alluvium

Sydney Olympic Park Site 68 Development - Ecove

Stormwater and Flooding Assessment including Integrated Water Management Plan

November 2014

Document history

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Contents

1 Introduction

Ecove is proposing to develop Site 68 at Sydney Olympic Park (SOP), including a residential tower, basement parking, ground floor retail tenancies, landscaping and public domain works. The site is located at the southern end of the Sydney Olympic Park 'Parkview Precinct' as shown in Figure 1, bounded by Bennelong Parkway, the railway line and a new road ('Road 3') yet to be constructed.

This stormwater and flooding assessment has been prepared to accompany the Site 68 development application (DA). The strategy has been developed in conjunction with the architects, landscape designers and engineers.

The 'Southern Water Quality Control Pond' (SWQCP), located on Site 68, was installed to reduce peak flows to the downstream environment and improve the quality of stormwater discharged. An objective of the Site 68 redevelopment is to ensure that SOPA's stormwater objectives are achieved with the removal of the existing SWQCP and replacement by appropriate stormwater management systems.

Figure 1: Site 68 location (SOPA 2010, p.159)

This report identifies the stormwater management targets, outlines the proposed stormwater treatment measures, and describes modeling undertaken to show that the proposed scheme will meet the targets.

1.1 Water management requirements

The water management requirements for Site 68 are outlined in the following sections.

1.1.1 Secretary's Environmental Assessment Requirements

The Secretary's Environmental Assessment Requirements (SEAR's – Ref SSD 6603) include the following selected requirements relating to stormwater and flooding:

Key Issues

1. Statutory and Strategic Context

- *State Environmental Planning Policy (Building Sustainability Index: BASIX) 2004*
- *Sydney Regional Environmental Plan (Sydney Harbour Catchment) 2005*

2. Policies

- *Sydney Olympic Park Environmental Guidelines* [outlined in Section 1.1.4]
- *Sydney Olympic Park Stormwater and Water Sensitive Urban Design Policy* [outlined in Section 1.1.2]

8. Ecologically Sustainable Development (ESD)

- *Include a description of the measures that would be implemented to minimised consumption of resources, water and energy, including an Integrated Water Management Plan which details any proposed alternative water supplies, proposed end uses of potable and non-potable water; and water sensitive urban design.*

15. Sediment, Erosion and Dust Controls

- *Identify measures and procedure to minimise and manage the generation and off-site transmission of sediment, dust and fine particles*

16. Water Quality and Flooding

- *Identify if the proposal involves any discharges to waters or dewatering requirements from the construction site and any associated impacts, including an assessment of any water discharges against relevant guidelines and licensing requirements under the Water Act 1912 and Protection of the Environment Operations Act 1997.*
- *Identify the source, volume and quality of any construction water (…), the discharge procedures and the receiving water body, the treatment of any construction water and any impacts on water quality of the receiving body.*
- *An assessment of any flood risk on site and consideration of any relevant provisions of the NSW Floodplain Development Manual (2005), including the potential effects of climate change, sea level rise and an increase in rainfall intensity.*

17. Drainage

- *Detail drainage associated with the proposal, including stormwater and drainage infrastructure*

Plans and Documents

- *Stormwater Concept Plan*

1.1.2 SOPA Stormwater Management and WSUD Policy (2013)

The *SOPA Stormwater Management and WSUD Policy* (2013) has been considered in the development of the water management strategy for Site 68. The WSUD Policy includes the following requirements:

1. Maximise harvesting and reuse of roof-water
2. Minimise volume and frequency of stormwater discharge from hardstand areas such as paving, driveways and car parks, and maximise quality of any stormwater discharged
3. Water conservation
4. Riparian protection (Development within 40 metres of a creek, river, lake or estuary)
5. Information to be submitted with a development application
6. Development that does not meet policy requirements
7. Public domain infrastructure and hard paving (including roads, footpaths and carparks)
8. Modelling tool inputs
9. Construction management
10. Asset maintenance

The specified water quality requirements are as follows:

- *All development must as a minimum meet the following baseline water quality targets:*
    - *45% reduction in the mean annual load of Total Nitrogen*
    - *65% reduction in the mean annual load of Total Phosphorus*
    - *85% reduction in the mean annual load of Total Suspended Solids*
    - *90% reduction in the mean annual load of hydrocarbons*
    - *95% reduction in the mean annual load of gross pollutants*
- *Development within a Sydney Olympic Park non-stormwater harvesting catchment (shaded in orange in Map 1) must strive to the maximum extent practicable, to meet the following water quality targets:*
    - *65% reduction in the mean annual load of Total Nitrogen*
    - *85% reduction in the mean annual load of Total Phosphorus*
    - *90% reduction in the mean annual load of Total Suspended Solids*
    - *90% reduction in the mean annual load of hydrocarbons*
    - *95% reduction in the mean annual load of gross pollutants*

The specified water quantity requirements are as follows:

- *Development within a Sydney Olympic Park non-stormwater harvesting catchment (shaded in orange in Map 1) must maintain a 1:5 year ARI (average recurrence interval) peak discharge to pre-development (non-urbanised) magnitude*

1.1.3 Sydney Olympic Park Master Plan 2030

In addition to the above the requirements the principles outlined in the *Sydney Olympic Park Master Plan 2030* (SOPA 2010) have been taken into consideration in the site stormwater management strategy.

The key principles within the *Sydney Olympic Park Master Plan 2030* (SOPA 2010) relating to stormwater includes:

- *protecting and enhancing biological diversity*
- *using construction methods and operational management processes with the least possible environmental impact*

- *connection to recycled water and effective water demand management practices*

- *maintaining and extending the existing stormwater system that recycles water, promotes infiltration to sub soil, filters pollutants and sediments, and minimises loads on adjoining waterways*

- *ensuring that development has no impact on existing habitats in adjacent parklands*

The *Sydney Olympic Park Master Plan 2030* also includes the following controls:

- *Connect all new development to Sydney Olympic Park's recycled water system for all approved uses of recycled water, including:*
    - *toilet and urinal flushing*
    - *irrigation of the parklands and gardens*
    - *fountains and water features*
    - *playing fields*
    - *fire fighting*
    - *construction*
    - *wash down and dust suppression*
    - *clothes washing (supply to washing machine only)*
    - *commercial air conditioning water cooling towers.*

- *Consideration of rising sea levels as a result of climate change, using the best current estimate scenario of the International Panel on Climate Change (IPCC) is required for all future development and project applications.*

- ***Stormwater Management for Open Space***
  To minimise the impact of stormwater from communal open space on the health and amenity of nearby waterways:
    - *Retain stormwater on site by:*
        - *collecting and storing water from roofs and hard surfaces*
        - *maximising porous surfaces and deep soil*
        - *draining paved surfaces to adjacent vegetation.*

    - *Protect stormwater quality by providing for:*
        - *sediment filters, traps or basins for hard surfaces*
        - *treatment of stormwater collected in sediment traps on soils containing dispersive clays.*

1.1.4 Sydney Olympic Park Environmental Guidelines (2008)

The Environmental Guidelines (SOPA 2008) have been taken into consideration in the site stormwater management. The key sustainability issues and objectives within the Environmental Guidelines relating to stormwater include:

- Water conservation:

a) Minimising overall public domain water use at Sydney Olympic Park (potable and non-potable water) using best practice environmental design principles, innovative technology, water sensitive urban design, water efficient landscaping and other demand management practices;

b) Requiring all new developments to maximise opportunities for building and infrastructure design to incorporate water collection and recycling systems;

c) Avoiding adverse impacts on water quality or quantity in local streams, wetlands and groundwater from operations, developments, and major event activities at Sydney Olympic Park; and *d) Working with lead agencies in the promotion of sustainable water resource management practices through integration of water infrastructure, sharing knowledge and experience, and supporting education and research programs.*

The above issues are addressed in the proposed stormwater management strategy.

Figure 2: Site 68 oblique image (SOPA - RFDP)

2 Existing Conditions

2.1 Stormwater infrastructure

Site 68 currently holds the Southern Water Quality Control Pond (SWQCP), which was constructed in 1997/98. An aerial image of Site 68 is shown in Figure 3. The site is dominated by the large embankment alongside Bennelong Parkway that was formed to create the basin. The top of the embankment varies in elevation from RL 8.4m AHD at the north eastern corner of the site to 13m AHD at the southern side of the site. Stormwater generated on the inside batter of the SWQCP (to the west of the existing footpath) currently runs off directly into the SWQCP whilst stormwater on the outside of the existing footpath runs off to Australia Ave and Bennelong Parkway.

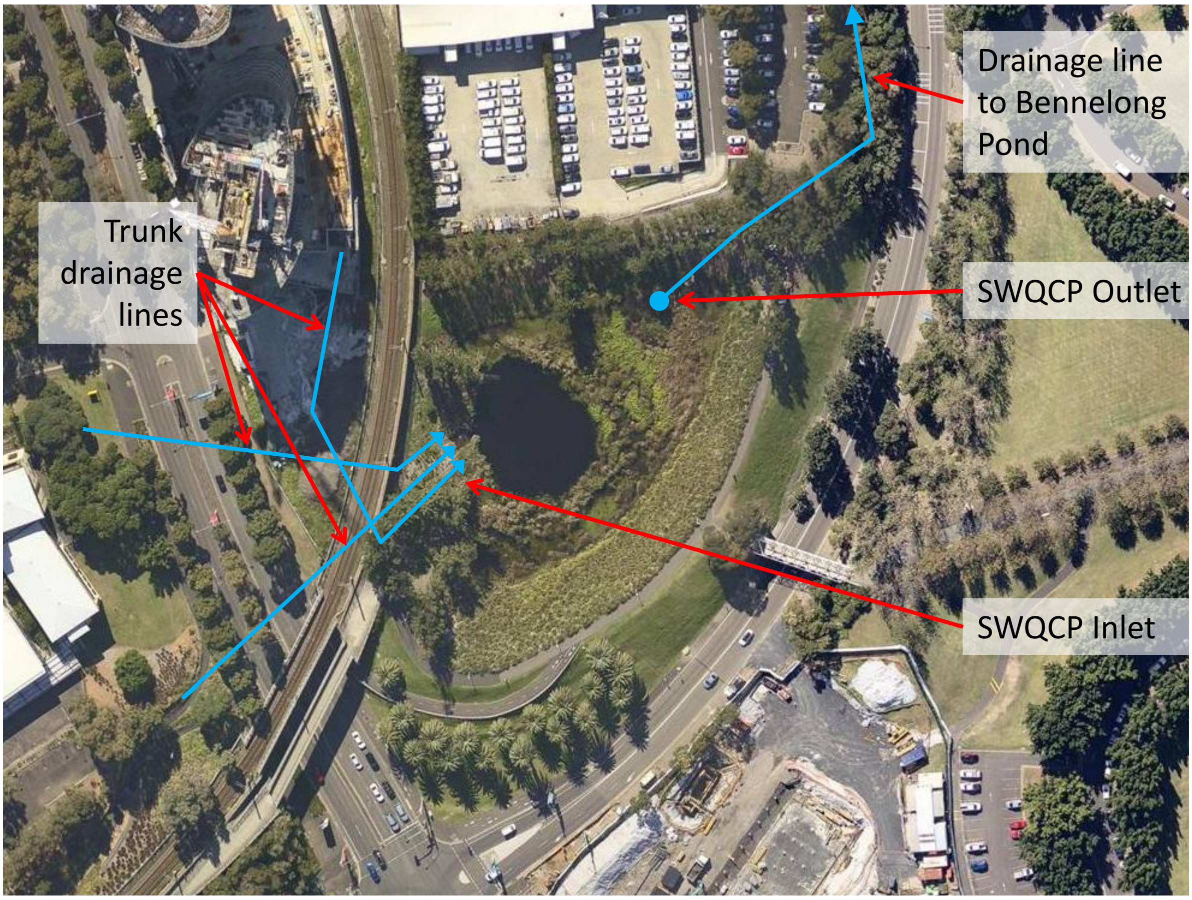

Figure 3: Site 68 aerial image (NearMap, 2014) with indicative existing stormwater infrastructure

There are 3 trunk drainage lines that discharge into the SWQCP at the inlet, shown in Figure 5. The catchment area draining to these trunk drainage lines is 20.45 hectares, as shown in Figure 4. The subcatchments used in the modelling were determined by assessment of drainage and contour plans (GIS data as well as work-as-executed civil and building hydraulics drawings) provided by SOPA. The trunk drainage lines include gross pollutant traps, screening stormwater before it discharges into the SWQCP.

