## 9.5. Provisional Flood Hazard and Preliminary True Hazard

Maps of provisional hydraulic hazard are presented on Figure 22 (10 Year ARI) to Figure 25 (PMF). Hazard categories were determined in accordance with Appendix L of the NSW Floodplain Development Manual (Reference 11).

The provisional hazards were reviewed in this study 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. These factors and related comments are given in Table 20.

Table 20: Weightings for Assessment of True Hazard

| Criteria | Weight [1] | Comment |
|---|---|---|
| **Rate of Rise of Floodwaters** | High | The rate of rise in the creek channels and onset of overland flow along roads would be very rapid, which would not allow time for residents to prepare. |
| **Duration of Flooding** | Low | The duration for local catchment flooding will generally be less than around 6 hours, resulting in inconvenience to affected residents but not generally a significant increase in hazard. |
| **Effective Flood Access** | High | Roads within the catchment will generally be inundated prior to property inundation, which may restrict vehicular access during a flood. |
| **Size of the Flood** | Moderate | The hazard can change significantly at some locations with the magnitude of the flood, particularly in the residential areas near Sims, Taylor and Sturt Streets and along Oxford Street. However, these higher hazard areas are generally captured by mapping a range of events using the provisional hazard criteria. |
| **Effective Warning and Evacuation Times** | High | There is very little, if any, warning time. During the day residents will be aware of the heavy rain but at night (if asleep) residential and non-residential building floors may be inundated with no prior warning. |
| **Additional Concerns such as Bank Erosion, Debris, Wind Wave Action** | Low | The main concern would be debris blocking culverts or bridges. This is considered to have a high probability of occurrence and will significantly increase the hazard. There is also the possibility of vehicles being swept into the main channels (as occurred in Newcastle in June 2007) causing blockage. However design modelling for this study includes significant blockage and the provisional hazard classification therefore includes this factor. Wind wave action is unlikely to be an issue but waves from traffic may be, due to the proximity of flood prone properties to main traffic routes. |
| **Evacuation Difficulties** | Low | Given the quick response of the catchment evacuation is not considered to be necessary (it is safer to remain than to cross fast flowing floodwaters) except in a few instances and therefore was not given significant weight for assessing true hazard. |
| **Flood Awareness of the Community** | Low | The flood awareness of the community is quite high due to the frequency of recent flood events. As a result of this awareness of problem flood areas, this factor is assigned a low weight in assessing true flood hazard. |
| **Depth and Velocity of Floodwaters** | High | In areas of overland flow roads are subject to fast flowing water. There is always a risk of a car or pedestrian being swept into flood waters. However this factor is largely included in the provisional hydraulic hazard calculation metrics. |

Note: (1) Relative weighting in assessing the preliminary true hazard.

For the Centennial Park catchment within the City of Sydney LGA, the factors with high weighting in relation to assessment or true hazard are generally related to the lack of flood warning, and the potential for flooding of access to residential properties prior to above-floor flooding of buildings occurring. In most cases, it is likely that remaining inside the property will present less risk to life than attempting evacuation via flooded routes, as refuge can generally be taken on furniture etc. There may be some properties where remaining inside would present a high risk to life due to very high flood depths, but these properties will generally already be classified as high hazard using provisional hazard criteria.

In general it was found that areas where a high flood hazard would be justified based on consideration of the high weight criteria in Table 20, the area was already designated high hazard as a result of the depth/velocity criteria used to develop the provisional hazard. However, additional information (particularly detailed flood level survey) may warrant revision of the true hazard categories at various properties during the Floodplain Risk Management Study phase.

## 9.6. Preliminary Hydraulic Categorisation

Preliminary hydraulic categorisation for the 20, 100 year ARI event is provided on Figure 26. There is no technical definition of hydraulic categorisation that would be suitable for all catchments, and different approaches are used by different consultants and authorities, based on the specific features of the study catchment in question.

For this study, preliminary hydraulic categories were defined using the approach adopted in Howells et al (Reference 12) and the following criteria were applied:

- Floodway is defined as areas where:
    - the peak value of velocity multiplied by depth (V x D) > 0.25 $m^2/s$ **AND** peak velocity > 0.25 m/s, **OR**
    - peak velocity > 1.0 m/s **AND** peak depth > 0.15m

  The remainder of the floodplain is either Flood Storage or Flood Fringe,
- Flood Storage comprises areas outside the floodway where peak depth > 0.5 m; and
- Flood Fringe comprises areas outside the Floodway where peak depth < 0.5m.

## 9.7. Preliminary Flood ERP Classification of Communities

The Floodplain Development Manual, 2005 requires flood studies to address the management of continuing flood risk to both existing and future development areas. As continuing flood risk varies across the floodplain so does the type and scale of emergency response problem and therefore the information necessary for effective Emergency Response Planning (ERP). Classification provides an indication of the vulnerability of the community in flood emergency response and identifies the type and scale of information needed by the SES to assist in emergency response planning (ERP).

Table 21 (taken from Reference 13) provides an indication of the response required for areas with different classifications. However, these may vary depending on local flood characteristics and resultant flood behaviour i.e. in flash flooding or overland flood areas. The criteria for classification of floodplain communities outlined in Reference 13 are generally more applicable to riverine flooding where significant flood warning time is available and emergency response action can be taken prior to the flood.

Table 21: Response Required for Different Flood ERP Classifications

| Classification | Response Required | | |
|---|---|---|---|
| | Resupply | Rescue/Medivac | Evacuation |
| **High Flood Island** | Yes | Possibly | Possibly |
| **Low Flood Island** | No | Yes | Yes |
| **Area with Rising Road Access** | No | Possibly | Yes |
| **Areas with Overland Escape Routes** | No | Possibly | Yes |
| **Low Trapped Perimeter** | No | Yes | Yes |
| **High Trapped Perimeter** | Yes | Possibly | Possibly |
| **Indirectly Affected Areas** | Possibly | Possibly | Possibly |

In urban areas like the Centennial Park catchment, flash flooding from local catchment and overland flow will generally occur as a direct response to intense rainfall without significant warning. At most flood affected properties in the catchment, remaining inside the home or building is likely to present less risk to life than attempting to drive or wade through floodwaters, as flow velocities and depths are likely to be greater in the roadway. Figure 27 shows a preliminary ERP classification within the study area.

A large proportion of the study area has been classified as high flood island, due to the reasonably high depths that would occur in road reserves surrounding properties, prior to inundation of the properties themselves.

# 10. SENSITIVITY ANALYSIS

## 10.1. Overview

Due to lack of historical data suitable for undertaking a thorough model calibration, a number of assumptions have been made for the selection of the design approach/parameters, primarily relying on default parameter values or values used in similar studies. The following sensitivity analyses were undertaken for the 100 Year ARI event to establish the variation in design flood level that may occur if different assumptions were made:

- Rainfall Losses: Varying rainfall losses in the hydrologic model were assessed;
- Impervious Percentage: Changed the impervious fraction of each hydrologic sub-catchment by ±20%;
- Manning's "n": The roughness values were increased and decreased by 20% at all locations;
- Inflows / Climate Change: Sensitivity to rainfall/runoff estimates was assessed by increasing the rainfall intensities by 10%, 20% and 30% as recommended under current guidelines. Refer to Section 10.3 below for discussion;
- Pipe Blockage: Sensitivity of blocking all pipes by 25% and 50% were considered;
- Downstream Boundary: Sensitivity of the downstream boundary assumptions were tested using PMF levels within Centennial Park lakes from Reference 1.

It should be noted that the parameters are not independent and adjustment of one parameter (Manning's "n") would generally require adjustment of other values (such as inflows) in order for the model to produce the same level at a given location.

## 10.2. Results of Sensitivity Analyses

Table 22 and Table 23 on the following page provide a summary of peak flood level changes at various locations for the sensitivity scenarios. Overall results were shown to be relatively insensitive to routing, roughness and blockage with results tending to be ± 0.1 m which can generally be accommodated within the 0.5 m freeboard applied to the 100 Year ARI results to determine the Flood Planning Levels (FPLs).

The sensitivity testing thus provides confidence that provided the model emulates ground conditions and hydraulic structures, within a range of typical values for parameters, the model will produce reasonably accurate and reliable design flood levels.

