Water Sensitive Urban Design
Sydney Heritage Fleet
Pyrmont, NSW 2009

Report Number 610.10676-R3R1

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EXECUTIVE SUMMARY

SLR Consulting Australia Pty Ltd (SLR Consulting) has been commissioned by Crawford Architects on behalf of Sydney Maritime Museum Ltd (Client) to provide environmental assessment reports to support a Development Application (DA) for the Sydney Heritage Fleet (SHF), Bank Street, Pyrmont

This report was prepared in response to the Director-General's Environmental Assessment Requirements issued 14 February 2011, to assesses and ascertain the likely impacts upon the local water environment and specifically stormwater characteristics and drainage, groundwater reserves and flood risk. The assessment also investigates constraints to and opportunities for the implementation of Water Sensitive Urban Design and water conservation and water re-use measures.

The current masterplan shows that the majority of the roof catchment area to the proposed development will be located under the Anzac Bridge, thus intercepting and far reducing the amount of rainfall onto the development site. It is also proposed to incorporate a 'green' roof over the workshop, which will enhance bio-diversity and water detention.

The aim of the stormwater quality assessment undertaken was to ensure the proposed development in operation, does not lead to an increase in the concentration of pollutants being discharged from the site and ultimately into Blackwattle Bay. The assessment included the development of a concept drainage design incorporating water quality treatment measures to manage and treat surface water runoff and roof runoff at source prior to a controlled release to the receiving waters.

The MUSIC modelling results show that the implementation of water quality improvement measures such as the green roof and rainwater harvesting tank will marginally improve the quality of stormwater being discharged from the site, therefore enhancing the local water environment. The provision of the green roof will also ultimately improve bio-diversity at the site. Although the water quality targets were not achieved, there will be a nett improvement of stormwater quality and thus the proposed development will not adversely affect the surface water or groundwater resources.

With regard to Flood Risk, the site and particularly the proposed ground floor level (1.6mAHD FFL) is at risk of flooding from the predicted rising sea level in Blackwattle Bay during a 100 year Average Recurrence Interval (ARI) flood event. The 100 year ARI still water level in Blackwattle Bay was predicted to currently be 1.435m AHD which could potentially rise to 1.835m AHD by 2050 and 2.335m AHD by 2100. No allowance for freeboard (recommended to be at least 300mm to 500mm above the 100 year ARI still water level) or the impact of waves/surging was made within the predicted still water level assessment. The impacts of Sea Level rise and proposed mitigation are covered in more detail within the Climate Change Induced Sea Level Rise report number 620.10676.0070 prepared by SLR.

The proposed building is sited over an existing stormwater drain which is located within a drainage easement from Bank Street. The existing site levels indicate that an overland flow path existing over the alignment of the stormwater drain. Therefore there is risk of local flooding from excess stormwater runoff, unable to drain via the existing drainage network (expected to reach full capacity at between a 1 in 2 year and 1 in 10 year ARI storm event), flowing overland from Bank Street into the north-west of the site and potentially impacting on the workshop and entry forecourt. To mitigate this impact, it is proposed to implement a form of boundary treatment to divert overland flow around the building and ultimately into Blackwattle Bay.

Given that the majority of the development site is located under the Anzac Bridge, and the sites location adjoining the bay, it is anticipated that there will be negligible change to groundwater flows from the development in the operational phase.

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1 INTRODUCTION

SLR Consulting Australia Pty Ltd (SLR Consulting) has been commissioned by Crawford Architects on behalf of Sydney Maritime Museum Ltd (Client) to provide environmental assessment reports to support a Development Application (DA) for the Sydney Heritage Fleet (SHF), Bank Street, Pyrmont.

This report presents an assessment of impacts on the water environment and preliminary Water Sensitive Urban Design (WSUD) assessment for Masterplanning purposes for the above proposed development.

This report has been undertaken in accordance with SLR's Offer of Services, Sydney Heritage Fleet Bank Street, Pyrmont; Specialist Building / Environmental Technology Services (Ref. 610.10676 SHF P1 20110823, dated 23 August 2011).

From the information provided by the Client, the following briefly describes the development:

- The development will comprise a non-profit making working museum and a home for the SHF.
- The site is located under the eastern pylon of the Anzac Bridge with a water frontage to Blackwattle Bay and a street frontage to Bank Street. Approximately half of the site adjacent to the bridge pylon will be occupied by the SHF and the other half to the east will become a community park. The land understood to be developed as a community park does not form part of this assessment.
- Located to the west of the bridge pylon is a freestanding Exhibition Pavilion with an attached refreshment kiosk and amenities also at sea wall/water level.
- The land based component of the project comprises two storage areas at sea wall/water level.
    - The first to store dragon boats operated by Dragon Boats NSW with direct access to a new boat ramp.
    - The second to store and operate small vessels owned by the SHF, which will also make use of the boat ramp.
- Directly above the boat storage areas are exhibition spaces, meeting rooms, amenities, and entry lobby and reception areas.
- Across from the entry courtyard fronting Bank Street is a single storey building with some mezzanine spaces over which are the SHF's maintenance workshops and storage areas which are required to service the SHF vessels. The roof of the maintenance areas will be "green", to provide sound insulation for the SHF's operations and a visually attractive landscape for the adjacent residential buildings.
- Where reference is made to the site being developed for commercial use, this terminology is used to differentiate from residential or industrial uses, and is not intended to construe a commercial (or business) venture.

1.1 Objectives

In response to the Director-General's Environmental Assessment Requirements issued 14 February 2011, an assessment has been undertaken to ascertain the likely impacts upon local catchment in regard to stormwater characteristics and drainage and groundwater resource. The assessment also investigates any constraints to and opportunities for the implementation of Water Sensitive Urban Design and water conservation and water re-use measures. A desk based assessment of flood risk at the site has also been undertaken in conjunction with the Climate Change and Sea Level report number 610.10676.0070 also prepared by SLR Consulting.

This assessment also considers the implementation of stormwater management devices (at a Concept level) to either maintain or improve the quality of stormwater being discharged from the site in the 'post-development', operational phase. This report also assesses potential options for water re-use with regards to the proposed operations on the site.

