Precinct (bounded by O'Dea Avenue and Lachlan Street) and Precinct E and the adjacent area between Link Road and Joynton Avenue.

## GREEN SQUARE-WEST KENSINGTON CATCHMENT FLOODPLAIN RISK MANAGEMENT STUDY

The specific aims of this study were to:

- review 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 together with a brief assessment of their viability for implementation as part of the Floodplain Risk Management Plan for the Green Square catchment.

Sydney Water and other floodplain stakeholders raised objections to the “Option 1a” works originally documented as part of the public exhibition phase of the Floodplain Risk Management Study in June 2011. Between 2011 and 2013, City of Sydney and Sydney Water undertook ongoing investigations to develop potential options to address the issues relating to the “Option 1a” works, resulting in a significantly revised trunk drainage option. The details of the revised option are documented in Sections 4 and 5.3.8 of this Plan.

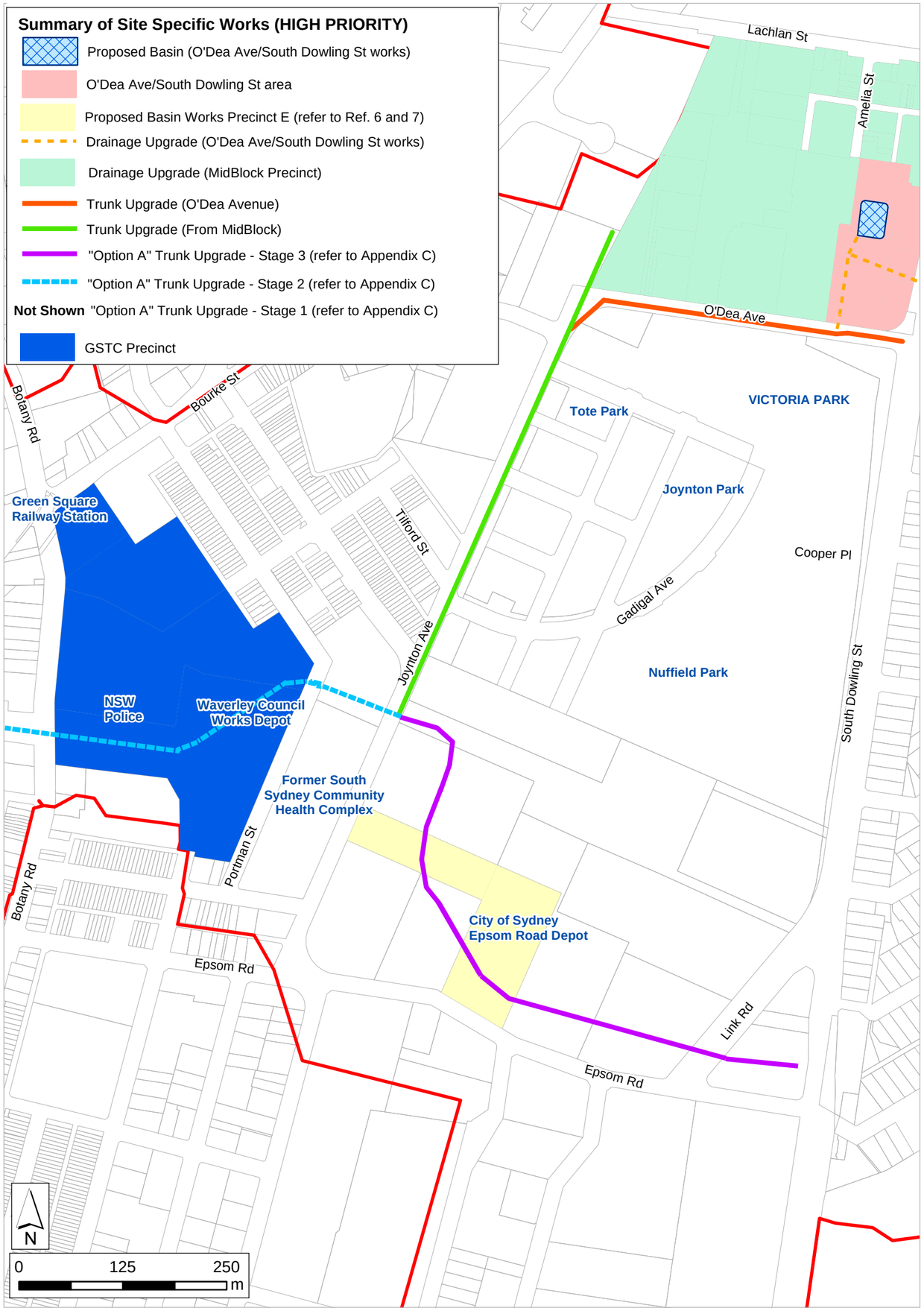
Table i) Review of Floodplain Management and Development Measures

| MEASURE | PURPOSE | COMMENTS | ECONOMIC ASSESSMENT | IMPLEMENTATION VIABILITY | ACTION | PRIORITY |
|---|---|---|---|---|---|---|
| **FLOOD MODIFICATION MEASURES:** | | | | | | |
| **FLOOD MITIGATION DAMS** | Reduce flows from upper catchment areas, water storage. | 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. | Generally not viable for small urban catchments. | Not viable. | No further consideration to be given. | - |
| **RETARDING (DETENTION) BASINS** | Reduce flows from upper catchment areas. | A number of basins already exist within the catchment.<br>Opportunities for new basins are constrained by land availability. Locations considered for larger basins include upstream of Joynton Avenue low-point (Precinct E) and the Moore Park golf course.<br>With implementation of the "Option A" trunk drainage upgrade and raising of Joynton Avenue low-point, there would not be significant additional benefit from a detention basin in Precinct E. | Generally not viable from a purely flooding perspective but more attractive if has water quality and stormwater harvesting benefits.<br>Can provide significant intangible benefits (e.g. reduce flood hazard, risk to personal safety etc.) | To be considered as a means of mitigating the effects of urban development.<br>Opportunity for basin construction may arise as part of current and future redevelopment activities. | Provision of basin opposite South Dowling Street low point to be considered as part of re-development of Mid Block precinct. | High |
| **PIT/PIPE and TRUNK SYSTEM UPGRADE** | To reduce the severity and hazard of overland flooding, particularly for more frequent events | Upgrades of trunk capacity have been considered at a number of locations, particularly where associated with re-development activities. Regional upgrades are required as part of major urban renewal (e.g. Mid-Block and GSTC precincts), but require coordination to ensure comprehensive outcomes for the catchment.<br>Local improvements should be considered for established areas where appropriate (e.g. Lachlan Avenue). | 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. | To be considered as part of any urban re-development activities.<br>Must ensure that any improvements in pipe capacity for upstream areas do not result in significant adverse impacts downstream. | Implement "Option A," which includes an upgrade of existing Sydney Water trunk system from Link Road to Joynton Avenue, augmentation of existing trunk system within GSTC precinct from Joynton Avenue to Botany Road, and new re-aligned trunk drainage line from Botany Road to Alexandra Canal.<br>Upgrade O'Dea Avenue trunk system.<br>Upgrade local and regional drainage as part of re-development of Mid-Block precinct (between Lachlan St and O'Dea Ave).<br>Augment trunk drainage from South Dowling Street to O'Dea Avenue (to be considered in conjunction with detention basin (see previous item). | High |

| | | | | | | |
|---|---|---|---|---|---|---|
| **LEVEES, FLOOD GATES AND PUMPS** | Prevents or reduces the frequency of inundation of protected areas, assists in reducing problems with local runoff issues. | No appropriate sites. | Not undertaken. | Not applicable. | No further consideration given. | - |
| **MANAGEMENT OF BLOCKAGE** | 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. | Council to consider blockage protection works at key locations (e.g. major trapped low points) and undertake works as appropriate. | High |
| | **PROPERTY MODIFICATION MEASURES** | | | | | |
| **HOUSE RAISING** | Prevent flooding of existing buildings by raising habitable floor levels. | No suitable candidates found within the study catchment. | High cost per property. May introduce social problems. | Not considered suitable. | No further consideration given. | - |
| **VOLUNTARY HOUSE PURCHASE** | To remove flood liable houses from the floodplain. | May be limited opportunities within West Kensington catchment | Nil. | Do nothing. | No further consideration given. | - |
| **FLOOD PROOFING** | 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. | Only suitable for retrofitting of existing development by property owner.<br>No further consideration to be given for the use of flood proofing for new development. | Medium |
| **FLOOD PLANNING LEVELS (FPLs)** | To minimise flood damages to new developments. | Existing controls have been reviewed for both Councils and potential improvements have been suggested. | Negligible cost. | Feasible | Council to consolidate and adopt consistent FPLs across LGA.<br>To be implemented via appropriate planning instruments (see below). | High |
| **DEVELOPMENT CONTROL PLANNING** | To ensure that new development does not have adverse flood and drainage impacts on other properties further downstream,<br>reduces the pollutant loads and conserves available 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. | Council to implement suitable development controls through the appropriate planning instruments.<br>Provide appropriate flood-related information on planning certificates. | High |

| | | | | | | |
|---|---|---|---|---|---|---|
| **CLIMATE CHANGE** | Assess possible impacts of climate change and include in Flood Planning Level | Potential increases in rainfall intensity will affect the entire catchment. | Unknown. | To be considered. | Incorporate climate change risk into Flood Planning Levels.<br>Monitor future scientific research and review management measures as required | Medium |
| **WATER SENSITIVE URBAN DESIGN** | 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 | Low |
| | **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 | Medium |
| **PUBLIC INFORMATION AND RAISING FLOOD AWARENESS** | Educate people to minimise flood damages and reduce the floodplain 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 flooding event. | Recommended. | Develop and implement suitable flood awareness program.<br>Maintain flooding database.<br>Provide access to flood studies, floodplain risk management studies and plans via Council's website. | High |

FIGURE A
**OVERVIEW OF GREEN SQUARE FLOODPLAIN RISK MANAGEMENT PLAN**




## OUTCOMES FOR SITE SPECIFIC WORKS IN GREEN SQUARE AREA

***(refer to Adjacent Map)***

**HIGH PRIORITY ACTIONS:**

**Pit/Pipe and Trunk System Upgrades**

- Re-development of Mid-Block Precinct and receiving trunk system along Joynton Avenue.
- Augmentation from South Dowling Street low point (O'Dea Ave./South Dowling St works).
- Upgrade of O'Dea Avenue trunk system.
- "Option A" Stage 1 – Augment trunk drainage system from Bourke Street to Alexandria Canal
- "Option A" Stage 1 – Augment trunk drainage system from Joynton Avenue to Bourke Street
- "Option A" Stage 1 – Upgrade trunk drainage system from Link Road to Joynton Avenue Augmentation of trunk system within GSTC precinct (Ref. 6. And 7.)

**Detention Basins**

- Precinct E basin to alleviate flooding in Joynton Avenue low point (Ref. 7).
- Proposed basin within O'Dea Avenue /South Dowling Street site

**Management of Blockage**

- Consider works to minimise blockage at major trapped low points and undertake works as appropriate

## OUTCOMES FOR BROADER GREEN SQUARE AREA

**HIGH PRIORITY ACTIONS:**

**Planning Instruments and Development Controls**

- Implement suitable development controls through creation/refinement 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 through appropriate planning instruments.

**Public Information and Flood Awareness**

- 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).

**MEDIUM PRIORITY ACTIONS:**

**Climate Change**

- Incorporate climate change risk into Flood Planning Levels.
- Monitor future scientific research and review management measures.

**Emergency Response Planning**

- Council to provide SES with flood information and work together to prepare Local Flood Plan.

**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.

**LOW PRIORITY ACTIONS:**

**Water Sensitive Urban Design**

- Incorporate Water Sensitive Urban Design into planning controls and future Council works as appropriate.

***J:\Jobs\28041\Arcview\Maps\GSPlan\FigureA_PlanSummary.mxd***

# 1. INTRODUCTION

## 1.1. Background

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

Flooding problems have been experienced at a number of locations within the Green Square area during periods of heavy rainfall. The catchment is fully urbanised and consists predominantly of established residential and commercial/industrial areas together with some recreational open space. The catchment is undergoing a transition from industrial land use to high density residential in several locations, such as the Victoria Park precinct currently, and the Midblock and GSTC precincts in the future.

Drainage within the catchment is mainly by pit and pipe networks. Flows exceeding the pipe network capacity are conveyed overland along streets and in some cases through private property. Surcharging of pits occurs at some locations. Flood problems typically result from ponding in trapped low-points such as those found in Lachlan Street, South Dowling Street, Botany Road and Joynton Avenue. A number of the trapped low points in the Green Square area 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 CoS initiated a joint floodplain risk management program for the broader Green Square - West Kensington (GSWK) catchment. The Flood Study and Floodplain Risk Management Study were prepared as combined reports. This current document, the Floodplain Risk Management Plan, has been prepared based on the results of the previous catchment-wide studies prepared, but is focussed on the outcomes and actions for CoS. A separate Plan was prepared for Randwick City Council and finalised in October 2011.

## 1.2. Floodplain Risk Management Process

As described in the Floodplain Development Manual (Reference 1), 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 Green Square Floodplain Risk Management Plan constitutes the third stage of the management process for the Green Square catchment. The Flood Study stage was completed in April 2008 with the publication of the Green Square-West Kensington Flood Study (Reference 2). A combination of hydrologic and hydraulic models was used in the Flood Study

to determine design flood levels for the Green Square catchment.

Additional modelling of the West Kensington catchment area was undertaken in 2010 to make use of more recent aerial survey data. The updated Flood Study used a 2D modelling approach for the West Kensington area, equivalent to the 2D approach that was used for the CoS areas in the April 2008 Flood Study. The revised Flood Study for the West Kensington part of the catchment (Reference 3) was included as an Appendix to the Floodplain Risk Management Study, which was completed for public exhibition in February 2011.

The Floodplain Risk Management Study was finalised by Randwick City Council in October 2011, but finalisation for the CoS was deferred, pending resolution of flood issues and refinement of trunk drainage options, particularly relating to the GSTC site. Since public exhibition of the Draft Floodplain Risk Management Study, CoS, Sydney Water and other stakeholders have worked together to develop a revised trunk drainage option to supersede the option originally documented in this Study (Option 1a).

Rather than doing a comprehensive update of the Floodplain Risk Management Study (Reference 5), the details of the revised trunk drainage option (termed Option A) are provided in this Floodplain Risk Management Plan for CoS. This Plan also includes outcomes of community consultation relating to Option 1a, arising from public exhibition of the Draft Floodplain Risk Management Study. This reporting approach was considered to provide clearer documentation of the process and outcomes, and to prevent confusion of this revision with the Randwick City Council components of the study, particularly in light of the significant time that has elapsed since publication of the Draft Floodplain Risk Management Study.

# 2. STUDY AREA

## 2.1. Catchment Description

Historically, the land use within the study area has been predominantly industrial and low-density commercial, with a pocket of residential area (mainly terraces) around Elizabeth Street between Bourke Street and Joynton Avenue. In the last ten to fifteen years, a large proportion of the catchment has been redeveloped into high density residential and mixed-use development. The ACI glass factory site north of Lachlan Street and Victoria Park precinct have been almost completely redeveloped, and similar re-development is planned for the Midblock, GSTC precincts and the area south of Victoria Park between Joynton Avenue and Link Road.

The upper reaches of the catchment are flanked by open space areas within the Moore Park and The Australian golf courses, and medium-density residential development east of South Dowling Street within the Randwick LGA. 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. Much of the Green Square catchment was developed between 1912-1920 and was fully developed by the 1940s, with most of the subsurface drainage system in the Green Square area estimated to have been constructed prior to the 1930s (Reference 4). 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.

## 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 2, 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 Green Square catchment include Lachlan Street, South Dowling Street (opposite the Moore Park Supacentre), Joynton Avenue and Botany Road. Peak flood depths within these locations are expected to exceed 1m in the 1% AEP event.

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 3).

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. When the capacity of the formal drainage system is exceeded, major overland flowpaths also form in a number of locations extending across both public and private properties in addition to along the road network itself. Examples of major overland flowpaths in the Green Square Area include:

- a flowpath that extends from Joynton Avenue to Portman Street and downstream through to Botany Road formed as waters overtop the low-point in Joynton Avenue low-point,
- the flowpath across the Green Square Railway Station plaza due to overtopping of the Botany Road trapped low-point, and
- various flowpaths that operate between the trapped low-point in Link Road and Joynton Road due to insufficient capacity in the trunk drainage system in large events.

Due to the natural topography and the large area of contributing catchment upstream, the Joynton Avenue trapped low point is one of the most significant flood-affected areas within the catchment.

Overland flow from the Botany Road low point occurs across the plaza adjacent to the western entrance of Green Square Railway station. The depth and velocity of floodwaters within this flowpath present a significant hazard in a 1% AEP (1 in 100 year) event and water will enter the underground Railway Station under current conditions.

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.

## 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 4). Water quality studies of the broader Sheas Creek catchment (of which the Green Square catchment is part) 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. At present much of the formal drainage system has no legal recreational amenity.

# 3. KEY DATASETS

## 3.1. Historical Flood Data

A detailed analysis of rainfall records and flood records and a survey questionnaire was distributed to the local community as part of Reference 2. However, 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 former South Sydney Community Health Centre site opposite the Joynton Avenue low-point.

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 Green Square-West Kensington Flood Study (Reference 3) 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 the Green Square area for the 1% AEP (1 in 100 year) and Probable Maximum Flood (PMF) events are shown in Figure 3 and Figure 4 (based on the results presented in Reference 5). A summary of peak flood levels and depths at major trapped low points within the Green Square area are shown in Table 1 and Table 2. Further details regarding peak flows in the pipe network and in terms of overland flows can be found in Reference 2.

Table 1: Peak Flood Levels and Depths – Major Trapped Low Points CoS LGA

| Location | Minimum Level At Low Point (mAHD) | 50% AEP Design Flood | | 20% AEP Design Flood | | 10% AEP Design Flood | | 5% AEP Design Flood | |
|---|---|---|---|---|---|---|---|---|---|
| | | Level (mAHD) | Depth (m) | Level (mAHD) | Depth (m) | Level (mAHD) | Depth (m) | Level (mAHD) | Depth (m) |
| **South Dowling Street Low Point opposite SupaCentre** | 25.7 | 26.1 | 0.4 | 26.2 | 0.5 | 26.2 | 0.5 | 26.3 | 0.6 |
| **Lachlan Avenue** | 25.9 | 26.0 | 0.1 | 26.3 | 0.4 | 26.3 | 0.4 | 26.4 | 0.5 |
| **Joynton Avenue** | 16.7 | 18.3 | 1.6 | 18.6 | 1.9 | 18.7 | 2.0 | 18.8 | 2.1 |
| **Botany Road** | 13.3 | 13.8 | 0.5 | 13.9 | 0.6 | 13.9 | 0.6 | 14.1 | 0.8 |

Table 2: Peak Flood Levels and Depths – Major Trapped Low Points CoS LGA (Cont.)

| Location | Minimum Level At Low Point (mAHD) | 2% AEP Design Flood | | 1% AEP Design Flood | | 0.2% AEP Design Flood | | Probable Maximum Flood | |
|---|---|---|---|---|---|---|---|---|---|
| | | Level (mAHD) | Depth (m) | Level (mAHD) | Depth (m) | Level (mAHD) | Depth (m) | Level (mAHD) | Depth (m) |
| **South Dowling Street Low Point opposite SupaCentre*** | 25.7 | 26.3* | 0.6* | 26.4* | 0.7* | 26.5* | 0.8* | 26.8* | 1.1* |
| **Lachlan Avenue** | 25.9 | 26.5 | 0.6 | 26.5 | 0.6 | 26.6 | 0.7 | 26.9 | 1.0 |
| **Joynton Avenue** | 16.7 | 18.9 | 2.2 | 19.0 | 2.3 | 19.1 | 2.4 | 19.7 | 3.0 |
| **Botany Road** | 13.3 | 14.2 | 0.9 | 14.3 | 1.0 | 14.5 | 1.2 | 15.4 | 2.1 |

Note: These flood levels assume the provision of an overland flowpath between South Dowling Street and a proposed extension of Amelia Street. Hence the peak levels at the South Dowling Street trapped low point reported above have been reduced by approximately 0.6 m compared to the results previously reported in Reference 2. However, subsequent to this modelling work for this study CoS advised that the DA for works in this area had not been approved.

### 3.2.2. Hydraulic Classification

Hydraulic classification of the floodplain was undertaken as part of Reference 5. A number of roadways within the Green Square 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, the areas contained by road reserve are considered to be floodways as floodwaters typically enter these low points via the road network. Exceptions to these include several major overland flowpaths that form as capacity of the formal drainage system is exceeded (discussed previously in Section 2.2). The remaining inundated area adjacent to each of the low points is regarded as being flood storage.