Table 22 – Results of Sensitivity Analyses – 100 Year ARI Event Flows ($m^3/s$)

| ID | Location | Type | 100 Year ARI Peak Flood Flow ($m^3/s$) | Imperviousness increased by 20% | Imperviousness decreased by 20% | AMC = 1 | AMC = 4 | Soil = 1 |
|---|---|---|---|---|---|---|---|---|
| | | | | Difference with 100 Year ARI base case ($m^3/s$) | | | | |
| 1 | Driver Avenue (North) | Overland | 2.0 | 0.0 | 0.0 | -0.3 | 0.2 | -0.5 |
| | | Piped | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2 | Football StadiumCar-park | Overland | 8.0 | 0.1 | -0.5 | -1.1 | 0.2 | -1.4 |
| | | Piped | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3 | Football Stadium Entrance at Regent St | Overland | 0.9 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 |
| 4 | Poate Road | Overland | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | Piped | 0.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 5 | Entertainment Quarter Show Ring | Overland | 2.6 | -0.1 | -0.1 | 0.0 | 0.0 | 0.0 |
| 6 | Errol Flynn Boulevard (at RHI) | Overland | 8.1 | -0.2 | -0.4 | -0.3 | 0.1 | -0.4 |
| 7 | Lang Road (West) | Overland | 15.1 | -0.1 | -0.6 | -1.4 | 0.5 | -1.9 |
| | | Piped | 4.1 | 0.0 | 0.0 | -0.1 | 0.0 | -0.1 |
| 8 | Parklands Sports Centre at Busway | Overland | 16.7 | 0.0 | -0.7 | -2.7 | 1.1 | -3.8 |
| | | Piped | 4.3 | 0.0 | 0.0 | -0.1 | 0.0 | -0.1 |
| 9 | Anzac Parade near Robertson Road | Overland | 16.7 | 0.0 | -0.7 | -2.7 | 1.1 | -3.8 |
| | | Piped | 3.3 | 0.0 | 0.0 | -0.2 | 0.1 | -0.3 |
| | | Piped | 1.4 | 0.0 | 0.0 | 0.0 | 0.0 | -0.1 |
| 10 | Centennial Park (East of Lang Road) | Overland | 2.3 | 0.0 | -0.1 | -0.2 | 0.1 | -0.3 |
| 11 | Centennial Park (East of Mitchell St) | Overland | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | Piped | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

| ID | Location | Type | 100 Year ARI Peak Flood Flow ($m^3/s$) | Roughness increased by 20% | Roughness decreased by 20% | Blockage 25% | Blockage 50% | PMF Tailwater |
|---|---|---|---|---|---|---|---|---|
| | | | | Difference with 100 Year ARI base case ($m^3/s$) | | | | |
| 1 | Driver Avenue (North) | Overland | 2.0 | 0.0 | 0.0 | -0.1 | -0.1 | -0.2 |
| | | Piped | 0.3 | 0.0 | 0.0 | 0.0 | -0.1 | 0.1 |
| 2 | Football StadiumCar-park | Overland | 8.0 | -0.5 | 0.3 | 0.3 | 0.5 | -0.1 |
| | | Piped | 0.4 | 0.0 | 0.0 | -0.1 | -0.2 | 0.0 |
| 3 | Football Stadium Entrance at Regent St | Overland | 0.9 | 0.1 | 0.0 | 0.0 | -0.1 | 0.0 |
| 4 | Poate Road | Overland | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | Piped | 0.9 | 0.0 | 0.0 | -0.3 | -0.5 | 0.0 |
| 5 | Entertainment Quarter Show Ring | Overland | 2.6 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 |
| 6 | Errol Flynn Boulevard (at RHI) | Overland | 8.1 | -0.2 | 0.1 | 0.0 | 0.3 | -0.3 |
| 7 | Lang Road (West) | Overland | 15.1 | -0.6 | 0.2 | 0.5 | 1.2 | -0.2 |
| | | Piped | 4.1 | 0.0 | 0.0 | -1.1 | -2.2 | 0.0 |
| 8 | Parklands Sports Centre at Busway | Overland | 16.7 | -0.8 | 0.9 | 0.4 | 1.2 | -0.5 |
| | | Piped | 4.3 | 0.0 | 0.0 | -1.1 | -2.3 | 0.0 |
| 9 | Anzac Parade near Robertson Road | Overland | 16.7 | -0.9 | 0.9 | 0.4 | 1.1 | -0.5 |
| | | Piped | 3.3 | 0.1 | -0.1 | -0.9 | -1.7 | 0.0 |
| | | Piped | 1.4 | 0.0 | 0.0 | -0.3 | -0.5 | 0.0 |
| 10 | Centennial Park (East of Lang Road) | Overland | 2.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 11 | Centennial Park (East of Mitchell St) | Overland | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | Piped | 0.3 | 0.0 | 0.0 | 0.0 | -0.1 | 0.1 |

Table 23 – Results of Sensitivity Analyses – 100 Year ARI Event Depths (m)

| ID | Location | 100 Year ARI Peak Flood Depth (m) | Imperviousness increased by 20% | Imperviousness decreased by 20% | AMC = 1 | AMC = 4 | Soil = 1 |
|---|---|---|---|---|---|---|---|
| | | | Difference with 100 Year ARI base case (m) | | | | |
| 1 | Stewart Street | 0.9 | - | -0.02 | -0.02 | - | -0.03 |
| 2 | Leinster Street | 1.4 | - | -0.01 | -0.03 | - | -0.04 |
| 3 | Poate Road | 1.7 | - | -0.02 | -0.03 | 0.02 | -0.05 |
| 4 | Driver Avenue | 1.5 | - | -0.02 | -0.09 | 0.04 | -0.12 |
| 5 | John Hargraves Ave | 0.6 | - | -0.03 | -0.19 | 0.05 | -0.28 |
| 6 | Erol Flynn Boulevard | 0.4 | - | - | - | - | - |
| 7 | Lang Road / Driver Ave | 0.9 | - | - | -0.03 | - | -0.04 |
| 8 | Parklands adjacent Lang Road/ Driver Ave | 0.9 | - | - | -0.03 | 0.01 | -0.04 |
| 9 | Lang Road (East) | 0.6 | - | - | -0.01 | - | -0.02 |
| 10 | Anzac Parade | 0.5 | - | - | -0.03 | - | -0.04 |

| ID | Location | 100 Year ARI Peak Flood Depth (m) | Roughness increased by 20% | Roughness decreased by 20% | Blockage 25% | Blockage 50% | PMF Tailwater |
|---|---|---|---|---|---|---|---|
| | | | Difference with 100 Year ARI base case (m) | | | | |
| 1 | Stewart Street | 0.9 | - | - | 0.03 | 0.06 | - |
| 2 | Leinster Street | 1.4 | - | - | - | - | - |
| 3 | Poate Road | 1.7 | - | - | 0.03 | 0.06 | - |
| 4 | Driver Avenue | 1.5 | - | - | 0.02 | 0.05 | - |
| 5 | John Hargraves Ave | 0.6 | - | - | 0.03 | 0.07 | - |
| 6 | Erol Flynn Boulevard | 0.4 | 0.02 | -0.03 | - | - | - |
| 7 | Lang Road / Driver Ave | 0.9 | - | - | - | - | - |
| 8 | Parklands adjacent Lang Road / Driver Ave | 0.9 | - | - | - | 0.01 | - |
| 9 | Lang Road (East) | 0.6 | - | - | -0.02 | - | -0.03 |
| 10 | Anzac Parade | 0.5 | - | 0.08 | - | - | - |

## 10.3. Climate Change

### 10.3.1. Rainfall Increase

The Bureau of Meteorology has indicated that there is no intention at present to revise design rainfalls to take account of the potential climate change, as the implications of temperature changes on extreme rainfall intensities are presently unclear, and there is no certainty that the changes would in fact increase design rainfalls for major flood producing storms. There is some recent literature by CSIRO that suggests extreme rainfall intensities may increase by up to 30% in parts of NSW (in other places the projected increases are much less or even decrease); however this information is not of sufficient accuracy for use as yet (Reference 14).

Any change in design flood rainfall intensities will increase the frequency, depth and extent of inundation across the catchment. It has also been suggested that the cyclone belt may move further southwards. The possible impacts of this on design rainfalls cannot be ascertained at this time as little is known about the mechanisms that determine the movement of cyclones under existing conditions.

Projected increases to evaporation are also an important consideration because increased evaporation would lead to generally dryer catchment conditions, resulting in lower runoff from rainfall. Mean annual rainfall is projected to decrease, which will also result in generally dryer catchment conditions. The influence of dry catchment conditions on river runoff is observable in climate variability using the Indian Pacific Oscillation (IPO) index (Reference 15). Although mean daily rainfall intensity is not observed to differ significantly between IPO phases, runoff is significantly reduced during periods with fewer rain days.

The combination of uncertainty about projected changes in rainfall and evaporation makes it extremely difficult to predict with confidence the likely changes to peak flows for large flood events within the Centennial Park catchment under warmer climate scenarios.