1.2 Scope of Work

The scope of work for the preliminary Water Sensitive Urban Design (WSUD) for approval purposes and includes the following:

- Preliminary stormwater drainage assessment and concept design for the proposed development site masterplan, including stormwater, drainage infrastructure and incorporation of WSUD applications and control measures;
- Preliminary desk-based assessment of impacts upon groundwater resources and development of initial management plans to include mitigation measures to remediate, reduce or control potential impacts;
- Assessment of stormwater retention or detention options to reduce discharge to agreed pre-development rates. The assessment does not include offsite drainage network analysis to be provided by Council or Sydney Water;
- Optioneering for re-use of local water to reduce and conserve potable water, including roof water harvesting. This element of the assessment will require input from other relevant team members to ensure the most appropriate options are assessed and incorporated in the design;
- Consultation and liaison with the design team to assess options for the use of vegetation and 'soft' constructed devices for water quality improvement purposes as part of the WSUD concept plan;
- Coordination with landscape architect and provide advice as required on WSUD to integrate with water efficient landscape design;
- Concept planning with relevant members of the design team (ecologist and landscape architect) for the water related elements for the potential improvement of the ecological, recreational and aesthetic values of urban streams and water bodies and incorporation of any necessary flood mitigation systems;
- The transportation of pollutant loads from impervious urban surfaces within the site, such as roads and pavements to receiving waters; and
- Desktop study of the groundwater resource and potential impacts from the proposed development.

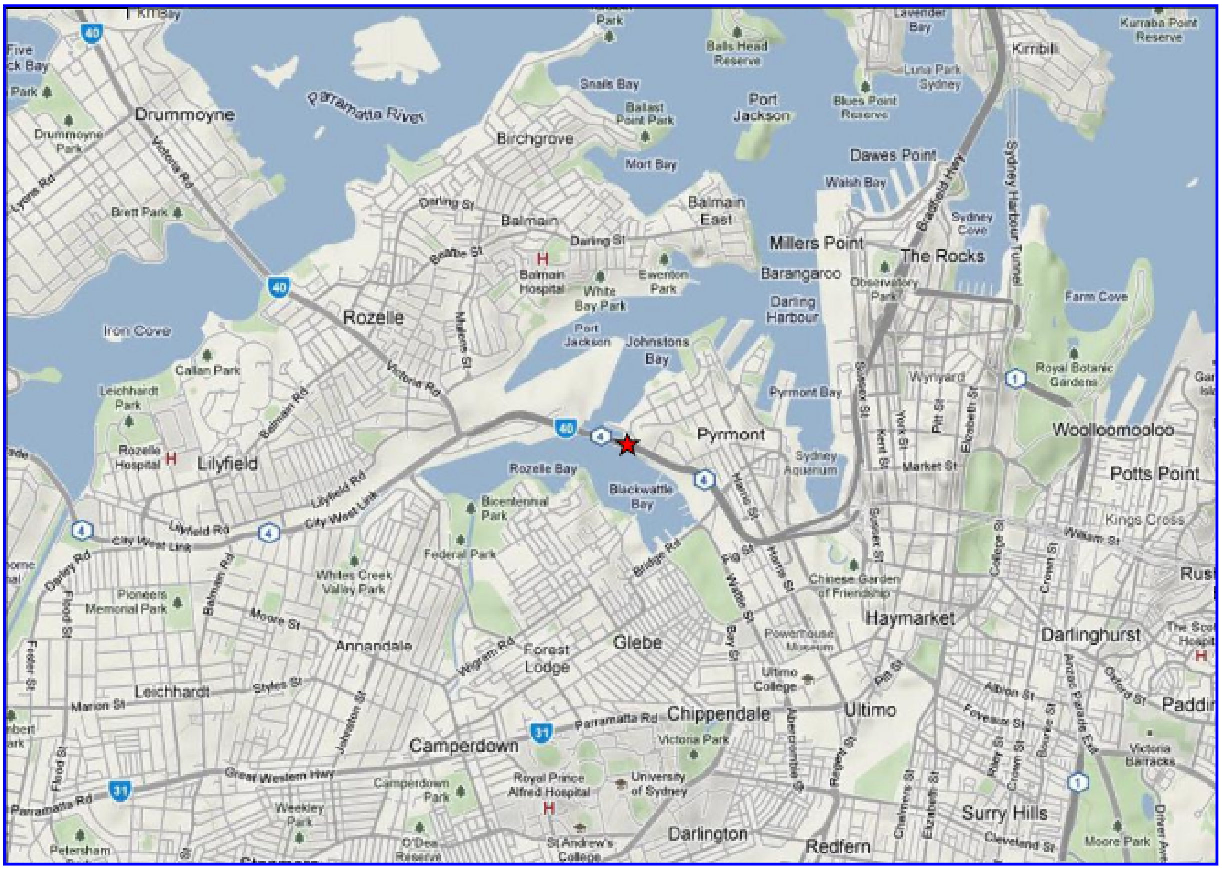
2 SITE DESCRIPTION

2.1 Site Location and Description

The Project Site is located off Bank Street, Pyrmont, NSW 2009, approximately 1.3 kilometres (km) west of Sydney Central Business District (CBD).

A Locality Map is provided below in **Figure 1**.