Hydraulic categories for the Green Square 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 Green Square catchment these factors do not significantly alter the provisional hazard classifications for the 1% AEP and PMF events although some allowance was made to identify key flowpaths likely to act as floodways. For example, much of the road network will convey fast flowing yet shallow (<0.4m) floodwaters. Depths along some roads can be higher increasing the hazard (e.g. Epsom Road and northern sections of Joynton Avenue). Significant flood depths

occur within the major trapped low points and formal detention basins. Areas adjacent to (and including) the open channel portion of the trunk system downstream of Link Road create high hazard areas between Link Road and Joynton Avenue. Cross-site flows between Joynton Avenue and Botany Road also create localised areas of high hazard.

Flood hazard categories for the Green Square 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. Note that the "Option A" trunk drainage works would significantly reduce the flood hazard for large parts of the catchment (see Appendix C).

### 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.

Table 3: Summary of Green Square Flood Damages (CoS LGA)

| Event | Commercial Properties | | Residential Properties | | All Properties | |
|---|---|---|---|---|---|---|
| | Above Floor Flooding | Tangible Damages | Above Floor Flooding | Tangible Damages | Above Floor Flooding | Tangible Damages |
| **50% AEP ( 1 in 2y)*** | 22 | $0.63M | 8 | $0.46M | 30 | $1.08M |
| **20 % AEP (1 in 5y)*** | 27 | $0.92M | 8 | $0.47M | 35 | $1.39M |
| **10 % AEP (1 in 10y)*** | 37 | $1.32M | 9 | $0.55M | 46 | $1.87M |
| **5% AEP (1 in 20y)*** | 42 | $1.51M | 11 | $0.62M | 53 | $2.14M |
| **2% AEP (1 in 50y)*** | 51 | $1.72M | 13 | $0.65M | 64 | $2.37M |
| **1% AEP (1 in 100y)*** | 56 | $1.93M | 17 | $0.71M | 73 | $2.63M |
| **0.2% AEP (1 in 500y)*** | 62 | $2.50M | 26 | $0.90M | 88 | $3.40M |
| **PMF*** | 95 | $5.80M | 35 | $1.94M | 130 | $7.74M |
| **Average. Annual Damages (AAD)** | | **$0.66M** | | **$0.37M** | | **$1.03M** |

*Tangible Damages.
^AAD are Tangible Damages weighted according to probability of occurrence.

A flood damages assessment was undertaken for existing residential properties within the Green Square catchment (refer to Table 3 and Figure 8). The assessment was based on a detailed floor level survey and results from the Flood Study (Reference 3).

Flood damages can be defined as being “tangible” or “intangible”. Tangible damages (as estimated in Table 3) 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.).

## 3.3. Previous Flood Mitigation Measures Considered

Given the significant amounts of urban renewal occurring (or planned to occur) within the Green Square catchment, the opportunity to implement flood mitigation measures as part of planned re-development activities has been considered in a number of previous investigations. The scale of the urban renewal for the Green Square area provides significant opportunities for a range of options that would normally be difficult to implement within an established urban area. These types of options include upgrades of sub-surface trunk drainage infrastructure and/or the provision of formal detention capacity. Outside of areas planned for re-development the potential to amplify existing drainage infrastructure will be complicated for those reaches not located within existing drainage easements or road reserves.

The potential options previously assessed were generally subject to downstream capacity constraints – any increase in system capacity to alleviate flooding in the Green Square catchment would exacerbate flooding in the lower reaches should the loading exceed the current capacity of the downstream system draining to Alexandra Canal.

The key components considered as part of previous investigations included:

- provision of trunk drainage and detention capacity within the Victoria Park precinct (since constructed),
- proposed limited amplification of the trunk drainage system within the GSTC precinct between Joynton Avenue and upstream of Botany Road
- proposed detention capacity immediately upstream of Joynton Avenue (within the area known as Precinct E) and
- trunk drainage upgrades and/or provision of detention capacity at other locations throughout the Green Square area within the Mid-Block precinct (between Lachlan Street and O’Dea Avenue), Email site (Joynton Avenue) and adjacent to the low-point in South Dowling Street.

A number of these measures are being constructed as part of current development activities (e.g. works at the Email and SydneyGate sites). CoS is also actively pursuing opportunities for regional stormwater upgrades as part of the re-development of broader precincts such as the GSTC and Mid-Block areas.

Development of a collaborative, catchment-wide approach to address the issues identified above was an important outcome of the public exhibition process. The progression of flood mitigation measures resulting from this process is documented in the following section.

# 4. PUBLIC EXHIBITION AND AMENDMENTS TO PLAN

Community feedback on the Draft Floodplain Risk Management Study and Plan was sought during a public exhibition period, which occurred between 9th May and 28th June 2011. Submissions were invited from community members and other stakeholders in response to the recommendations of the reports. The documents were exhibited at:

- Town Hall House, Level 2, 456 Kent Street, Sydney; and
- Green Square Library & Customer Service Centre, 100 Joynton Avenue, Zetland.

## 4.1. Public Exhibition Submissions

Two submissions were received from the public exhibition period (see Appendix B). The submissions and relevant outcomes for this Floodplain Risk Management Plan are summarised below.

Sydney Water provided a submission indicating that the organisation did not support the drainage works proposed within the GSTC development ("Option 1a"). The specific objections raised by Sydney Water to this drainage option were that:

- preferred Option 1a would simply shift the flood problem from the GSTC onto nearby roads and property owners, particularly worsening impacts in the more common flood events (e.g. flood levels downstream of the GSTC were shown to increase by up to 190mm for the 50% AEP design event);
- the Floodplain Risk Management Study and Plan should be re-cast with a view to articulating a more sustainable and equitable strategy for addressing flood risk within Green Square and the GSTC, and one that allows for flood risk in Green Square to be gradually reduced over time; and
- Sydney Water would be willing to contribute towards development of this strategy if requested by CoS.

A submission was also provided by consultants SJB Planning, representing LML, the development consortium for the GSTC site, comprising Landcom (now Urban Growth NSW), Mirvac Projects and Leighton Properties. The SJB Planning submission raised the following issues and desired outcomes:

- The proposed raising of Joynton Avenue to remove the low point should be required to not adversely impact the proposed road grading within the core site area of the GSTC;
- The proposed raising of Joynton Avenue should be required to not exacerbate the flood risk for the core site area of the GSTC; and
- LML identified that the development application for the GSTC site relied on implementation of trunk drainage upgrades ("Option 1a"), and sought confirmation that such works would be undertaken.

These submissions therefore reflected a core underlying problem for floodplain management in the Green Square catchment. Development of the GSTC core sites was not deemed

appropriate unless the existing flood risk at the site and in neighbouring areas (such as the Botany Road and Joynton Avenue low-points) could be mitigated significantly. However, the options for mitigation proposed at the time, specifically "Option 1a", produced adverse flood risk impacts on existing developments, landowners and public infrastructure such as roadways.

While the GSTC development was acknowledged by all parties to be a project of high priority and significance, it was not considered appropriate to approve the development without a reduction in the flood risk at the site, nor if the works to achieve this flood mitigation would produce inequitable flood impacts at other locations in the catchment.

## 4.2. Outcomes from Public Exhibition Process

A key outcome of the public exhibition process was the collaboration between Sydney Water and CoS to further refine and develop options for trunk drainage upgrades. This joint involvement of major stakeholders led to development of a more balanced and equitable drainage option that addresses flood risk on a catchment-wide basis, rather than at individual "hot-spots" like the GSTC development site.

Crucially, this process also facilitates a direct contribution of funding from Sydney Water, enabling consideration of more comprehensive, expensive drainage upgrades, which were not originally considered feasible during preparation of the Draft Floodplain Risk Management Study and Plan. It is clear that comprehensive catchment-wide solutions are necessary to resolve flood issues at several key development precincts, arising from the piecemeal nature of historical development in the catchment. Progress towards suitable outcomes has been stifled in recent years primarily because the issues are too broad to be addressed by a single entity or landowner, and require a major infrastructure overhaul coordinated amongst all stakeholders. The revised trunk drainage option developed by Sydney Water and CoS is a significant improvement in this regard over options previously investigated.

## 4.3. Revised Preferred Trunk Drainage Upgrade – "Option A"

The revised proposal ("Option A") is to provide a significantly larger trunk drainage culvert to drain the entire Green Square catchment area. The proposed culvert includes an upgrade to the Sydney Water trunk drainage line from Link Road, Zetland through Precinct E to Joynton Avenue, augmenting the existing drainage line from Joynton Avenue to Botany Road (adjacent to the GSTC site), with a new second trunk system from Botany Road to Alexandra Canal. A report prepared by CoS (Appendix C) provides details about the culvert alignment, design, and impact on flood behaviour. Key aspects of the proposal are summarised below.

The land acquisition required for the proposed drainage alignment has already been undertaken by CoS. The new culvert would primarily run underneath roadways (some of which will be newly constructed as part of development precincts) and other public land, apart from one section along the rear of properties from 42 to 70 Bourke Street, where an easement would be required. If problems arise with the acquisition of the easement, an alternative alignment along Bourke Road is feasible.

The design capacity of the proposed culvert is to contain a 5% AEP (20 year ARI) flow. The flows above the 5% AEP storm event and up to a 1% AEP storm event will be conveyed as overland flow above the trunk drainage line, along the proposed and existing road carriageways to Alexandra Canal.

The proposed culvert is approximately 2.3km long and the size varies from 4.5m wide by 1.5m high at Link Road to 6m wide by 1.8m high at the entry to Alexandra Canal. The proposed culvert would be covered and is fully below ground level.

This proposed trunk drainage upgrade ("Option A") would eliminate the requirement to provide retarding basins within the Epsom Park Precinct as well as within the GSTC site.

## 4.4. Summary of "Option A" Modelling Investigations

Appendix C documents hydraulic modelling of the proposed culvert commissioned by CoS and Sydney Water. The modelling results indicate a significant reduction in flood risk along the entire length of the upgrade, although some increases to peak flows and flood levels are expected within the open channel portion of Alexandra Canal, from near Huntley Street to the bridge at Ricketty Street/Canal Road (discussed further below).

The benefits of the "Option A" works would include:

- Reduced disruption to traffic at Botany Road and Joynton Street, both of which are frequently closed to traffic as a result of flooding (sometimes on multiple occasions in a single year);
- Reduced flood risk for private property along the existing trunk drainage line from Botany Road to Alexandra Canal, where there are areas severely affected by flood inundation. "Option A" would reduce 1% AEP flood levels by more than 0.5 m at various locations along O'Riordan Street, Bourke Road, Mandible Street, Bowden Street, Maddox Street, and the open channel section between Bowden Street and Huntley Street.
- Increased potential for regional trunk drainage upgrades for upstream areas, including the Midblock precinct, South Downling Street low-point, Lachlan Avenue low-point, O'Dea Avenue, and Joynton Avenue pipe systems. Without the "Option A" infrastructure, these upgrades would be expected to produce adverse flood impacts for existing development, particularly along the existing trunk drainage line from Botany Road to Alexandra Canal;
- Increased development potential for the Epsom Road Precinct (Precinct E) and GSTC site, which have regional planning significance. Under existing conditions for events greater than the 5% AEP high hazard flow is expected to occur through the GSTC site and into the underground Green Square railway station entry. "Option A" would prevent this overland flow from occurring, enabling the GSTC site to be developed to its potential and significantly reducing the flood risk for public assets such as Botany Road and the railway station.

Modelling also indicates that there may be increases to peak flows and flood levels in Alexandra Canal as a result of the proposed "Option A" upgrade. The increase to the 1% AEP level is estimated to vary from 0.08 m at the head of Alexandra Canal to around 0.01 m at the Canal Road/Ricketty Street bridge crossing.

Further investigation is required to identify the extent to which these increases may adversely impact existing buildings adjacent to Alexandra Canal. A preliminary assessment of the overbank flood affectation (Appendix A) suggests that many of these buildings may not be affected by above floor inundation in the 1% AEP flood.

It will be necessary to undertake a more rigorous assessment of these potential adverse impacts as part of the detailed design work to refine "Option A." If adverse impacts are identified, the following potential options should be explored to mitigate the impacts to a level acceptable to the affected landholders:

- widening of the Alexandra Canal waterway for all or part of the impacted area. Adjacent land on the eastern bank is understood to be owned by CoS, so additional acquisition may not be required to undertake widening works;
- throttling of downstream sections of the proposed "Option A" culvert, or staging of the upgrade works, to allow sufficient time for redevelopment of affected buildings;
- localised flood proofing works such as flood defense barriers or levee walls for affected properties; or
- financial compensation to affected tenants and landholders, based on estimated increases to average annual damages resulting from flood inundation.

Consultation will be required during further design stages with landholders identified as being affected by flood level increases, once more detailed modelling of the potential impacts has been completed. Further modelling should include consideration of the sensitivity of results to assumed levels of coincident backwater flooding in Alexandra Canal from the Cooks River

It is considered likely that a combination of the above options will be able to address potential adverse impacts arising from the "Option A" upgrade works. Considerable effort in addressing these potential issues is warranted, as the benefits produced by the upgrade are substantial, both for public assets and private property. The "Option A" works represent a distinctive opportunity to address many of the legacy flood issues within the catchment.

The proposed drainage works should include stormwater quality improvement devices to meet the objectives of the City's Decentralised Water Master Plan. These requirements should be addressed during further design stages for the proposed works.

The proposed drainage solutions have been assessed by staff from Sydney Water and the NSW Office of Environment and Heritage. These organisations have provided in-principle agreement subject to the issues above being addressed.

# 5. FLOODPLAIN RISK MANAGEMENT PLAN

## 5.1. Introduction

The Green Square Floodplain Risk Management Plan has been prepared in accordance with the NSW Floodplain Development Manual (April 2005) 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.*

All possible management measures were evaluated in the Floodplain Risk Management Study (Reference 5) taking into account a range of parameters. This process eliminated a number of measures including:

- Flood mitigation dams (no available space in catchment). Note that these options are distinct from detention basins which are proposed as part of the plan,
- Levees, flood gates and pumps,
- Flood warning (available warning time too short),
- House raising (no suitable buildings), and
- Voluntary purchase.

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 0 to 5.5. Note that the various measures are presented in no particular order within each priority group.

## 5.2. Other Existing Floodplain Risk Management Plans

CoS and Landcom commissioned the Floodplain Risk Management Plan for the GSTC precinct in 2008 (Reference 6). The GSTC Floodplain Risk Management Plan was provided by the CoS for direct inclusion in this report. The outcomes of the GSTC Floodplain Risk Management Plan are supported by existing technical assessments commissioned by the CoS and Landcom (Reference 7).

The GSTC Floodplain Risk Management Plan (Reference 6) was prepared to address flood risk management issues and manage impacts associated with re-development of the GSTC precinct between Joynton Avenue and Botany Road. The outcomes include a combination of structural flood mitigation measures, property modification measures (e.g. development controls) and emergency response modification measures (e.g. community awareness, emergency response plans). Full details of the measures can be found in Reference 6.

This present Floodplain Risk Management Plan for the broader Green Square catchment makes

reference to the corresponding GSTC Plan where relevant in the following sections.

## 5.3. HIGH Priority Floodplain Management Measures

### 5.3.1. 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.

### 5.3.2. Public Information and Raising Flood Awareness

- **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 Green Square catchment generally have low flood awareness and it is expected that there is a correspondingly low level of preparedness. This can be attributed to the quick onset of flooding, the influx/turnover of residents within the area (particularly since the last major flooding that occurred in November 1984), a general low awareness of flooding in an urban area (as opposed to say a rural area such as the Hunter Valley) and the possibility of flooding occurring at night.

A suitable Council wide flood awareness program should be implemented by Council using appropriate elements. 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 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.

### 5.3.3. Planning Instruments and Development Control Planning

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

**OUTCOMES**
The South Sydney Local Environment Plan (1998) (SSLEP) currently includes general provisions for development on flood prone land. In addition to site specific conditions, the GTSC LEP amendment also includes a reference to the Floodplain Development Manual (2005) and requires the use of relevant floodplain risk management principles in accordance with the Manual.

Council has adopted flood-related development controls through a number of Development Control Plans (DCP) for the Green Square area and specifically for the GSTC precinct. Whilst not precluding the specific conditions for the GTSC development, it is recommended that the flood risk management provisions within the more general "*South Sydney Development Control Plan 1997: Urban Design - Part G: Special Precinct No.9 Green Square*" and other relevant DCPs be reviewed and consolidated by Council for adoption across the CoS LGA. This would enable Council to implement sound floodplain management and drainage strategies across the all catchments in a consistent manner.

**ACTIONS**
Council should consider including a reference to the Floodplain Development Manual and/or relevant floodplain risk management principles in the SSLEP with regards to development on flood prone land.

Council should review and consolidate existing flood-related DCPs and in time formally adopt a Flood Risk Management DCP applicable for the broader LGA. Note that this does not preclude the use of more refined, site specific control conditions where needed.

### 5.3.4. Flood Planning Levels

- **Cost:** negligible,

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

**OUTCOMES**

Flood Planning Levels for the Green Square region are documented as part of the "*South Sydney Development Control Plan 1997: Urban Design - Part G: Special Precinct No.9 Green Square*". Council should consider the implementation of similar Flood Planning Levels applicable to all catchments throughout the LGA.

**ACTIONS**

It is recommended that Council undertake to review and consolidate existing Flood Planning Level conditions documented in a number of current DCPs to produce a consistent set of Flood Planning Levels applicable across the CoS LGA. Note that this does not preclude the use of more refined, site specific controls where needed.

### 5.3.5. Notations to the Section 149 Certificate

- **Cost:** internally within Council,
- **Responsibility:** Council,
- **Timeframe:** proposed commencement in 2014–2015.

**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**

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

- the development of a formal CoS Flood Policy,
- the exact content for s149 notations and the nature of the information to be included and;
- Council's internal processes used to manage this aspect.

### 5.3.6. 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,
- consider adopting parking controls at locations where the flow is large and regularly inundates adjacent properties,
- review the street tree planting strategy to minimise leaf litter as far as possible and assist residents to collect and dispose of leaf litter,
- 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.

### 5.3.7. Detention Basins

- **Cost:** Significant - typically in the order of $0.3M to > $1.0M (subject to capacity and site constraints)
- **Responsibility:** Council, Property Owners
- **Timeframe:** Ongoing, to be incorporated as part of re-development activities within catchment as opportunities arise.

**OUTCOMES**

Within the Green Square portion of the catchment a number of detention basins have been constructed (or are planned for construction) as part of ongoing urban renewal activities (details can be found in Reference 3).

Under the Draft Plan, CoS identified potential for detention basins to be constructed as part of the GSTC development and the Precinct E area immediately upstream of Joynton Avenue (References 6 and 7). To reduce the flood hazard across Joynton Avenue, CoS proposes to eliminate the Joynton Avenue low-point (i.e. raise the roadway) and construct a new detention basin within the Precinct E area. Precinct E is Council owned land that is located upstream of the existing Joynton Avenue low-point. However, with the revised trunk drainage upgrades ("Option A"), these basins would not be required, as the trunk drainage capacity would be sufficient to substantially reduce overland flow and flood hazard in these areas.

It has also been previously identified that there is potential for a detention basin to be constructed near the north-west corner of South Dowling Street and O'Dea Avenue to mitigate flooding in the South Dowling Street low-point. However this basin was associated with re-development of private land at this location, which did not proceed

**ACTIONS**

Under existing conditions, the Joynton Avenue low-point experiences nuisance flooding in

smaller, more frequent events and is subject to significant ponding (flood depths greater than 0.8m) in larger events. It is a significant flood hazard within the catchment and opportunities to reduce the flood hazard are supported. Construction of a detention basin at Precinct E would be one way to achieve this outcome, but would not provide significant downstream benefits (Reference 7), and the basin would be largely redundant if the "Option A" trunk drainage work are constructed (see following section).

Therefore no specific sites for detention basins are identified for construction as part of this Plan. However opportunities to construct basins may arise as part of large future developments, particularly in the Midblock precinct. Potential sites should be investigated as part of the water management strategies for renewal precincts.

### 5.3.8. Pit/Pipe and Trunk Drainage Upgrades

- **Cost:** Significant – estimated $79.8M indicative cost for the comprehensive "Option A" trunk drainage upgrade, and further costs typically in the order of $3.0M to $6.0M for localised works (subject to extent of works and site constraints),
- **Responsibility:** Council, Sydney Water, Precinct Developers, Property Owners
- **Timeframe:** Ongoing, to be incorporated as part of re-development activities within catchment as opportunities arise.