In light of this uncertainty, the NSW State Government advice (Reference 14) recommends sensitivity analysis on flood modelling should be undertaken to develop an understanding of the effect of various levels of change in the hydrologic regime on the project at hand. Specifically, it is suggested that increases of 10%, 20% and 30% to rainfall intensity be considered.

### 10.3.2. Sea Level Rise

Given the elevations in the catchment area well above sea level, the effect of Climate Change induced sea level rise has not been considered in this study

### 10.3.3. Results

The effect of increasing the design rainfalls by 10%, 20% and 30% was evaluated for the 100 Year ARI event, resulting in a relatively insignificant impact on peak flood levels in the study area. Generally speaking, each incremental 10% increase in flow results in a 0.02 m to 0.05 m increase in peak flood levels at most of the locations analysed. A 30% increase in rainfalls would therefore not exceed the typical freeboard for most residential properties.

There are some notable exceptions among the locations analysed where flood levels are more highly sensitive to rainfall increases, particularly at Lang Street in the vicinity of the Parklands Tennis club and adjacent to Centennial Park along the main trunk drainage path.

Table 24 and Table 25 show the change in peak flows and flood levels due to the effect of climate change induced rainfall increases.

Table 24 – Results of Climate Change Analyses – 100 Year ARI Event Flows ($m^3/s$)

| ID | Location | Type | 100 Year ARI Peak Flood Flow ($m^3/s$) | Rainfall Increase 10% | Rainfall Increase 20% | Rainfall Increase 30% |
|---|---|---|---|---|---|---|
| | | | | Difference with 100 Year ARI Base Case ($m^3/s$) | | |
| 1 | Driver Avenue (North) | Overland | 2.0 | 0.3 | 0.6 | 0.9 |
| | | Piped | 0.3 | 0.0 | 0.0 | 0.0 |
| 2 | Football Stadium Car-park | Overland | 8.0 | 1.3 | 2.9 | 4.4 |
| | | Piped | 0.4 | 0.0 | 0.0 | 0.0 |
| 3 | Football Stadium Entrance at Regent St | Overland | 0.9 | 0.2 | 0.3 | 0.4 |
| 4 | Poate Road | Overland | 0.0 | 0.0 | 0.0 | 0.0 |
| | | Piped | 0.9 | 0.0 | 0.0 | 0.0 |
| 5 | Entertainment Quarter Show Ring | Overland | 2.6 | 0.3 | 0.5 | 0.8 |
| 6 | Errol Flynn Boulevard (at RHI) | Overland | 8.1 | 1.2 | 2.2 | 3.2 |
| 7 | Lang Road (West) | Overland | 15.1 | 2.2 | 4.3 | 6.7 |
| | | Piped | 4.1 | 0.1 | 0.2 | 0.2 |
| 8 | Parklands Sports Centre at Busway | Overland | 16.7 | 2.8 | 5.5 | 8.3 |
| | | Piped | 4.3 | 0.1 | 0.2 | 0.2 |
| 9 | Anzac Parade near Robertson Road | Overland | 16.7 | 2.7 | 5.7 | 8.7 |
| | | Piped | 3.3 | 0.2 | 0.3 | 0.5 |
| | | Piped | 1.4 | 0.0 | 0.1 | 0.1 |
| 10 | Centennial Park (East of Lang Road) | Overland | 2.3 | 0.3 | 0.5 | 0.8 |
| 11 | Centennial Park (East of Mitchell St) | Overland | 0.1 | 0.0 | 0.0 | 0.0 |
| | | Piped | 0.3 | 0.0 | 0.0 | 0.0 |

Table 25 – Results of Climate Change Analyses – 100 Year ARI Event Depths (m)

| ID | Location | 100 Year ARI Peak Flood Depth (m) | Rainfall Increase 10% | Rainfall Increase 20% | Rainfall Increase 30% |
|---|---|---|---|---|---|
| | | | Difference with 100 Year ARI Base Case (m) | | |
| 1 | Stewart Street | 0.9 | 0.05 | 0.09 | 0.12 |
| 2 | Leinster Street | 1.4 | 0.04 | 0.08 | 0.12 |
| 3 | Poate Road | 1.7 | 0.06 | 0.11 | 0.16 |
| 4 | Driver Avenue | 1.5 | 0.07 | 0.14 | 0.20 |
| 5 | John Hargraves Ave | 0.6 | 0.10 | 0.17 | 0.24 |
| 6 | Erol Flynn Boulevard | 0.4 | 0.03 | 0.05 | 0.06 |
| 7 | Lang Road / Driver Ave | 0.9 | 0.03 | 0.06 | 0.09 |
| 8 | Parklands adjacent Lang Road / Driver Ave | 0.9 | 0.03 | 0.06 | 0.09 |
| 9 | Lang Road adjacent 62 | 0.6 | 0.02 | 0.03 | 0.05 |
| 10 | Anzac Parade | 0.5 | 0.02 | 0.05 | 0.07 |

# 11. DAMAGES ASSESSMENT

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

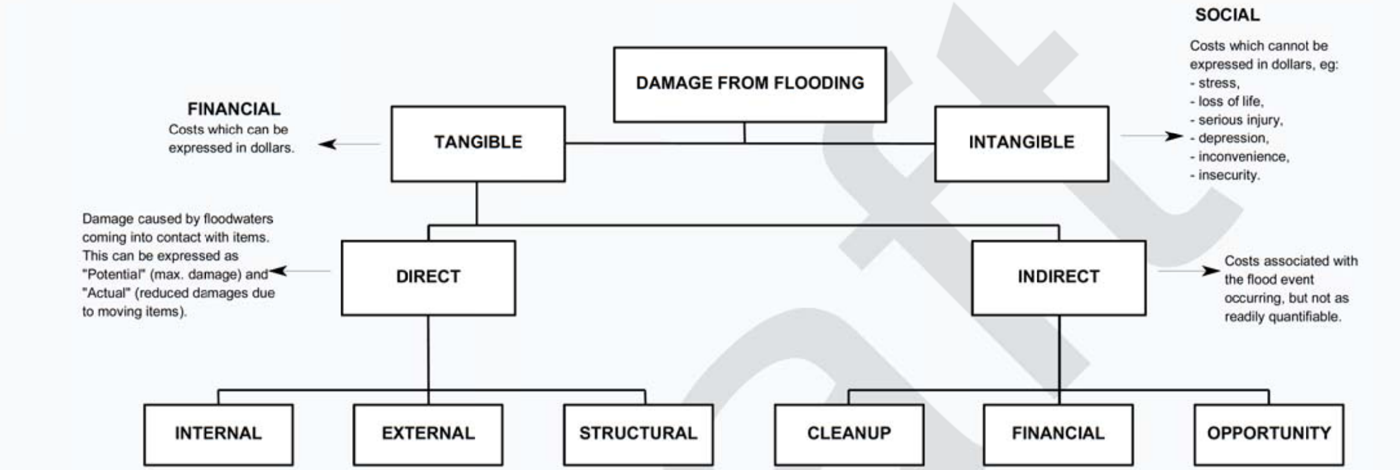
- the magnitude (depth, velocity and duration) of the flood,
- land usage and susceptibility to damage,
- awareness of the community to flooding,
- effective warning time,
- the availability of an evacuation plan or damage minimisation program,
- physical factors such as failure of services (pits and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

The estimation of flood damages tends to focus on the physical impact of damages on the human environment but there is also a need to consider the ecological cost and benefits associated with flooding. Flood damages can be defined as being tangible or intangible. Intangible damages are those to which a monetary value cannot easily be attributed. Types of flood damages are shown on Table 26.

While the total likely damages in a given flood are useful to get a "feel" for the magnitude of the flood problem, it is of little value for absolute economic evaluation. When considering the economic effectiveness of a proposed mitigation measure, the key question is what are the total damages prevented over the life of the measure? This is a function not only of the high damages which occur in large floods but also of the lesser but more frequent damages which occur in small floods.

The standard way of expressing flood damages is in terms of average annual damages (AAD). AAD represents the equivalent average damages that would be experienced by the community on an annual basis, by taking into the account the probability of a flood occurrence. By this means, the smaller floods, which occur more frequently, are given a greater weighting than the rare catastrophic floods.