Figure 1 Locality Map



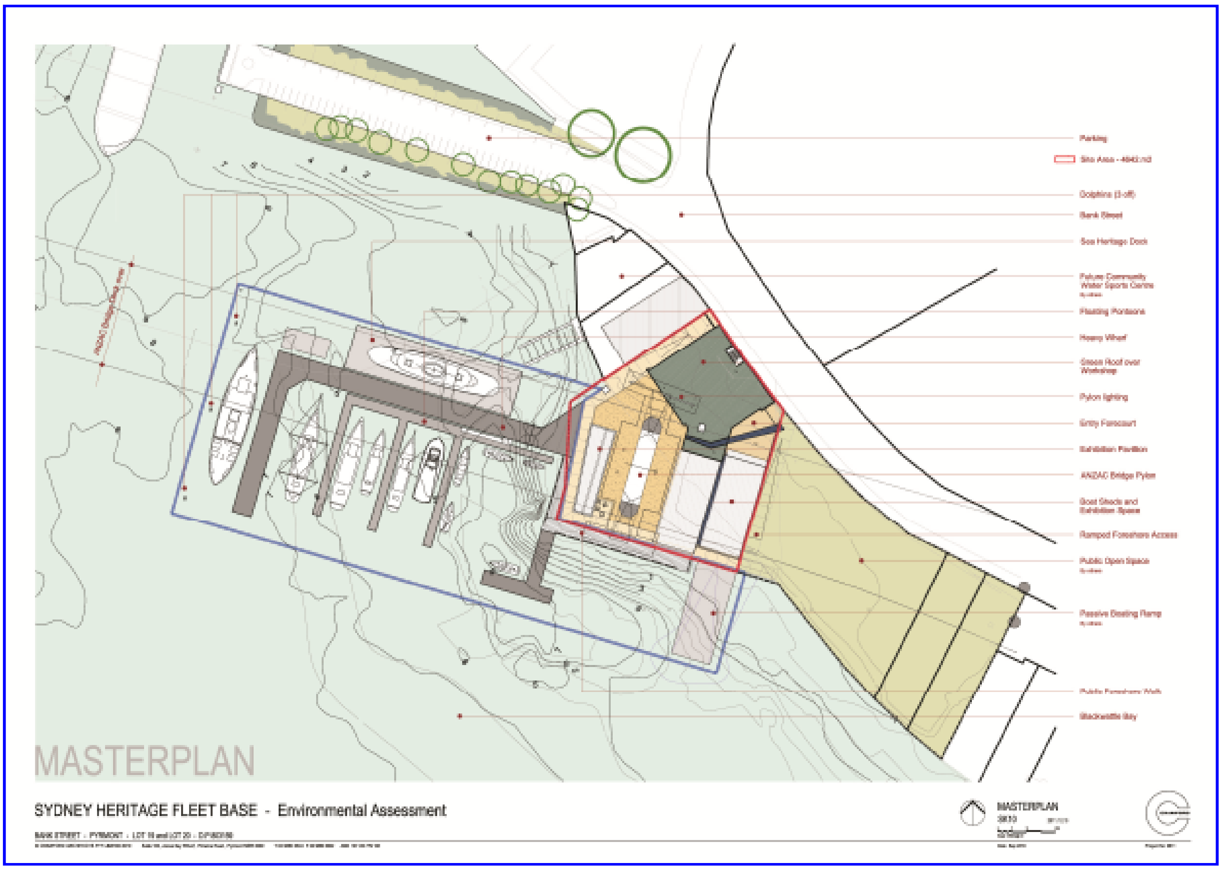
Source: SLR Consulting

The Project Site is a combination of two lots located beneath the eastern pylon of the Anzac Bridge, comprising Lot 19 and Lot 20 of Deposit Plan 803159. The area included within this DA is shown in **Figure 2** and is approximately 4,642 m^2 in area.

For clarity, throughout this report when both lots are being referred to, the term 'Project Site' will be used. If they need to be discussed individually the lots will be referred to by their associated lot and Deposit Plan number.

Two leases exist on the site, a land lease (identified in **Figure 2** by a red boundary) and a water lease (identified by a blue boundary). The public open space (shaded in green in **Figure 2**) is shown, although this is not included within this DA, and does not form part of this assessment.

Figure 2 Site Plan



Source: Crawford Architects

The Project Site is bordered to the south and west by Blackwattle Bay, to the north by Bank Street. The surrounding land uses include:

- North and Northwest: On the other side of Bank Street is Jackson's Landing residential and community estate.
- South and West: Blackwattle Bay borders the Project Site.
- Northeast: There is a small cluster of commercial buildings located on the opposing side of Bank Street.
- Southeast: A series of buildings operated by Poulos Bros Seafoods Pty Ltd, Bidvest Australia Pty Ltd, Hymix Australia Pty Ltd and the Sydney Fish Markets.

2.2 Project Description

The proposed development works shall incorporate the following:

- A two storey building with some mezzanine spaces.
- Located west of the bridge pylon is a freestanding Exhibition Pavilion with an attached kiosk and amenities.
- Boat sheds and vessel storage for dragon boating.
- Shipwrights and boat storage area which includes a machine shop, workshop, timber store, lunch room and amenities.

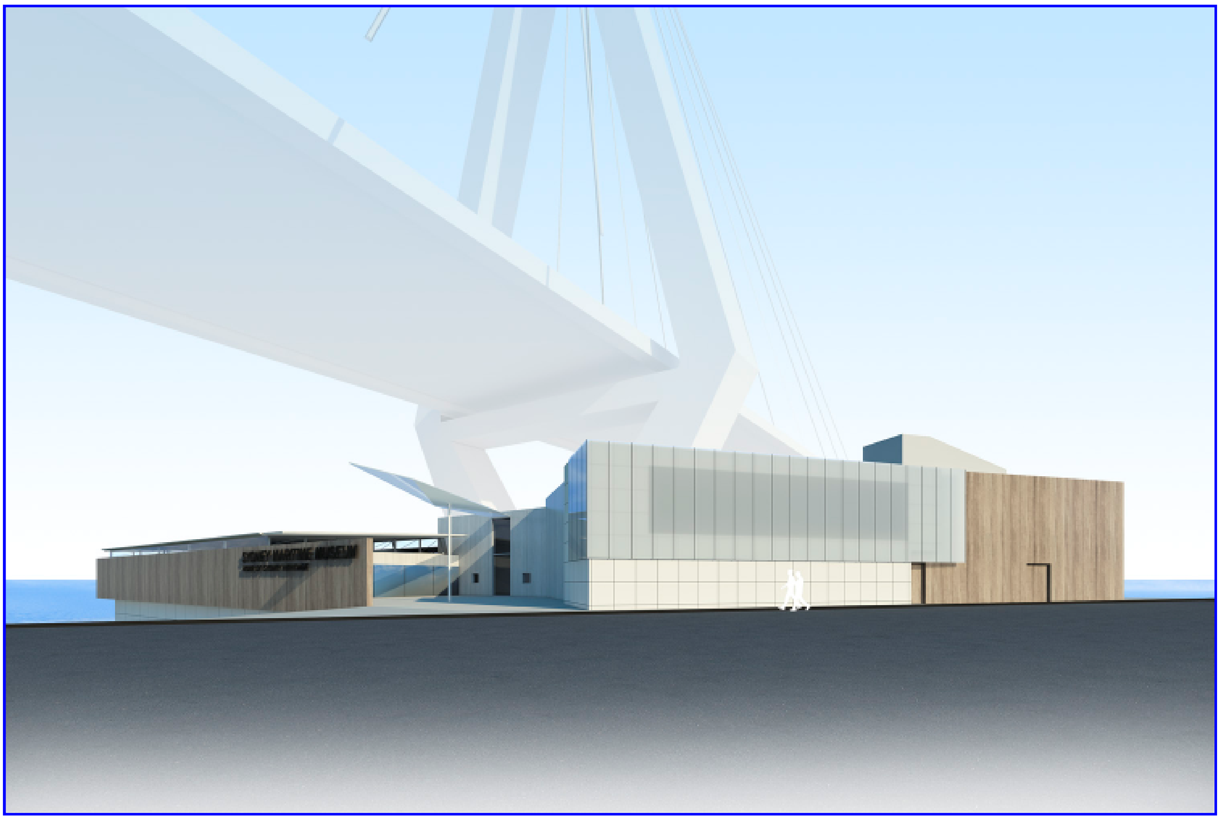
- Directly above the storage areas are exhibition spaces, meeting rooms, amenities, and entry, lobby and reception areas.
- Restoration and maintenance workshop, including a metal fabrication workshop, coal stores, garbage and recycling stores, paint and flammable goods store.
- Working living museum.
- Lay apart stores and electrical workshop.
- The mezzanine which incorporates amenities.
- Heavy wharf.
- Floating pontoons.