Cost estimates for the "Option A" trunk drainage were undertaken in January 2013 by WT Partnership Cost Engineering Consultants. For each of the other options indicative costs were provided by the CoS based on estimates of similar type of works in the Green Square area (e.g. the proposed trunk upgrade along O'Dea Avenue) and maybe significantly impacted due to the need to relocate existing services. Hence the costs provided herein are 'order of magnitude' only and will need to be reviewed during the course of more detailed assessment during the civil design phase.

When considering these costs, it should be noted that each measure can provide significant benefit e.g. reduction of flood hazard and improvements to personal safety and risk to life. Other works have the potential to reduce nuisance flooding from more frequent events. Although these intangible aspects are difficult to quantify in strict monetary terms, they provide significant incentive for the implementation of the following works.

**OUTCOMES**

There are several options available that will provide some reduction in overland flow and thus reductions in peak levels and overall flooding:

**"OPTION A" WORKS**

The revised "Option A" works are proposed for construction superseding the previously proposed "Option 1a" works. The location of the GSTC within the overall catchment and the scale of the proposed re-development presents a unique opportunity to implement mitigation

works that provide benefits for the broader catchment. The previous proposed works did not provide any benefits off-site ("Option 1a – Limited Works option" – refer to Reference 6 for details). In contrast the "Option A" works, although significantly more expensive, represent a distinctive opportunity to address many of the legacy flood issues within the catchment, and provide broad benefits for both public and private assets/development.

- ***Stage 1 – Bourke Street to Alexandra Canal (estimated costs $18.9M to be funded by Sydney Water)***
  A major new trunk drainage culvert with 5% AEP (20 year ARI) capacity is to be provided along a different alignment to the current trunk system (with the existing system retained). The alignment would be along existing and new road reserves, with required land already acquired by CoS (see Appendix C for details). These works are a necessary precursor to the other drainage upgrades proposed below, in order that existing developments from Botany Road to Alexandra Canal are not adversely affected by increased flows from upstream.

- ***Stage 2 – Joynton Avenue to Bourke Street (estimated costs $42.9M to be funded by CoS)***
  The works include construction of a large new culvert with 5% AEP (20 year ARI) capacity, roughly parallel to the existing drainage system between Joynton Avenue and Botany Road, then branching south to a new road linking O'Riordan Street to Bowden Street (see Appendix C for details).

- ***Stage 3 – Upgrade of existing Sydney Water trunk system from Link Road to Joynton Avenue (estimated costs $18.0M to be funded by Sydney Water)***
  The works involve replacement of the existing trunk system (a disjointed combination of pipes and open channel) with a new culvert with 5% AEP (20 year ARI) capacity. The culvert is to be constructed under a new road reserve as part of the Epsom Road Precinct renewal (see Appendix C for details).

Modelling indicates that these works produce significant widespread benefits, but may cause slight increases to peak flows and flood levels within Alexandra Canal. These potential impacts are to be addressed by the CoS during the next design stage for the works, but it is considered that feasible options exist for mitigation of these impacts (see Section 4.4).

**OTHER WORKS**

- ***Re-development of Mid-block Precinct (between O'Dea Avenue and Lachlan Street)***
  For this area CoS is investigating local drainage upgrades as part of a number of major urban re-development projects occurring (or planned to occur) within this area. The extent of the proposed re-development area creates opportunities to provide upgrades to the regional trunk system serving this portion of the catchment.

- ***Upgrade of O'Dea Avenue and Joynton Avenue trunk system (estimated cost $3.0M)***

  CoS is currently investigating upgrading the trunk system within O'Dea Avenue, into which much of the Mid-block precinct will drain. When considered together with the proposed upgrades to the Mid-block system, there is the potential to provide regional improvements to trunk drainage throughout O'Dea Avenue and Joynton Avenue. Note that upgrades to the inlet and pipe capacities along Joynton Avenue will be required to gain the full benefit of the "Option A" culvert works in reducing flooding of the Joynton Avenue low point (see Section 7.3 of Appendix C).

- ***Potential Works in proximity of South Dowling Street trapped low point (estimated costs: $1.5M)***

  The creation of a managed overland flow path from the South Dowling Street low-point together with upgraded trunk drainage capacity and/or a detention basin was found to significantly reduce peak flood levels within the South Dowling Street low-point. There is also the potential for these works to be integrated into the future re-development of the Mid-block precinct.

**ACTIONS**

There is potential for the works described above to significantly improve the local flood behaviour in each area. It is recommended that the implementation of these options be supported as funding opportunities arise through planned re-development within the Green Square area.

It is noted that the indicative funding requirements to construct the above works are approximately $36.9M from Sydney Water and up to approximately $50.0M from CoS. City of Sydney's current 10-year provision for drainage upgrades is $75.0M for the entire LGA. CoS has indicated that the Green Square catchment is a high priority area, and given the high level of existing flood risk, and the opportunity to substantially reduce future flood risk, this relatively high proportion of spending is supported by Council staff.

In each case a detailed assessment is needed to ensure that the proposed works do not adversely impact other areas within the catchment. The above investigations will all require a ground and floor level survey and a detailed drainage investigation is to be undertaken to identify potential inundated properties, assess impacts to downstream properties, estimate the potential flood damages and scope design requirements.

## 5.4. MEDIUM Priority Floodplain Management Measures

### 5.4.1. Implement Climate Change Policy

- **Cost:** minimal for Council but will add to developer costs,
- **Responsibility:** Council, DECCW, property owner,
- **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 event for existing conditions as part of the GSWK Floodplain Risk Management Study (Reference 5). As the lowest elevation within the study area is in the order of 10.0 mAHD, flood levels within the study catchment are not affected by potential changes in sea-level rise.

Within the Green Square study area, the potential increase in peak flood level resulting from a +30% increase in rainfall was generally found to be less than 0.25m. The greatest increases were found to occur in trapped low-points. Corresponding increases along unobstructed overland flowpaths (e.g. within roadways and through property) were typically less than 0.15m. Impacts of this magnitude can be readily accommodated through the use of appropriate Flood Planning Level freeboards, particularly for residential development and critical infrastructure.

**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.

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.

### 5.4.2. Local Flood Plan

- **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 Green Square 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 with SES seek to develop and adopt a Local Flood Plan.

### 5.4.3. 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 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).

## 5.5. LOW Priority Floodplain Management Measures

### 5.5.1. 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 1) including:

- Opportunities to maximise the pervious area in developments as part of BASIX requirements to reduce potable water demand should be encouraged. These principles can also be applied to other 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.

# 6. ACKNOWLEDGEMENTS

This study was carried out by WMAwater and funded by City of Sydney and the Office of Environment and Heritage. The assistance of the following in providing data and guidance to the study is gratefully acknowledged:

- City of Sydney;
- Randwick City Council;
- Office of Environment and Heritage;
- Green Square - West Kensington Floodplain Management Committees;
- Sydney Water;
- Residents of the Green Square catchment.

# 7. REFERENCES


1. **NSW Government**
**Floodplain Development Manual**
April 2005

2. **Webb McKeown and Associates**
**Green Square – West Kensington (Sheas Creek Victoria Branch) Flood Study**
April 2008

3. **WMAwater**
**West Kensington (DRAFT) Flood Study**
Prepared on behalf of Randwick City Council, April 2010

4. **Public Works Department NSW**
**West Kensington Flooding Drainage Works Investigation**
Technical Report No. 85037, December 1985

5. **WMAwater**
**City of Sydney Green Square - West Kensington Floodplain Risk Management Study**
July 2013

6. **Cardno Lawson Treloar Pty. Ltd**
**Green Square Town Centre Draft Floodplain Risk Management Plan**
Technical Report prepared for City of Sydney, 18 July 2008

7. **Connell Wagner Pty. Ltd. and Cardno Lawson Treloar Pty. Ltd**
**Flood Mitigation Options Report Green Square**
Draft Technical Report prepared for City of Sydney, 16 July 2008

8. **WMAwater**
**O'Dea Avenue Drainage Works Hydraulic Impact Assessment**
Letter Report prepared for City of Sydney
28 May 2008

9. **WMAwater**
**Midblock Drainage Strategy Assessment**
Letter Report prepared for City of Sydney
8 September 2008

# Figures

FIGURE 1
**STUDY AREA**

ACI site
Lachlan St
Amelia St
Dacey Ave
Moore Park Supacentre
Moore Park Golf Course
Wyndham St
Hunter St
Powell St
Elizabeth St
George St
O'Dea Ave
Botany Rd
Bourke St
Mandible St
Wyndham St
Tote Park
VICTORIA PARK
Joynton Park
Green Square Railway Station
Tilford St
Todman Ave
Cooper Pl
Raleigh Park
Cooper Pl
Gadigal Ave
Bowden St
Nuffield Park
South Dowling St
Winkurra St
Baker St
Balfour Rd
Kensington Rd
Duke St
Milroy Ave
McDougall St
NSW Police
Waverley Council Works Depot
Joynton Ave
O'Riordan St
Portman St
Royal South Sydney Community Health Complex
City of Sydney Epsom Road Depot
Myrtle St
Virginia St
Ingram St
Lenthall St
Epsom Rd
Botany Rd
Epsom Rd
Link Rd
The Australian Golf Course

N

Midblock Precinct
Study Area

0 125 250 m

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FIGURE 2
**LAND USE ZONINGS**


Source: South Sydney Local Environment Plan 1998 (As Amended)
*J:\Jobs\28041-01\Admin\Report\Plans\CoS\Figures\Figure02_LanduseZonings.cdr*

FIGURE 3A

**PEAK FLOOD LEVELS AND DEPTHS 1% AEP EVENT**

**Peak Depth (m)**

- < 0.2
- 0.21 - 0.5
- 0.51 - 1
- > 1

**Peak Flood Level (m AHD)**

- Major Contour (1m)
- Intermediate Contour (0.2m)
- Building Outlines

0 25 50 100 150 m

N

PORTMAN ST

JOYNTON AVE

GADIGAL AVE

O'DEA AVE

LACHLAN ST

Waverley Council Works Depot

Royal South Sydney Community Health Complex

Tote Park

Joynton Park

Nuffield Park

Refer to Note 1

Refer to Note 1

NOTES:
1: Flowpaths in these areas (denoted by ▨) maybe subject to localised ground features - to be confirmed via Site Inspection
2: Base Photos Dated 2004

J:\Jobs\28041\Arcview\Maps\GSPlan\Figure03A_Depth_100yr.mxd

FIGURE 3B
**PEAK FLOOD LEVELS AND DEPTHS 1% AEP EVENT**

WYNDHAM ST
BOURKE RD
Green Square Railway Station
O'RIORDAN ST
NSW Police
BOTANY RD
Waverley Council Works Depot
PORTMAN ST
Royal South Sydney Community Health Complex
JOYNTON AVE
Joynton Park
GADIGAL AVE
Nuffield Park
SOUTH DOWLING ST
Refer to Note 1
City of Sydney Epsom Road Depot
EPSOM RD
LINK RD

N

**Peak Depth (m)**

- < 0.2
- 0.21 - 0.5
- 0.51 - 1
- > 1
- Building Outlines

**Peak Flood Level (m AHD)**

- Intermediate Contour (0.2m)
- Major Contour (1m)

NOTES:
1: Flowpaths in these areas (denoted by ▨) maybe subject to localised ground features - to be confirmed via Site Inspection
2: Base Photos Dated 2004, except for West of Portman St Dated 2007

0 25 50 100 150 200 250 300 350 400 m

J:\Jobs\28041\Arcview\Maps\GSPlan\Figure03B_Depth_100yr.mxd

J:\Jobs\28041\Arcview\Maps\GSPlan\Figure03C_Depth_100yr.mxd

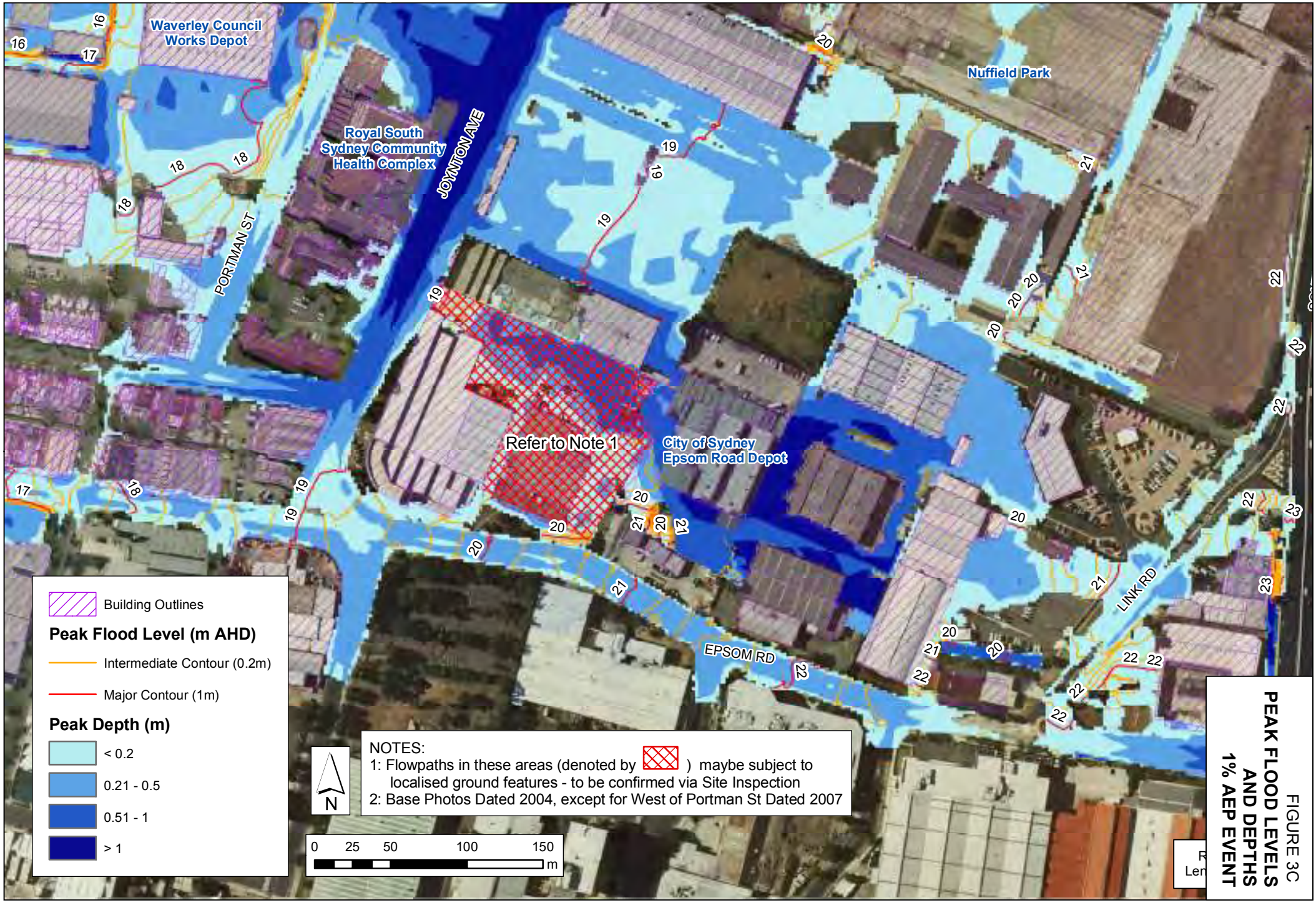


FIGURE 3C
**PEAK FLOOD LEVELS AND DEPTHS 1% AEP EVENT**

FIGURE 4A

# PEAK FLOOD LEVELS AND DEPTHS PMF ENVELOPE

**Peak Depth (m)**

- < 0.2
- 0.21 - 0.5
- 0.51 - 1
- > 1

**Peak Flood Level (m AHD)**

- Major Contour (1m)
- Intermediate Contour (0.2m)
- Building Outlines

0 25 50 100 150 m

N

Waverley Council Works Depot

PORTMAN ST

Royal South Sydney Community Health Complex

JOYNTON AVE

Refer to Note 1

Tote Park

ity of Sydney
psom Road Depot

GADIGAL AVE

Joynton Park

Nuffield Park

ODEA AVE

Refer to Note 1

LACHLAN ST

SOUTH DOWLING ST

NOTES:
1: Flowpaths in these areas (denoted by ▨) maybe subject to localised ground features - to be confirmed via Site Inspection
2: Base Photos Dated 2004

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FIGURE 4B

**PEAK FLOOD LEVELS AND DEPTHS PMF ENVELOPE**

WYNDHAM ST
BOURKE RD
Green Square Railway Station
O'RIORDAN ST
NSW Police
BOTANY RD
Waverley Council Works Depot
Royal South Sydney Community Health Complex
JOYNTON AVE
PORTMAN ST
Joynton Park
GADIGAL AVE
Nuffield Park
Refer to Note 1
City of Sydney Epsom Road Depot
EPSOM RD
LINK RD
SOUTH DOWLING ST

N

Building Outlines

**Peak Flood Level (m AHD)**

Intermediate Contour (0.2m)

Major Contour (1m)

**Peak Depth (m)**

< 0.2

0.2 - 0.5

0.5 - 1

> 1

0 25 50 100 150 m

NOTES:
1: Flowpaths in these areas (denoted by ▨ ) maybe subject to localised ground features - to be confirmed via Site Inspection
2: Base Photos Dated 2004, except for West of Portman St Dated 2007

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J:\Jobs\28041\Arcview\Maps\GSPlan\Figure04C_Depth_PMFmax.mxd