The work as executed drawings for the SWQCP indicate that there is a deep pool near the inlet structure and large bench with shallow water depth on the north eastern side of the water body.

The SWQCP outlet control pit (shown in Figure 5) is a circular pit of 2.5m diameter and with a 600mm diameter outlet pipe. The pit also includes two lower level 50mm diameter weep holes to provide some extended detention. The 600mm diameter outlet pipe drains to the major junction pit (shown in Figure 6) on the western side of Bennelong Parkway 200m north of Site 68 that is connected to Bennelong Pond via three 1.5m x 0.75m culverts (stormwater 'crossing 1').

The Bennelong Pond ‘forebay’ at the southern end of Bennelong Pond is the receiving waters for flows from the SWQCP. Three years of water quality monitoring (Cardno, 2011, p.34) has indicated that the SWQCP is currently leaching nutrients to the downstream receiving waters. In addition to the outflows from the SWQCP the flows discharging to the Bennelong Pond ‘forebay’ also include stormwater flows from the Parkview Precinct, Bennelong Parkway and Bicentennial Park.

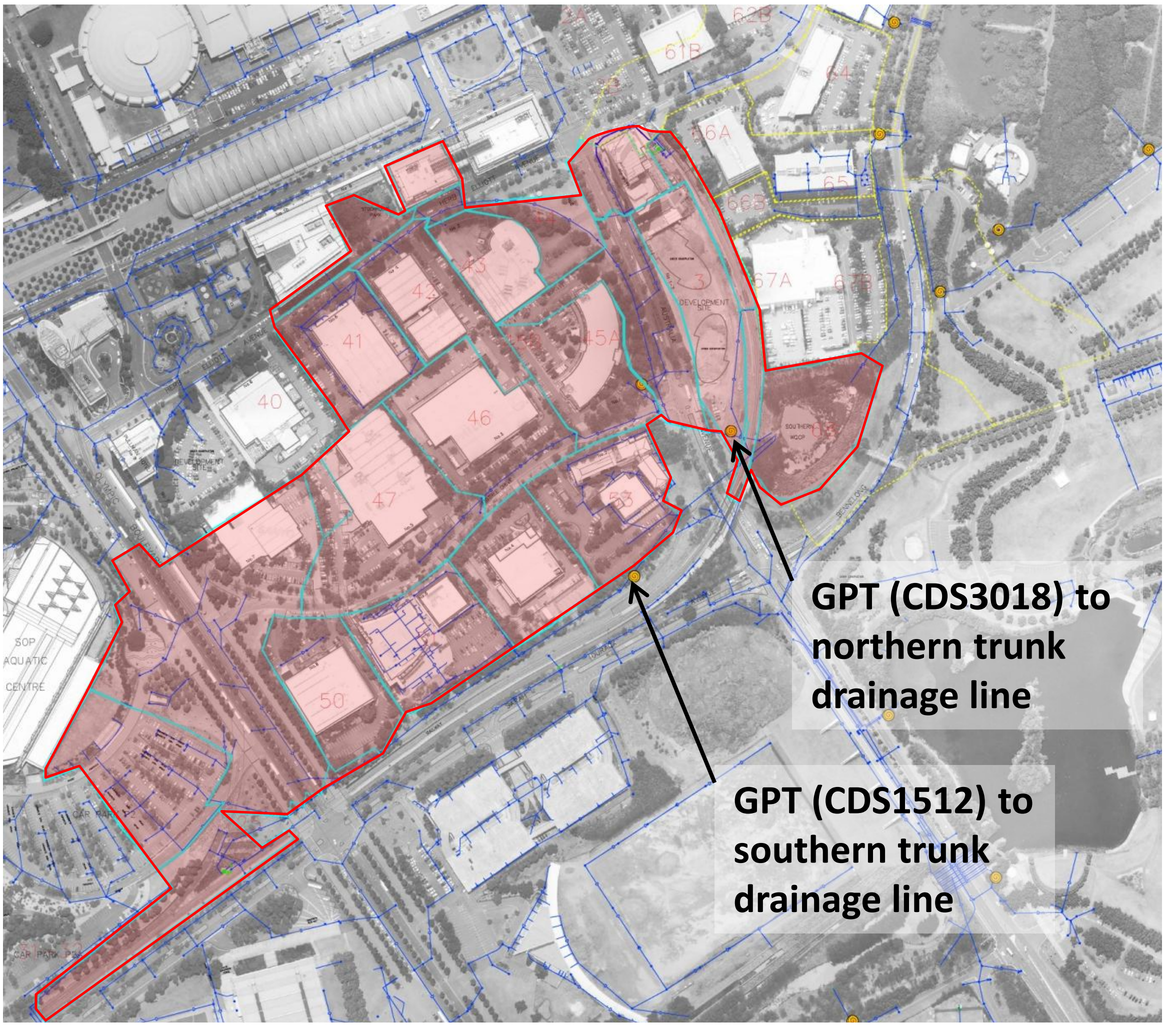

Figure 4: SWQCP catchment extents (GIS data from SOPA; subcatchment delineation by Alluvium)

Figure 5: SWQCP inlet (L) and outlet (R) (Cardno 2012)

Figure 6: SWQCP downstream discharge point – junction pit at 'Crossing 1' culverts to Bennelong Pond 'forebay'

2.2 Receiving environment

Bennelong Pond, the receiving waters for flows from Site 68 …

> *"is part of the Badu Mangroves estuarine wetland system, which is listed on the Commonwealth's Directory of Wetlands of National Importance because of its high ecological values. The pond is the most ecologically diverse of all of the Park's wetlands. It provides habitat for two threatened species (Green and Golden Bell Frog and Zannichellia palustris), It contains mature mangrove forest (classified as protected marine vegetation), provides important habitat for fauna including waterbirds and fish."*

(Cardno, 2012, p.15).

SOPA's fauna records show that from 2000 to 2014 the Bennelong Pond monitoring quadrat has featured 12 sightings of Latham's snipe and 2 sightings of the green & golden bell frog; however it is not known how recently these sightings took place.

Bennelong Pond receives inflows of stormwater from a number of outlets. In addition to the flows from the Site 68 upstream ('Central Precinct') catchment, Bennelong Pond receives stormwater inflows from the 'Parkview Precinct' to the north of Site 68 as well as from Bicentennial Park. The 'forebay' zone of Bennelong Pond at the southern end of the pond near the 'Crossing 1' outlets is considered highly disturbed and the *Zannichellia palustris* is concentrated at the northern end of Bennelong Pond.

As shown in Figure 7, Bennelong Pond is included within a 'Wetlands Protection Area' under the *Sydney Regional Environmental Plan (Sydney Harbour Catchment) 2005*. Given that drainage from Site 68 discharges to a 'Wetlands Protection Area, the development should "not adversely affect the wetland or wetlands protection area" (http://www.austlii.edu.au/au/legis/nsw/consol_reg/srephc2005587/s62.html).

Given that the receiving water is a sensitive environment Site 68 has been designed to ensure that the development will enhance where possible the stormwater runoff and as a minimum have no adverse downstream impacts.

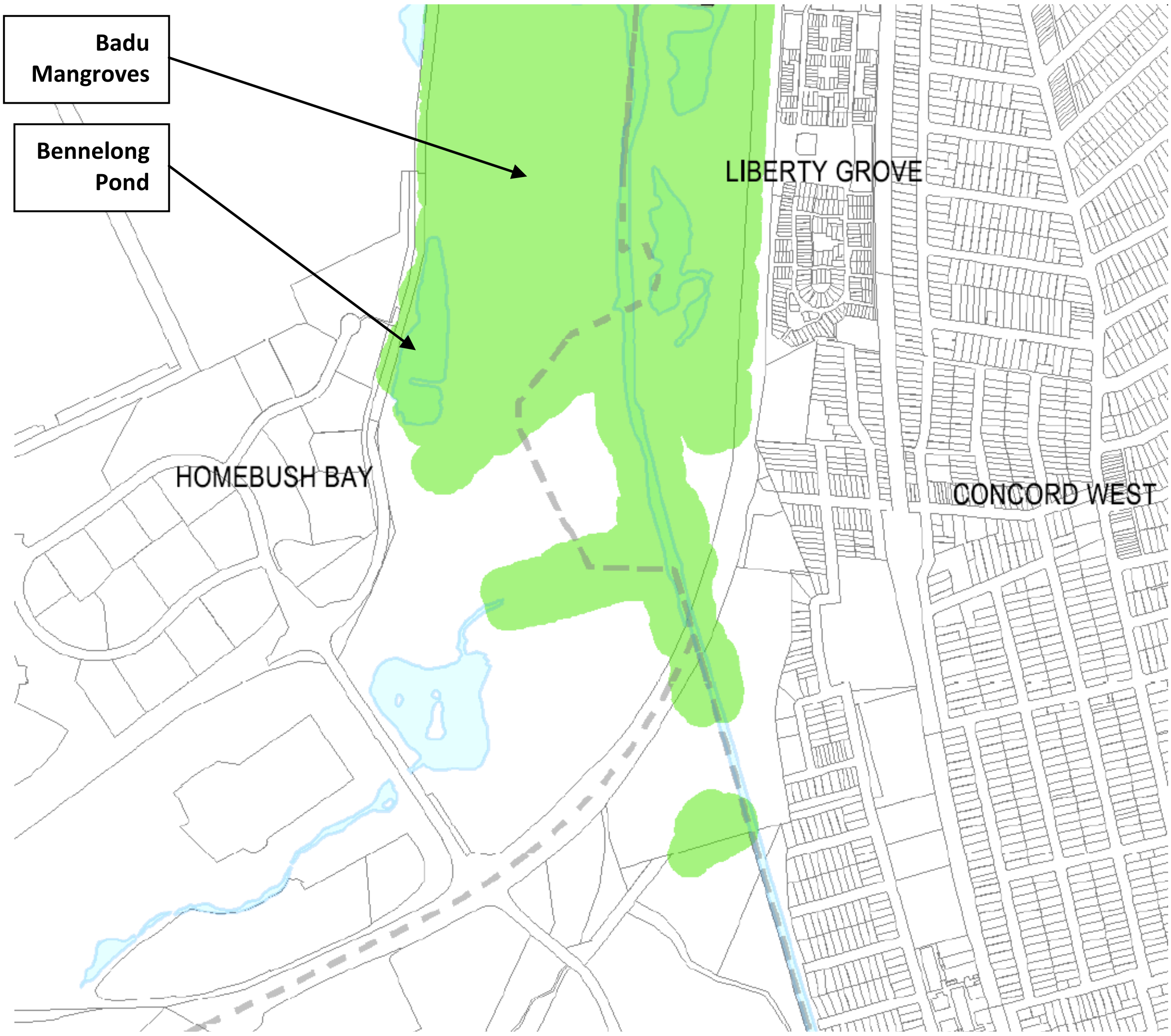

Figure 7: Snapshot from 'Sydney Regional Environmental Plan (Sydney Harbour Catchment) 2005 Wetlands Protection Area Map' – Sheet 3.