Table 26 – Breakdown of Flood Damages Categories




| | INTERNAL | EXTERNAL | STRUCTURAL | CLEANUP | FINANCIAL | OPPORTUNITY |
|---|---|---|---|---|---|---|
| RESIDENTIAL | Contents of Buildings: Clothes, Carpets, Furniture, Valuables, Fittings, Appliances | External Items: Vehicles, Laundries, Caravans, Sheds, Tools, Gardens, Fences | Physical Damage to Buildings: Gyprock, Cupboards, Scour of Footings, Houses becoming buoyant (floating off footings) | Clean Carpets, Walls, Clothes; Re-instate Furniture; Remove Mud and Debris | Loss of wages, Living costs (temporary accomodation and food), Time to repair/replace damaged items | Not Applicable |
| RURAL | Contents of Buildings: Clothes, Carpets, Furniture, Valuables, Fittings, Appliances | External Items: Vehicles, Sheds (stables/barns), Machinery, Tools, Fences, Feed storage, Saddles, Crops &/or Stock, Irrigation Systems | Physical Damage to Structures: Damage to Homestead, Sheds, Access tracks, Protection levees | Clean Homestead and Out-buildings; Remove Debris; Dispose of affected crops &/or stock | Loss of Farm Production and Income, Re-instatement of Pastures, Supplementary feeding of stock (by hand or outside agistment), Stock movement/ transport, Living costs (temporary accomodation and food) | Sowing or harvesting of Crops, Sale of Stock (at depreciated value or dependent on market influences) |
| COMMERCIAL | Contents of Buildings: Products, Stock, Fittings, Tools, Machinery, Raw Materials | External Items: Vehicles, Machinery, Display, Raw Materials/Stockpiles, Fences | Physical Damage to Buildings | Dispose of damaged products, stock, materials; Cleaning and Re-instatement | Loss of Productivity and Income, Bank Interest Charges | Loss of existing &/or Potential Trade |
| PUBLIC AUTHORITIES | Contents of Public Buildings and Facilities | Public Property and Facilities: Parks, Signs, Machinery, Equipment | Physical Damage to Infrastructure: Electricity, Water, Telephone, Gas, Road & Rail Transport Links | Remove Mud & Debris from Facilities, Public & Private Property Repairs (temporary & permanent) | Disruption of Services, Community Service Relief Grants | Provision of Public Service |

A flood damages assessment was undertaken for existing development for overland flooding within the Centennial Park catchment. This was based on a detailed floor level survey which was undertaken for 55 properties (332 properties are flood affected in the PMF event). Only properties which have surveyed floor levels have been included in the flood damages assessment.

Damages to public structures have not been assessed. A summary of flood damages for the catchment is provided in Table 27 and with the building floors inundated shown on Figure 28.

Table 27 – Summary of Flood Damages

| Design Flood Event | Total Number Flooded Above Floor Level | Total Tangible Flood Damages* |
|---|---|---|
| **2 Year ARI** | 15 | $1,050,000 |
| **5 Year ARI** | 23 | $1,440,000 |
| **10 Year ARI** | 25 | $1,620,000 |
| **20 Year ARI** | 28 | $1,760,000 |
| **50 Year ARI** | 28 | $1,890,000 |
| **100 Year ARI** | 29 | $1,910,000 |
| **PMF** | 39 | $2,730,000 |
| **Average Annual Damages** | | $969,000 |

Note: * Excludes all damages to public assets

## 11.1. Limitations of Flood Damage Assessment in Centennial Park

In most areas the extent of above floor inundation is difficult to accurately assess. The effect of buildings, sheds, fences and other structures can have a significant impact on the direction and depth of floodwaters. Also the exact location and level of all entry points to buildings is unknown.

It should be noted that the number of floors inundated in the smaller events (say up to the 10 year ARI) is probably over estimated to what has been observed in past events. It is unlikely that all above floor flooding during past events has been reported and some properties may have localised features (such as solid brick walls) that prevent above-floor inundation from a certain direction. Additional inaccuracies may result from the estimation of flood levels which ultimately are based on the ALS ground survey (accuracy of approximately 0.2m or more on uneven surfaces).

# 12. ACKNOWLEDGEMENTS

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The assistance of the following in providing data and guidance to the study is gratefully acknowledged:

- City of Sydney;
- Office of Environment and Heritage;
- Residents of the City of Sydney within the study area; and
- Bureau of Meteorology.

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# Figures


FIGURE 1
LOCALITY MAP
ST JAMES
KINGS CROSS
SYDNEY HARBOUR
TOWN HALL
MUSEUM
EDGECLIFF
CENTRAL
BONDI JUNCTION
KING
WAITARA
ST IVES CHASE
ST IVES
BELROSE
DAVIDSON
PYMBLE
WARRINGAH
GORDON
FRENCHS FOREST
KILLARA
EPPING
ROSEVILLE
EASTWOOD
MANLY
RYDE
ARTARMON
BALGOWLAH
LANE COVE
MOSMAN
RHODES
WAVERTON
CONCORD
DRUMMOYNE
HOMEBUSH
CIRCULAR QUAY
MUSEUM
CROYDON
EDGECLIFF
ASHFIELD
NEWTOWN
ST PETERS
RANDWICK
BELMORE
TEMPE
KINGSFORD
MASCOT
BANKSIA
BOTANY
ALLAWAH
CARLTON
KURNELL
GYMEA
KURNELL PENINSULA
MIRANDA
CRONULLA
N
Study Area
0
0.5
1
km
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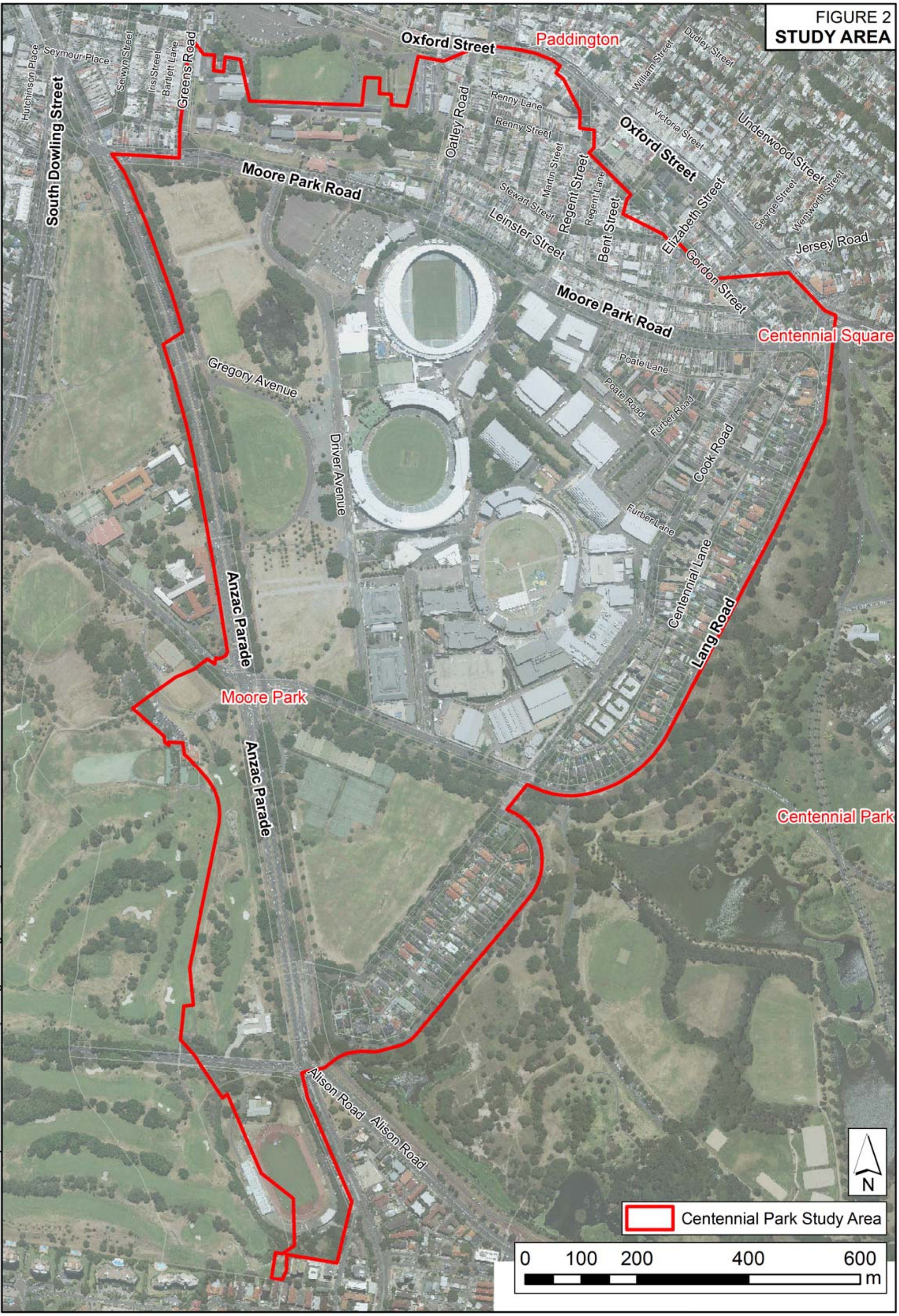