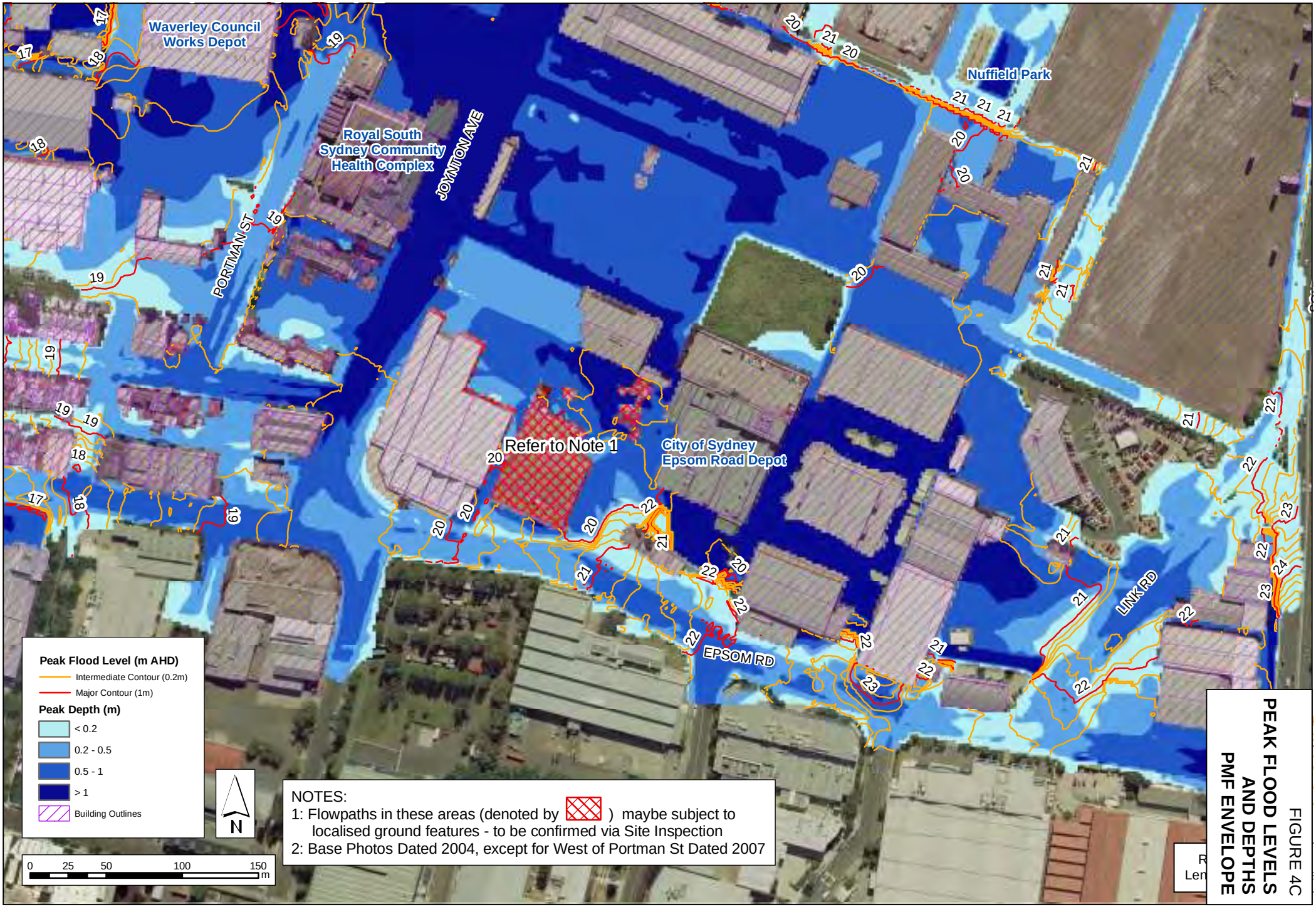
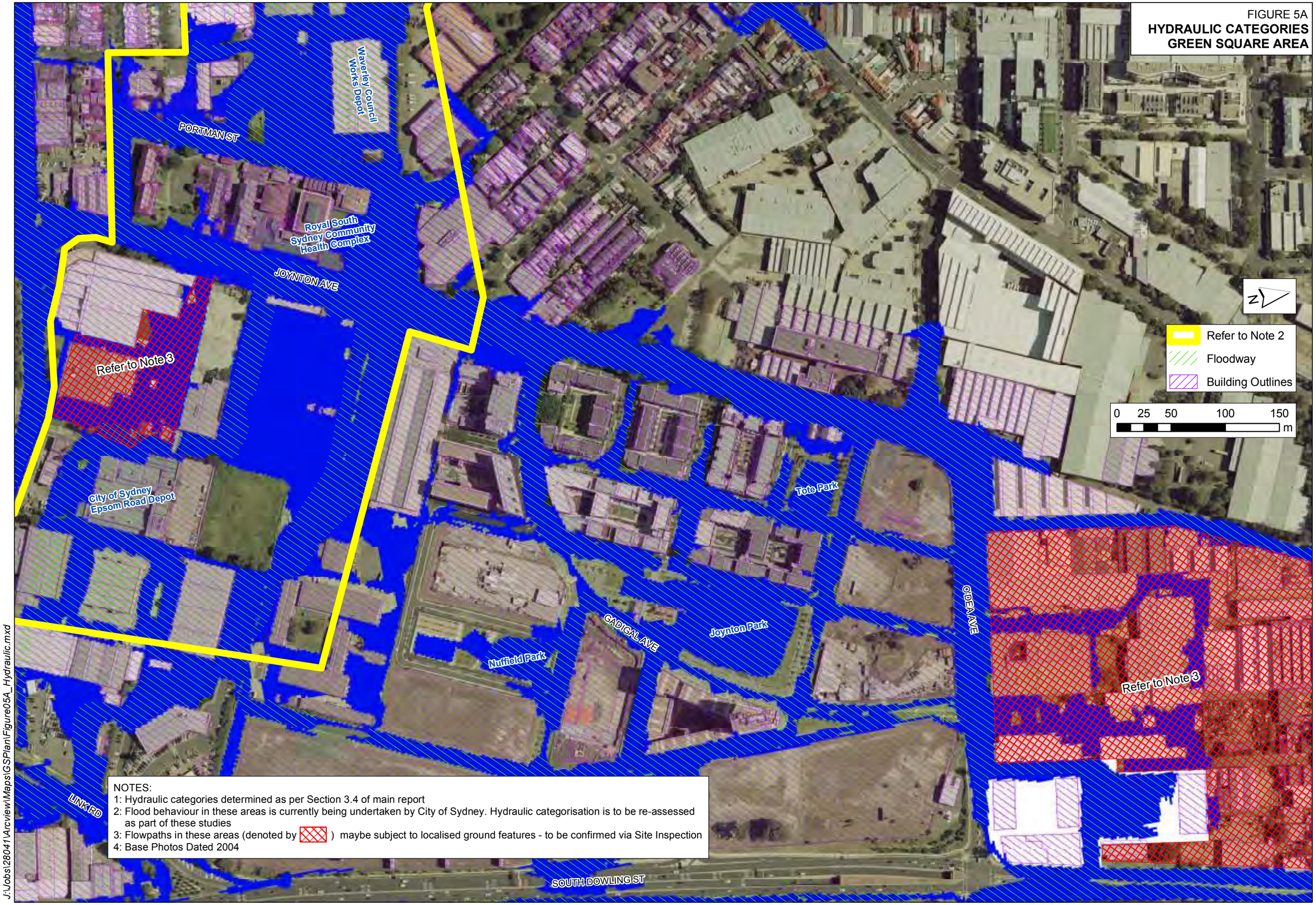



FIGURE 4C

**PEAK FLOOD LEVELS AND DEPTHS PMF ENVELOPE**

FIGURE 5A
**HYDRAULIC CATEGORIES**
**GREEN SQUARE AREA**




NOTES:
1: Hydraulic categories determined as per Section 3.4 of main report
2: Flood behaviour in these areas is currently being undertaken by City of Sydney. Hydraulic categorisation is to be re-assessed as part of these studies
3: Flowpaths in these areas (denoted by ▨) maybe subject to localised ground features - to be confirmed via Site Inspection
4: Base Photos Dated 2004

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FIGURE 5B
**HYDRAULIC CATEGORIES**
**GREEN SQUARE AREA**

WYNDHAM ST
BOURKE RD
Green Square Railway Station
O'RIORDAN ST
NSW Police
Waverley Council Works Depot
BOTANY RD
Royal South Sydney Community Health Complex
JOYNTON AVE
PORTMAN ST
Joynton P
GADIGAL AVE
Nuffield Park
SOUTH DOWLING ST
Refer to Note 3
City of Sydney Epsom Road Depot
EPSOM RD
EPSOM RD
LINK RD

N

Refer to Note 2
Floodways
Building Outlines

**Hydraulic Categories**

Flood Storage

0 25 50 100 150 m

NOTES:
1: Hydraulic categories determined as per Section 3.4 of main report
2: Flood behaviour in these areas is currently being undertaken by City of Sydney. Hydraulic categorisation is to be re-assessed as part of these studies
3: Flowpaths in these areas (denoted by ▨) maybe subject to localised ground features - to be confirmed via Site Inspection
4: Base Photos Dated 2004, except for West of Portman St Dated 2007

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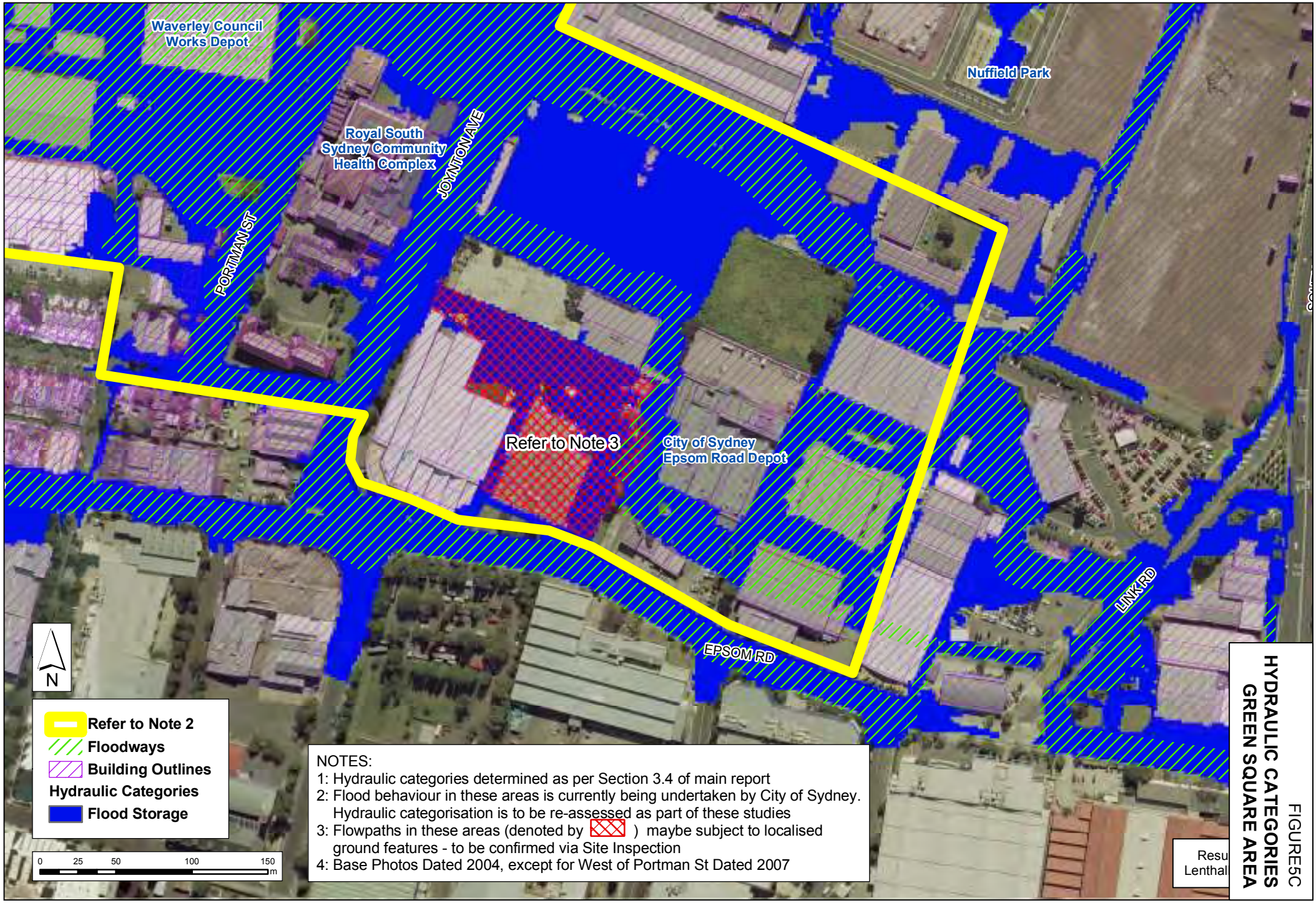


NOTES:
1: Hydraulic categories determined as per Section 3.4 of main report
2: Flood behaviour in these areas is currently being undertaken by City of Sydney. Hydraulic categorisation is to be re-assessed as part of these studies
3: Flowpaths in these areas (denoted by ▨) maybe subject to localised ground features - to be confirmed via Site Inspection
4: Base Photos Dated 2004, except for West of Portman St Dated 2007

Resu
Lenthal

**HYDRAULIC CATEGORIES GREEN SQUARE AREA**

FIGURE5C

FIGURE 6
**FLOOD HAZARD CATEGORIES**
**1% AEP EVENT**

Lachlan St
Dacey Ave
Abram St
Hunter St
Amelia St
Powell St
Elizabeth St
Moore Park Supacentre
Moore Park Golf Course
George St
O'Dea Ave
Botany Rd
Bourke St
Mandible St
Wyndham St
Tote Park
Toohan Ave
Joynton Park
Green Square Railway Station
Tilford St
Cooper Pl
Raleigh Park
Cadigal Ave
Victoria Park
Nuffield Park
Winkura St
Baker St
Duke St
Milroy Ave
McDougall St
Myrtle St
Virginia St
Ingram St
Lenthall St
Link Rd
Epsom Rd
Kensington Rd
Balfour Rd
South Dowling St
Joynton Ave
O'Riordan St
NSW Police
Waverley Council Works Depot
Portman St
Royal South Sydney Community Health Complex
City of Sydney Epsom Road Depot
The Australian Golf Course

NOTES:
1: Flowpaths in these areas (denoted by ▨) maybe subject to localised ground features - to be confirmed via Site Inspection
2: Base Photos Dated 2004, except for West of Portman St Dated 2007
3: Refer to Section 3.5 of report

N

0 125 250 m

Building Outlines

**Flood Hazard Categories**

Low

High

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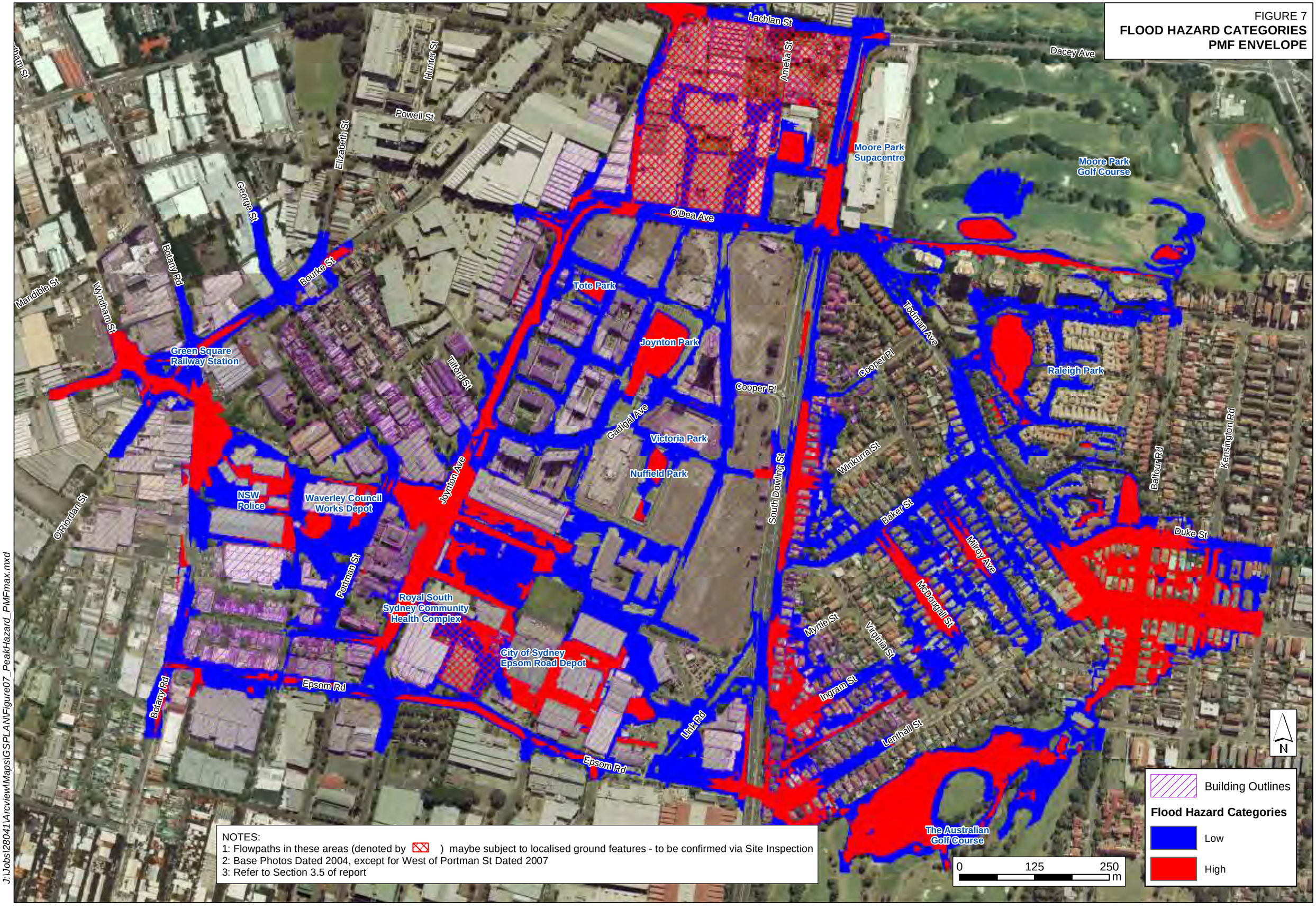
FIGURE 7
**FLOOD HAZARD CATEGORIES**
**PMF ENVELOPE**




NOTES:
1: Flowpaths in these areas (denoted by ▨) maybe subject to localised ground features - to be confirmed via Site Inspection
2: Base Photos Dated 2004, except for West of Portman St Dated 2007
3: Refer to Section 3.5 of report

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NOTES:
1: Base Photos Dated 2004, except for West of Portman St Dated 2007
2: Vacant blocks not assessed for damage estimate

FIGURE 8
**FLOOD DAMAGES ASSESSMENT**

Lachlan St
Hunter St
Amelia St
Dacey Ave
Powell St
Elizabeth St
Moore Park Supacentre
Moore Park Golf Course
George St
O'Dea Ave
Botany Rd
Bourke St
Tote Park
Wyndham St
Joynton Park
Toohan Ave
Green Square Railway Station
Tilford St
Cooper Pl
Raleigh Park
Gadigal Ave
Victoria Park
Nuffield Park
O'Riordan St
NSW Police
Waverley Council Works Depot
Joynton Ave
South Dowling St
Winkurra St
Baker St
Balfour Rd
Kensington Rd
Duke St
McDougall St
Milroy Ave
Portman St
Royal South Sydney Community Health Complex
Myrtle St
Virginia St
Ingram St
Lenthall St
City of Sydney Epsom Road Depot
Epsom Rd
Link Rd
The Australian Golf Course

N

**Event First Inundated Building Floor**

- 50% AEP (1 in 2yr)
- 20% AEP (1 in 5yr)
- 10% AEP (1 in 10yr)
- 5% AEP (1 in 20yr)
- 2% AEP (1 in 50yr)
- 1% AEP (1 in 100yr)
- 0.2% AEP (1 in 500yr)
- PMF
- Not Inundated
- Not Assessed

0 125 250 m

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# Appendix A

# APPENDIX A: GLOSSARY

## 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).<br><br>**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.<br>**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.<br>**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 an 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 diagrammetic 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) | FPL's 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.<br><br>**existing flood risk:** the risk a community is exposed to as a result of its location on the floodplain.<br>**future flood risk:** the risk a community may be exposed to as a result of new development on the floodplain.<br>**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.<br>**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:<br>• 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<br>• 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<br>• major overland flow paths through developed areas outside of defined drainage reserves; and/or<br>• 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.<br><br>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:<br><br>**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.<br>**moderate flooding:** low-lying areas are inundated requiring removal of stock and/or evacuation of some houses. Main traffic routes may be covered.<br>**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. |


Appendix B

2011/162665

Submission 1
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Sydney WATER

17th June 2011


Chief Executive Officer
City of Sydney
GPO Box 1591
SYDNEY NSW 2001

Dear Sir/Madam,

**Re: Public Exhibition: Draft Green Square – West Kensington Floodplain Risk Management Study and Plan**

Thank you for providing Sydney Water with the opportunity to comment on the Draft Green Square – West Kensington Floodplain Risk Management Study and Plan.

**Sydney Water does not support the Draft Study and Plan for the reasons outlined below.**

Cardno have undertaken an extensive analysis of the flooding issues related to the proposed Green Square Town Centre (GSTC) development and a short list of flood mitigation strategy options were identified in the 'Flood Mitigations Options Report – Green Square Town Centre'. City of Sydney has confirmed Option 1a as the preferred option to be implemented through the GSTC essential infrastructure works.

Sydney Water expressed concern that preferred Option 1a would simply shift the flood problem from the GSTC onto nearby roads and property owners, particularly worsening impacts in the more common flood events. These concerns were validated in the Cardno report 'GSTC Essential Infrastructure – Supplementary Flood Information' where flood levels downstream of the GSTC were shown to increase by up to 190mm for the once in two years design event (2 year Annual Recurrence Interval).

From Sydney Water's perspective, it is not an acceptable or sustainable strategy to unfairly burden downstream landowners and the broader community for the benefit of GSTC developers. A development of the magnitude of the GSTC should result in improvements to floodplain management, not adverse outcomes.

The Draft Green Square – West Kensington Floodplain Risk Management Study and Plan covers a broad catchment area of which the GSTC is a relatively small part. The current plan briefly mentions, but does not quantify, the lost opportunity and inequity of Option 1a. The plan to be placed on public exhibition needs to be more open and frank in terms of revealing these issues to the public and in particular explicitly explaining the potential consequences of Option 1a to disaffected landowners.

Sydney Water recommends the Draft Green Square – West Kensington Floodplain Risk Management Study and Plan be re-cast with a view to articulating a more sustainable and equitable strategy for addressing flood risk within Green Square and the GSTC, and

Submission 1
Page 2 of 2

Sydney WATER

specifically one that allows for flood risk in Green Square to be gradually reduced over time (i.e. a long term vision). While Sydney Water would be willing to contribute towards the development of this strategy, we would do so at the request of the City of Sydney, being the primary agency responsible for floodplain risk management.

We trust the above satisfactorily explains Sydney Water's position. Should any further information be required, please feel free to contact the undersigned directly on telephone number 8849 4001.