Figure 3 and **Figure 4** below show design perspectives for the proposed development from the proposed public open space and from Bank Street, respectively.

Figure 3 View of Proposed Development from Public Open Space

Source: Crawford Architects

Figure 4 View of Proposed Development from Bank Street



Source: Crawford Architects

3 LEGISLATION AND GUIDANCE

The assessment has been based on the requirements of the following documents:

- *Director-General's Requirements, February, 2011;*
- *Interim Reference Guideline for the South East Queensland Concept Design Guidelines for WSUD (with Sydney specific references);*
- *NSW EPA, Managing Urban Stormwater: Treatment Techniques (1997);*
- *Department of Environment and Conservation NSW, Managing Urban Stormwater: Harvesting and Re-Use (2006); and*
- *NSW Floodplain Development Manual (2005).*
- *Draft Sydney Water Stormwater Drainage Design Code (2009)*

4 THE EXISTING ENVIRONMENT

4.1 Existing Catchment

SLR Consulting personnel inspected the Project Site in October 2011. The vast majority of the Project Site, which is approximately 0.47ha in area, comprised unsealed hardstand, consisting of sand and gravel with some small grassed areas. The Anzac Bridge currently covers approximately 0.26ha of the 0.47ha subject site.

4.2 Regional Geological Information

Soil landscape information has been obtained from ‘Soil Landscapes of the Sydney 1:100,000 sheet’ 1989 (Soil Conservation Service of NSW, Sydney).

Across the site there is a combination of ‘Gymea’ and ‘disturbed terrain’ soil landscapes. It is difficult to assess the exact place where the soil landscape changes from Disturbed Terrain to Gymea, however it seems the western end of the site (Lot 19 and some of Lot 20) is mostly ‘disturbed terrain’ while the eastern end of the site is Gymea.

The disturbed terrain is likely to have been created through the placing of imported fill over swamps and estuarine shores to create the reclaimed area/s. It is understood that fill material can be made up of dredged estuarine sand/mud, rock, roots, sticks, waste (industrial and residential) along with other debris.

4.3 Hydrogeology

No detailed information is currently available regarding groundwater flow or depth. However it is assumed that groundwater would tend to flow from Pyrmont across the site towards Blackwattle Bay.

4.4 Hydrology

The southern and western parts of the site directly adjoin Blackwattle Bay. Blackwattle Bay is part of the greater Sydney Harbour and lies approximately 9kms inland from the opening to the Pacific Ocean (Sydney Heads).

The current masterplan shows that the majority of the roof catchment area to the proposed development will be located under the Anzac Bridge, thus intercepting and far reducing the amount of rainfall onto the development site. It is also proposed to incorporate a ‘green’ roof over the workshop, which will enhance bio-diversity and water retention.

Rainwater which is not intercepted by drainage systems within Pyrmont (i.e. Bank Street) could potentially flow overland, down gradient onto the site. Overland flow from Pyrmont, in addition to rainwater falling on the site, would tend to currently either seep into the ground or flow via natural flow routes into Blackwattle Bay.

4.5 Stormwater Drainage

Schematic information provided by the City of Sydney Environment and Drainage Department (refer to **Appendix B**) in addition to information shown on DP1041963 was used to review the existing drainage network within, and surrounding, the site. The DP1041963 indicates that the City of Sydney Schematic Drainage Plan is incorrect in terms of the current route of the 225mm pipe.

A 225mm pipe was identified as potentially running through the west of the site and a 900mm pipe (as shown in **Appendix B**) was identified to potentially be running adjacent to the eastern boundary of the site. However an outlet approximately 300mm in diameter was identified at the sea well where the 900mm pipe was expected to outfall into Blackwattle Bay. The 225mm pipe outlet is located adjacent to where the sea wall changes angle in the centre of the southern boundary of the site.

It is recommended that a full survey be conducted to confirm the presence, location and size of the existing pipes.

4.6 Flood Risk

4.6.1 Coastal Flood Risk

Due to the site's location in relation to Blackwattle Bay, rising coastal floodwaters in Blackwattle Bay could potentially pose an increased flood risk to the site.