FIGURE 2
STUDY AREA
Paddington
Oxford Street
Seymour Place
Hutchinson Place
Selwyn Street
Iris Street
Bartlett Lane
Greens Road
South Dowling Street
Oatley Road
Renny Lane
Renny Street
Dudley Street
William Street
Victoria Street
Underwood Street
Moore Park Road
Stewart Street
Martin Street
Regent Street
Regent Lane
Bent Street
Leinster Street
Elizabeth Street
George Street
Wentworth Street
Jersey Road
Gordon Street
Centennial Square
Poate Lane
Poate Road
Furber Road
Cook Road
Gregory Avenue
Driver Avenue
Furber Lane
Centennial Lane
Lang Road
Anzac Parade
Moore Park
Centennial Park
Alison Road
N
Centennial Park Study Area
0 100 200 400 600 m
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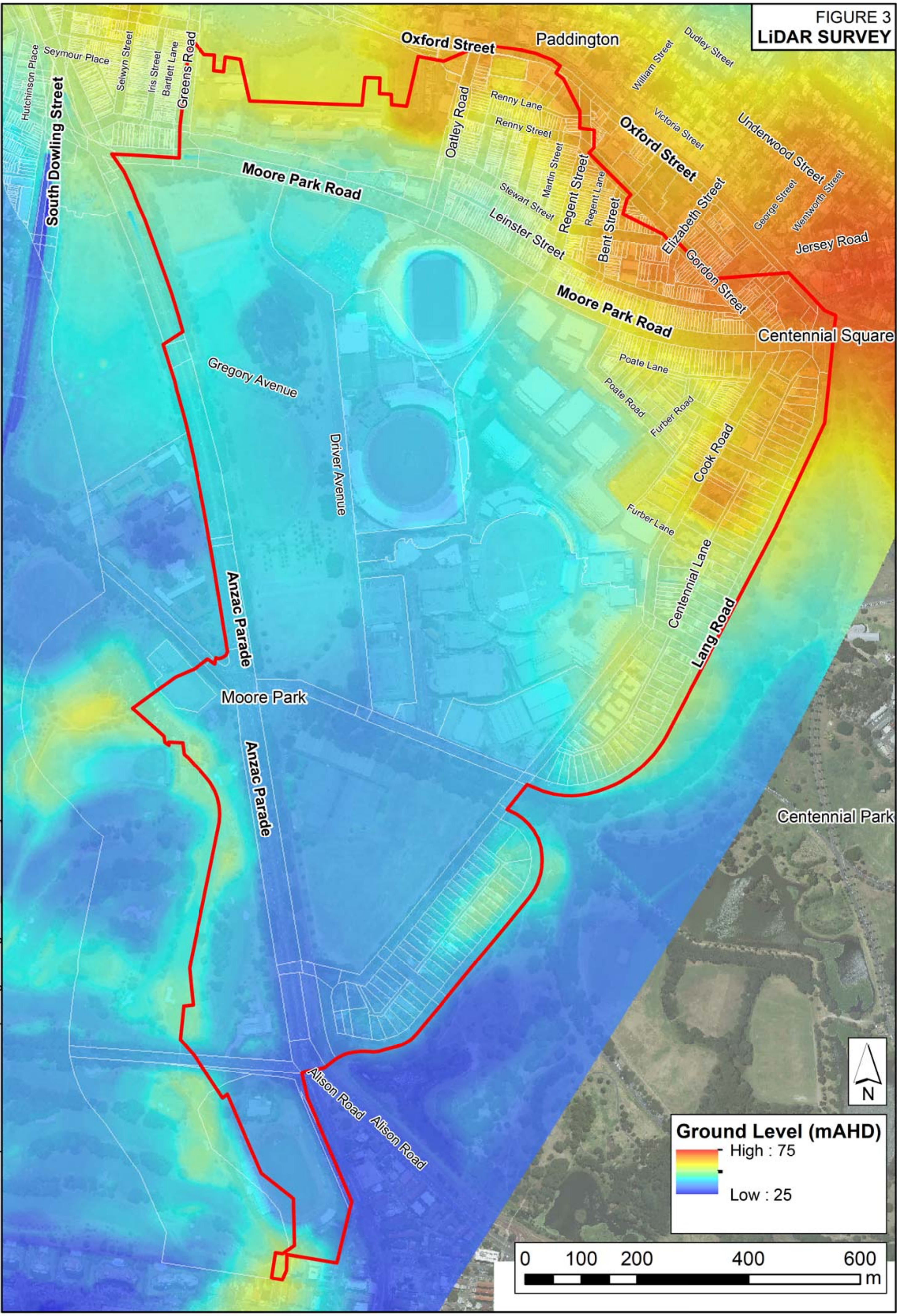


FIGURE 3
**LiDAR SURVEY**

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FIGURE 4
**RAINFALL GAUGES**