Yours faithfully,

**Matthew Lewis**
**Senior Stormwater Asset Planner**

Submission 2
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**SJB Planning**

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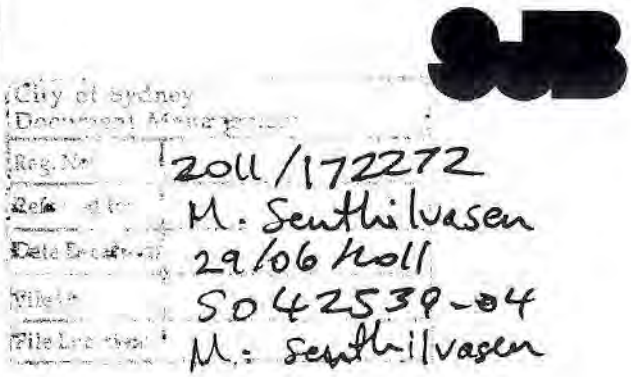


Monica Barone
Chief Executive Officer
City of Sydney Council
456 Kent Street
Sydney 2000

Attention: Myl Senthilvasan

7 June 2011

**Re: Draft Floodplain Risk Management Study and draft Floodplain Risk Management Plan for the Green Square - West Kensington Catchment**

Dear Ms Barone

SJB Planning and Mott Macdonald Hughes Truman are specialist planning and engineering (including infrastructure and flood management) consultants respectively, engaged by Landcom, Mirvac Projects and Leighton Properties (LML) to assist with the planning and future development of the Green Square Town Centre Town Core sites, as defined in the current Planning Proposal being considered by the Council and Central Sydney Planning Committee. The Planning Proposal includes approximately 40% of the land area of the Town Centre, including a significant component of the future public domain.

We are aware that the Council, at its meeting of 7 March 2011, considered a Council officer report on the subject of the Green Square-West Kensington Catchment Area Flood Plain Risk Management Study and Floodplain Risk Management Plan. The Council resolved as follows:

*It is resolved that:*

*(A) Council place the draft Green Square-West Kensington Catchment Area Floodplain Risk Management Study and the Floodplain Risk Management Plan, as shown at Attachments B and C to the subject report, on public exhibition for 28 days; and*

*(B) a further report on the draft Green Square-West Kensington Catchment Area Floodplain Risk Management Study and the Floodplain Risk Management Plan be submitted to Council following the public exhibition process with any proposed changes.*

The draft Study and draft Plan are currently on public exhibition until 28 June 2011.

On behalf of LML, Mott Macdonald Hughes Truman have reviewed the draft Study and draft Plan. Detailed comments are provided by Mott Macdonald Hughes Truman and are attached to this covering letter.

On behalf of LML, we wish to point out to the Council that the draft Study and draft Plan represent a significant departure from the assessment work undertaken to date for the Green Square Town Centre, and in particular the work that was undertaken on behalf of the Council by Cardno, at the time of lodgement and determination of the Essential Infrastructure DA - D/2008/1195. The current Planning Proposal is also based on this previous analysis.

As a result, implementation of the recommendations of the draft Study and draft Plan will have a significant impact on Green Square Town Centre sites contained on LML land. We recommend that the Council review the draft Study and draft Plan based on the attached comments provided by MMHT.

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We also note that the Council may be proposing to undertake a community workshop to discuss the findings of the Study and Plan and we look forward to LML representatives contributing to the workshop.

Should you wish to discuss matters raised in the attached report provided by MMHT we request that you contact Phillip McBride on 94392633 or by email at Phil.mcbride@mottmac.com.au

Yours sincerely

Stuart McDonald

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Mott MacDonald
Hughes Trueman

Report

# Review of Green Square Town Centre Draft of West Kensington Catchment Area Flood Plain Risk Management Study and Floodplain Risk Management Plan - Related to GSTC LML Area

Attention: Monica Barone
Chief Executive Officer – City of Sydney

June 2011

On Behalf of LML Consortium

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Mott MacDonald
Hughes Trueman

**Review of Green Square Town Centre Draft of West Kensington Catchment Area Floodplain Risk Management Study and Floodplain Risk Management Plan – Related to GSTC LML area**

This report provides

1. A review of the following draft documents relating to flood management and identifies the potential implications for the LML consortium area.

a) Green Square-West Kensington Catchment Area Floodplain Risk Management Study by WMA – Draft Report for Public Exhibition – February 2011 (WMA FRMS)
b) Green Square Floodplain Risk Management Plan by WMA – Draft Report for Public Exhibition February 2011 (WMA FRMP 2011)

2. Provides other comments on the regional flooding issues relevant to the release of the Town Core sites within the LML area

Mott MacDonald Hughes Trueman (MMHT) is assisting the consortium on infrastructure and flood management issues related to the development of the Town Centre core sites as defined in the current Planning Proposal being considered by Council.

**1. Review of the draft documents with respect to the LML area**

The WMA FRMP (2011) refers to the lifting of Joynton Avenue at the lowpoint.

a) The lifting of the lowpoint in Joynton Avenue has the potential to impact on the proposed grading of roads within the Town Centre Core site area as proposed in the current LML Planning Proposal being considered by Council. It is recommended that Council be requested to confirm that the lifting of the Joynton Avenue lowpoint shall not impact on the proposed road grading within the core town centre.
b) It is recommended that Council be requested to confirm that any proposed lifting of Joynton Avenue at the lowpoint shall not exacerbate the flood risk for the Town Centre Core sites under consideration by the LML consortium.
c) It is recommended that Council be requested to provide details of the proposed grading changes to all of the affected roads. These changes may impact on the flooding regime for the area and a 3D model of the proposed ultimate road grading for the total Green Square Town Centre area and it is recommended that a 3D model of the area of affected works be obtained.

**2. Other comments relating to the Town Centre Core sites being developed by the LML consortium and the proposed staging of the works.**

The Essential Infrastructure Works to be undertaken by the LML consortium provide for the development of approximately forty (40) percent of the Green Square Town Centre. It is proposed to construct this work in stages.
The following implications are evident.

a) The current approval D/2008/1195 is based on **Option 1a** of the Cardno GSTC FRMP (2008). This provides a development specific 'limited works' option that accords with the LEP/DCP. It provides a mitigation solution for the ultimate development of the **whole** of the Town Centre area layout proposed according to the development layout in D/2008/1195.

It is understood that the flood modelling in Option 1a is based on the following 'dependent' stormwater works to mitigate for increases in downstream flood levels:

- Raising intersection at O'Riordan Street intersection with Bourke Road and some associated stormwater works
- Construction of Boulevard Park/Sheas Stream flood storage basin and associated stormwater pipe works
- Construction of a 1.5m diameter pipe to convey flows from the flood storage area to Bourke Road to reduce overland flow along New Cross Street
- Ground level of RL14.25m at Transport Place facing Botany Road to mitigate flows between Botany Road and O'Riordan Street and construction of a 1.5m x1.5m culvert (limited to 8.5 cumecs capacity) discharging to the O'Riordan Street/Bourke Road intersection

The above 'dependent' mitigation works are located outside the defined work area of the Town Centre Core sites and cannot be delivered as part of the LML consortium works. The exclusion of these works has potential implications for flood mitigation and it is recommended that Council's confirmation that these works shall be undertaken in advance of the LML works is obtained. Alternatively it is suggested that Council's undertaking be obtained that it will consider an alternative management strategy for flood mitigation of this partial area to permit the works to proceed.

MMHT personnel would be pleased to discuss any aspects of these comments with council officers to assist identify an agreed way forward to facilitate the works.

# Appendix C

# Green Square Trunk Drain Concept Design

City of Sydney
Town Hall House
456 Kent Street
Sydney NSW 2000

Issue 1, 15 May 2013


Sydney2030/Green/Global/Connected
city of villages

CITYOFSYDNEY 2030

## Issue Details

| Issue | Date | Prepared By | Approved By | Edition | Notes |
|---|---|---|---|---|---|
| 1 | 21/05/13 | H Rahman | P Shields | Draft | For Internal Comment |
| | | | | | |
| | | | | | |
| | | | | | |

# Contents

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# 1 Introduction

The Green Square Town Centre (GSTC) is an urban renewal project which will transform old industrial properties in Green Square to a mixed commercial/residential land use. The large scale provision of residential units at GSTC would contribute to the State Government's objective of increasing the housing supply in Sydney Metropolitan Area.

The proposed GSTC is located in a floodplain and appropriate flood risk management measures are required to facilitate the urban renewal of this area.

The City of Sydney (City) is finalising the flood risk management plan for the Green Square – West Kensington catchment, which includes the GSTC. As part of this flood planning, the City has identified a flood management option and a few associated sub-options in consultation with Sydney Water Corporation (Sydney Water) to reduce the flood risk at GSTC. The review of options and subsequent concept design of the preferred option is the subject of this report. The funding for implementation of this option is currently being pursued through the State Government's Housing Acceleration Fund and from the City's Long term Financial Plan.

The works are proposed to address flood risk within the catchment through improved trunk stormwater infrastructure.

This report summarises the outcomes of the hydraulic modelling undertaken for developing the preferred flood management option. It also highlights the reduction in flood risk achieved through this design.

# 2 Background

Flooding at GSTC has been assessed in a number of studies in the past. The recent studies include:

1. Green Square - West Kensington Flood Study (WMA, 2008)
2. Flood Mitigation Options Report Green Square Town Centre (Cardno, July 2008)
3. West Kensington - Green Square Flood Study Update (WMA , October 2011)
4. Mid-term Drainage Concept for GSTC (Cardno, 2012)
5. Green Square - West Kensington Floodplain Risk Management Study and Plan (WMA, October 2011) and as amended (WMA, May 2013)
6. Alexandra Canal Flood Risk Management Study and Plan (In progress)

The West Kensington – Green Square Floodplain Risk Management Study evaluated a proposed basin in Epsom Park Precinct and concluded that the basin would provide only limited benefits by providing relief at Joynton Ave sag.

The Flood Mitigation Options Report for GSTC considered additional pipe capacity along an existing stormwater trunk route through the GSTC and the provision of an additional trunk route to bypass the GSTC Public Domain area. This drainage upgrade was not considered optimal and further investigations were recommended as part of stakeholder consultation.

The Mid-term Drainage Concept Plan was prepared in response to the issues associated with the flood management option presented in the Flood Mitigation Options Report for

GSTC. The proposed drainage concept provided for additional capacity along the entire length of existing trunk drainage from Link Road to the Alexandra Canal.

After consultation with Sydney Water, who owns the trunk drainage from Link Road to Alexandra Canal, the City resolved to implement the Mid-term drainage concept to facilitate the development at GSTC. Sydney Water emphasized the need to implement the proposed upgrades before commencement of the development of the GSTC.

The City revised the Mid-term drainage concept in late 2012. After discussions with Sydney Water, the City agreed to prepare a concept design for a new trunk drain along the proposed road corridors instead of upgrading the existing trunk drainage primarily because of the constraints along the existing alignment.

This trunk drain option is the subject of this report. The proposed option eliminates the need to provide a detention basin for the development scenario assessed in this report.

# 3 Existing Flood Behaviour

The GSTC site currently experiences flooding at Joynton Ave and Botany Road. Floodwaters arrive at Joynton Avenue primarily from three different directions - from the West Kensington catchment to the east, from the catchments south of Epsom Road to the south and from the from Mid-block Precinct to the north. After ponding to a depth of approximately 2.2 m at this location, the floodwaters in a 100 year ARI event move westward through the GSTC site and arrive at Botany Road where ponding occurs to an approximate depth of 1.1 m. The floodwaters escape from this Botany Road pond from a low point near the Green Square Railway Station and travel westward and ultimately discharge into Alexandra Canal.

Details of the flow behaviour at Joynton Avenue are presented in Appendix B.

# 4 Flood Management Objective

The primary objective of flood management at GSTC is to reduce the flood risk to the future community of GSTC, arising from the flooding of Joynton Avenue and Botany Road. It is envisaged that the GSTC will have an approximate population of 20,000 at full development. Flood management measures are therefore required to reduce the flood risk to the community.

Given the limitations of implementing large scale flood modification measures in built up areas, the following goals were set for any flood modification option to reduce flood risk at GSTC

1. No or minimal ponding to occur at Joynton Avenue in a 20 year ARI flood event
2. Achieve significant reduction in ponding at Joynton Avenue and Botany Road in a 100 year ARI event

Another objective was to manage the flood risk for the future developments at Epsom Park and Mid-block Precincts by accommodating a 20 year ARI pipe flow from these precincts in the GSTC flood modification measure.

# 5 GSTC Development Scenario

In addition to the GSTC, Epsom Park and Mid-block Precincts are the other two major redevelopment sites. Under existing conditions, the Epsom Park and Mid-block precincts drain towards the Joynton Ave sag and the development of these precincts and their associated drainage systems vis-a-vis GSTC would determine the flood behaviour at the Joynton Ave sag.

Following assumptions have been made in developing the concept design of the proposed trunk drain:

1. The proposed trunk drainage option would be implemented before the GSTC, Epsom Park and Mid-block precinct developments.
2. The Epsom Park and Mid-block precincts would provide for a 20 year ARI pipe drainage capacity and would be connected to the proposed trunk drain.
3. The Joynton Ave sag would be retained at the time of implementing the proposed trunk drain option. It is understood that the City is currently considering lifting of this sag.
4. Enhanced drainage inlet capacity would be required at the Joynton Avenue sag for the period leading to the development of Epsom Park and Mid-block precincts.

It is noted that the proposed trunk drain would carry the 20 year ARI flood, both overland and through pipe, for the entire catchment upstream of Joynton Ave, including the Epsom Park and Mid-block precincts.

# 6 Option Identification

Various options were considered for a general concept of providing trunk drainage from Link Road to Alexandra Canal. These options vary in alignment at a few locations but generally have a common alignment. Figure 1 shows these options.

An assessment was undertaken to determine the feasibility of these options and a preferred option identified through this process. A summary of option evaluation is presented in Table 1.

**Table 1: Option Identification**

| Option # | Option Detail | Feasibility | Comment |
|---|---|---|---|
| 1 | Sections A1, A21, A31, A4, A51, A6 | Feasible | The trunk drain lies within the road reserve providing opportunity for large bend radii. Maximises the development potential of the area. |
| 2 | Same as above except A22 replaces A21 | Low | The reach A22 passes through Perry Park, which is an old contaminated site. Site remediation would be required for construction and maintenance purposes |
| 3 | Same as 1 above | Feasible | The reach A32 passes through |

| Option # | Option Detail | Feasibility | Comment |
|---|---|---|---|
| | except A32 replaces A31 | | AusGrid site for which easement would be required. Also impacts a property near Bourke Street.<br>The development potential of the site would be compromised |
| 4 | Same as 1 above except A52 replaces A51 | Low | Hydraulically not efficient as it contains two sharp bends. Also affects the development potential |
| 5 | Same as 1 above except A53 replaces A51 | Low | Easement through the properties is difficult to achieve. Also affects the development potential of the crossing sites |

Based on the above analysis, Option 1 above is considered to be the preferred option.

# 7 Option Details

The proposed option provides for a trunk drain to carry flow from the entire catchment upstream of Joynton Ave and discharge into Alexandra Canal. It considers amplification and re-direction of an existing trunk drain (box culvert) from the Link Road to Joynton Ave and the provision of a new trunk drain from Joynton Avenue to Alexandra Canal.

The entire route for the option follows existing or proposed road reserves. Downstream of Maddox Street, the proposed trunk drain would follow the open channel alignment within the Sydney Water easement. Considering the limited width of available easement, a box culvert has been adopted for the proposed trunk drain.

The proposed option is expected to capture the 20 year ARI flow upstream of Joynton Avenue (both overland and pipe flow) and hence significantly reduce the flood risk for these areas.

Approximately 2 km of new stormwater asset would be created by this option.

## 7.1 Service Crossings

A preliminary review of gravity based services (sewer/stormwater) along the proposed trunk drain route suggests that significant works would need to be carried out at a major sewer crossing in O'Riordan Street. At the time of writing this report it is understood that the City is progressing sewer upgrade design works in the GSTC and these would be undertaken with due consideration of the proposed trunk drain.

The proposed trunk drain also crosses an existing 900 mm diameter City's stormwater pipe at Bourke Street near the Sydney Water easement. This pipe has been assumed to be connected to the proposed trunk drain.

Further investigations for service locations and the design for the relocation of these services would be established at the preliminary/detailed design stage.

### 7.2 Easement Width

The proposed route for the trunk drain is intended to be within the existing/proposed road reserve wherever possible. Should the trunk drain need to cross land beyond the road reserve an easement would be required.

The concept design is based on a 9 m wide easement being required for future maintenance and construction purposes. The concept alignment plan (Figure 1) identifies possible easement locations.

### 7.3 Additional Inlet Capacity

The proposed option would carry the 20 year ARI flow arriving at the Joynton Avenue sag. Currently a large proportion of this flow arrives as overland flow and after ponding in the sag, flows westward towards Botany Road. The inlet capacity of the existing pits in Joynton Ave is insufficient, resulting in ponding at this sag for extended periods even in frequent storm events.

Under the development scenario considered in Section 5, a significant increase in the inlet capacity would be required at the Joynton Avenue sag for effective implementation of the proposed option by capturing overland flow. A preliminary estimate suggests that approximately 25 m long extended curb inlet would be required on both sides of the road along the flat part of the sag to capture overland flow. In addition drainage upgrade to an approximate 100 m stretch of Joynton Ave would also be required. This upgrade would include provision of additional combination inlets and enhanced pipe size to capture the 20 year ARI flow arriving from the north and south of the Joynton Ave sag. Further assessment for the required stormwater inlets would be undertaken at the detailed design stage.

For the purpose of hydraulic modelling, it has been assumed that the overland flow arriving at the sag is able to be conveyed to the proposed trunk drain without inlet capacity constraints.

Enhanced inlet capacities may be required at other locations in the floodplain to capture overland flow. This would be further investigated at the detailed design stage.

## 8 Hydraulic Modelling

Two hydraulic models are available for assessment of the proposed option. These are the Mid-term Drainage Concept model (GSTC Model) and the Alexandra Canal model (AC Model). The GSTC model was prepared in 2011 and was the basis of the West Kensington – Green Square Floodplain Risk Management Study. The AC model remains currently under development and is the basis of the yet to be completed Alexandra Canal Flood Risk Management Plan.

As the Alexandra Canal Flood Risk Management Study and Plan is still under preparation, the GSTC model was used for assessment of the proposed option.

The GSTC model is based on the SOBEK modelling system. The model extends from west of South Dowling Street in the West Kensington catchment to Ricketty Street crossing of Alexandra Canal.

### 8.1 Model History

The GSTC model was originally developed as part of the West Kensington – Green Square Flood Study. The model extents were from east of South Dowling Street to west of Botany Road near GSTC. The inflow hydrographs for the model were derived from the MIKESTORM modelling system.

The GSTC model was extended from Botany Road to Alexandra Canal for the Flood Mitigations Options Report for the GSTC. The model was extended to assess the downstream impacts of the proposed flood mitigation options at GSTC. The inflow hydrographs for the extended part of the model were derived from an existing DRAINS model for the area.

The GSTC model was further modified to assess the Mid-term Drainage Concept. In general, the capacity of the existing trunk drainage was enhanced along with other modifications to capture the 20 year ARI flood at the GSTC. Details of the drainage concept are provided in the Mid-term Drainage Concept Study (Cardno, 2012).

For the purpose of assessing the proposed option, the above model was further extended downstream to Ricketty Street crossing of Alexandra Canal. The model was extended to assess any changes in the flow behaviour along Alexandra Canal that may arise from implementing the proposed option.

### 8.1.1 Recent West Kensington Modelling

The West Kensington – Green Square Flood Study was recently updated by Randwick Council (WMA, 2011). The update was required to better represent the West Kensington area after Randwick Council acquired more accurate survey data for the study area. A TUFLOW model was developed for the study update.

A comparison of overland flows at the Epsom Road underpass of South Dowling Street suggests that the TUFLOW model provides negligible flow at this location in a 20 year ARI event compared to approximately 5 $m^3$/s of flow from the MIKESTROM model, which provided inflow data to the SOBEK GSTC model. Since the MIKESTORM output is used in the GSTC model, it provides a level of conservatism to the proposed concept design.

## 8.2 Model Details

The hydraulic model is a coupled 1D/2D model and includes street level pit and pipe network as well as existing trunk drainage (culverts, covered channel and open channels) in the modelled area.

The model is based on a 2 m grid derived from the City's aerial survey data. The proposed development levels for the GSTC have been incorporated in the 2D grid for assessment of the proposed option. The extent of the two-dimensional model grid is shown in Figure 2. The model becomes 1D from the head of Alexandra Canal to the downstream end at Ricketty Street crossing of the canal.

The upstream boundaries or the inflow to the hydraulic model is derived from hydrological modelling. Inflow hydrographs are applied at the boundary of the 2D grid to represent overland flow and to 1D element where the flow is conveyed in a channel or pipe drainage.