3 Proposed integrated water management plan

The proposed integrated water management plan for Site 68 stormwater is shown in schematic form in Figure 8.

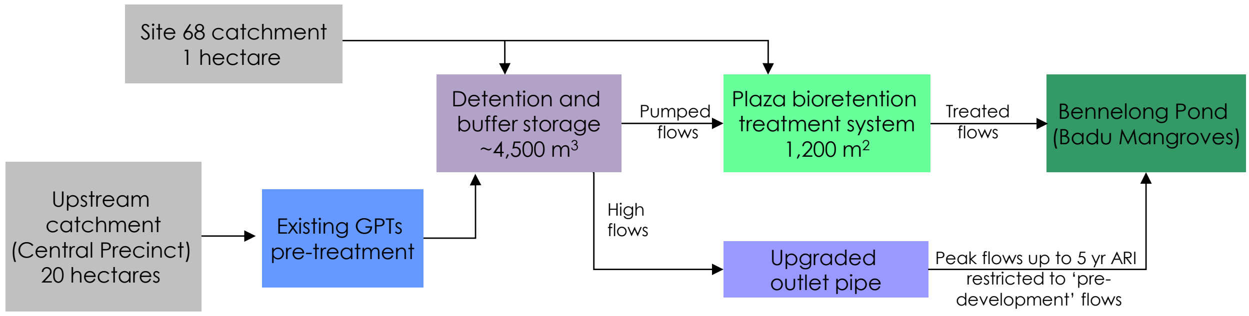

Figure 8: Schematic of integrated water management plan

The water management measures proposed as part of the Site 68 development are summarised in Table 1. These measures are able to meet the targets required for the project as detailed in the referenced sections.

Table 1: Site 68 Proposed Integrated Water Management Plan

Component	Description	Report Reference
Existing Gross Pollutant Traps (GPT's)	The existing GPT in the Site 3 Pocket Park (a Rocla CDS 3018) is to be retained in its current location to treat flows that are conveyed to Site 68 in the northern trunk drainage line. The GPT located adjacent to Site 53 on the southern trunk drainage line will also be maintained.	Refer Site 3 Pocket park drawings (separate DA).
Buffer Storage	A sediment basin and buffer storage is to be provided within the combined storage tank. The buffer storage will be used to detain and capture incoming stormwater, capture any gross pollutants and coarse sediment and provide temporary storage for stormflow pumps.	Refer Section 4.3.
Stormflow Pumps	Stormflow pumps will be located within the buffer storage to pump stormwater to the surface of the plaza for treatment in the bioretention systems.	Refer Section 4.3.
Detention Storage	Detention storage is to be provided in the combined storage tank. The detention storage is used to provide a temporary storage of stormwater in large storm events. The detention storage is required to ensure the total peak flows from the catchment do not exceed the natural pre-development flows downstream of the site.	Refer Section 5 for detention modelling.

Component	Description	Report Reference
Plaza Treatment System	A series of bioretention systems are proposed to be installed within the new plaza open space area and in the embankment adjacent to the water feature. Stormwater will be pumped from the buffer storage within the tank up to the bioretention treatment systems via a rising main. The bioretention systems will be integrated into the plaza forecourt to create a unique and interesting design of the plaza which provides both a well designed plaza space and park for passive recreation, but also a functioning treatment system which also provides education about water management at SOPA.	Refer Section 4.2 for water quality modelling. Refer Section 4.4 for details on bioretention treatment and concept plans in Appendix A.
Water Reuse and Conservation	A connection will be made to the SOPA WRAMS (Water Reclamation and Management Scheme). It is proposed to install additional reticulation to Site 68 for a 'third pipe' supplying non potable uses such as toilet flushing, irrigation and clothes washing (supply to washing machine only). This will preserve precious drinking water supplies and contribute to the developments requirements to meet a minimum 40% water conservation target under BASIX, combined with water efficient fixtures and/or appliances.	Refer separate ESD/BASIX report and documentation by building services engineer.
Rainwater harvesting	Rainwater from the tower roof will be harvested in a tank within the basement for reuse by irrigation. Overflows from the rainwater tank will overflow into the detention tank.	Refer separate ESD/BASIX report and documentation by building services engineer.
Overflow and system outlet	All stormwater will be discharged via an outlet drainage line to the existing culvert outlet to Bennelong Pond (then ultimately to the Badu Mangroves). The existing 600mm/750mm diameter overflow drainage line from the site will need to be augmented to cater for the increased peak flow from the detention tank.	Refer Section 5.4.

The majority of the Site 68 plaza area will drain to the detention tank, from where it will be pumped to the bioretention treatment sytems, whilst a smaller portion of the site stormwater will run off directly to the terraced bioretention systems and downstream drainage line. A preliminary site landscape plan for Site 68 is shown in Figure 9 and stormwater concept plans are provided in Appendix A.

The proposed stormwater drainage will comply with the relevant standards and design guidelines.

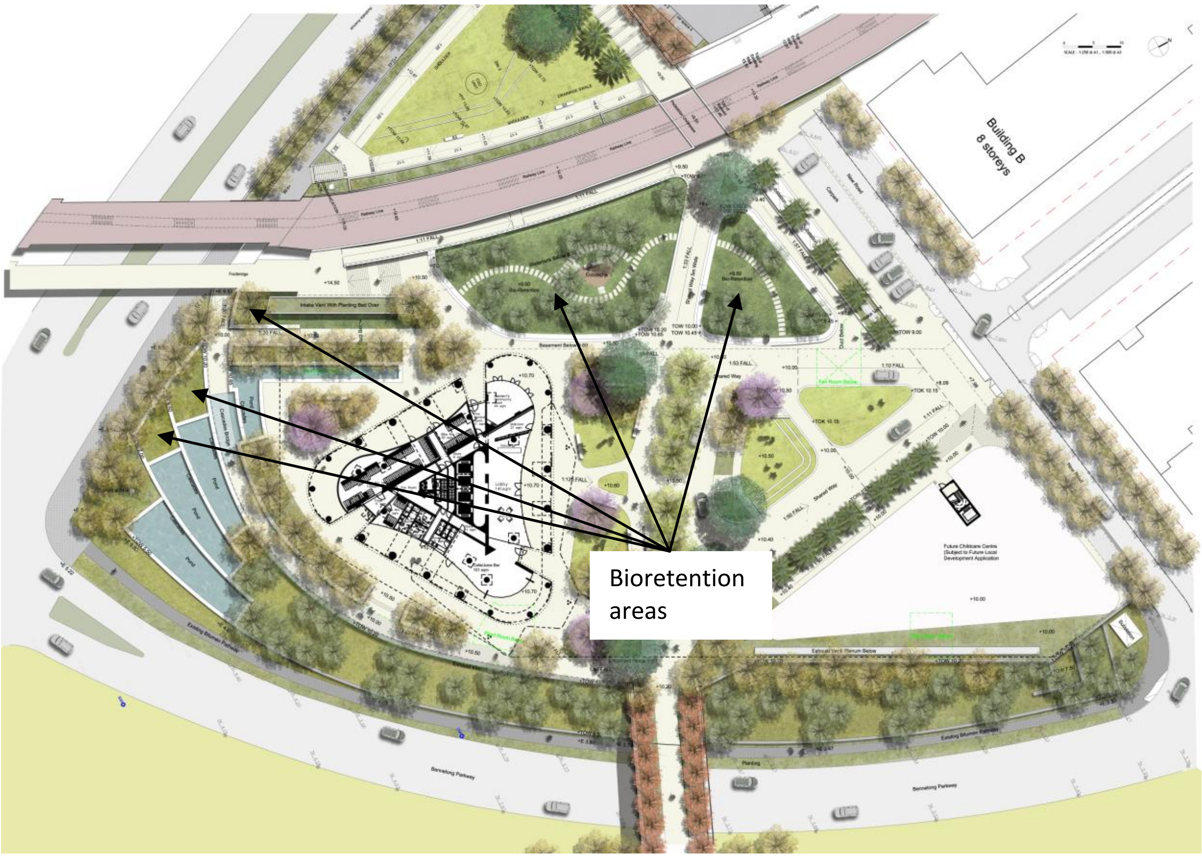

Figure 9: Site 68 landscape plan showing location of bioretention systems

4 Water Quality

4.1 Water Quality Requirements

The *SOPA Stormwater and WSUD Policy* states that "all development must as a minimum meet the following baseline water quality targets" (referred to as 'best practice targets'):

- Total Nitrogen - 45% reduction
- Total Phosphorus - 65% reduction
- Total Suspended Solids - 85% reduction
- Hydrocarbons – 90% reduction
- Gross pollutants – 95% reduction

The WSUD Policy also states that development within non-stormwater harvesting [WRAMS] catchments "must strive to the maximum extent practicable" to meet the following water quality targets (referred to as 'stretch targets'):

- Total Nitrogen - 65% reduction
- Total Phosphorus - 85% reduction
- Total Suspended Solids - 90% reduction
- Hydrocarbons – 90% reduction
- Gross pollutants – 95% reduction

4.2 Water Quality Strategy Treatment Strategy

The treatment strategy for Site 68 is shown in Figure 8. It includes the following treatment train to treat all flows from the upstream catchment as well as internal runoff generated within Site 68:

1. GPT's, to remove litter and large organic debris.
   The strategy utilises the existing gross pollutant traps which have been installed upstream of Site 68 within the Site 3 'Pocket Park', and adjacent to site 53.
2. Sediment basin, to remove coarse sediment.
   The sediment basin will be integrated within the tank.
3. Pumps within the tank, to direct stormwater to the upper plaza level via a rising main.
4. Bioretention treatment systems, to remove fine suspended solids and dissolved nutrients.
   The bioretention systems will be located across the plaza area and in the embankment adjacent to the water feature.