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FIGURE 5
**IFD DATA AND RAINFALL COMPARISON**
**PADDINGTON GAUGE**

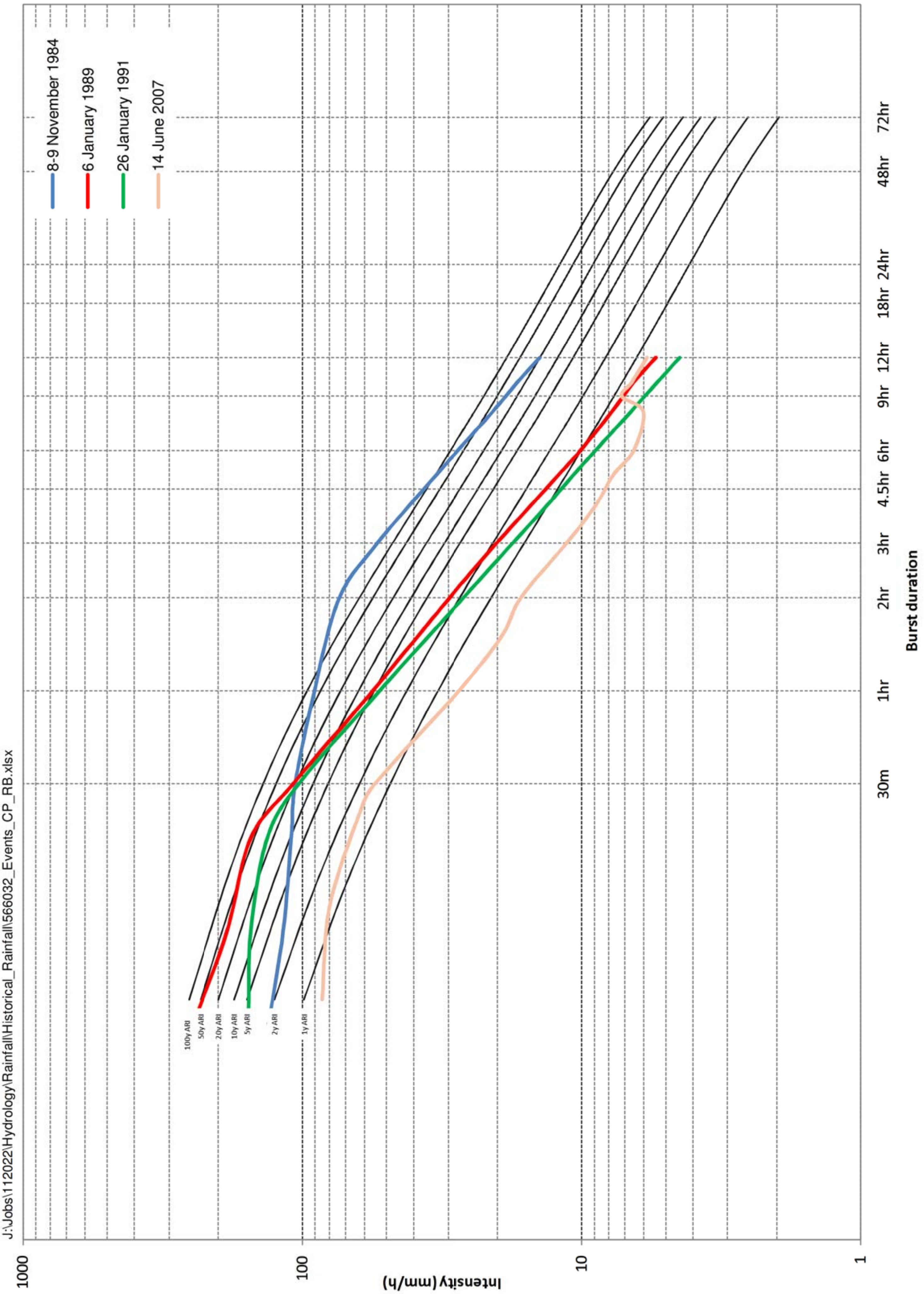
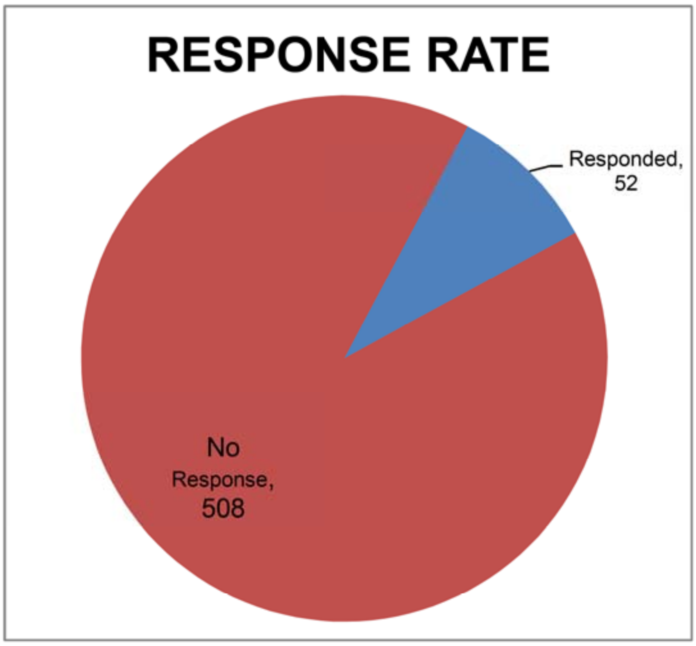
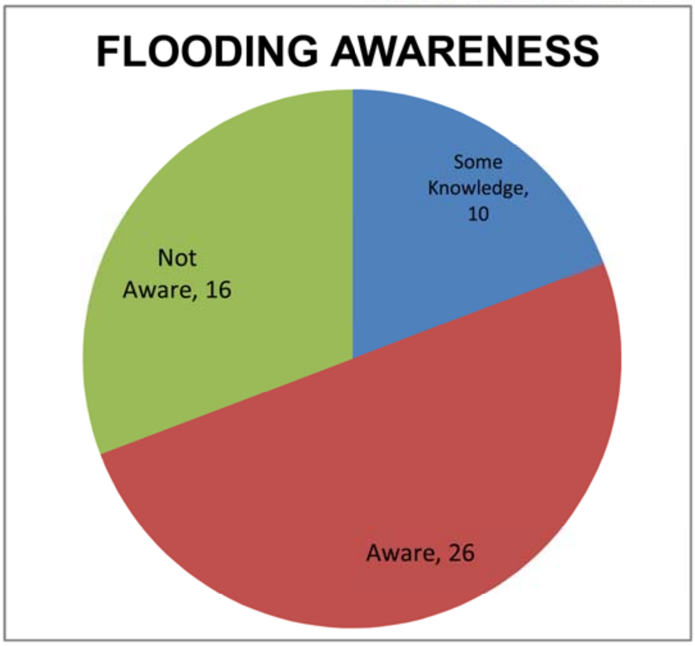
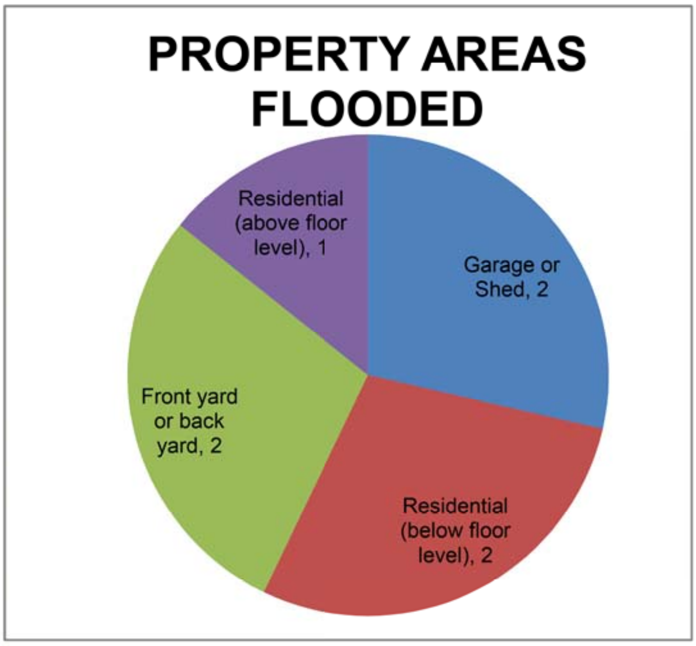
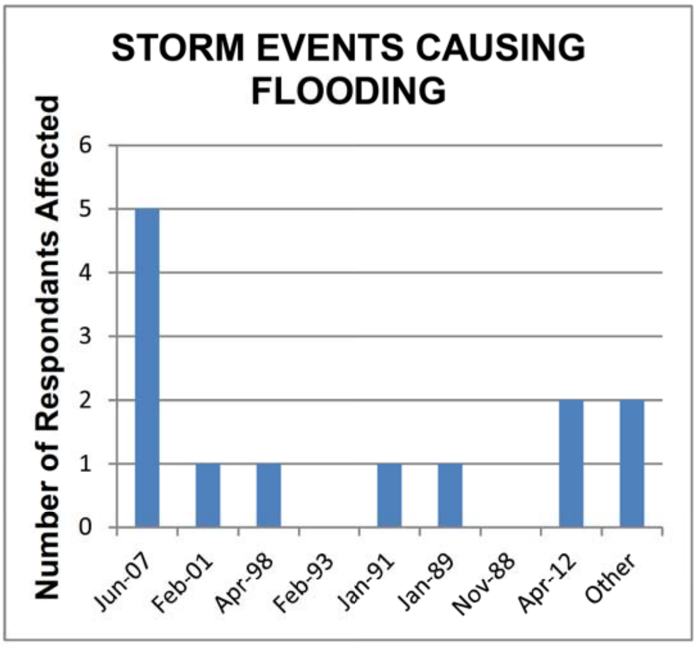