The downstream boundary is assumed to be a constant water level of 1.9 m AHD. Modelling has been undertaken for the critical 60 minute 20 year and the 100 year ARI flood events. The critical flood event duration has been determined in earlier studies.

Further model details are presented in the West Kensington - Green Square Flood Study (WMA, 2008) and Flood Mitigation Options Report Green Square Town Centre (Cardno, 2008)

## 8.3 Bend Losses

The proposed trunk drain alignment has a number of bends, which would result in a local head loss in the trunk. These bend losses have not been modelled in assessing the capacity of the proposed trunk. Assessment of these losses would be carried out at the

detailed design stage. It is noted that there may be a need to undertake physical modelling to determine these losses.

For the purpose of current analysis, an allowance of 0.3-0.4 m has been made for the bend losses in estimating the size of the trunk drain.

### 8.4 Option Modelling

The proposed trunk drainage provides for 20 year ARI capacity. The size of the proposed trunk was determined after iterative modelling with different sizes. The required box culvert varies in size from 4.5 m x 1.5 m (width x height) to 6 m x 1.8 m.

### 8.5 Additional Option Modelling

The proposed option allows the entire trunk drain to be located in the public road reserve. A modified option has also been considered where the trunk drain may cross private land and this would provide some improvement in hydraulic efficiency.

The modification to the route was made between O'Riordan Street and Bourke Street. The modified route follows the East West Relief Road (EWRR) and approximately mid-way down this road deviates into the land owned by AusGrid prior to joining Bourke Street and then continues along the proposed route. Figure 1 shows the modified route (along A32).

## 9 Option Assessment

The impact of the proposed trunk drain was determined for the developed conditions at the GSTC. The Joynton Avenue sag is also retained for the purpose of assessment as discussed in Section 5.

The assessment establishes reduction in flood risk to the GSTC with the provision of proposed trunk drain. Although not assessed, it can be inferred that the existing flood behaviour would also improve with the proposed trunk.

### 9.1 Model Results

The 100 year ARI flood depth with the proposed trunk drain is shown in Figure 3. The 100 year ARI flood hazard is shown in Figure 4. The impact of proposed trunk drain is presented in Figures 5 for the 20 year ARI event and Figure 6 for the 100 year ARI event. The profile of the trunk drain for the two flood events is presented in Figure 7 and Figure 8.

Model results indicate that the ponding does not occur at the Joynton Avenue sag in a 20 year ARI event although the depth of flow may vary from 0.1 - 0.15 m near the sag. The ponding depth is approximately 0.2 m in a 100 year event, which is approximately 2.0 m lower without the proposed trunk.

The 100 year ARI flood level at the Botany Road sag is approximately 14.0 m AHD with the provision of the proposed trunk drain. This is a reduction of 0.7 m from the existing conditions.

The proposed trunk drain is also able to carry a significant proportion of runoff from the catchment to the south of Epsom Road. Consequently, the flood depths reduce by approximately 0.1 m along Epsom Road in a 100 year event.

In addition, the proposed trunk reduces flood levels significantly throughout the modelled area. Flood depths reduce by approximately 0.5 m at the O'Riordan Street, Bourke Road and Mandible Street sags for the 100 year event.

### 9.2 Adverse Impacts

The proposed option results in higher peak flow in Alexandra Canal. Model results for the 100 year ARI event indicate that the flood level increases by 0.08 m at the head of the canal and gradually reduces to 0.01-0.02 m near Ricketty Street crossing of the canal.

Model results for the 100 year ARI event indicate that the flood levels vary from 2.1 m AHD at the head of the canal to 1.9 m AHD at the downstream end (model boundary level) near Ricketty Street/Gardeners Rd under the existing conditions. For the proposed trunk drainage option, these levels are 2.18 m AHD to 1.91 m AHD. Thus the flood level increases from 0.08 m at the head of the canal to 0.01 m near the downstream end.

Approximate flood extents for the two modelling scenarios are shown in Figure 9 and Figure 10. These extents show that the majority of the increase in flood level and only small areas along the canal experience flooding over larger area.

The impact of the proposed trunk drain is localised and a preliminary analysis suggests that this impact can be managed by localised measures such as channel widening using City of Sydney land on the eastern bank, localised flood proofing works and staging of the proposed option. Further investigations for impact management would be undertaken at the detailed design stage.

Additional details are presented in Appendix B.

# 10 Conclusions and Recommendations

The modelling of the proposed trunk drain suggests that a significant benefit can be obtained by implementing this option. The proposed trunk captures the entire 20 year ARI flow upstream of Joynton Avenue and hence significantly reduces the flood risk for these areas. In particular, the high hazard flooding at Joynton Avenue is eliminated for the 20 year ARI event. A significant improvement is also achieved downstream of Joynton Avenue not only for the 20 year ARI event but also for the larger 100 year ARI event.

The proposed trunk drain also results in significant reduction in flood levels in a 100 year ARI event. However, there is an increase in flood levels in Alexandra Canal. This increase varies from 0.08m at the head of the canal to 0.01-0.02 m at Ricketty Street crossing of the canal. Preliminary assessment suggests that this increase in flood level can be managed through various flood management options.

The assessment carried out for the proposed trunk drain is preliminary in nature and appropriate for the concept design of the trunk drain. It is recommended that the following assessments be undertaken at the detailed design stage:

1. Alignment of the proposed trunk drain should be confirmed after detailed services survey along the suggested alignment.
2. Undertake hydraulic assessment if the location of services results in regrading of the trunk drain.
3. A review of the hydraulic model used for the assessment of the proposed trunk drain should be undertaken. The model should be updated if necessary.
4. Sensitivity analysis should be undertaken to assess the downstream impact of the proposed trunk drain. In this regard climate change impacts, downstream boundary and other relevant parameters should be checked for model sensitivity.

5. Bend losses should be further investigated and appropriate losses should be incorporated in the hydraulic modelling of the proposed trunk drain. Investigation for bend losses can be based on literature search or physical modelling at a hydraulic laboratory.
6. Flood management options be investigated to manage the increase in flood level in Alexandra Canal.

# 11 Appendix A – Supporting Figures

# CONCEPT ALIGNMENT


| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 5 | | | | ALEXANDRIA | | | | CITY OF SYDNEY |
| | 4 | | | | | | | | |
| | 3 | | | | STORMWATER DRAINAGE CONCEPT ALIGNMENT PLAN | | | | |
| 17.05.2013 | 2 | AC | Issued for review | HR | | | | | PRELIMINARY ONLY NOT TO BE USED FOR CONSTRUCTION — Issue 1 |
| 03.05.2013 | 1 | AC | Issued for review | HR | Designed: HR | Checked: HR | SCALE: 1:2500 | PAPER: A1 | |
| Date | No. | By | Amendments | Chckd | Drawn: AC | Approved: PS | | | Drawing No. ---- — Sheet No. 1 OF 1 |