Flows from Site 68 and its upstream catchment discharge to Bennelong Pond, therefore the target for the catchment is that it should as a minimum meet the 85%/65%/45% reduction for TSS/TP/TN and strive to meet the 'stretch targets' for stormwater quality of 90%/85%/65% outlined above in Section 4.1. Normally these targets would only apply to the development footprint. However as Site 68 contains an existing stormwater treatment system on the site, Site 68 strives to achieve this for the whole upstream catchment.

All new developments within Site 68's upstream catchment will be required to install stormwater treatment systems to meet the water quality targets for their own site, and their own site only.

The approach for this project is that the treatment systems on Site 68 are sized to ensure that the upstream catchment will be treated to meet the 'stretch targets' when all the catchment upstream has been re-developed. In the interim this achieves a performance standard better than the minimum stormwater policy required by SOPA. Hence the proposed treatment systems within site 68 are also sized to exceed the 'best practice targets' <u>*for the whole catchment*</u>.

The above treatment train was modelled to determine the volume of the sediment basin, maximum pump diversion rate and area of bioretention required to achieve the nominated pollution reduction targets.

This also exceeds the requirement to ensure that there is no downstream impact on water quality. In contrast there is a significant improvement in water quality discharging to the receiving waters downstream.

4.2.1 Water Quality Modelling

Water quality modelling of the scheme has been carried out using MUSIC (Model for Urban Stormwater Improvement Conceptualisation) software (version 6), to determine if the water quality targets will be achieved. The modeling parameters and results are described below.

For modelling of stormwater quality, 6 minute pluviograph data from Sydney Observatory (BOM station 66037) was used. The period from 1975 to 1980 was adopted for the modelling as it constitutes an appropriate period of continuous 6 minute data, with an average annual rainfall of 1133 mm. This modelled rainfall matches the average annual rainfall for the nearby Concord Golf Club (BOM station 66013) which has a long term average annual rainfall of 1135.5mm. The rainfall / runoff parameters and pollutant concentration parameters were taken from the *NSW MUSIC Modelling Guidelines* (Sydney CMA, 2010). The bioretention systems, GPT's and sediment basin were modelled with the parameters as shown in Table 2.

Table 2: Properties for MUSIC Treatment Nodes

Parameter	Adopted values
GPT (Generic) Treatment Node	
Concentration based capture efficiency	Yes
TSS input/output value	75/75; 100/306
TP input/output value	0.5/0.5; 5.0/3.3
TN input/output value	50/50 (no reduction)
Gross pollutants input/output value	0.5/0
Sediment Basin (tank) Treatment Node	
Surface area	1800 sqm
Extended detention depth	1.7 m
Permanent pool volume	400 cum
Equivalent pipe diameter	460 mm
Overflow weir width	1.6 m
Bioretention Treatment Node	
Extended detention depth	300 mm
Saturated Hydraulic conductivity	300 mm/hr
Filter Depth	0.6 m
TN Content of the filter media	600 mg/kg
Orthophosphate Content of the filter media	30 mg/kg
Exfiltration	0 mm/hr
Vegetated with Effective Nutrient Removal plants	Yes

The MUSIC modelling was undertaken for Site 68 by trialling different pump rates and bioretention treatment areas, utilising the summed upstream subcatchments based on the drainage plan. A snapshot of the MUSIC model is shown in Figure 10. Note that baseflows from the pervious portion of the catchment were conservatively excluded from the treatment systems. For the ultimate scenario it was assumed that stormwater from each development sites is treated within each site and that public domain areas outside development sites are only treated by the existing GPT's.

A pump rate of approximately 500L/s was determined as the optimal diversion rate following the testing of a number of different pump rates and identification of the rate required to direct a sufficient proportion of total catchment runoff to the bioretention treatment systems.

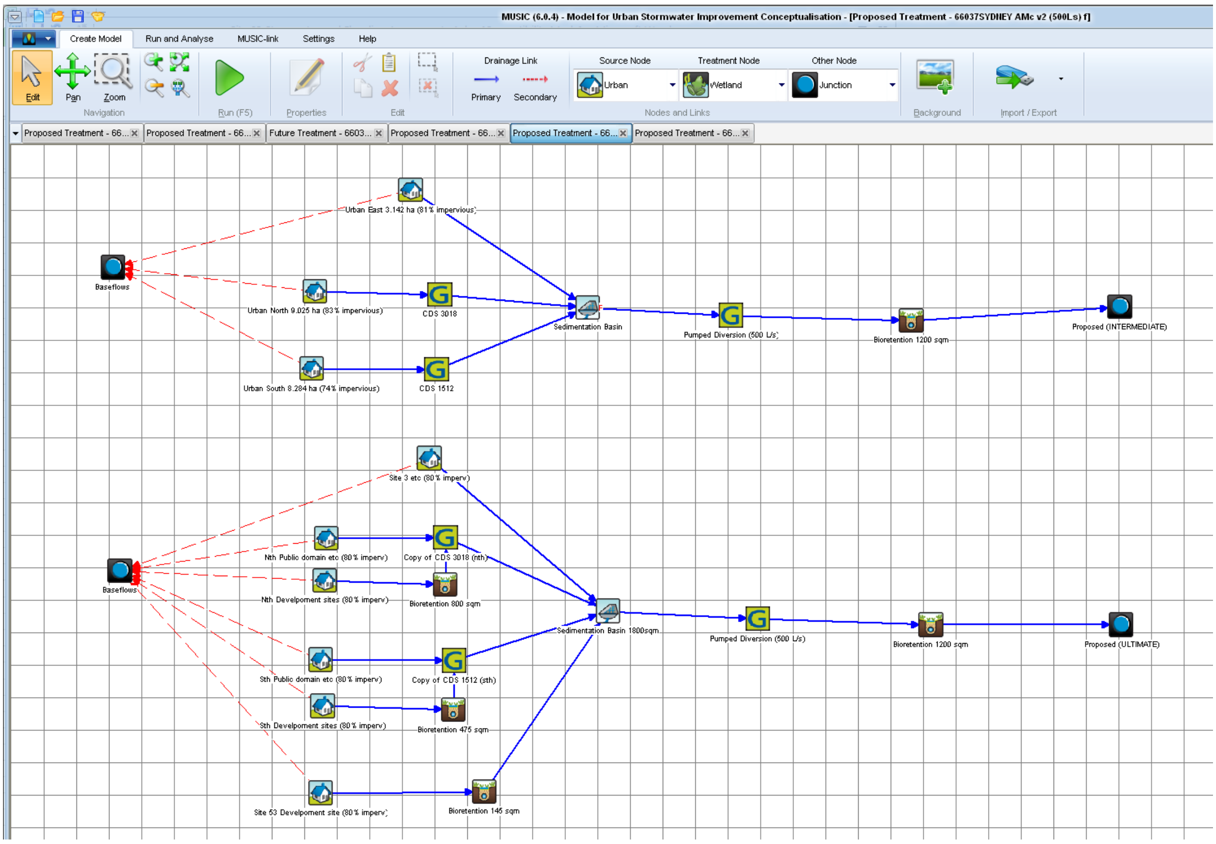

Figure 10: Screenshot of MUSIC model ('intermediate' at top, 'ultimate' at bottom)

4.2.2 Water Quality Modelling Results

The results of the water quality modelling are shown in Table 3. The values shown are the summed values for the entire treatment train including GPTs, sediment basin and bioretention systems. All water quality results are for pollutant loads from the upstream catchment and Site 68 only (not including the Parkview Precinct). Note that the SWQCP was modelled as a functional wetland, though there is anecdotal evidence that the orifice is prone to blockage reducing the SWQCP's effectiveness.

Table 3: Stormwater quality modelling results

	Existing Scenario		Site 68 Proposal (Intermediate scenario, after Site 68 developed)		Site 68 Proposal (Ultimate scenario, after all sites in catchment are developed)	
Parameter	**Pollutant load discharged to Bennelong Pond from SWQCP (kg/yr)**	**Percentage of Pollutant Load Removed**	**Pollutant load discharged to Bennelong Pond from Site 68 (kg/yr)**	**Percentage of Pollutant Load removed**	**Pollutant load discharged to Bennelong Pond from Site 68 (kg/yr)**	**Percentage of Pollutant Load removed**
TSS	13680	62%	5010	86%	3220	**91%**

	Existing Scenario		Site 68 Proposal (Intermediate scenario, after Site 68 developed)		Site 68 Proposal (Ultimate scenario, after all sites in catchment are developed)	
TP	48	35%	18	75%	12	**85%**
TN	404	20%	218	58%	174	**65%**

After completion of the Site 68 stormwater treatment systems there will be a significant pollutant load improvement for the downstream receiving waters (Bennelong Pond) from the existing scenario. This pollutant load reduction achieved in the intermediate scenario significantly exceeds the baseline ('best practice') water quality targets outlined in the SOPA Stormwater and WSUD Policy. Furthermore the water quality modelling results show that the proposed treatment strategy will also meet the 'stretch' targets in combination with redevelopment of the upstream private lots within the catchment.

4.3 Sediment Basin and Pump Diversion

The sediment basin will be incorporated into the combined detention tank. A drawing of the tank including sediment basin and preliminary pump arrangement is provided in provided in Appendix A. The tank is generally not expected to collect litter as upstream stormwater flows are screened by GPT's prior to discharging into the tank.

The site is significantly constrained and due to the levels of the stormwater infrastructure pumping is required to deliver stormwater from the tank to the bioretention treatment systems within the plaza.

The maximum pump diversion rate of approximately 500L/s is based on determining the optimal pump rate required for pollutant reduction, determined by MUSIC modelling. A 500 L/s diversion rate was able to meet the stormwater quality targets. The pump system will include a number of pumps so that a staged increase in pump rate is achieved rather than single level cut-in and cut-out at the maximum pump rate. The pumped stormwater will be distributed across the separate bioretention systems proportionate to their treatment area.

The pumps will divert an average of approximately 148 ML of stormwater each year to the bioretention systems. High flows of around 26 ML per year will exceed the pump diversion flow rate and bypass the bioretention system. At the nominated diversion rate of 500L/s the pumps will run intermittently for a total of approximately 300 hours per year (around 3% of the time). The energy required for this pump use will be offset.

The tank will be designed to allow all maintenance activities to take place from the surface at the northern end of the tank (at the western end of the new road). The tank will grade towards the sediment sump which will be located at the northern end of the tank below the parking bays. An access cover will be located near the parking bays to allow cleanout of the sediment sump by eductor truck.

The proposed diversion pumps will be submersible sewage grade pumps installed on guiderails, with an auto-coupling fitting at the base of the tank. A removable lifting davit would be used to hoist the pumps to the surface for maintenance. The diversion pumps will enable the drawdown of the water level to a low level within the sediment sump zone, reducing the pump-out volume required during cleanout by eductor truck.

4.4 Plaza Bioretention

Bioretention is proposed to be constructed at Site 68 in a number of areas throughout the site including within the plaza area to the northwest of the tower and in the embankment adjacent to the cascading water feature. The proposed bioretention areas are shown in the site landscape plan (Figure 9) and stormwater concept plans in Appendix A.