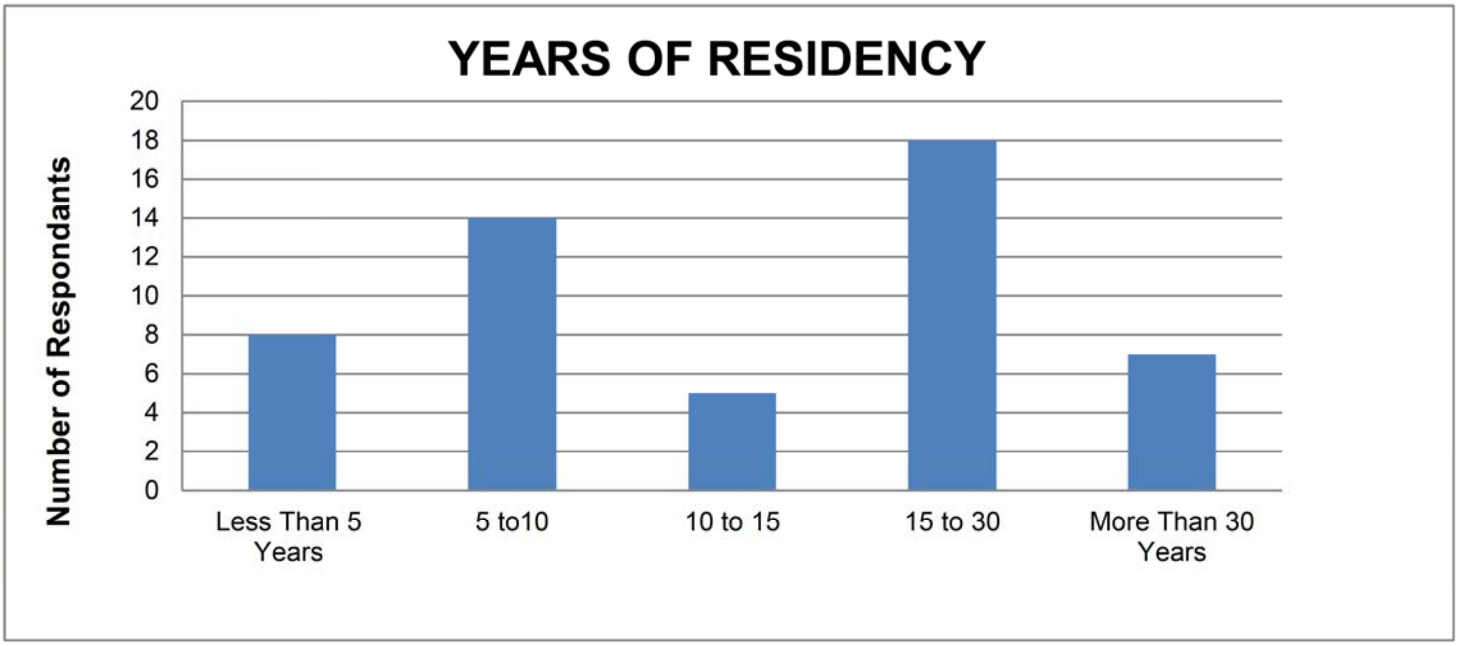
FIGURE 6
**QUESTIONNAIRE RESULTS**

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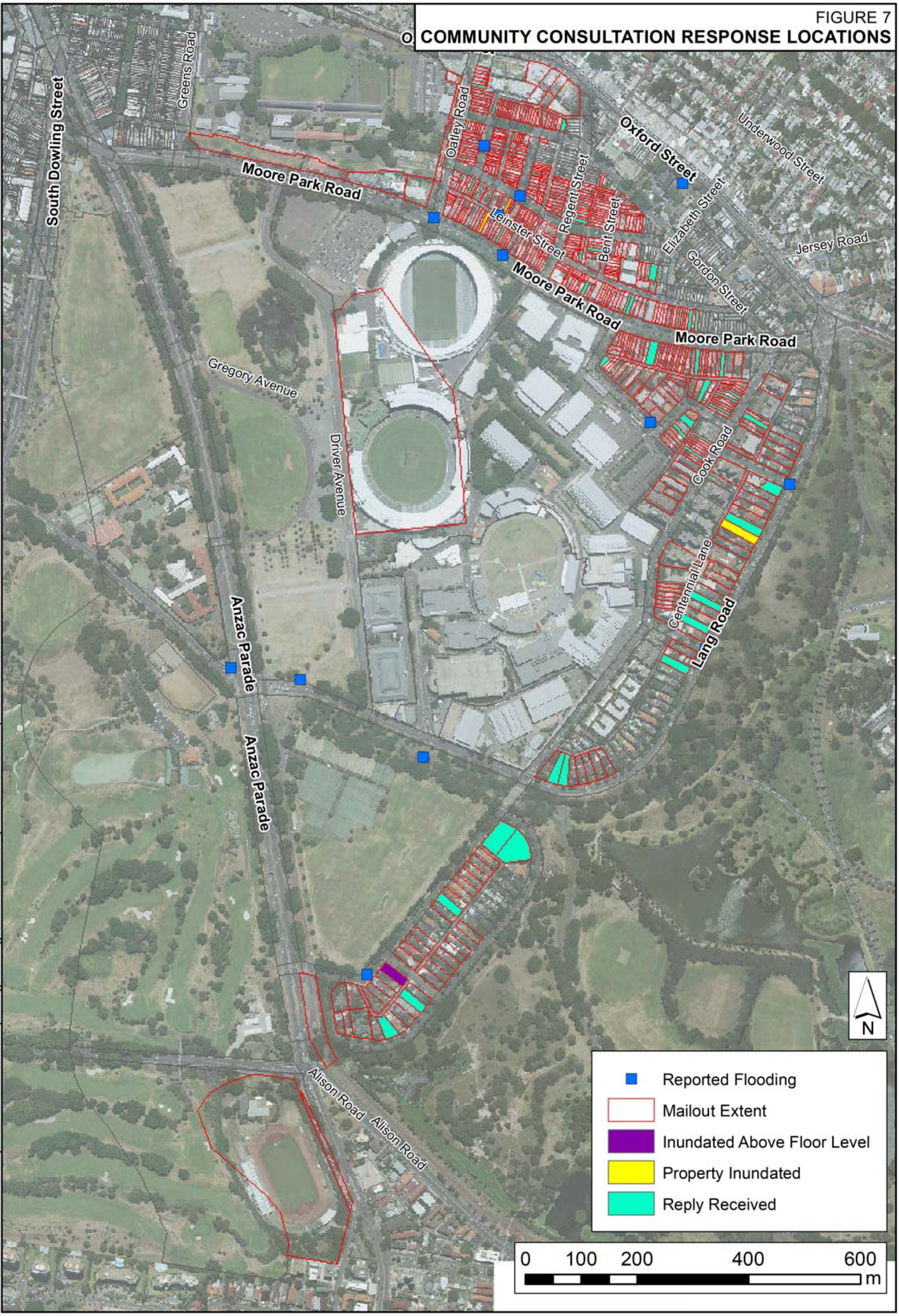

FIGURE 7
COMMUNITY CONSULTATION RESPONSE LOCATIONS
South Dowling Street
Greens Road
Oatley Road
Moore Park Road
Oxford Street
Underwood Street
Regent Street
Bent Street
Elizabeth Street
Leinster Street
Jersey Road
Gordon Street
Moore Park Road
Moore Park Road
Gregory Avenue
Driver Avenue
Cook Road
Centennial Lane
Lang Road
Anzac Parade
Anzac Parade
Alison Road
Alison Road
N
Reported Flooding
Mailout Extent
Inundated Above Floor Level
Property Inundated
Reply Received
0 100 200 400 600
m
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FIGURE 8
**FLOODING PICTURES**


Lang Road, Centennial Park, showing approximate elevation of peak flood levels during a 2Y ARI storm event.

Lang Road, Centennial Park, showing settlement of leaves following flooding above height of raised front lawn.

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# FIGURE 9
# HISTORICAL FLOOD DATA