Figure 1: Layout of the Proposed Trunk Drain Options

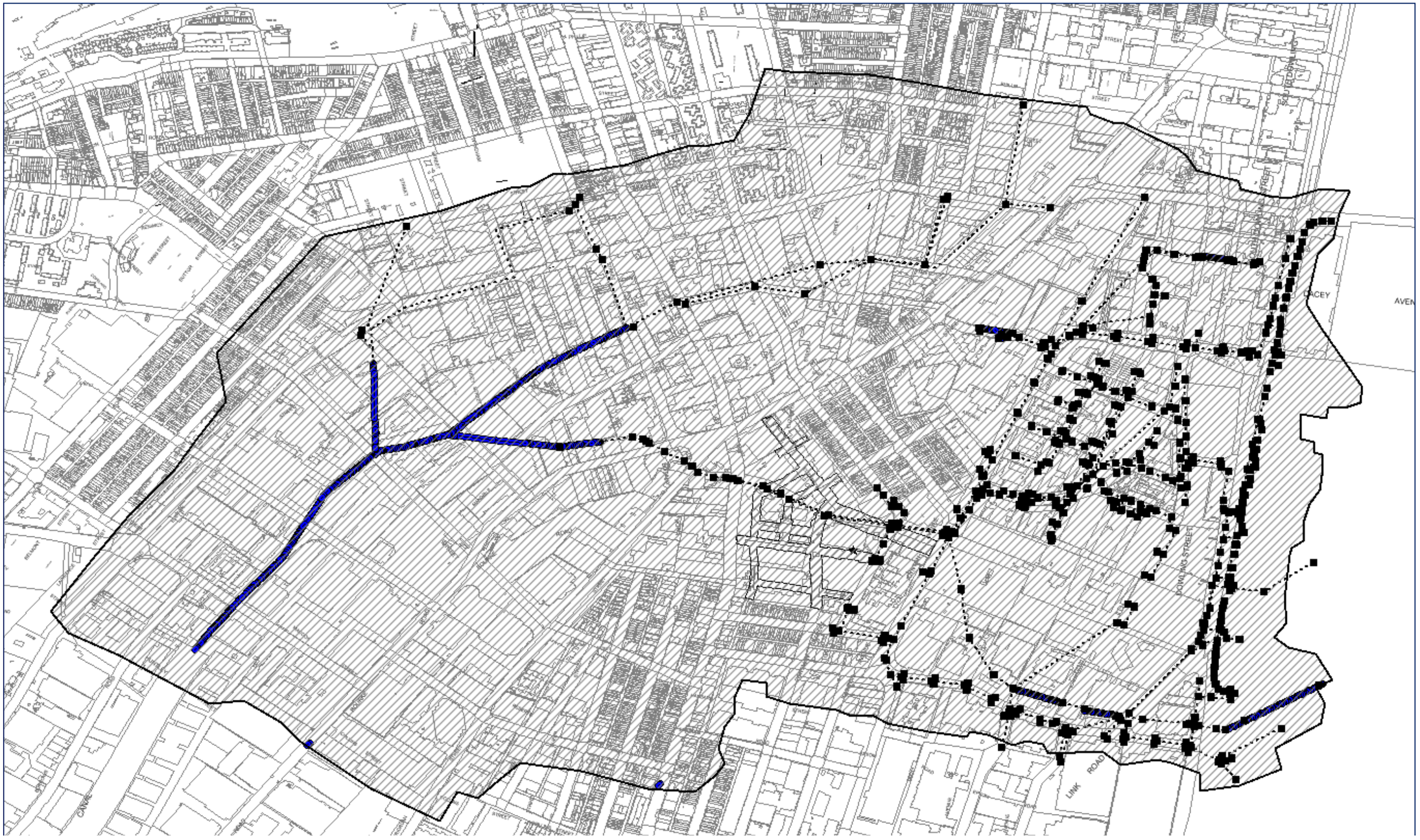


Figure 2: 2D Model Grid Extent

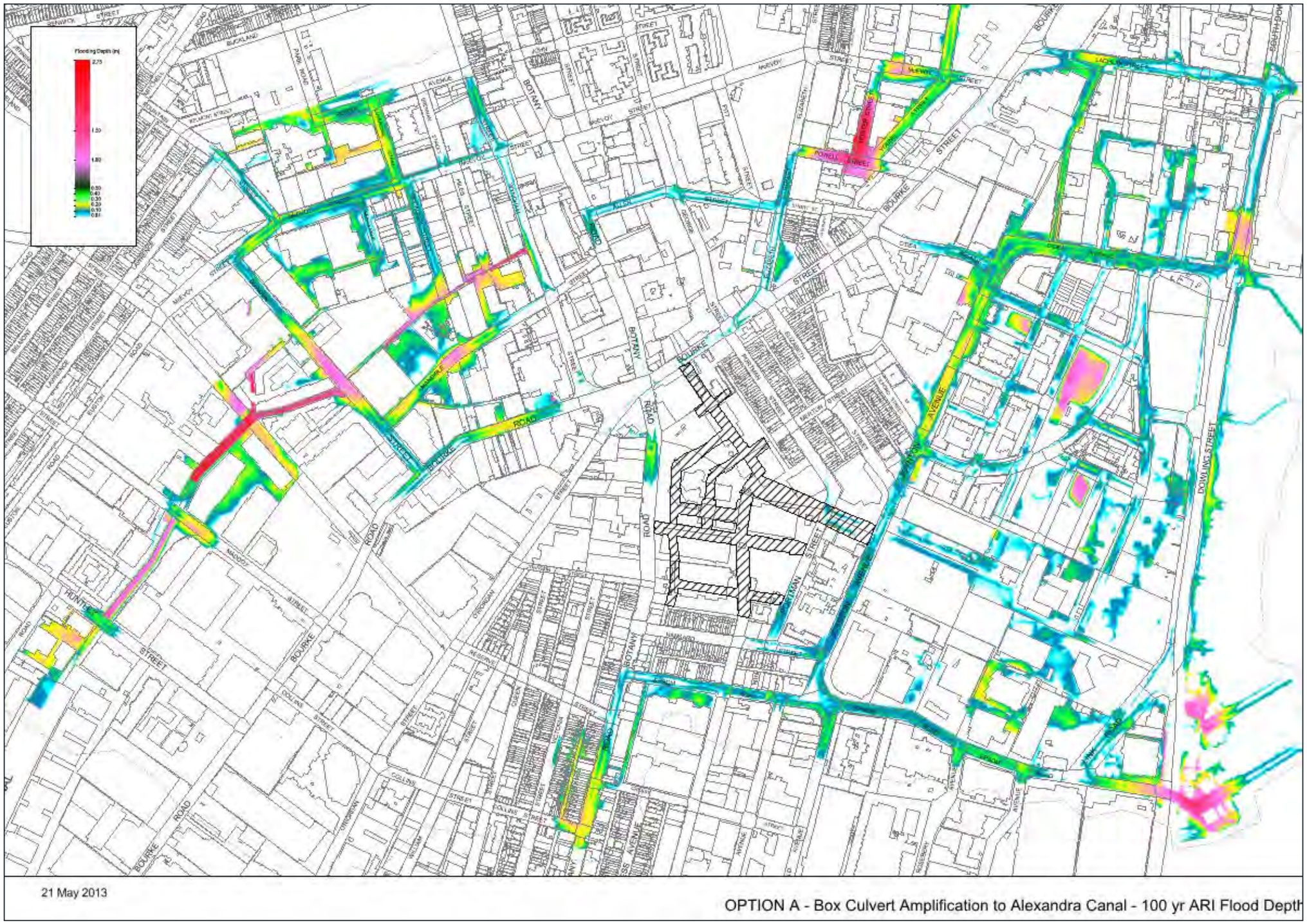


Figure 3: 100 year ARI Flood Depth with Proposed Trunk Drain


Figure 4: 100 year ARI Flood Hazard with Proposed Trunk Drain

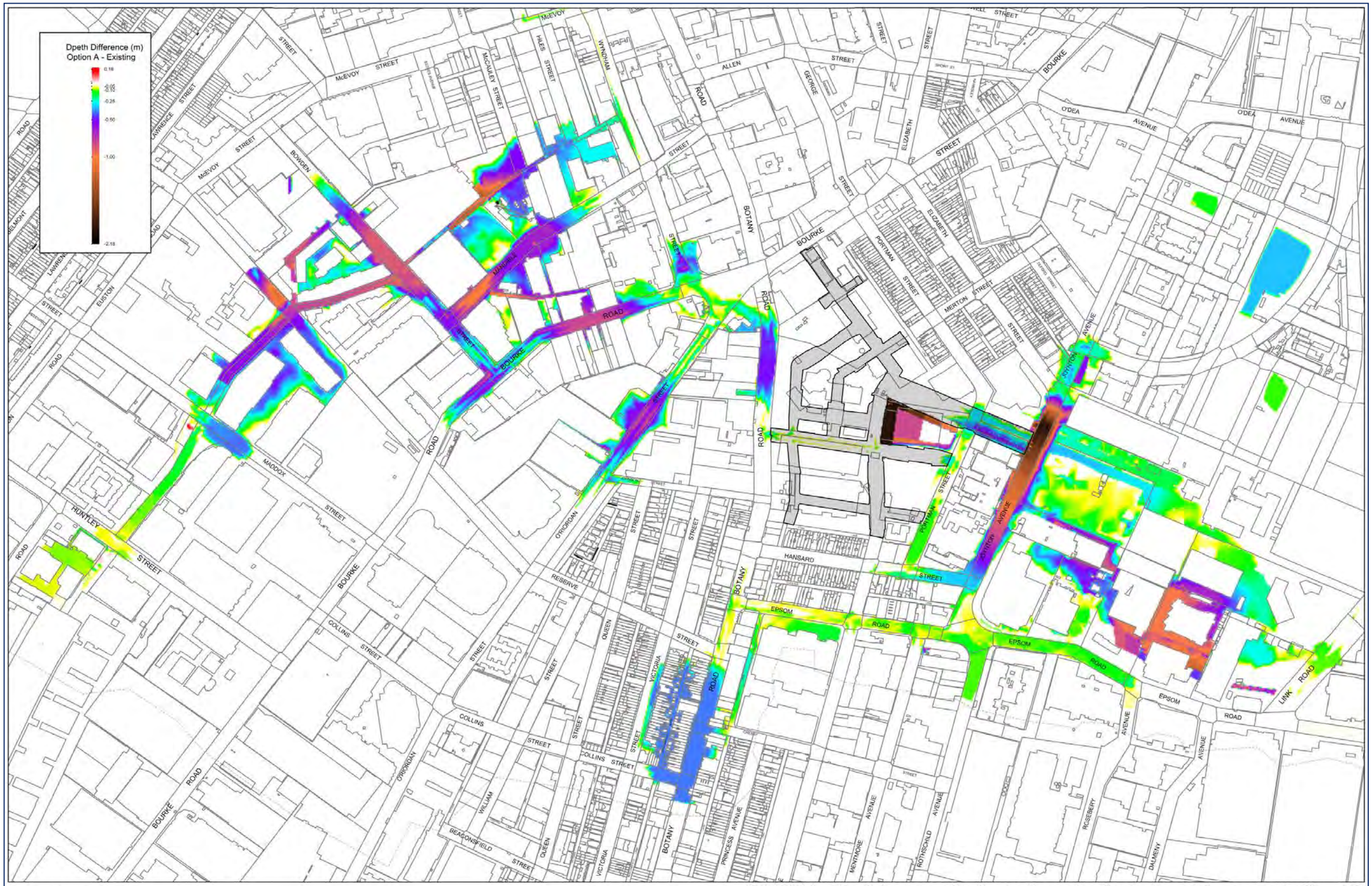


Figure 5 : Option A Impact - 20 yr ARI Event

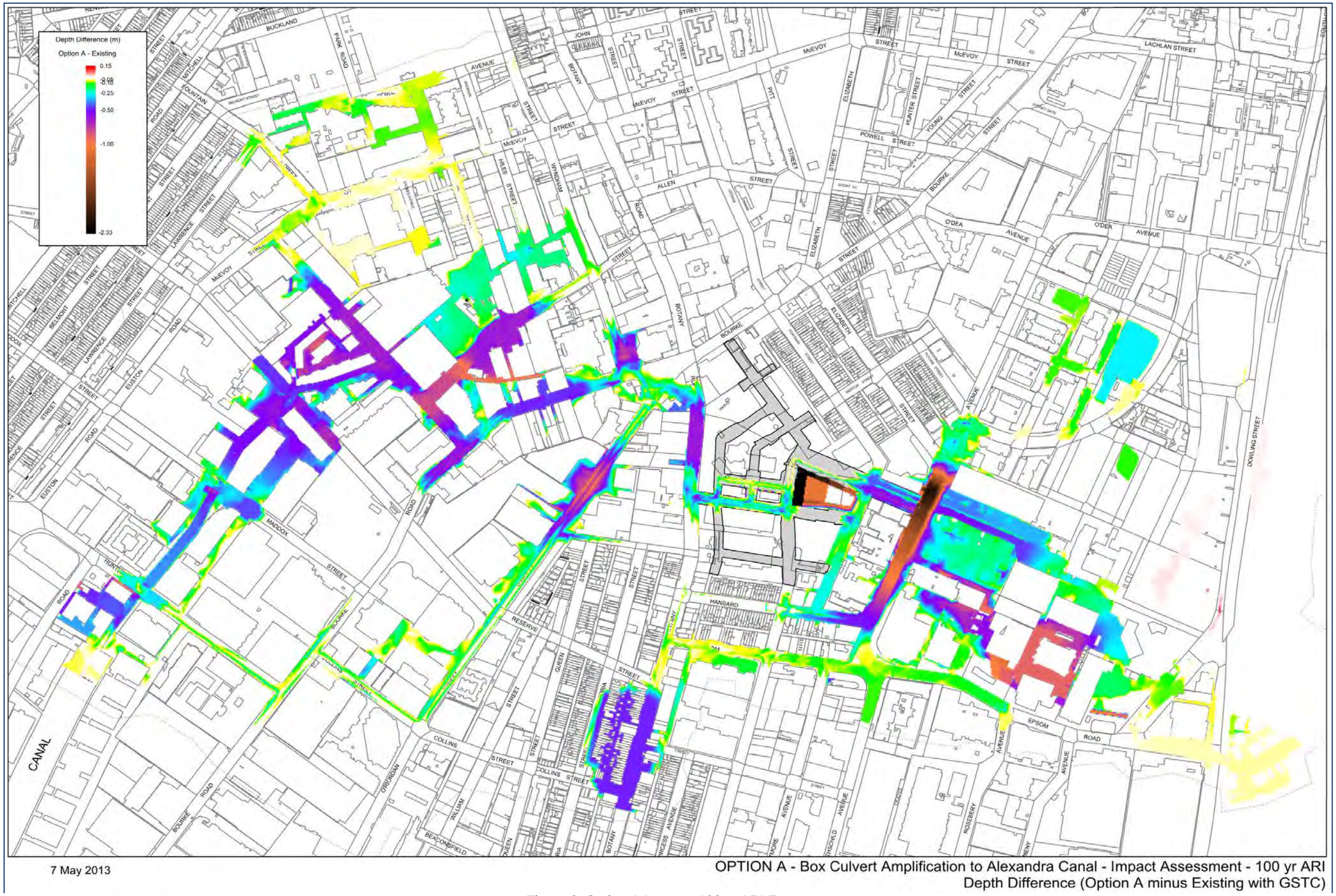


Figure 6: Option A Impact - 100 yr ARI Event


Figure 7 : Profile for the Proposed Trunk Drain - 20 year ARI Flood Event

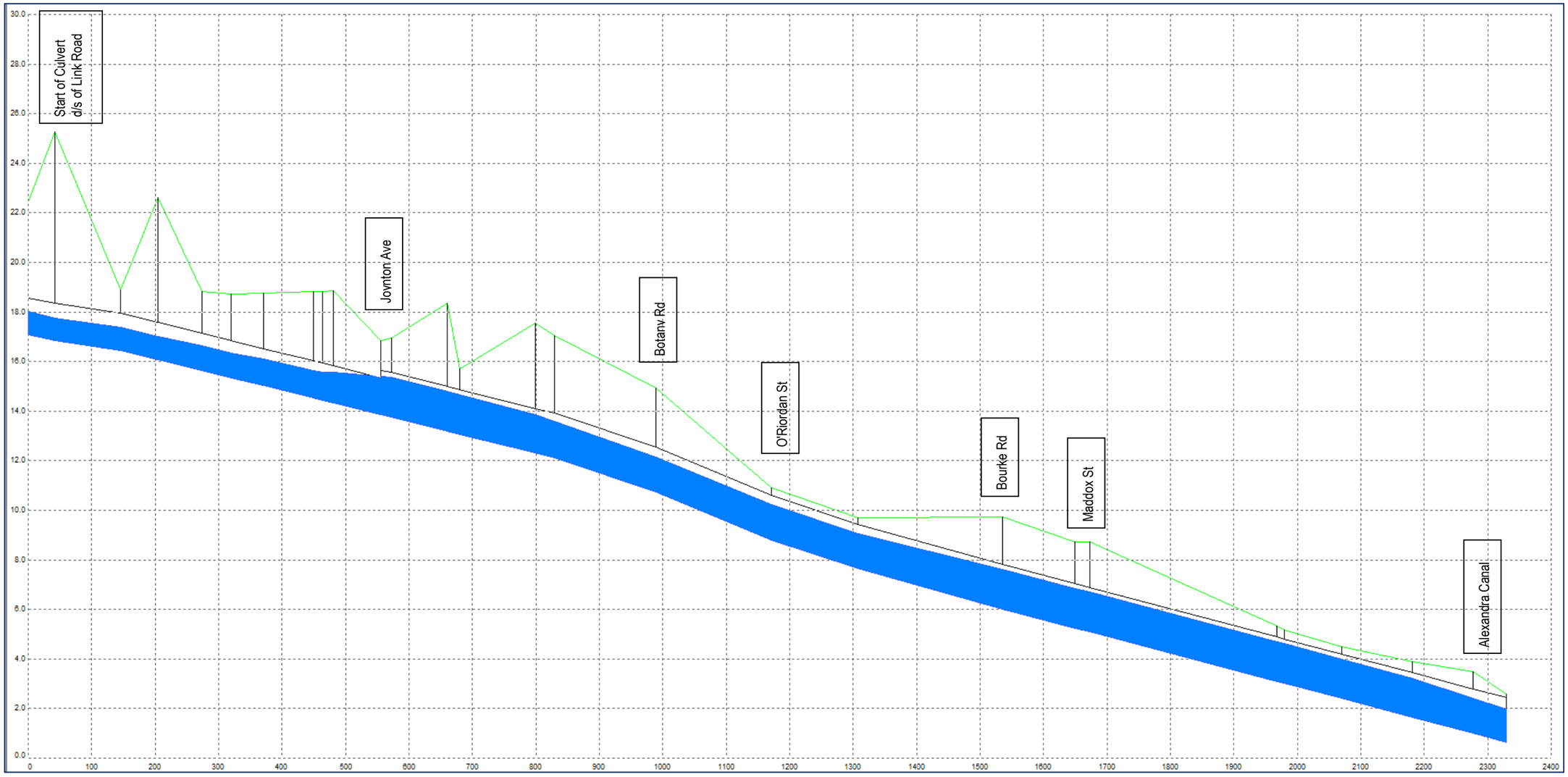


Figure 8 : Profile for the Proposed Trunk Drain - 100 year ARI Flood Event

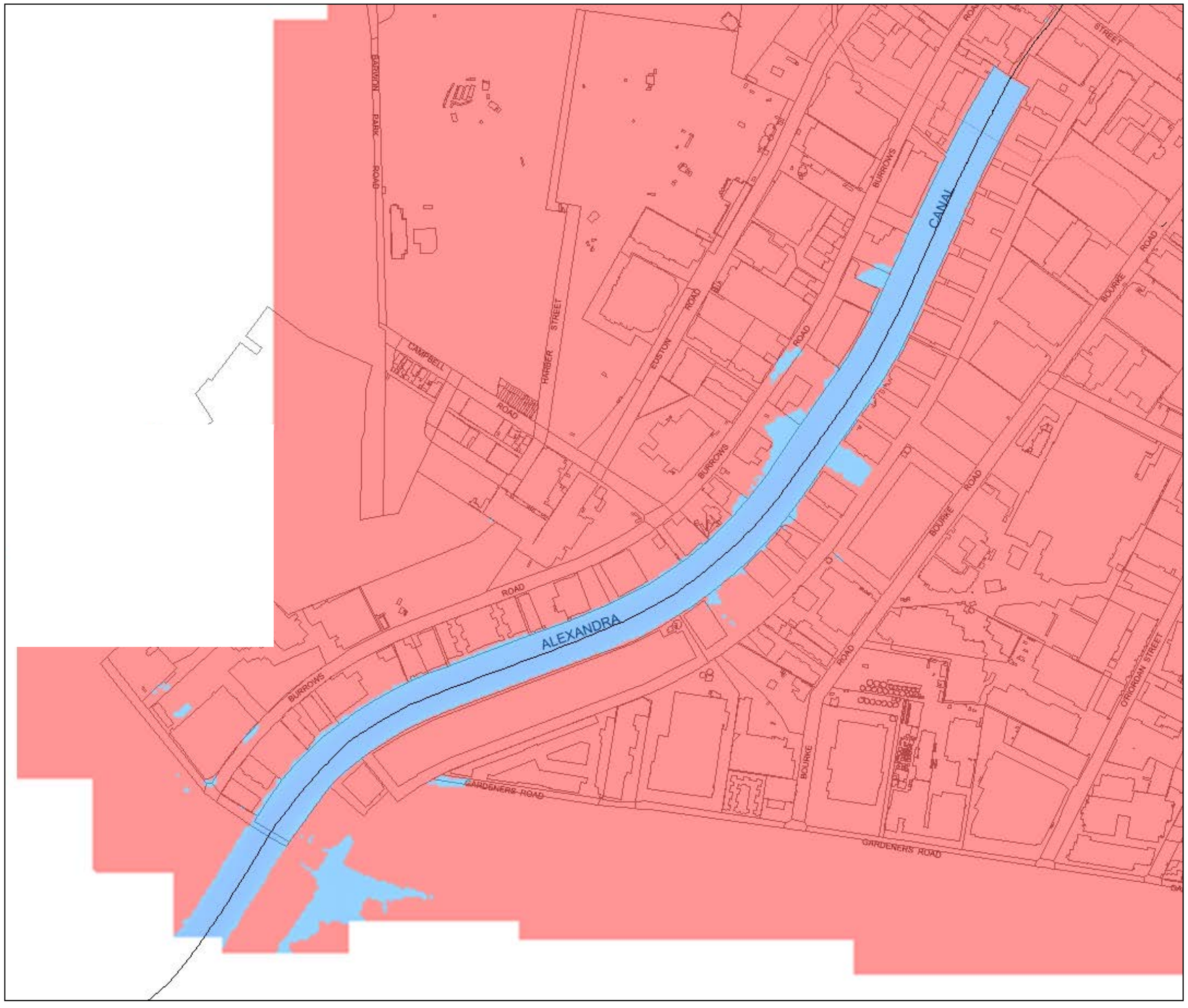


Figure 9: Existing Flood Extent (Approx) - Blue Area 2.1 m AHD or lower (2.1 m AHD is the 100 yr flood level at the head of Alexandra canal. The level drops to 1.9 near the downstream end)

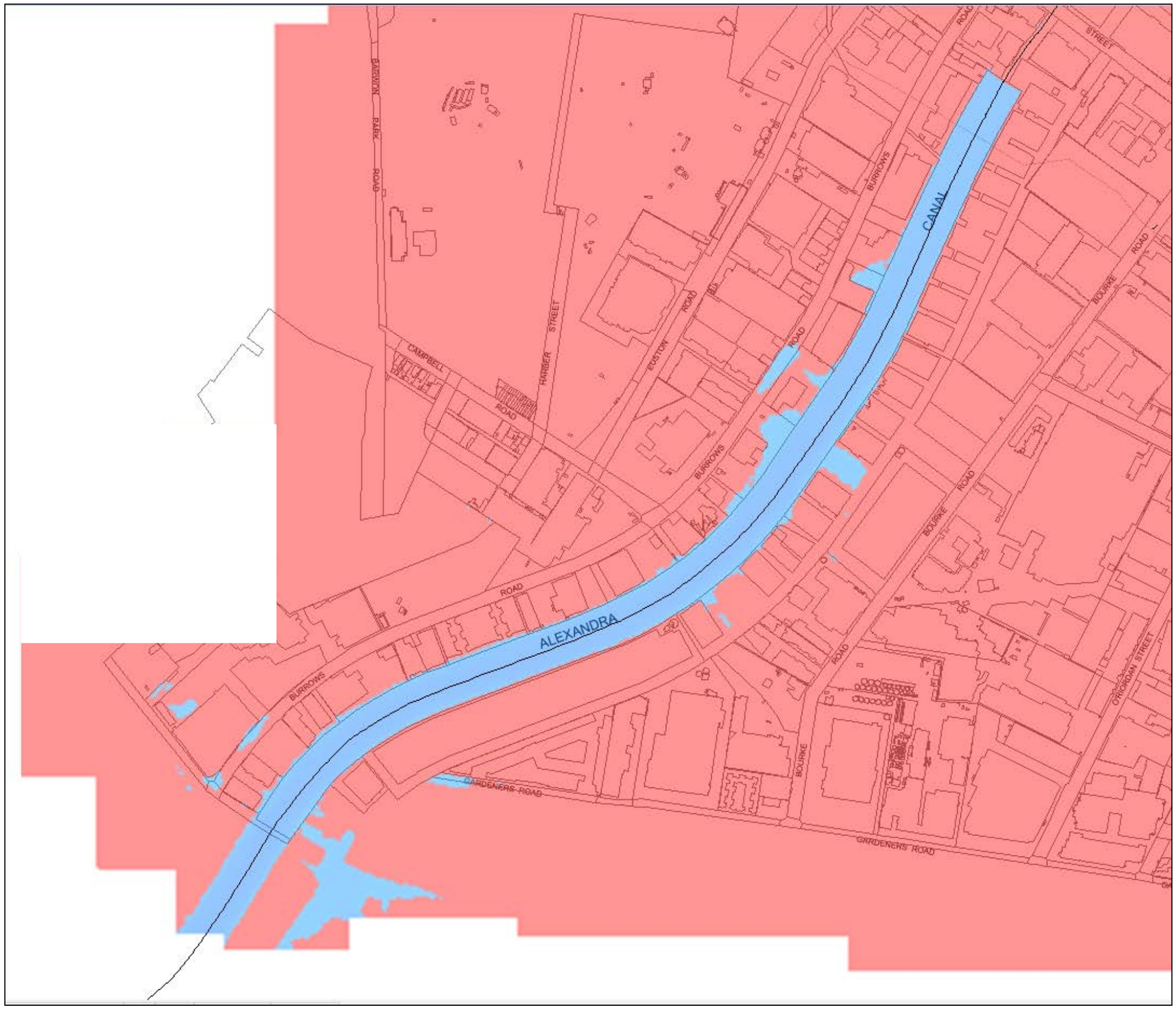


Figure 10: Proposed Option Flood Extent (Approx) - Blue Area 2.18 m AHD or lower (2.18 m AHD is the 100 yr flood level at the head of Alexandra canal. The level drops to 1.91 near the downstream end)

# 12 Appendix B – Flooding Details

## 12.1 Existing Flood Behaviour

The schematic for existing drainage at Joynton Avenue is shown in Figure B1. The trunk drains arriving at the Joynton Avenue sag and the peak flow carried by these trunks in a 20 year ARI event is provided below:

1. 1.5 m diameter pipe from the north - 3.8 $m^3/s$
2. 1.35 m x 1.1 m box culvert from the north - 3.6 $m^3/s$
3. 2.54 m x 1.38 m box culvert from the east - 8.7 $m^3/s$

The trunk drains leaving the sag include:

1. 1.85 m x 1.87 m box culvert to the west - 9.9 $m^3/s$
2. 1.68 m x 1.68 m to the west - 9.8 $m^3/s$

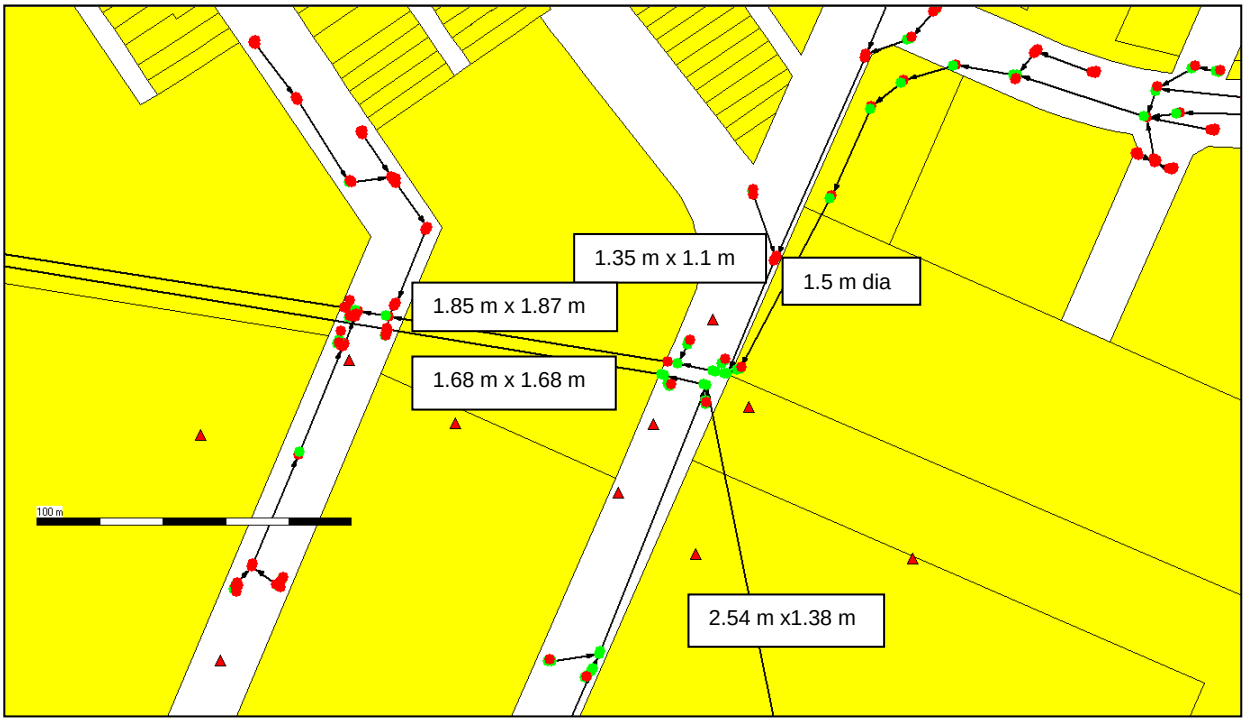


Figure B1: Trunk Drainage at Joynton Avenue

In addition to the pipe flow, a significant amount of overland flow also arrives at the Joynton Avenue sag. Overland flow arriving from various direction is as follows:

1. from north along Joynton Avenue - 9.2 $m^3/s$
2. from south along Joynton Avenue - 2.6 $m^3/s$
3. from east through industrial properties - 5.0 $m^3/s$

Under existing conditions, approximately 3.4 $m^3/s$ enters the GSTC from Joynton Avenue in a 20 year ARI flood. Peak flow into Alexandra Canal under existing conditions is approximately 84 $m^3/s$ in a 20 year ARI event.

## 12.2 Proposed Trunk Drainage Flood Behaviour

With the flood management option, all the pipe and overland flow arriving at Joynton Avenue sag is carried by the proposed trunk drain and discharged into Alexandra Canal. In addition, approximately 5 $m^3/s$ from the catchment south of Epsom Road is also discharged into the proposed trunk drain in a 20 year event.

Peak flow in the proposed trunk downstream of Joynton Avenue is 39 $m^3/s$ in a 20 year ARI event.

Peak flow into Alexandra Canal increases to 121 $m^3/s$ with the proposed trunk drainage in a 20 year ARI event.

The flood levels increase in Alexandra Canal with the proposed trunk drain. The increase in flood levels for the 100 year ARI event is shown in Figure B2.

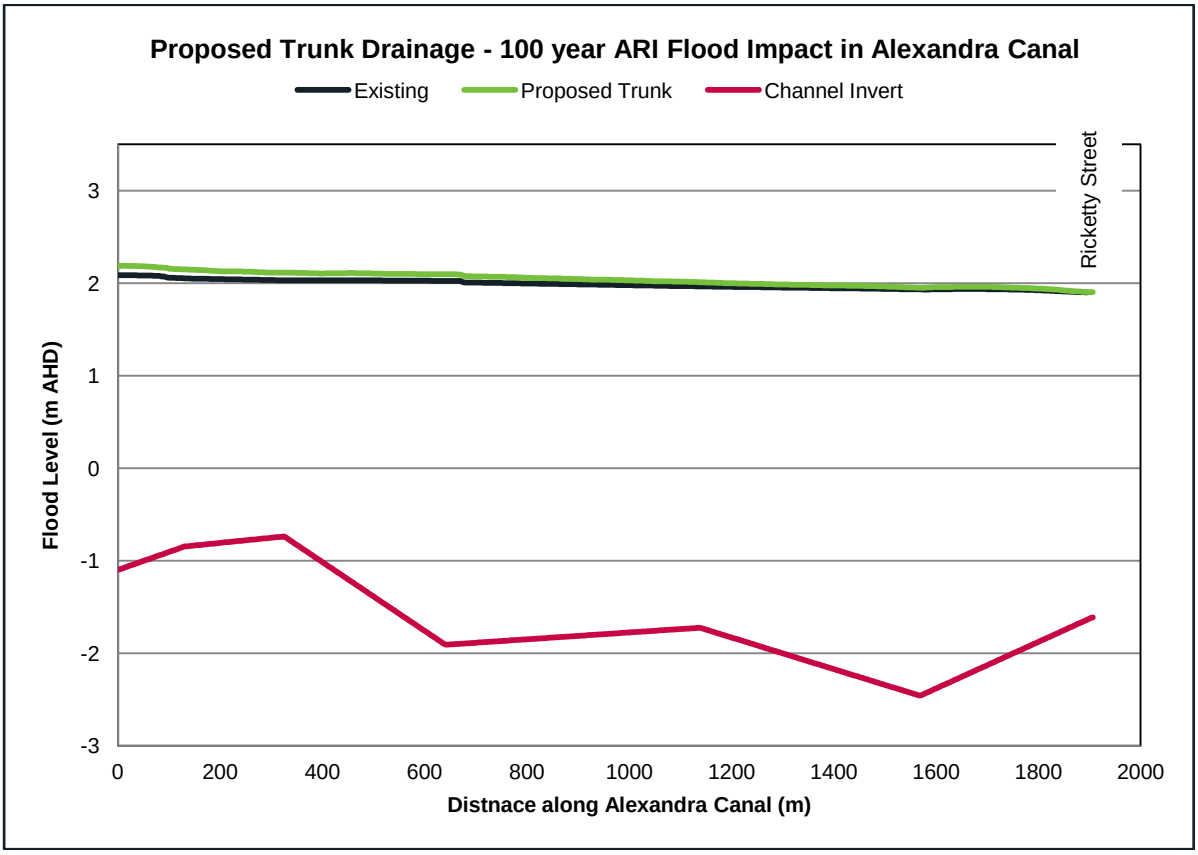


Figure B2: Flood Profile Along Alexandra Canal - 100 year ARI

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**International Association**

Brunei - MRBC Partnership

WT Partnership Aust Pty Ltd
trading as WT Partnership
ACN 006 040 768
ABN 45 997 181 713

14 January 2013

City of Sydney Council
Level 2
Town Hall House
456 Kent Street
SYDNEY NSW 2010

**FOR THE ATTENTION OF: JOHN DWYER**

Dear Sir,

**GREEN SQUARE TRUNK DRAINAGE**

As requested we have prepared our Feasibility Estimate for the above. The estimated cost for the works, based upon the drawings provided, is **$79,780,472** inclusive of preliminaries, margin, contingencies, professional fees and exclusive of GST.