Bioretention systems, also known as raingardens, are commonly constructed in Sydney to meet stormwater quality targets such as those identified by SOPA. They are suitable in hard urban areas, and can be implemented at a range of scales in almost any size and shape.

Bioretention systems are vegetated soil filters. Stormwater runoff is treated by draining vertically through a vegetated filter media (typically a sandy loam). Treated stormwater is then collected by a perforated underdrain and directed to the downstream stormwater drainage system. A schematic of a typical bioretention system is shown in Figure 11.

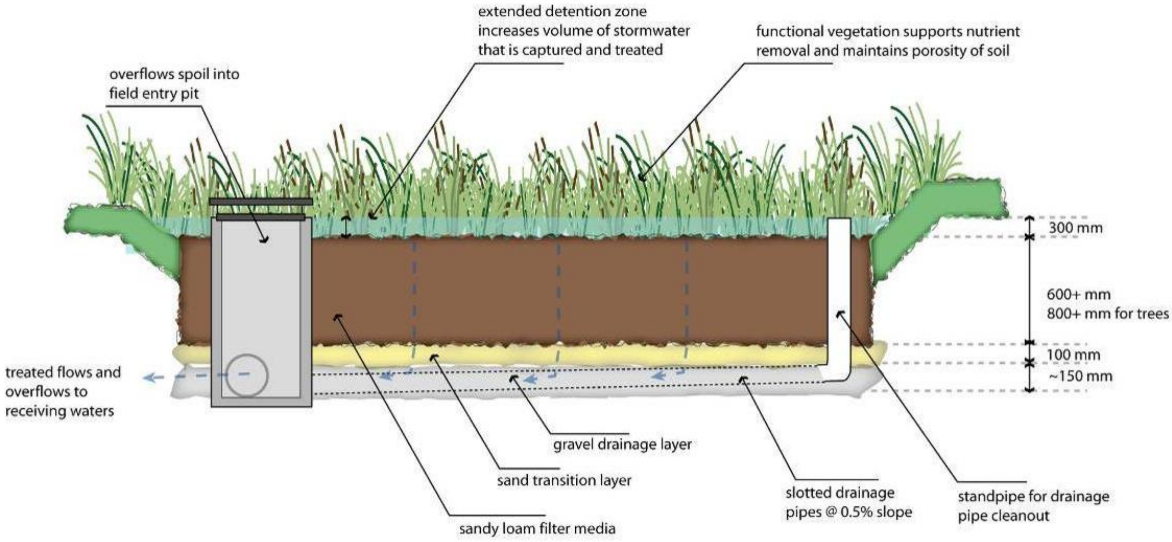

Figure 11: Schematic section through a typical bioretention system

Bioretention systems have a temporary ponding depth (extended detention) of between 100-300mm above the filter media surface to temporarily store stormwater thereby increasing the volume of runoff treated through the filter media.

Vegetation plays a key role in bioretention systems. The surface is densely planted with ground level grasses, sedges, and also some selected tree and shrub species. The agitation of the surface of the bioretention caused by movement of the vegetation and the growth and die off of root systems helps to prevent sediments from clogging the filtration media. Beneath the surface, vegetation provides a substrate for biofilm growth within the upper layer of the filter media. Vegetation facilitates the transport of oxygen to the soil and enhances soil microbial communities which enhance biological transformation of pollutants.

The bioretention systems will be designed to include vegetation species that are appropriate for the location of the treatment systems, particularly where systems are overshadowed. The bioretention systems will be passively irrigated by the stormwater and every rain event will provide significant irrigation volume to the vegetation. In addition to this the vegetation chosen will be drought tolerant species such as *Lomandra longifolia*.

An operation and maintenance plan for the bioretention systems will be developed during the detailed design stage.

5 Water Quantity

Investigations and modelling have been carried out to assess the detention storage volume requirements as well as the preliminary design of the downstream drainage line to connect to the 'Crossing 1' culverts junction pit that discharges into Bennelong Pond.

5.1 SOPA Requirements

The SOPA Stormwater Management & WSUD Policy (2013) specifies the following water quantity requirements:

- *Development within a Sydney Olympic Park non-stormwater harvesting catchment (shaded in orange in Map 1) must maintain a 1:5 year ARI (average recurrence interval) peak discharge to pre-development (non-urbanised) magnitude*

5.2 Proposed Water Quantity Strategy

A detention tank is proposed to be constructed as part of the Site 68 Early Works. The three trunk drainage lines that currently drain to the SWQCP will be directed into the new tank.

The tank will be provided with an outlet control structure that will restrict the outflows from the tank, in order to satisfy the above water quantity requirements. A new outlet drainage line will be constructed to convey flows from the tank to the Bennelong Pond culvert outlets junction pit.

5.3 Water Quantity Modelling

Water quantity modelling has been carried out, including the following:

- Investigations into the existing drainage system conveying stormwater to the Southern Water Quality Control Pond (SWQCP) and delineation of sub-catchments, based on GIS data and all relevant building hydraulic and civil work-as-executed drawings provided by SOPA.
- Setting up a sufficiently detailed DRAINS hydraulic model
- Modelling of the existing performance of the SWQCP and resulting peak flows to Bennelong Pond (including the downstream Parkview Precinct catchments)
- Modelling of the proposed detention tank and resulting peak flows to Bennelong Pond (including the downstream Parkview Precinct catchments)

5.3.1 Model

DRAINS is a computer modelling program similar to other popular hydrologic models used in Australia such as RORB, RAFTS and WBNM (Watershed Bounded Network Model). The DRAINS model simulates runoff routing processes, pit and pipe hydraulics and detention basin structures.

The DRAINS model used rainfall intensity, frequency and duration (IFD) data generated for Homebush Bay. The model was run for rainfall durations between 5 minutes to 72 hours for 1, 2, 5, 10, 20, 50, and 100 year average recurrence intervals (ARI).

The upstream catchment and downstream 'Parkview Precinct' catchments were estimated using drainage and topographical data provided by SOPA. Given there was insufficient information to undertake a complete hydraulic model including every individual pit and pipe within the upstream catchment the model included the primary trunk drainage lines and used the following assumptions:

- Where pipe invert level data was not available, invert levels were generated by interpolating between known invert levels upstream and downstream.
- Pits were conservatively modelled as having unlimited inlet capacity such that the sizes of the installed trunk drainage lines are the limiting factor in determining the peak flows that are directed into the SWQCP;
- There are two rail corridor catchments that are discharged to the SWQCP catchment via pump stations. These catchments were modelled as flowing directly to trunk drainage lines;

- The following Mannings n roughness values were adopted:
    - Existing impervious areas 0.015
    - Existing pervious areas 0.03
    - 'pre-development non-urbanised' pervious areas 0.05
- Any overland flows that bypassed the existing drainage system (regardless of which receiving water they would flow to) were combined with the outflows from the detention storage to provide the total peak catchment outflow, as per the requirement outlined in the RFDP.

For the existing scenario the bathymetry and outlet controls of the SWQCP were taken from the site survey to determine an accurate stage-storage-discharge relationship. For the proposed scenario the detention tank footprint was taken as $1800m^2$.

As the outlet drainage line was also modelled, the boundary condition adopted was a downstream water level (within Bennelong Pond) of 1.5m AHD, based on the surveyed elevated water level in the forebay zone and noting that the normal water level within Bennelong Pond is 1.2m AHD, set by an outlet weir at that level.

A concept schematic of the modelling approach as per the SOPA requirements is shown in Figure 12, and a screenshot of the DRAINS model layout is provided in Figure 13.