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FIGURE 10
**HYDROLOGIC MODEL CATCHMENT LAYOUT**

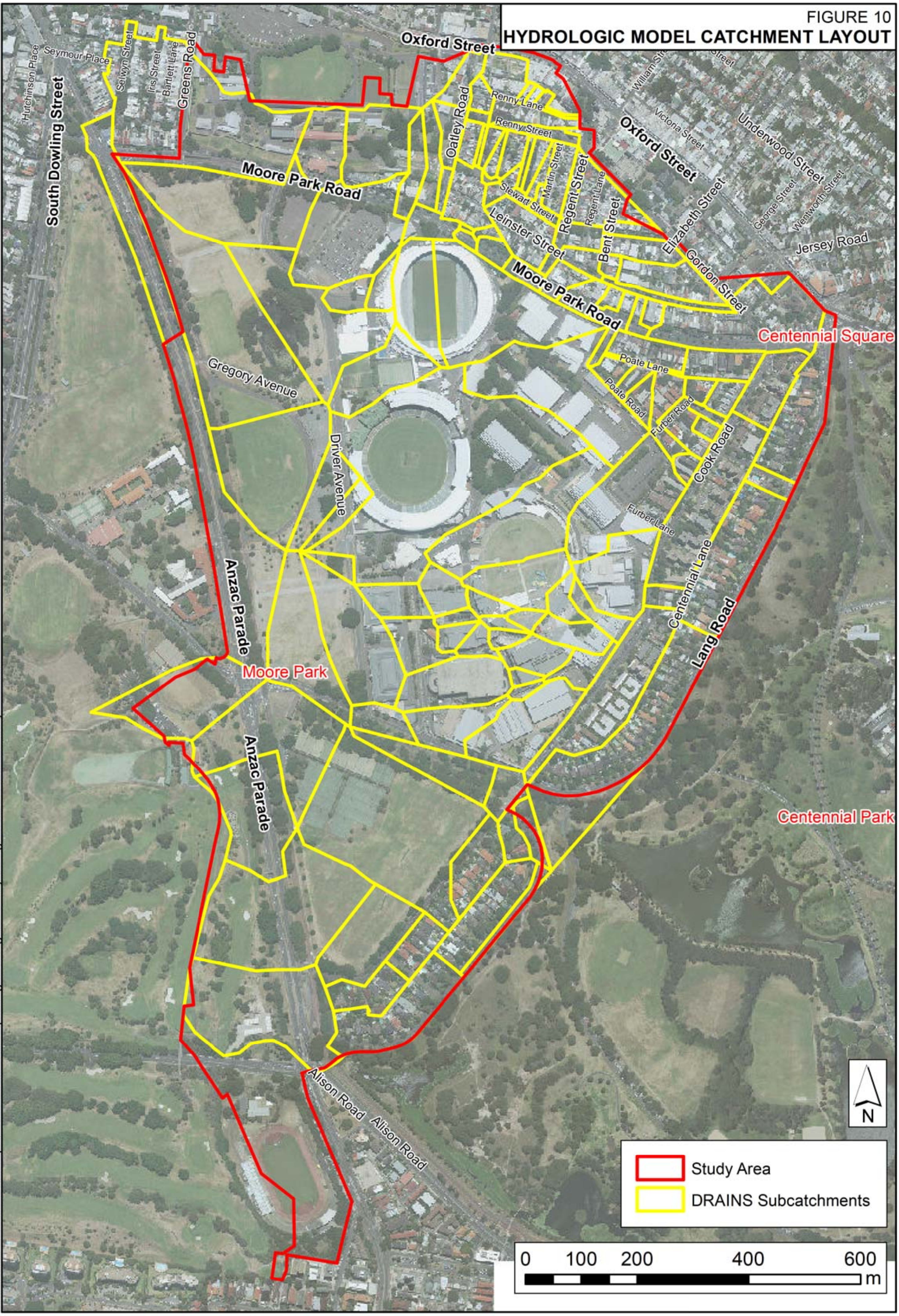

FIGURE 11
**HYDRAULIC MODEL CATCHMENT LAYOUT**

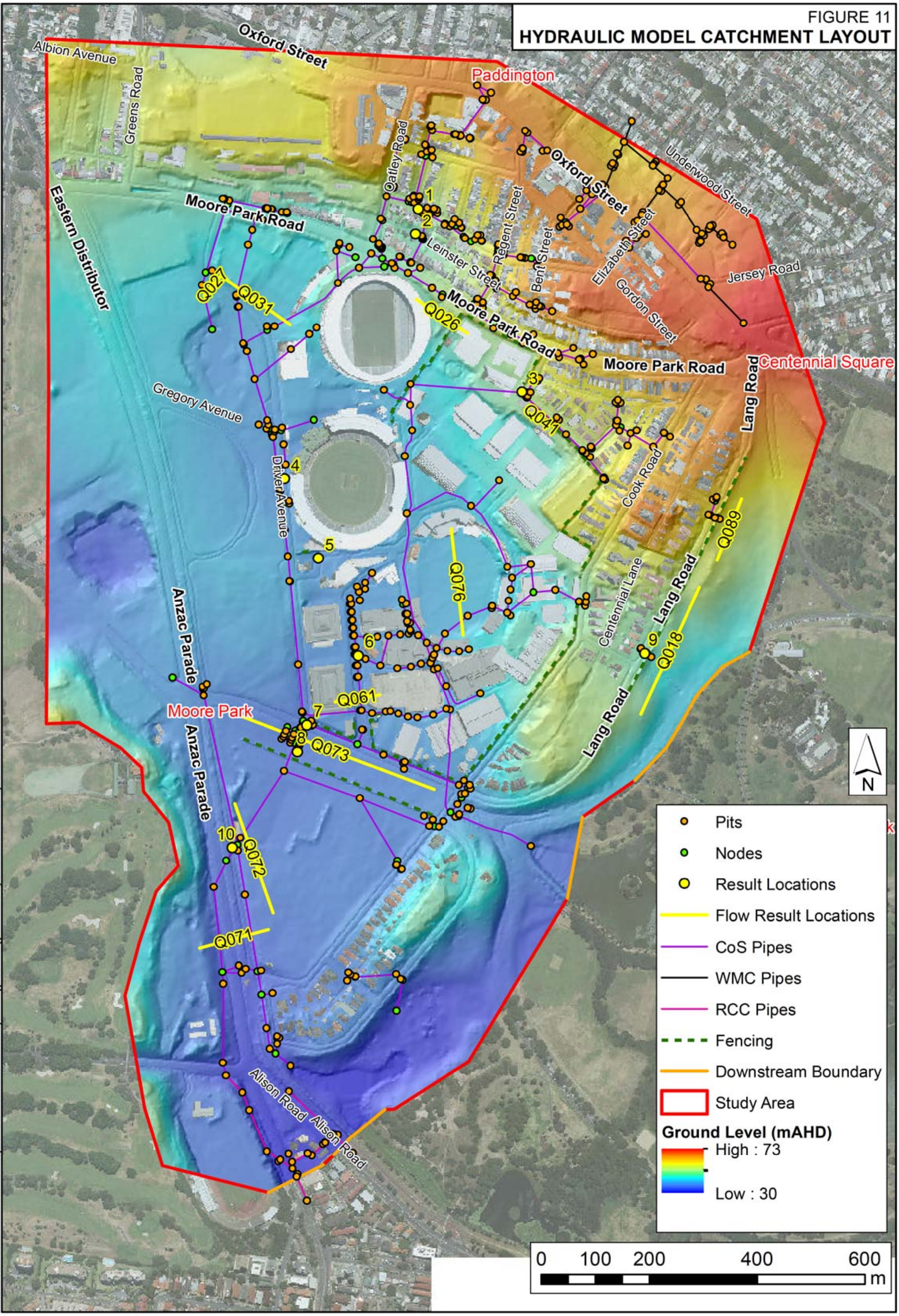


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FIGURE 12
**DESIGN FLOOD PROFILES**
**STEWART STREET**
**RENNY STREET TO MOORE PARK ROAD**

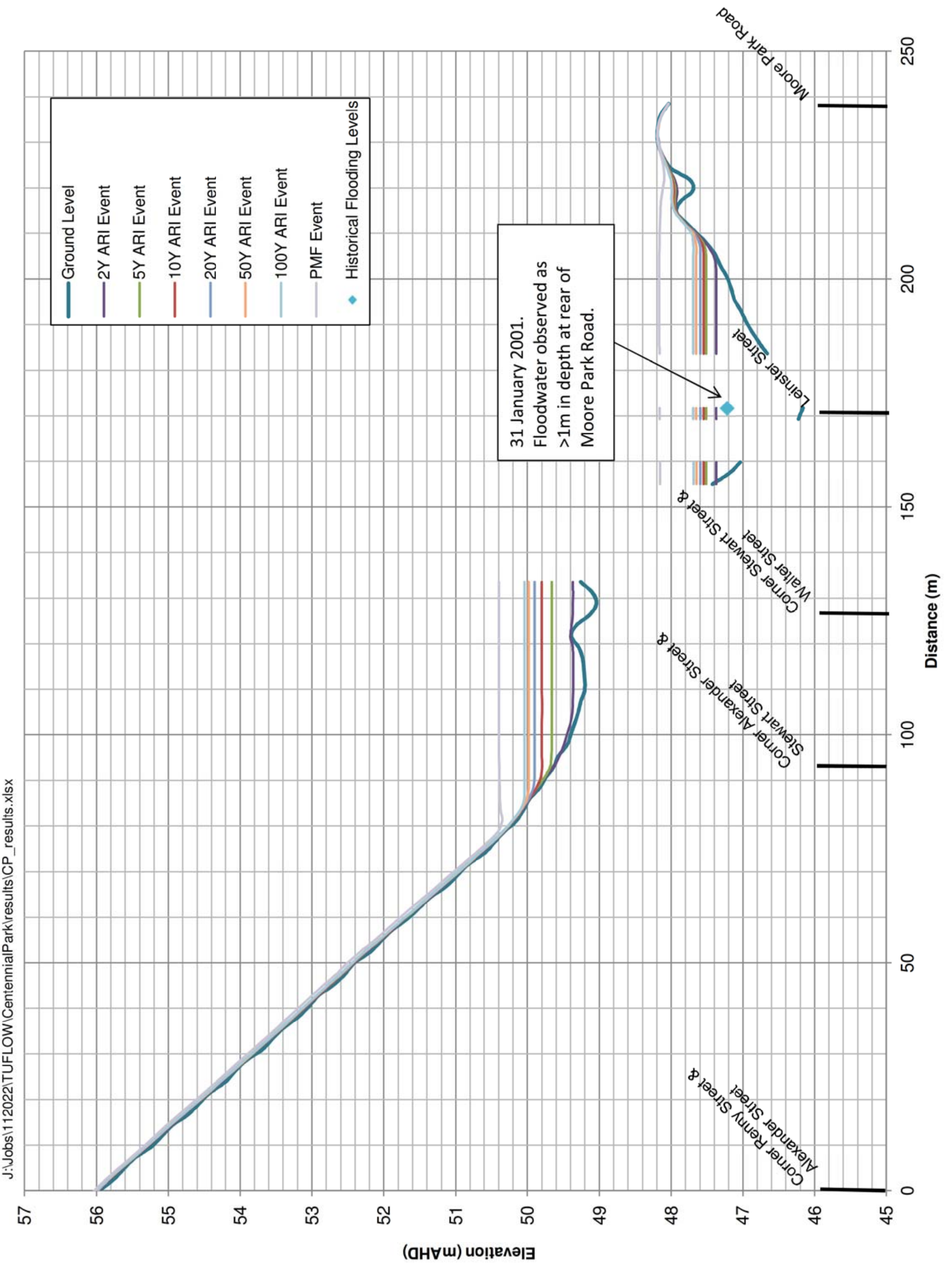

FIGURE 13
**DESIGN FLOOD PROFILES**
**DRIVER AVENUE**
**MOORE PARK ROAD TO JOHN HARGREAVES AVENUE**