We refer you to the attached report which provides a Main Summary of Cost together with, Schedules of Information Used, Assumptions and Exclusions. We specifically refer you to the Exclusions and Assumptions which are identified on pages 2 and 3 of the report.

We note that the enclosed estimate should be considered as indicative only at this stage and that, prior to finalising any design or agreements, detailed estimates should be prepared from further developed design information.

Should you require further information or wish to discuss any aspect of the attached, please do not hesitate to contact us.

Yours faithfully
**WT PARTNERSHIP**

**NICK DEEKS**

WT PARTNERSHIP

# GREEN SQUARE TRUNK DRAINAGE

## FEASIBILITY ESTIMATE

JANUARY 2013

## CONTENTS

## A. MAIN SUMMARY

| STAGE | TOTAL $ |
|---|---|
| STAGE 1 (BOURKE STREET – ALEXANDRA CANAL) | 11,526,003 |
| STAGE 2 (JOYNTON AVENUE – BOURKE STREET) | 26,206,240 |
| STAGE 3 (LINK ROAD – JOYNTON AVENUE) | 10,988,619 |
| **SUB TOTAL** | **48,720,862** |
| SUPERVISION & PRELIMINARIES | 4,872,086 |
| OVERHEAD & MARGIN | 3,751,506 |
| CONSTRUCTION CONTINGENCY | 14,336,114 |
| **SUB TOTAL (INCLUDING PRELIMINARIES, MARGIN & CONTINGENCY)** | **71,680,568** |
| DESIGN & PROFESSIONAL FEES | 4,300,834 |
| DESIGN CONTINGENCY | 3,799,070 |
| **TOTAL (EXCL GST)** | **79,780,472** |

## B. SCHEDULE OF INFORMATION USED

The following information has been used in the preparation of the estimate:

- Outline drainage plans from City of Sydney;
- Aerial photographs from City of Sydney;
- Mid-term drainage response from Cardno, dated 5th July 2012;
  - Information from meetings at City of Sydney (10th & 14th January 2013).

## C. SCHEDULE OF ASSUMPTIONS

The full estimate, detailing assumptions and allowances, is included within Annexure B. The following summarises the main assumptions and allowances that have been made in the preparation of the estimate:

- Excavated material classified general solid waste;
- Allowance for shoring to trench excavations;
- 20% of excavated material to remain onsite;
- Base slab to culverts assumed as 300mm thick;
- 375mm uPVC pipework used to divert existing drainage during works ;
- Allowance for diversion of existing services;
- Allowance for potential underpinning required between Maddox and Huntley Street;
- A provisional sum allowance has been made for the following items following meeting with Sydney Water & City of Sydney, 14th January 2013;
  - Diversion of existing services;
  - Traffic management;
- Supervision & Preliminaries have been calculated at 10%;
- Builder's overheads and margin have been calculated at 7%;
- Construction contingency allowance of 25%.

## D. SCHEDULE OF EXCLUSIONS

The following items have been excluded from the estimate:

- Land costs, legal fees, taxes and stamp duty;
- Interest charges and holding costs;
- Statutory and Authority fees and charges;
- Latent conditions other than the contingencies nominated in the estimate;
- Demolition of existing buildings;
- Proposed sewer line between O'Riordan Street and Dowling Road ;
- Staging costs;
- Escalation in costs or changes in market conditions beyond January 2013.

WT PARTNERSHIP

# ANNEXURE A
# FULL FEASIBILITY ESTIMATE

| | Stage 1 - Bourke Street to Alexandra Canal | | | | |
|---|---|---|---|---|---|
| **Item** | **Item Description** | **Quantity** | **Unit** | **Rate** | **Amount** |
| | **DEMOLITION & EXCAVATION** | | | | |
| 1 | Excavate for proposed culverts and open channels including allowances for working space and bases | 11,906.00 | m3 | 80.00 | 952,480.00 |
| 2 | Allow for disposal of excavated material including transport and tip fees - assume excavated material to be classified as General Solid Waste with 20% to remain onsite | 9,524.80 | m3 | 310.00 | 2,952,688.00 |
| 3 | Allow extra for shoring to trenches 1.00 - 3.00m deep | 3,196.00 | m2 | 25.00 | 79,900.00 |
| 4 | Testing, reporting and site audits | 1.00 | Item | 20,000.00 | 20,000.00 |
| 5 | Backfill workspace with onsite fill around new culverts | 3,196.00 | m3 | 30.00 | 95,880.00 |
| 6 | Temporary fence and barrier to the side of trench during works | 1,598.00 | m | 30.00 | 47,940.00 |
| | **SERVICE DIVERSIONS** | | | | |
| 7 | Allow provisional sum for safe working allowance near existing Ausgrid/sewer services to allow construction of new stormwater culverts | 1.00 | PCsum | 50,000.00 | 50,000.00 |
| 8 | Allow provisional sum for potential service diversions not currently indicated | 1.00 | PCsum | 1,500,000.00 | 1,500,000.00 |
| | **CULVERTS** | | | | |
| | **Base** | | | | |
| 9 | Compact subgrade (allowed for to RCBC and pits) | 4,355.00 | m2 | 10.00 | 43,550.00 |
| 10 | 50mm thick mass concrete working slab (allowed for to RCBC and pits) | 218.00 | m3 | 320.00 | 69,760.00 |
| 11 | Formwork to sides of 300mm thick slab base and pit base | 1,598.00 | m | 50.00 | 79,900.00 |
| 12 | 20Mpa 300mm thick reinforced concrete slab with concrete additive (allowed for additive for waterproofing and hardener so works can be completed quicker to close in trench). | 1,306.50 | m3 | 320.00 | 418,080.00 |
| 13 | Mesh to slab | 4,355.00 | m2 | 25.00 | 108,875.00 |
| 14 | Allowances for control joints in RCBC base slab (allow 1 per 10m) | 480.00 | m | 80.00 | 38,400.00 |
| 15 | Subsoil drainage along the culvert route | 799.00 | m | 50.00 | 39,950.00 |
| 16 | Allowance for spear points and temporary pump hire during construction (no allowance has been made for stand by generator) | 1.00 | Item | 20,000.00 | 20,000.00 |
| | **Reinforced concrete box culverts (RCBC - standard lengths 2.464m length)** | | | | |
| 17 | Supply and install 5000 x 1800 including bonding to base and sealing joints | 439.00 | m | 4,000.00 | 1,756,000.00 |
| 18 | Supply and install 6000 x 1800 including bonding to base and sealing joints | 360.00 | m | 5,000.00 | 1,800,000.00 |
| | **PITS** | | | | |
| 19 | Allow for inspection/access point every 200m | 4.00 | No | 2,500.00 | 10,000.00 |
| 20 | Allowance for Gross Pollutant Trap | 1.00 | No | 500,000.00 | 500,000.00 |
| | **Miscellaneous** | | | | |
| 21 | Allowances for miscellaneous connection of existing or new stormwater pipe to new RCBC | 1.00 | Item | 20,000.00 | 20,000.00 |
| 22 | Allowance for out of hours/night work | 1.00 | Item | 200,000.00 | 200,000.00 |
| 23 | Allow for traffic management | 1.00 | Item | 200,000.00 | 200,000.00 |
| | **REINSTATE ROADS** | | | | |
| 24 | Reinstate above new culverts and pits | 4,355.00 | m2 | 120.00 | 522,600.00 |
| | **SUBTOTAL (Excl Fees and GST)** | | | | **11,526,003.00** |
| 25 | Supervision & Preliminaries (10%) | | Item | | 1,152,600.00 |
| 26 | Builders overheads & margin (7%) | | Item | | 887,502.00 |
| 27 | Construction contingency (25%) | | Item | | 3,391,526.00 |
| | | | | | |
| | **SUBTOTAL (Excl Design and GST)** | | | | **16,957,631.00** |
| 28 | Design and professional fees (6%) | | Item | | 1,017,458.00 |
| 29 | Design contingency (5%) | | Item | | 898,754.00 |
| | **TOTAL ESTIMATED CONSTRUCTION COST (excl GST)** | | | | **18,873,843.00** |
| | | | | | |
| | EXCLUSIONS | | | | |
| | Escalation beyond January '13 | | | | |
| | Any demolition of existing buildings | | | | |

| | Stage 2 - Joynton Avenue to Bourke Street | | | | |
|---|---|---|---|---|---|
| Item | Item Description | Quantity | Unit | Rate | Amount |
| | **DEMOLITION & EXCAVATION** | | | | |
| 1 | Allow for demolition of existing buildings along proposed culvert line between Botany Rd & O'Riordain St. | | m2 | | Excluded |
| 2 | Allow for demolition of existing building along at 41 Mandible St. to be used for future detention of culverts | | m2 | | Excluded |
| 4 | Excavate for proposed culverts and open channels including allowances for working space and bases | 30,730.00 | m3 | 80.00 | 2,458,400.00 |
| 5 | Allow extra for shoring 1.00 - 3.00m deep | 8,780.00 | m2 | 25.00 | 219,500.00 |
| 6 | Allow for disposal of excavated material including transport and tip fees - assume excavated material to be classified as General Solid Waste with 20% to remain onsite | 24,584.00 | m3 | 310.00 | 7,621,040.00 |
| 7 | Testing, reporting and site audits | 1.00 | Item | 35,000.00 | 35,000.00 |
| 8 | Backfill workspace with onsite fill around new culverts | 8,780.00 | m3 | 30.00 | 263,400.00 |
| 9 | Temporary fence and barrier to the side of trench during works | 2,264.00 | m | 30.00 | 67,920.00 |
| | **SERVICE DIVERSIONS** | | | | |
| 10 | Allowance to to divert existing brick sewer at O'Riordain Street | 1.00 | PCsum | 2,500,000.00 | 2,500,000.00 |
| 11 | Allow provisional sum for safe working allowance near existing Ausgrid/sewer services to allow construction of new stormwater culverts | 1.00 | PCsum | 100,000.00 | 100,000.00 |
| 12 | Allow provisional sum for potential service diversions not currently indicated | 1.00 | PCsum | 1,500,000.00 | 1,500,000.00 |
| | **CULVERTS** | | | | |
| | **Base** | | | | |
| 13 | Compact subgrade (allowed for to RCBC and pits) | 5,660.00 | m2 | 10.00 | 56,600.00 |
| 14 | 50mm thick mass concrete working slab (allowed for to RCBC and pits) | 283.00 | m3 | 320.00 | 90,560.00 |
| 15 | Formwork to sides of 300mm thick slab base and pit base | 2,264.00 | m | 50.00 | 113,200.00 |
| 16 | 20Mpa 300mm thick reinforced concrete slab with concrete additive (allowed for additive for waterproofing and hardener so works can be completed quicker to close in trench). | 1,698.00 | m3 | 320.00 | 543,360.00 |
| 17 | Mesh to slab | 5,660.00 | m2 | 25.00 | 141,500.00 |
| 18 | Allowances for control joints in RCBC base slab (allow 1 per 10m) | 566.00 | m | 80.00 | 45,280.00 |
| 19 | Subsoil drainage along the culvert route | 1,132.00 | m | 50.00 | 56,600.00 |
| 20 | Allowance for spear points and temporary pump hire during construction (no allowance has been made for stand by generator) | 1.00 | Item | 30,000.00 | 30,000.00 |
| | **Reinforced concrete box culverts (RCBC - standard lengths 2.464m length)** | | | | |
| 21 | Supply and install 5000 x 1800 including bonding to base and sealing joints | 1,132.00 | m | 4,000.00 | 4,528,000.00 |
| | **PITS** | | | | |
| 22 | Allow for inspection/access point every 200m | 6.00 | No | 2,500.00 | 15,000.00 |
| | **Miscellaneous** | | | | |
| 22 | Allowances for miscellaneous connection of existing or new stormwater pipe to new RCBC | 1.00 | Item | 20,000.00 | 20,000.00 |
| 23 | Allowance for out of hours/night work | 1.00 | Item | 400,000.00 | 400,000.00 |
| 24 | Allow for traffic management including crossovers at major roads | 1.00 | Item | 350,000.00 | 350,000.00 |
| 25 | Allow for proposed 600 RC sewer line from O'Riordain to Botany Rd | 0.00 | m | 570.00 | Excl. |
| 26 | Allow for proposed 600 RC sewer line between Botany Rd and proposed Zetland Avenue | 0.00 | m | 570.00 | Excl. |
| 27 | Allow for proposed 600 RC sewer line along proposed Zetland Avenue | 0.00 | m | 570.00 | Excl. |
| 28 | Allow provisional sum for potential underpinning required between Maddox & Huntley | 1.00 | PCsum | 100,000.00 | 100,000.00 |
| | **REINSTATE ROADS** | | | | |
| 29 | Reinstate above new culverts and pits | 7,924.00 | m2 | 120.00 | 950,880.00 |
| | | | | | |
| | **SUBTOTAL (Excl Fees and GST)** | | | | **26,206,240.00** |
| 30 | Supervision & Preliminaries (10%) | | Item | | 2,620,624.00 |
| 31 | Builders overheads & margin (7%) | | Item | | 2,017,880.00 |
| 32 | Construction contingency (25%) | | Item | | 7,711,186.00 |
| | | | | | |
| | **SUBTOTAL (Excl Design and GST)** | | | | **38,555,930.00** |
| 33 | Design and professional fees (6%) | | Item | | 2,313,356.00 |
| 34 | Design contingency (5%) | | Item | | 2,043,464.00 |
| | **TOTAL ESTIMATED CONSTRUCTION COST (excl GST)** | | | | **42,912,750.00** |
| | | | | | |
| | EXCLUSIONS | | | | |
| | Escalation beyond January '13 | | | | |
| | Any demolition of existing buildings | | | | |

| | Stage 3 - Link Road to Joynton Avenue | | | | |
|---|---|---|---|---|---|
| Item | Item Description | Quantity | Unit | Rate | Amount |
| | **DEMOLITION & EXCAVATION** | | | | |
| 1 | Demolish and remove existing 2540 x 1380 RC pipe assuming surrounding fill is classified as general solid waste (441m) | 5,954.00 | m3 | 100.00 | 595,400.00 |
| 2 | Demolish and remove existing 2700 x 1200 open channel assuming surrounding fill is classified as solid general waste (169m) | 548.00 | m3 | 55.00 | 30,140.00 |
| 3 | Excavate for proposed culverts and open channels including allowances for working space and bases | 12,049.25 | m3 | 80.00 | 963,940.00 |
| 4 | Allow extra for shoring to trenching 1.00 - 3.00m deep | 2,644.00 | m2 | 25.00 | 66,100.00 |
| 5 | Allow for disposal of excavated material including transport and tip fees - assume excavated material to be classified as General Solid Waste with 20% to remain onsite | 9,639.40 | m3 | 310.00 | 2,988,214.00 |
| 6 | Testing, reporting and site audits | 1.00 | Item | 25,000.00 | 25,000.00 |
| 7 | Backfill workspace with fill around new culverts | 1,983.00 | m3 | 30.00 | 59,490.00 |
| 8 | Temporary fence and barrier to the side of trench during works | 1,236.00 | m | 30.00 | 37,080.00 |
| | **SERVICE DIVERSIONS** | | | | |
| 9 | Allowance to replace existing drainage with 375 dia uPVC pipe, and backfill on completion | 610.00 | m | 210.00 | 128,100.00 |
| 10 | Allow provisional sum for safe working allowance near existing Ausgrid/sewer services to allow construction of new stormwater culverts | 1.00 | PCsum | 50,000.00 | 50,000.00 |
| 11 | Allow provisional sum for potential service diversions not currently indicated | 1.00 | PCsum | 250,000.00 | 250,000.00 |
| | **CULVERTS** | | | | |
| | **Base** | | | | |
| 12 | Compact subgrade (allowed for to RCBC and pits) | 5,065.00 | m2 | 10.00 | 50,650.00 |
| 13 | 50mm thick mass concrete working slab (allowed for to RCBC and pits) | 254.00 | m3 | 320.00 | 81,280.00 |
| 14 | Formwork to sides of 300mm thick slab base and pit base | 1,236.00 | m | 50.00 | 61,800.00 |
| 15 | 20Mpa 300mm thick reinforced concrete slab with concrete additive (allowed for additive for waterproofing and hardener so works can be completed quicker to close in trench). | 1,519.50 | m3 | 320.00 | 486,240.00 |
| 16 | Mesh to slab | 5,065.00 | m2 | 25.00 | 126,625.00 |
| 17 | Allowances for control joints in RCBC base slab (allow 1 per 10m) | 464.00 | m | 80.00 | 37,120.00 |
| 18 | Subsoil drainage along the culvert route | 618.00 | m | 50.00 | 30,900.00 |
| 19 | Allowance for spear points and temporary pump hire during construction (no allowance has been made for stand by generator) | 1.00 | Item | 20,000.00 | 20,000.00 |
| | **Reinforced concrete box culverts (RCBC - standard lengths 2.464m length)** | | | | |
| 20 | Supply and install 4000 x 1500 including bonding to base and sealing joints | 117.00 | m | 3,000.00 | 351,000.00 |
| 21 | Supply and install 5500 x 1500 including bonding to base and sealing joints | 106.00 | m | 4,500.00 | 477,000.00 |
| 22 | Supply and install 8000 x 1500 including bonding to base and sealing joints | 395.00 | m | 6,500.00 | 2,567,500.00 |
| | **PITS** | | | | |
| 23 | Allow for inspection/access point every 200m | 4.00 | No | 5,000.00 | 20,000.00 |
| | **Miscellaneous** | | | | |
| 23 | Allowances for miscellaneous connection of existing or new stormwater pipe to new RCBC | 1.00 | Item | 20,000.00 | 20,000.00 |
| 24 | Allowance for out of hours/night work | 1.00 | Item | 250,000.00 | 250,000.00 |
| 25 | Allow for traffic management including road barriers etc | 1.00 | Item | 250,000.00 | 250,000.00 |
| | **REINSTATE ROADS** | | | | |
| 26 | Reinstate above existing demolished culverts | 2,442.00 | m2 | 120 | 293,040.00 |
| 27 | Reinstate above new culverts and pits | 5,600.00 | m2 | 120 | 672,000.00 |
| | | | | | |
| | **SUBTOTAL (Excl Fees and GST)** | | | | **10,988,619.00** |
| 28 | Supervision & Preliminaries (10%) | | Item | | 1,098,862.00 |
| 29 | Builders overheads & margin (7%) | | Item | | 846,124.00 |
| 30 | Construction contingency (25%) | | Item | | 3,233,401.00 |
| | | | | | |
| | **SUBTOTAL (Excl Design and GST)** | | | | **16,167,006.00** |
| 31 | Design and professional fees (6%) | | Item | | 970,020.00 |
| 32 | Design contingency (5%) | | Item | | 856,851.00 |
| | **TOTAL ESTIMATED CONSTRUCTION COST (excl GST)** | | | | **17,993,877.00** |
| | | | | | |
| | EXCLUSIONS | | | | |
| | Escalation beyond January '13 | | | | |
| | Any demolition of existing buildings | | | | |