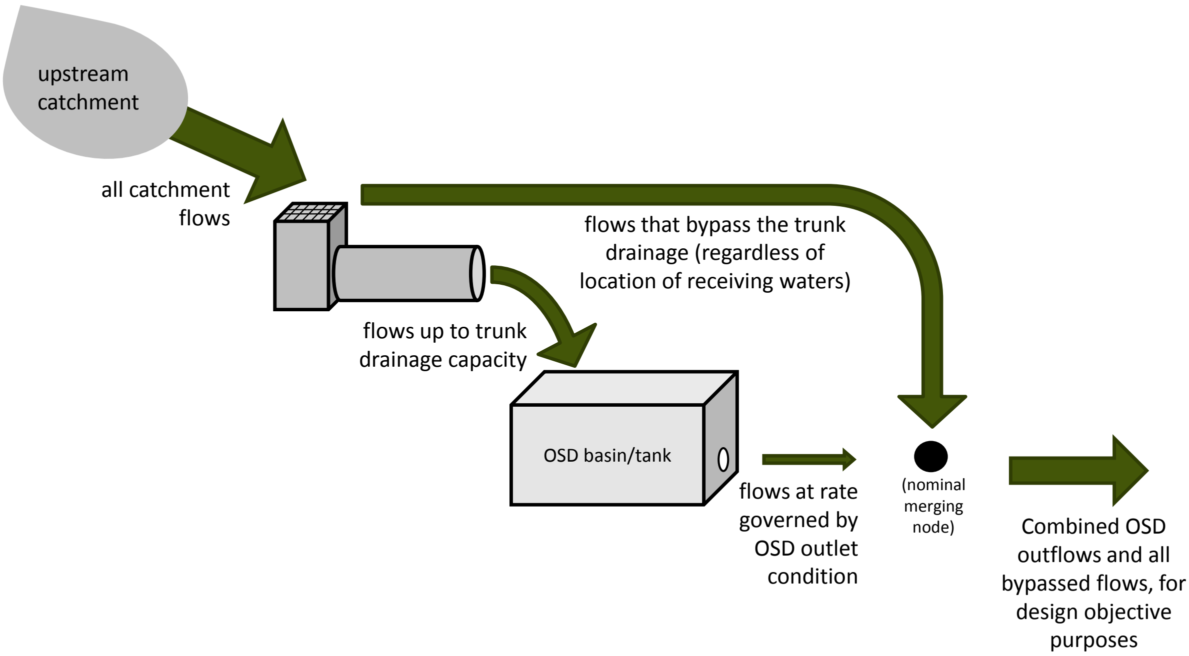

Figure 12: DRAINS modelling concept

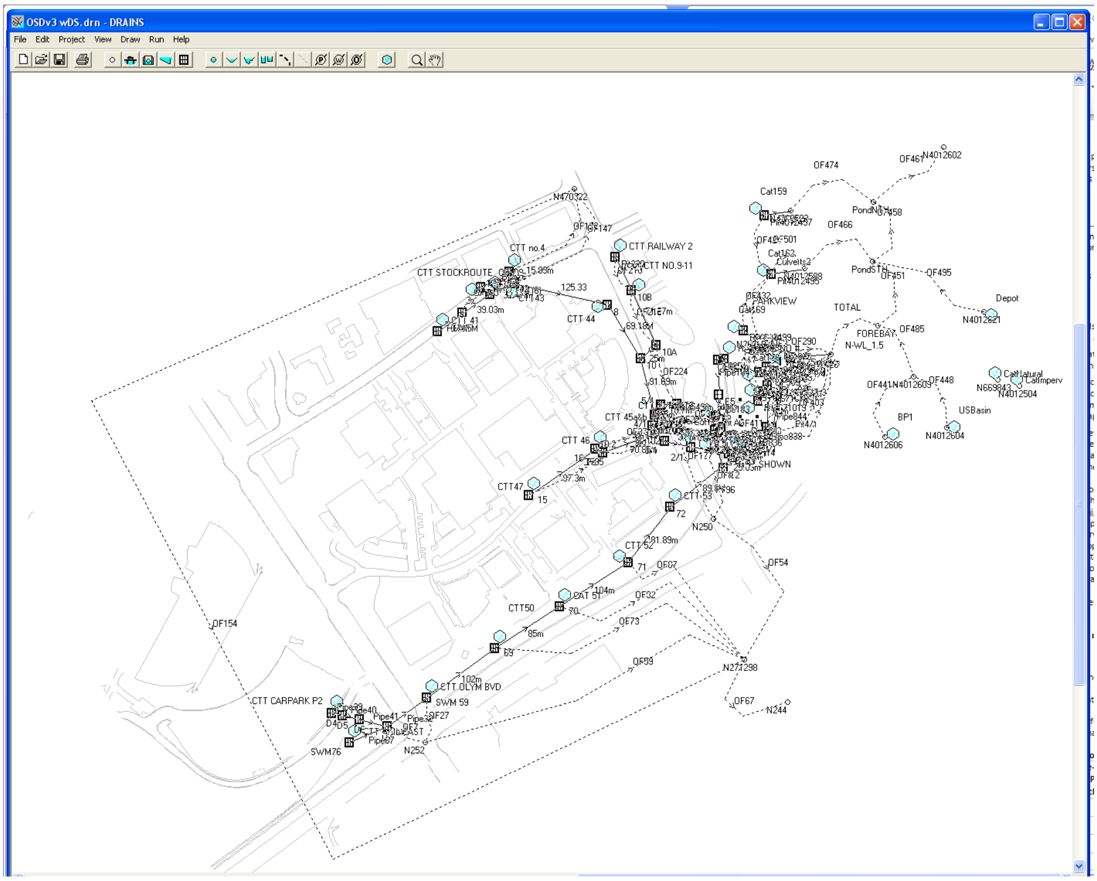

Figure 13: Screenshot of DRAINS model

5.3.2 Results – Detention

The detention tank and two stage outlet (including a low level orifice and high level weir outlet) was modelled to reduce the peak flows for all events from the 1 year ARI to 5 year ARI event to the 'pre development non-urbanised state' flow rate as required by the SOPA Stormwater and WSUD Policy.

The modelling determined that a detention tank with a volume of 4500m^3, an internal area of 1800m^2, and outlet invert level of RL 5.0m AHD was an optimal solution to meet the objectives. The model was run a number of times whilst increasing the low level orifice diameter until the 1 year ARI peak flow for the proposed scenario matched the 'pre-development non-urbanised state' scenario. Following this, the length of the high level outlet weir was tested iteratively ensuring that the peak flow for the proposed scenario would not exceed the 'pre-development non-urbanised state' scenario for the 2 year and 5 year ARI events.

To meet the peak flow objectives the following outlet structure is required:

- low level orifice diameter is 460mm with an invert level of RL 5.0m AHD, and
- high level outlet weir of length 1.6m with a crest level of RL 6.7m AHD.

The results of the modelling for the Site 68 upstream catchment (including Site 68) are shown in Table 4, including:

- The pre-development non-urbanised peak flow for a catchment of 20.45 hectares.
- The total peak flow for the Site 68 upstream catchment, including the combined outflow from the detention tank and all overland flows that bypass the trunk drainage system.

- A ‘do nothing’ scenario. The total peak flow for the Site 68 upstream catchment, including the combined outflow from the site if no detention storage were to be constructed as well as all overland flows that bypass the trunk drainage system.

Table 4: Site 68 catchment peak outflow (including overland flows bypassing drainage system)

Storm event	‘Pre-development Non-Urbanised’ Peak Flow (targeted total catchment peak outflow) – m^3/s	Proposed Total Catchment Peak Outflow with detention tank (including bypassed flows) – m^3/s	Total Catchment Peak Outflow with zero detention (including bypassed flows) – m^3/s
1 year ARI	0.57	0.57	3.17
2 year ARI	1.36	1.23	4.01
5 year ARI	2.47	2.47	5.4
10 year ARI	3.13	3.43	6.09
20 year ARI	4.05	4.74	7.07
50 year ARI	4.97	6.03	7.86
100 year ARI	5.79	7.79	8.93

The results in Table 4 show that the peak flow objectives as set by SOPA within their stormwater policy (up to the 5 year ARI) will be met by the proposed detention tank. It is noted that the current detention provided by the SWQCP exceeds the objectives set by SOPA, reducing the peak total flows to a rate less than would be expected for a ‘predevelopment non-urbanised state’ catchment.

To provide additional assessment of the impacts of the increased Site 68 peak discharge the modelling was also carried out to assess the total peak inflow to Bennelong Pond. The results of the modelling for the resulting total peak inflow to Bennelong Pond are shown in Table 56, including:

- The total existing peak inflow into Bennelong Pond, including the combined outflows from the SWQCP, all of the Parkview Precinct, and Bicentennial Park subcatchments.

- The total proposed peak flow into Bennelong Pond, including the combined outflows from the Site 68 detention tank, all of the Parkview Precinct, and Bicentennial Park subcatchments.

- A ‘do nothing’ scenario. The total peak flow into Bennelong Pond, including the combined outflows from Site 68 if no detention storage were to be constructed, all of the Parkview Precinct, and Bicentennial Park subcatchments.

Table 5: Bennelong Pond total peak inflow (including Site 68, all Parkview Precinct and Bicentennial Park)

Storm event	Existing Total Peak Inflow to Bennelong Pond – m3/s	Proposed Total Peak Inflow to Bennelong Pond – m^3/s	Total Peak Inflow to Bennelong Pond with zero detention at Site 68 – m^3/s
1 year ARI	2.27	2.05	4.94
2 year ARI	2.97	2.83	6.38
5 year ARI	3.87	3.82	8.16
10 year ARI	4.41	4.82	8.96
20 year ARI	5.17	6.46	10.1
50 year ARI	5.8	7.91	11.1

100 year ARI	6.53	9.10	12.2

The modelling shows that the total peak inflow to Bennelong Pond will be reduced for the 1 to 5 year ARI events, whilst the peak inflow to the pond will increase for the 10 to 100 year ARI events.

Two dimensional modelling of flows in the vicinity of Bennelong Pond has previously been carried out (Cardno, 2011). As shown in Figure 14 the modelled flood velocities within Bennelong Pond in the 100 year ARI storm event are relatively low. Vegetation can withstand velocities up to 1.5m/s and the velocities (even in the 1 in 100 year ARI event) are below 0.5m/s. This corresponds with site observations which shows that vegetation is not impacted during flow events. Hence there will be no disturbance to vegetation in the ponds due to the very low velocities in the pond.

The flows generated by frequent storm events (i.e 3 month to 2 year ARI) are most significant for flora & fauna due to their regular occurrence, and "maintaining pre-development peak discharge for the 1.5 year Average Recurrence Interval (ARI) event is becoming a common design objective for aquatic habitat protection" (Engineers Australia, 2006, p.1-6). Given that the total peak flows into Bennelong Pond for events up to the 5 year ARI are reduced by the proposed detention strategy significant impacts are unlikely. Furthermore, the reduction of the pollutant loads compared to the existing case will also have a positive impact on the downstream receiving waters, particularly in the reduction of sediment to Bennelong Pond which is causing siltation of the Pond and mangroves.

Based on this assessment, it is concluded that the increased peak flows caused by the adherence of Site 68 to the SOPA peak flow objectives will not create adverse impacts on Bennelong Pond, and the planned improvement works to the Bennelong Pond forebay can mitigate any localised impacts at the 'Crossing 1' culvert outlets. It is noted that the high flow velocities in the forebay zone are likely to be artificial as the no flow zone appears to have been created by ALS data from the top of the macrophytes.

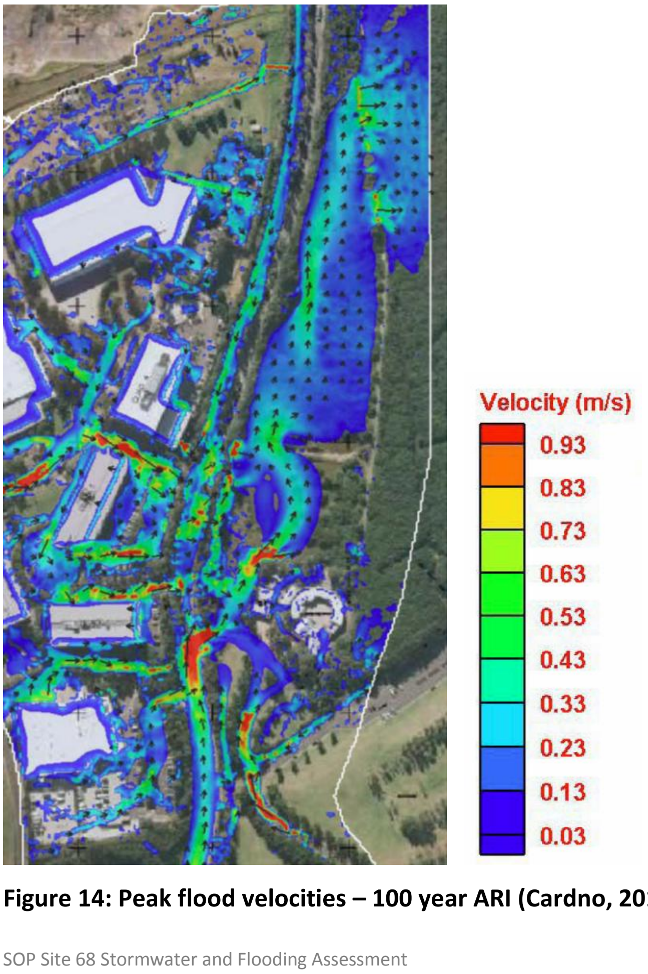

Figure 14: Peak flood velocities – 100 year ARI (Cardno, 2011, p.28)

5.4 Downstream drainage

As outlined in the Section 5.3.2, for events us to the 5 year ARI event the peak flow discharged from Site 68 will be increased up to the flow rate expected for a 'pre-development non-urbanised' catchment of the same area as that draining to Site 68. The increased peak discharge from Site 68 will require an upgrade of the downstream drainage line to ensure that all flows up to the 100 year ARI event are conveyed to the 'Crossing 1' outlet contained within the new downstream drainage line.

A plan showing the proposed outlet drainage pipeline is provided in Appendix A. The outlet drainage line will require tree removal and trench excavation within the existing embankment adjacent to Bennelong Parkway, to the western side of the existing footpath.

Currently the downstream drainage line is a 600mm diameter and 750mm diameter pipe connecting to the 'Crossing 1' culverts junction pit (shown in Figure 6). It is proposed to leave the existing drainage line in place and install an additional pipeline running in parallel. When the flow capacity of the new drainage line is reached the higher flows will divert into the existing drainage line.