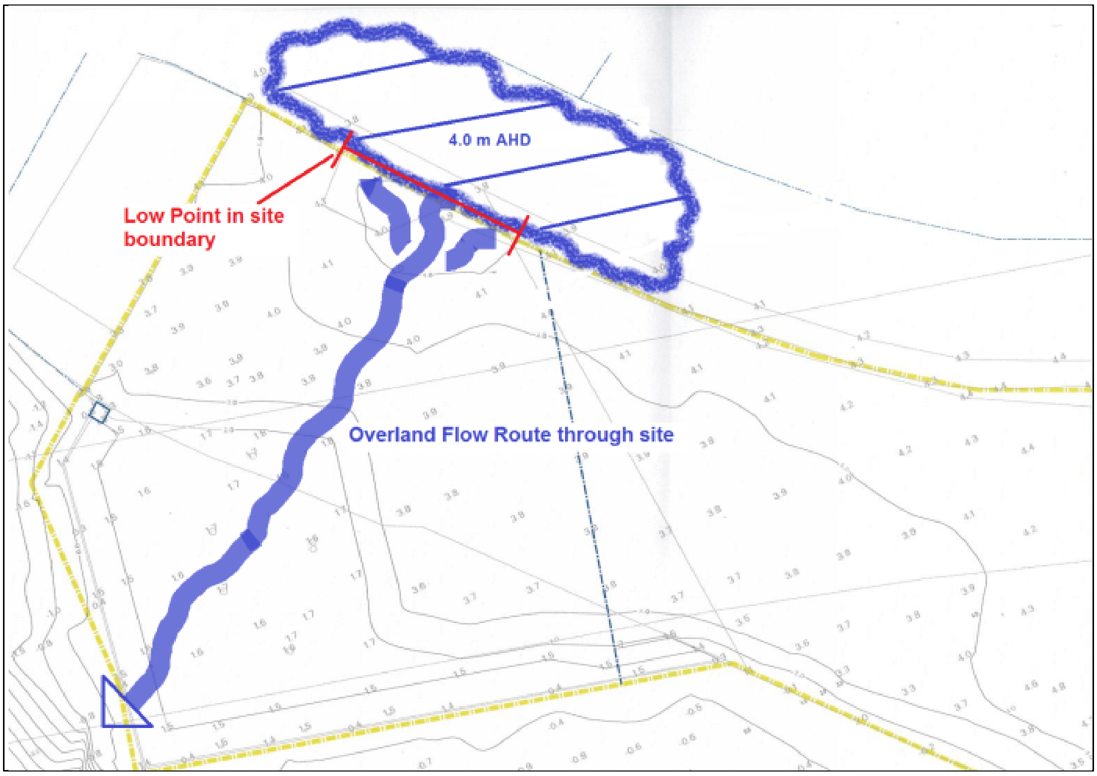
The Fort Denison Flood Vulnerability Study was used to estimate the still water level for a variety of Average Recurrence Interval (ARI) events. Based on the findings of the above study, the site is currently potentially at risk of flooding as a result of rising waters in Blackwattle Bay inundating the site during the 100 year ARI flood event. However a greater, residual, flood risk, associated with rising sea levels as a result of climate change is also posed to the site. Reference should be made to the Climate Change Induced Sea Level Rise report.

4.6.2 Overland Flow Routing

There is a risk of local flooding associated with overland flow from Bank Street flowing onto the site during storm events which exceed the capacity of the existing road drainage in line with the criteria as outlined below.

Based on the topographical information and proposed landform, stormwater runoff generated within Bank Street, unable to be intercepted by the drainage network, would tend to build up in Bank Street until approximately 4.0 mAHD. Stormwater would then flow overland into the site in the north-western fringes of the site prior to either soaking into the ground or flowing via natural flow paths through the site into Blackwattle Bay as shown in **Figure 5** below.

Figure 5 Potential Existing Overland Flow Route



4.6.3 Stormwater Runoff

Stormwater runoff generated within the existing site would tend to flow via natural flow routes into Blackwattle Bay.

4.7 Stormwater Quality

The vast majority of the existing site comprised unsealed hardstand, consisting of sand and gravel with some small grassed areas.

During storm events, surface water runoff generated within the existing site would tend to mobilise and transport pollutants from the soil, discharging them into Blackwattle Bay.

Potential pollutants include:

- Gross pollutants (e.g. trash);
- Nutrients;
- Suspended solids;
- Oxygen demanding materials; and
- Micro-organisms.

A full assessment of the predicted pre-development annual pollutant load is provided within the Water Sensitive Urban Design Strategy, refer to **Section 6**.

5 IMPACT ASSESSMENT

5.1 Identified Environmental Impacts and Effects

5.1.1 Construction Phase

Potential environmental impacts associated with the construction phase may be associated with:

- Reduction in stormwater quality;
- Reduction in groundwater quality; and
- Increase in water demand.

5.1.2 Operational Phase

Environmental impacts associated with the operational phase may be associated with:

- Coastal flood risk;
- Overland flow flood risk;
- Increase in stormwater runoff;
- Reduction in the quality of stormwater being discharged to receiving waters;
- Increase in water demand; and
- Reduction in groundwater recharge.

5.2 Environmental Impacts

5.2.1 Construction Phase

Reduction in Stormwater Quality

During the construction phase the Project Site's ground surface will consist of areas of exposed soil, excavation areas and stockpile areas. There is potential for an increase in soil erosion of exposed soils and an increase in the amount of suspended solids being transported by stormwater, eventually discharging into Blackwattle Bay causing an adverse affect to the receiving waters.

Due to the nature of the existing ground surface (sand and gravel) and relatively minor catchment area of the Project Site, any adverse impact is considered to be negligible. Best management practices in terms of reducing contamination to surface waters are set out in **Section 5.3.1**.

Reduction in Groundwater Quality

During the construction phase the rainwater which falls with the Project Site could potentially transport surface contaminants associated with construction activities down through the subsurface to the underlying groundwater table. This could potentially lead to adverse impacts on the underlying groundwater table.

Due to the relatively minor catchment area (approximately 0.21ha) within the site which is currently exposed to rainfall (i.e. not beneath the Anzac Bridge), low permeability of the existing site ground surface (hardstand) and close proximity to Blackwattle Bay, it is considered that construction activities would cause a negligible impact to the groundwater characteristics beneath the site.

Water Demand

During the construction phase a mains potable water supply will be required for site amenities and construction activities. The minor and temporary increase in potable water demand for the Project Site is considered negligible. No mitigation is deemed to be required.

5.2.2 Operational Phase

Coastal Flood Risk

Due to the site's location in relation to Blackwattle Bay, rising coastal floodwaters in Blackwattle Bay could potentially pose an increased flood risk to the site during the operational phase. Reference should be made to the *Climate Change Induced Sea Level Rise* report.

The NSW Floodplain Manual recognises the need to consider the full range of flood sizes up to and including the probable maximum flood (PMF) whilst noting that with few exceptions, it is neither feasible nor socially or economically justifiable to adopt the PMF as the basis for setting flood planning levels. Flood planning levels for typical residential development would generally be based around the 100 year Average Recurrence Interval (ARI) flood event plus an appropriate freeboard (typically 0.5m). The ARI is a statistical estimate of the average period in years between the occurrence of a flood of a given size. For example, the 100 year ARI event will occur on average every 100 years, equivalent to a 1% probability of occurrence in any given year.

With consideration to the potential economic risks associated with flood damage of the proposed development a similar approach has been adopted within a preliminary assessment of coastal flood risk at the development, by considering events up to and including the 100 year ARI event.

A preliminary assessment has been undertaken to estimate the still water levels adjacent to the site during various Average Recurrence Interval (ARI) events relating to current and future conditions, taking account of the predicted rise in sea level. The full assessment is provided within SLR Consulting's *Climate Change Induced Sea Level Rise* report (ref. 610.10676 R2D2).