The modelling indicates that the existing three culverts at 'Crossing 1' to the Bennelong Pond forebay have sufficient capacity to convey the increased peak flow, and the modelling has shown that the junction pit would not surcharge to Bennelong Parkway.

5.5 Flooding Assessment

As described in the previous sections, Site 68 currently receives inflows from the upstream catchment via the trunk drainage system, however any overland flows generated in the upstream catchment that are in excess of the trunk drainage system capacity bypass the trunk drainage lines and flow overland to the receiving waters as indicated in Figure 15.

Note that the proposed detention tank arrangement does not change the peak flows that bypass the trunk drainage system and travel overland.

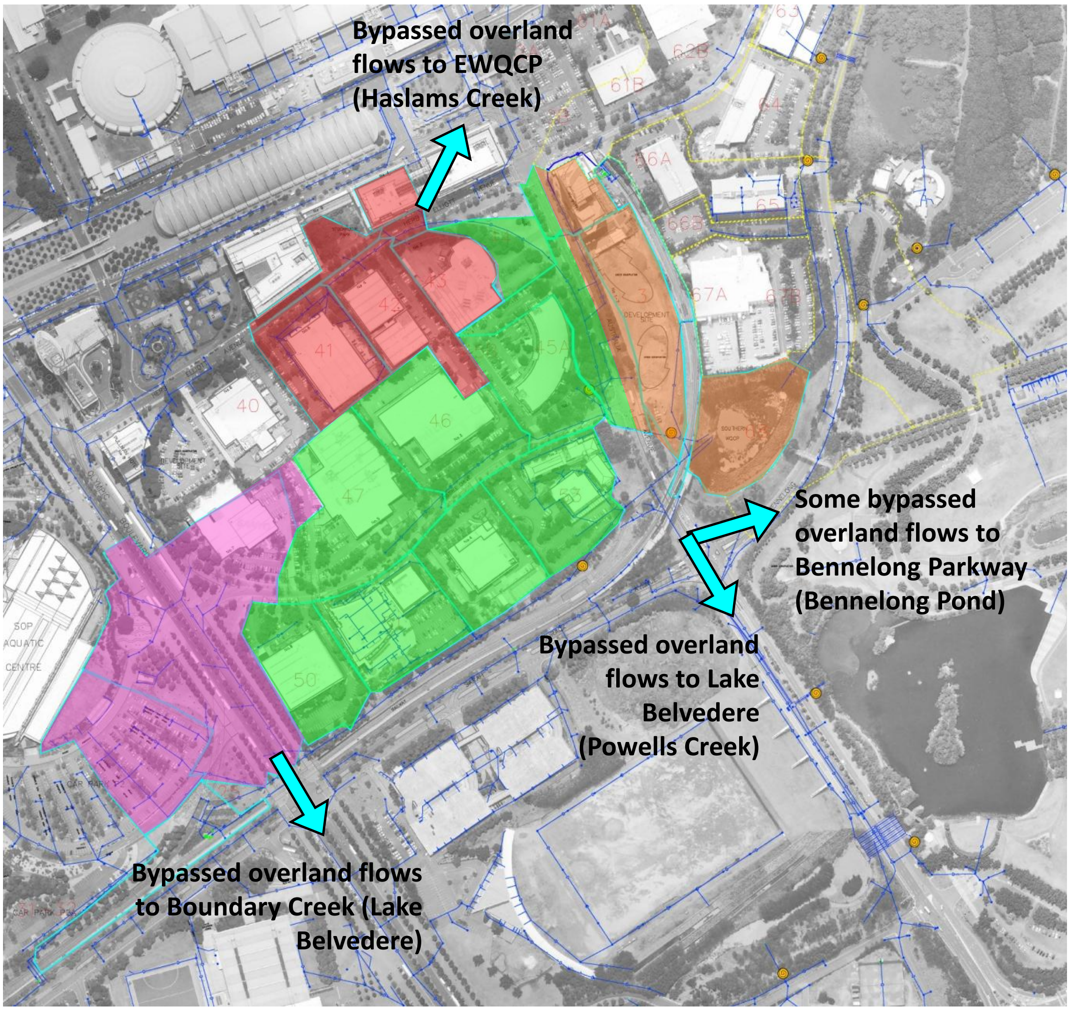

Figure 15: Site 68 upstream catchment, with indicative bypassed overland flow directions

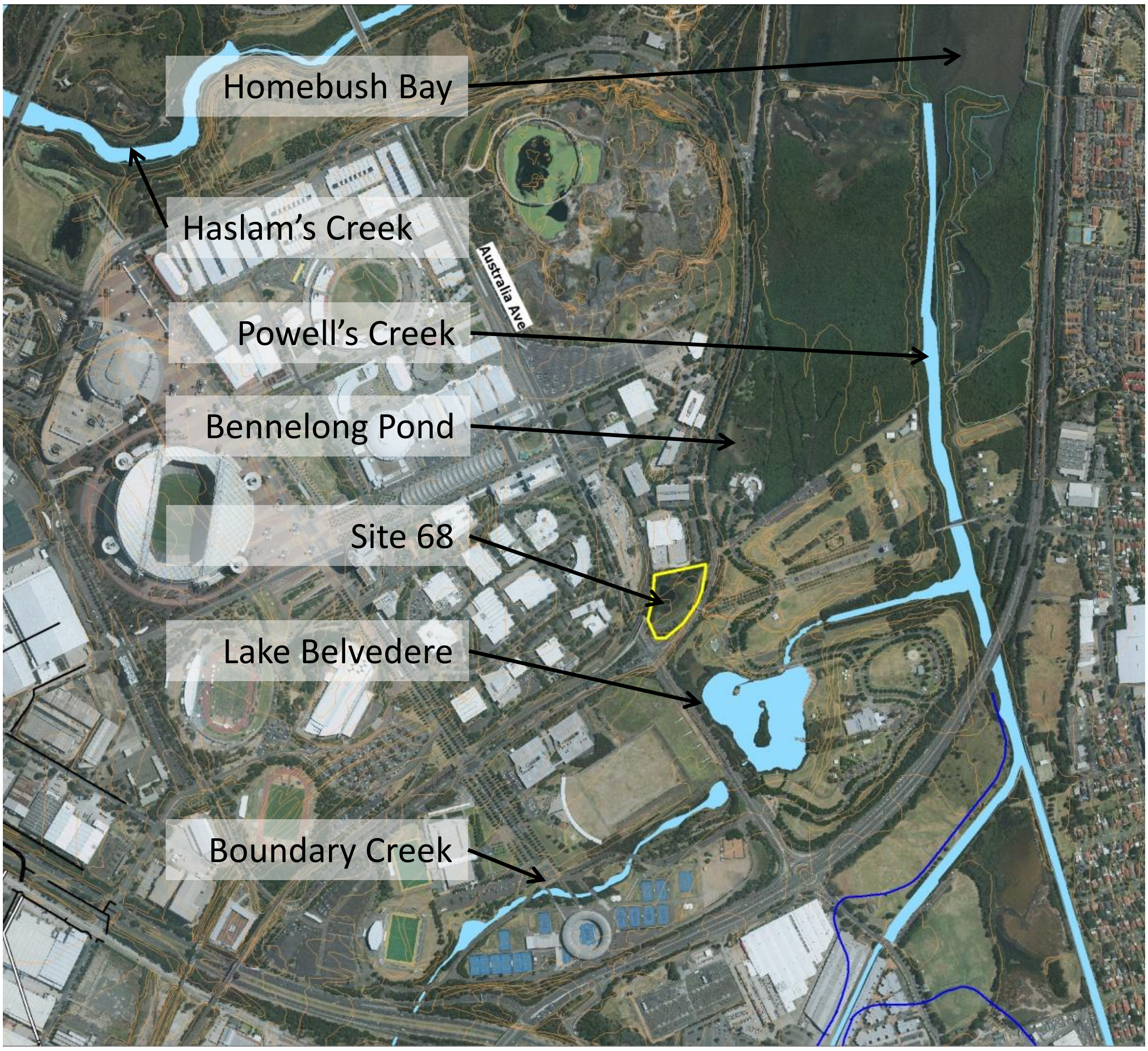

Figure 16: Waterways in the vicinity of Site 68

The surface level of Bennelong Parkway drops from RL 5.2 m AHD near the corner of Bennelong Parkway and Australia Ave to RL 3.0 m AHD near the corner of Bennelong Parkway and the new 'Road 3'. The peak 100 year ARI flood depths along Bennelong Parkway are shown in Figure 17, with the flood depth at the corner of the proposed new 'Road 3' and Bennelong Parkway around 0.6m depth. The flood level in this vicinity is therefore taken as approximately 3.6m AHD.

The level of the proposed Site 68 plaza area is generally RL 10.7 m AHD to RL 10, sloping down at the northern side of the site to meet the proposed new 'Road 3' at approximately RL 8 m AHD. The level of the car park entrance to basement 2 from 'Road 3' is approximately RL 4.5m AHD, approximately 0.9m above the flood level in Bennelong Parkway.

The car park driveway layback and access ramp would be designed to ensure that nuisance overland flows generated by the new 'Road 3' would continue down the roadway and not enter the Site 68 basement. The design of the new 'Road 3' is being undertaken by SOPA.

All flows discharged from Site 68 up to the 100 year ARI event are to be contained within the augmented downstream drainage line and as such there is not expected to be any flooding impacts on Bennelong Parkway.

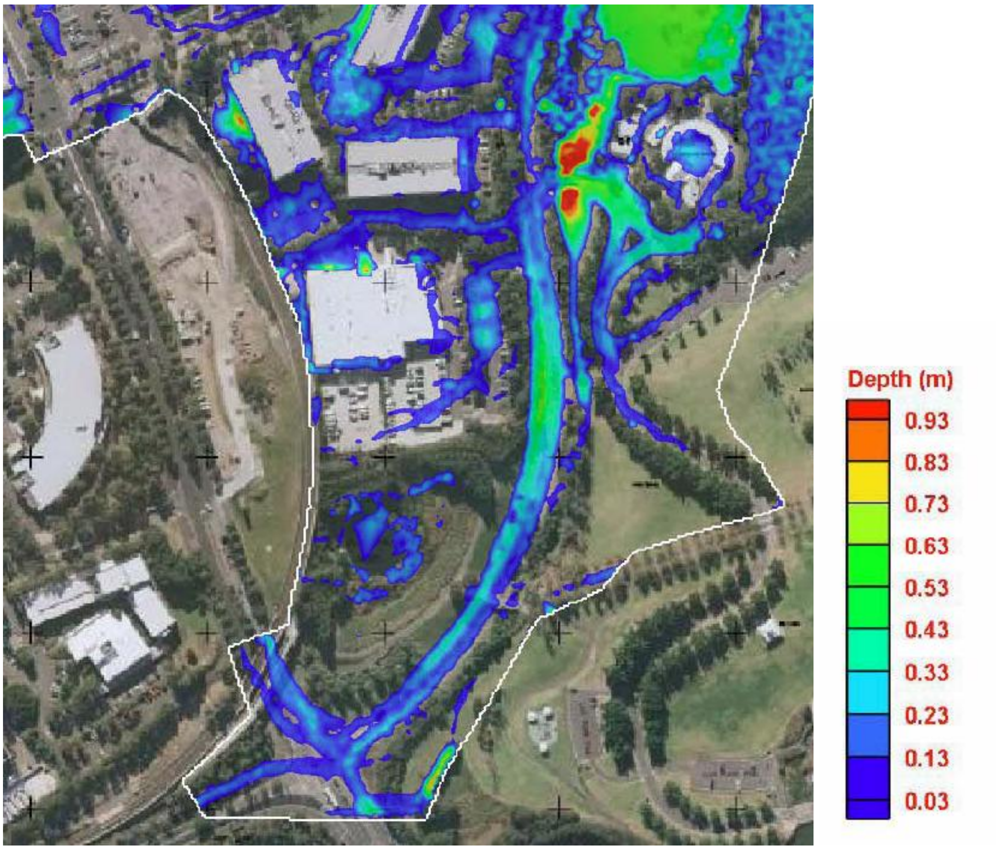

Figure 17: Peak flood depths around Site 68 – 100 year ARI (Cardno, 2011, p.26)