Based on SLR Consulting's *Climate Change Induced Sea Level Rise* report:

- Currently the SHF ground finished floor level (FFL) is 0.165m above the existing 100 year ARI still water level. It should be noted that standard freeboard would be set at 300mm to 500mm above design water level;
- In 2050 the SHF ground FFL is predicted to be 0.115m below the 5 year ARI design water level and 0.235m below the 100 year ARI still water level; and
- In 2100 the SHF ground FFL is predicted to be 0.345m below the 0.05 year ARI design water level (equivalent to less than a monthly rainfall event) and 0.735m below the 100 year ARI still water level.

The predicted extent of the current and projected design still water level in relation to the proposed development are presented within **Appendix A**.

Conclusions and recommendations for addressing the residual flood risk associated with rising sea levels are provided in full within SLR Consulting's *Climate Change Induced Sea Level Rise* report. A summary of the proposed design adaptations recommended within the *Climate Change Induced Sea Level Rise* report are provided in **Section 5.3.2**.

Overland Flow Routing

Comparison between the Masterplan **(***Dwg No. SK10)* and **Figure 5** indicates that the proposed development may impact on the existing overland flow route through the Project Site, causing a potential flood risk to the development and potentially to upstream areas (e.g. Bank Street).

The City of Sydney Stormwater Drainage Design Code, V1-1 (March 2009) stipulates that overland flowpaths shall be provided to convey flows in excess of the capacity of the in-ground drainage system. The combined in-ground and overland flowpath capacity must cater for the design 100 year ARI flows.

The development shall need to be designed to ensure that overland flow routing is adequately addressed to ensure that no adverse impacts occur within the site and that there are no worsening effects upon adjoining properties or Bank Street. Recommendations on how to address the overland flow risks are provided within **Section 5.3.2**.

Increase in Stormwater Runoff

The proposed development will lead to an increase in impermeable surfaces within the Project Site which will increase the volume and rate of stormwater runoff being discharged from the Project Site. This could potentially cause a flood risk impact on adjoining and other properties.

In accordance with the *City of Sydney Stormwater Drainage Design Code* (Draft August 2009) Onsite Stormwater Detention (OSD) may be required to limit the increases in site discharges resulting from the development.

Reduction in Groundwater Recharge

The sealed surfaces within the proposed development will prevent rainfall from continuing to soak to ground within the Project Site. Due to the relatively minor catchment area (approximately 0.21ha) within the site which is currently exposed to rainfall (i.e. not beneath the Anzac Bridge), low permeability of the existing site ground surface (hardstand) and close proximity to Blackwattle Bay, it is considered that the proposed development would cause a negligible impact to the groundwater characteristics beneath the site.

Reduction in Stormwater Quality

During storm events, surface water runoff generated within the proposed development would tend to mobilise and transport pollutants from impermeable surfaces such as pavements and road areas before discharging them into Blackwattle Bay.

Potential pollutants include:

- Gross pollutants (e.g. trash);
- Nutrients;
- Suspended solids;
- Oxygen demanding materials; and
- Micro-organisms.

A full assessment of the predicted post-development impact on pollutant load transport is provided within the Water Sensitive Urban Design Strategy, refer to **Section 6.4**.

Water Demand

The proposed development will lead to an increase in mains water demand for the Project Site. This will cause an adverse impact on local water resources. Proposed mitigation measures relating to water conservation and water reuse are provided within **Section 5.3.2**.

5.3 Mitigation and Monitoring

5.3.1 Construction Phase

Stormwater Quality

In order to minimise the amount of sediment and potentially contaminated water which leaves the construction site, the following measures are recommended:

- A designated wash out area should be set aside for waste water generating activities. The wash out area should be located away from drainage lines and street gutters. All runoff from the wash out area should be upstream of a sediment fence which will intercept sediment;
- Stockpiles of sand and soil should be sheltered or covered with a plastic sheet to prevent rainfall from mobilising soils. Stockpiles of building materials should be located away from drainage lines to prevent potentially contaminated surface water runoff from being routed directly into gutters; and
- The preparation and implementation of a Construction Phase Erosion and Sedimentation Control Plan as part of an over-arching Construction Environment Management Plan (CEMP) prior to commencement of site works.

5.3.2 Operational Phase

Coastal Flood Risk

SLR Consulting's *Climate Change and Sea Level Rise* report fully outlines the proposed design adaptions to mitigate the potential coastal flood risk. A summary of the proposed design adaption's recommended within the *Climate Change and Sea Level Rise* report is provided below.

- Raise the sea wall to defend against projected potential sea level rise.
- Develop and construct a "flexible design" whereby in the future the ground floor can be raised.
- Establish all services (particularly electricity) above the projected inundation levels within the ground level building.
- Raise the height of the ground level as part of the current development to accomodate the projected higher sea levels.
- Development of an adaptation management plan which identifies:
  - Monitoring requirements
  - Future building adaptability/adaptation measures
  - Emergency response elements to minimise damage to property and avoid damage to humans.

Overland Flow Routing

The development should be designed to ensure an overland flow path is maintained between Bank Street and Blackwattle Bay. The overland flow path should be designed to convey the excess stormwater flow unable to be conveyed within the below ground stormwater pipe network for events up to and including the 100 year ARI storm flow.

It is expected that some form of boundary treatment will be required to divert overland flow during major storm events around the building to the eastern access way (east of the boat sheds) and if required to the western access way (along western boundary). Potential forms of boundary treatment include:

- Detailed ground levelling to ensure that runoff is diverted away from the proposed building; and
- Detail of proposed boundary fence to Bank Street to be designed so that bottom 600mm is constructed from impermeable material such as blockwork or concrete.

The overland flow mitigation strategy is shown schematically within the Preliminary Stormwater Drainage Concept Plan provided within **Appendix C**.

Further works are required in order to gain approval from Sydney City Council for the proposed overland flow mitigation strategy. A full network assessment will be required to determine the required capacity of the overland flow path and potential mitigation measures.

However, a preliminary assessment has been undertaken to provide an initial estimate of the overland flow rate which will need to be conveyed via the proposed overland flow path. An SLR Consulting representative undertook a site walkover to assess the likely contributing catchment within Bank Street. The rational method was then used to determine the excess flow, unable to be conveyed via the pipe network, which would need to be conveyed within the proposed overland flow path.

The overland flow rate during a 100 year ARI event was calculated to be between 84 L/s and 116 L/s, depending on the capacity of the existing pipe network. The full calculation is provided within **Appendix C**. It should be noted that in accordance with *City of Sydney Stormwater Drainage Design Code* (Draft August 2009) the depth of flow should generally be less than 0.2 m and the velocity less than 1 m/s.

It is considered that the proposed overland flow mitigation strategy (refer to **Appendix C**) would be able to convey the overland flow rate determined within the above preliminary assessment (84 L/s to 116 L/s).

Onsite Stormwater Detention (OSD)

In accordance with the *City of Sydney Stormwater Drainage Design Code* (Draft August 2009) OSD may be required to limit the increases in site discharges resulting from a development or re-development in order to prevent any adverse impacts on adjoining or any other properties.

SLR Consulting consulted the City of Sydney Council Drainage department to ascertain and confirm their requirements for drainage and onsite stormwater detention requirements onsite. SLR Consulting was advised by the Council's drainage engineer that, as the site fronts Blackwattle Bay, there is no requirement for OSD at the site or any restriction on the rate of stormwater discharge from the site.

However, some restrictions may need to be implemented if new drainage connections are to be established to the existing drainage network. This issue will be addressed at the detailed design phase.

Stormwater Quality Improvement

A detailed water quality treatment strategy is provided within the Water Sensitive Urban Design Strategy, refer to **Section 6.4**.

It is proposed to implement a green roof over the workshop. This will provide benefit in terms of water quality by filtering stormwater within the green roof substrate.

Water Conservation

The use of water efficient fixtures, appliances and equipment can provide long term benefits in terms of conserving water. A detailed assessment of potential water conservation options is provided in **Section 6.2**.

Water Re-use

A detailed assessment of potential water-reuse options to reduce the mains water demand for the proposed development is provided within the Water Sensitive Urban Design Strategy, refer to **Section 6.3**.

There is a potential opportunity to collect roof runoff from the green roof within a rainwater harvesting tank for re-use in toilets in the site buildings. It is proposed that a $15m^3$ rainwater harvesting tank be installed underground within the entry forecourt. It is predicted that a rainwater harvesting tank of this size would be able to supply approximately 71% of the predicted annual toilet flushing water demand considered to be 0.19 ML/year.

6 WATER SENSITIVE URBAN DESIGN STRATEGY

6.1 Water Sensitive Urban Design Objectives

Water Sensitive Urban Design (WSUD) involves planning and designing urban environments that are sensitive to the issues of water sustainability and environmental protection.

The key objectives of WSUD include:

- Reducing potable water demand through water efficient appliances, rainwater reuse and greywater reuse;
- Minimising wastewater generation and treatment of wastewater to a standard suitable for effluent reuse opportunities and/or release to receiving waters;
- Protect and restore aquatic ecosystems and habitats;
- Providing treatment for urban stormwater to meet water quality objectives for reuse and/or discharge to surface waters;
- Preserving / replicating the natural hydrological regime of catchments;
- Protect the scenic, landscape and recreational values of waterways; and
- Reducing minor flood risks in urban areas.

6.2 Water Conservation

A widespread reduction in water consumption is required to conserve water resources and offset the rising demand from an increasing population and minimising the affects of depleting resources during times of low rainfall conditions.

The use of water efficient fixtures, appliances and equipment can provide long term benefits in terms of conserving water. Rainwater harvesting can also significantly reduce the demand for mains supplied potable water, which is addressed in **Section 6.3.1**.

The Government of Australia Water Efficiency Labelling and Standards (WELS) Scheme advises that the minimum sustainable standard for water efficient water fixtures and fittings is 3 Star (with the highest being 5 star). As a minimum and where possible, it is recommended that the following water efficient fixtures be considered for use throughout the development:

- 4 Star water efficiency rated WCs;
- 4 Star water efficiency rated sink, basin and bathroom taps and showers; and
- Waterless urinals in commercial / retail areas.

6.3 Water Re-use Options

6.3.1 Rainwater Harvesting

The capturing or harvesting of rainwater from roof areas can contribute to water conservation and water quality objectives in terms of reducing potable water use and reducing the volume of water and thereby nutrient and suspended solid load being discharged to sewer and ultimately the receiving watercourse.

There is potential to harvest rainwater from the green roof (the only exposed roof onsite) over the workshop. This water could potentially be harvested, stored and used for irrigation or non-potable use, such as toilet flushing. The substrate also provides a filtration function improving the quality of water collected.

It is proposed that collected rainwater be directed to an underground cellular storage system located adjacent to the workshop prior to reticulation and re-use.

Discussions with Crawford Architects identified the potential for reusing collected rainwater to supplement water demand for flushing toilets.

A preliminary rainwater harvesting assessment was undertaken using the MUSIC software suite to compare the proportion of re-use demand for toilet flushing which can potentially be met by supply from a range of rainwater harvesting tank volumes. **Table 1** compares supply and demand (assumed for the purposes of this assessment to be toilet flushing) with a range of rainwater harvesting tank volumes.

Assumptions

In order to account for percolation into the substrate of the green roof, a rainfall threshold of 10mm was assumed. This means that only rainfall during a rainfall event larger than 10mm/day would produce runoff. This equates to approximately 55% of the annual runoff from an impermeable roof of equal size. This criterion is consistent with various case studies assessed, which found that between 25% and 90% of rainfall was adsorbed within the substrate, depending on season and substrate depth.

It was assumed that 3.5L of water would be used per toilet flush and each toilet (15 in total) would be flushed a minimum of 10 times a day.

Table 1 Rainwater Harvesting Assessment

Tank Size	Annual Runoff from Impermeable Roof (ML/year)	Annual Runoff from Green Roof (ML/year)	Potential Demand for Toilet Flushing (ML/year)	Demand met by Green Roof Supply (%)
5	0.82	0.45	0.19	45%
10	0.82	0.45	0.19	62%
15	0.82	0.45	0.19	71%

Benefits

- Reduce potable water demand providing operating cost savings and water conservation;
- Minimal treatment required prior to re-use;
- Reduce the need for water restrictions;
- Reduce flows to drainage system during periods of heavy rainfall; and
- Water Quality Benefits from filtration through green roof substrate.

Risks

- Water born disease in the stored water tanks due to stagnation and poor management;
- Overflows out of system causing damage; and
- Pumping failure due to inadequate maintenance.

Environmental Issues

- Cost of electricity for pumping.

Maintenance and Infrastructure

- Requires storage system; and
- Requires dual reticulation system.