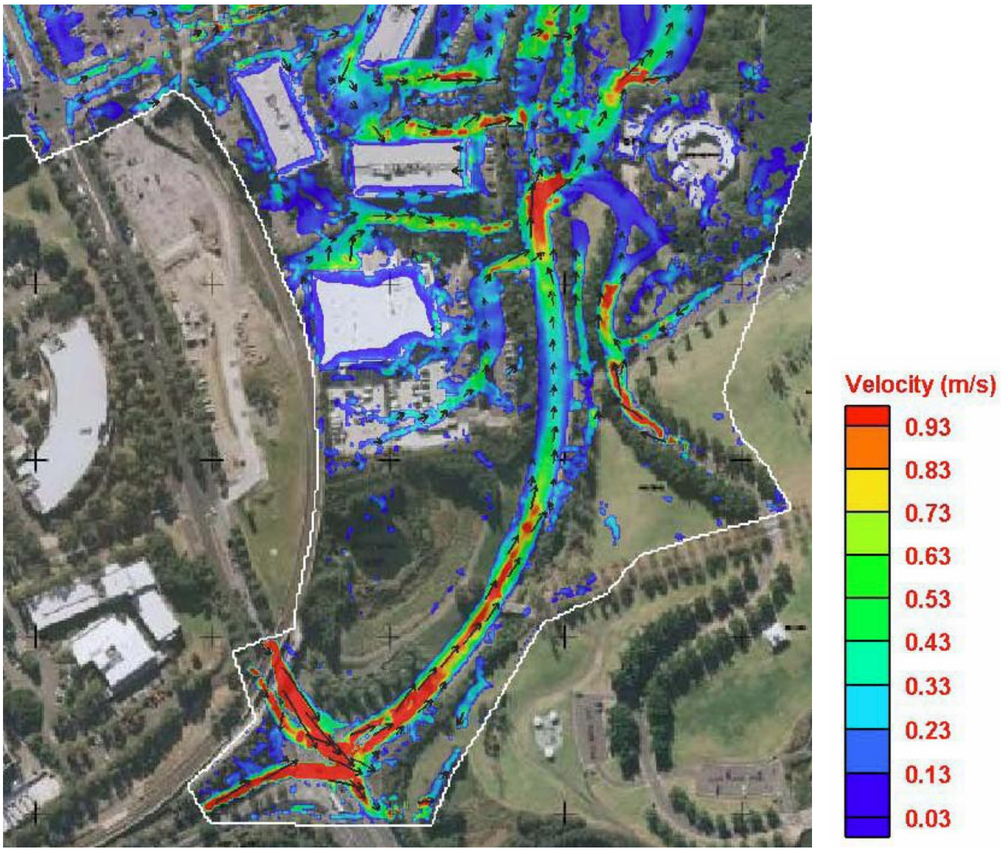

Figure 18: Peak flood velocities around Site 68 – 100 year ARI (Cardno, 2011, p.28)

The tailwater level adopted for the hydraulic modelling of the detention tank and downstream drainage line was taken as RL 1.5m AHD. As shown in Table 67 this is equivalent to the mean high water level for Sydney Harbour after 0.9m of sea level rise. Given that the proposed invert level of the detention tank outlet is RL 5.0 m AHD there will not be any impact on the operation of the tank by sea level rise.

Table 6: Sydney Harbour tailwater conditions with sea level rise

Water level condition	Current (m AHD)	2050 (m AHD) (0.4m sea level rise)	2100 (m AHD) (0.9m sea level rise)
Mean high water	0.575	0.975	1.475
Mean sea level	0.065	0.465	0.965
Mean low water	-0.435	-0.035	0.465

There is potential for increased rainfall intensities as a result of climate change. These would be assessed as part of the hydrological and hydraulic modelling for detailed design. Whilst increased rainfall intensities are not likely to lead to a significant increase in flood depths on Bennelong Parkway, the freeboard provided from the current 100 year flood level to the car park entrance level of 0.9m allows for 0.6m increase in flood level whilst maintaining 0.3m of freeboard to the car park entrance.

The flood levels of overland flows in Bennelong Parkway are not likely to be impacted by sea level rise as the flooding is controlled by conveyance rather that the downstream outlet condition of the water level in Homebush Bay.

6 Construction Water Management

6.1 Construction Requirements

The SOPA Stormwater Management & WSUD Policy (2013) includes the following requirements for construction sites:

1. *Erosion and sediment management*

   a. *All works involving soil disturbance:*
   Erosion, sediment and dust control measures must be installed and maintained throughout the works in accordance with the provisions of the "Blue Book" Part 1. [Landcom (2004) Managing Urban Stormwater: Soils and Construction, 4th edition]

   b. *Cleared area 250-2500m2 OR where soil stockpiles will be in place for over 10 days:*
   An Erosion and Sediment Control Plan prepared by an appropriately qualified person, must be submitted with an application for development consent, and implemented throughout the works. The Plan must be prepared in accordance with the provisions of the "Blue Book" Part 1. [Landcom (2004) Managing Urban Stormwater: Soils and Construction, 4th edition]. The plan must consider likely stages of the works and provide for appropriate control of sediment and erosion for each stage.

   c. *Cleared area >2500m^2:*
   A Soil and Water Management Plan prepared by an appropriately-qualified person must be submitted with an application for development consent, and implemented throughout the works. The Plan must be prepared in accordance with the provisions of the "Blue Book" Part 1. [Landcom (2004) Managing Urban Stormwater: Soils and Construction, 4th edition]. The plan must consider likely stages of the works and provide for appropriate control of sediment and erosion for each stage.

2. *Discharge standards for temporary sedimentation basins*
   Approval of the Sydney Olympic Park Authority must be obtained prior to discharge of water from temporary sedimentation basins into the Park's waterways and wetlands. All stormwater water proposed to be discharged must comply with the NSW Protection of the Environment Operations Act 1997, and demonstrate compliance with the following standards:

- *Discharge point*	*As approved by SOPA*
- *Total suspended solids*	*<50mg/litre*
- *pH*	*pH 6.5 – 8.5*
- *Oil & Grease*	*No visible sheen on released waters*
- *Flow rate*	*As approved by SOPA and dependent upon the nature of the receiving waters and design of the outlet structure*

3. *Record-keeping*
   The Developer should keep appropriate records of construction stormwater management activities and make available to Sydney Olympic Park Authority or relevant regulatory authorities upon request:

   - *records relating to maintenance of sediment and erosion controls*
   - *all sampling and analytical data relating to water quality testing of temporary sedimentation basins prior to discharge*
   - *records of dates and volumes of discharge*

6.2 Construction sediment and water management controls

Sediment and erosion controls will be installed and maintained throughout the construction period, in accordance with the 'Blue Book' – Soils & Construction (Landcom, 2004) and the SOPA requirements for construction sites as outlined in Section 6.1.

Whilst a detailed site water management plan would be developed with the appointed contractor during the Construction Certificate phase, it would be ensured that all flows receive treatment and adhere to SOPA's construction water quality discharge standards. Sediment controls would be maintained around the perimeter of the site to treat any local runoff as per the Soil and Water Management plan (by others).

Dewatering of the excavation for the basement is addressed by the geotechnical report.

7 Conclusions

It is proposed to incorporate the following stormwater management systems as part of the Site 68 development:

- Integrated tank
    i. sediment basin
    ii. diversion pumps
    iii. detention storage
- Bioretention treatment systems within the plaza areas
- Rainwater harvesting (refer building services documentation)
- Dual reticulation for WRAMS non-potable reuse (refer ESD/BASIX documentation)
- Water efficient fixtures and fittings to BASIX requirements (refer ESD/BASIX documentation)

Overall there is expected to be a significant net benefit to Bennelong Pond due to the improvement in water quality of inflows and limiting peak flows in the frequent storm events to the Pond as a result of the proposed works. This is discussed further below.

Water quality summary

As shown by the results of the water quality modelling in Section 4, the water quality treatment concepts proposed for Site 68 will achieve the pollutant reduction targets as required by SOPA's Stormwater Management & WSUD Policy. Further to this, the pollutant load to the receiving waters (Bennelong Pond and Badu Mangroves) will be significantly reduced. It is important to note that Site 68 is achieving this objective not just for its own site (which is more typical for a new development) but is undertaking this for the whole upstream catchment. This is being undertaken to ensure that by removing the existing water quality control pond, there is no adverse impact on the downstream receiving waters. The proposed system will actually improve the water quality performance compared to the existing base case.

Water quantity summary

The hydraulic modelling in Section 5 shows that the proposed detention tank will meet the specific water quantity targets as required by the SOPA Stormwater Management & WSUD Policy. The strategy for the site consisting of a detention tank to manage flows up to the 1 in 5 year ARI and an expanded stormwater drainage system will convey flows to the downstream receiving water within the pit and pipe drainage system with no overland flow.

This report has demonstrated that there will be no adverse impact on the receiving waters. The flows generated by frequent storm events (i.e 3 month to 2 year ARI) are most significant in terms of erosion and damage to vegetation and fauna due to their regular occurrence. Given that the peak flows into Bennelong Pond 'forebay' for events up to the 5 year ARI will be limited to non-urbanised rates by the proposed detention strategy there is unlikely to be any adverse impacts.

The only area that may be subject to localised impacts is the Bennelong Pond 'forebay' at the 'Crossing 1' culverts outlet. The forebay is currently considered highly disturbed and impacted by urban stormwater runoff. This forebay zone requires de-silting and removal of invasive aquatic vegetation. It is currently in the process of being redesigned for an upgrade to address these issues. The stormwater strategy has focussed on Bennelong Pond as a whole given that the 'forebay' is degraded and *Zannichellia palustris* is primarily located within the northern section of Bennelong Pond.

Water reuse summary

Site 68 will exceed the BASIX potable water use reduction target by utilising recycled water from the SOPA WRAMS Scheme and rainwater harvesting. Recycled water will be utilised for supplying non-potable uses such as toilet flushing, irrigation and clothes washing (supply to washing machine only) and harvested rainwater will be used for irrigation on Site 68.

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Appendix A – Stormwater Concept Drawings