6.4 Stormwater Quality Assessment

This section focuses on the potential increase in stormwater pollutants as a result of the development and recommends treatment measures to mitigate the potential pollution increase. This assessment has harnessed the objectives set out in the *Interim Reference Guideline for WSUD practitioners in Sydney* and supports the implementation of Best Management Practices (BMP) to ensure that no adverse impacts occur directly from the proposed development.

The aim of the stormwater quality assessment is to ensure the proposed development activities do not lead to an increase in the concentration of pollutants being discharged from the site.

Pollutants include:

- Gross pollutants (e.g. trash);
- Nutrients;
- Suspended solids;
- Oxygen demanding materials; and
- Micro-organisms.

Gross pollutants (trash) are commonly washed from pavements and can be at high concentration in urban runoff.

Increases in nutrients can promote growth of aquatic plants, particularly algae which can lead to a reduction in light penetration of the water and cause the oxygen levels in the water to decrease.

Increases in suspended solids (particularly sediment) leads to an increase in the concentration of nutrients being transported downstream as well as impacting on downstream water turbidity. Finer suspended sediment particles (<0.005mm) tend to transport pollutants such as nutrients where as relatively coarse particles (>0.02mm) hold very few pollutants.

Oxygen-demanding materials can deplete levels of dissolved oxygen in the water leading to anaerobic conditions which can cause aquatic plants and other aquatic organisms to be adversely impacted.

Micro-organisms frequently occur at high levels in urban runoff, associated with sewage/septic outfalls, animal faeces, soil, decaying vegetation and putrescible matter.

6.4.1 Design Objectives

The following design objectives for stormwater quality (in terms of reduction in pollutant load compared to untreated stormwater from the same development) have been obtained from the Interim Reference Guideline for WSUD practitioners in Sydney, which is based on the South East Queensland Concept Design Guidelines for WSUD.

Required reductions are as follows:

- 90% of the post development mean annual load of total gross pollutant loads (greater than 5mm);

- 85% of the post development mean annual load of total suspended solids;
- 65% of the post development mean annual load of total phosphorus; and
- 45% of the post development mean annual load of total nitrogen.

6.4.2 Water Quality Treatment Model

The Model for Urban Stormwater Improvement Conceptualisation (MUSIC) has been used to assess and estimate stormwater quality improvement elements and model the 'Pre' and 'Post' development pollutant loading.

Modelling parameters have been determined in accordance with the *Draft NSW Water Sensitive Urban Design MUSIC Modelling Guideline*.

In order to calculate the target pollutant concentrations in accordance with the design objectives (refer to **Section 6.4.1**) a pre-development model was created and compared to a post-development model incorporating treatment systems.

Various water quality treatment measures were discussed with Crawford Architects. Those considered appropriate for the development with consideration to space and development constraints were then modelled either individually or in combination (a treatment train) to assess the most appropriate means of achieving the stormwater quality targets presented in **Section 6.4.1**.

6.4.3 Proposed Water Quality Treatment Strategy

It is the intention of the Client and design team to ensure that measures are assessed and where appropriate, implemented to ensure that the quality of the stormwater and groundwater are not adversely impacted, and where possible, are improved by appropriate design and site management. It is proposed to construct a green roof over the workshop providing benefit in terms of filtering stormwater to improve water quality, stormwater retention within the substrate and improving biodiversity. The green roof will also provide wider environmental benefits in terms of air quality, noise reduction and thermal insulation.

There is a potential opportunity to collect roof runoff from the green roof within a rainwater harvesting tank for re-use in toilets in the site buildings. Overflow from the storage tanks would be directed to the existing drainage network, eventually discharging to the receiving watercourse in a controlled manner.

Due to space and development constraints surface water runoff generated with the proposed entry forecourt, the exposed areas to the west of the workshop and the exposed proportion of the eastern access way is unable to be treated for water quality improvement purposes.

It is proposed that surface water runoff from the entry forecourt and eastern access way be gravity drained via a grate drain with connection to the existing drainage network, eventually discharging to the receiving watercourse in a controlled manner.

It is proposed that surface water runoff from the southern exposed portion of the eastern access way and areas exposed to the west of the workshop drain overland into Blackwattle Bay.

As discussed in **Section 6.2** it is proposed that the eastern access way be used as the primary overland flow route to convey overland flow from Bank Street to Blackwattle Bay in the event the capacity of the in-ground drainage system in Bank Street is exceeded.

The WSUD treatment strategy is shown in the Stormwater Drainage Concept Plan in **Appendix D**.

MUSIC Modelling – Development Assumptions

The assumptions set out in **Table 2** and **Table 3** were applied during the modelling process.

Table 2 Assumed Pre-development Catchment Inputs

Catchment	Catchment (m^2)	Impermeable (%)	Permeable (%)
Exposed Hardstanding	1955	80	20
Contributing Hardstanding under bridge*	649	80	20
Grassed Area	171	0	100

* Note: 25% of area beneath the bridge was assumed to contribute runoff

Table 3 Assumed Post-development Catchment Inputs

Catchment	Catchment (m^2)	Impermeable (%)	Permeable (%)
Exposed Access Ways and Pavement	1114	100	0
Green Roof	899	100	0
Other Exposed Roof areas	113	100	0
Contributing Impermeable Areas under bridge*	649	100	0
Grassed Area	0	0	100

*Note: 25% of area beneath the bridge was assumed to contribute runoff

Following a review of the rainwater harvesting assessment presented in **Section 5.3.1** a $15m^3$ rainwater harvesting tank was selected for inclusion within the MUSIC model. This tank was selected with consideration to space constraints, storage potential and costs.

Rainfall and evaporation inputs, rainfall runoff parameters, pollutant generation parameters and stormwater treatment parameters were selected in accordance with *Strathfield Council WSUD Reference Guideline (Nov 2010)* deemed to be applicable given the close proximity of the Strathfield and City of Sydney catchment areas. A full list of assumptions is provided in **Appendix E**.

MUSIC - Modelling Results

The water quality modelling results are provided within **Table 4** below.

Full modelling results are provided within **Appendix E**.

Table 4 Water Quality Modelling - Annual Results

Parameter	Total Suspended Solids	Total Phosphorus	Total Nitrogen	Total Gross Pollutants
Pre-development Annual Load	367kg/yr	0.581kg/yr	4.37kg/yr	54.8 kg/yr
Target Reduction	85%	65%	45%	90%
Post-development (treated) Annual Load	324kg/yr	0.553kg/yr	4.36kg/yr	43.6kg/yr
Reduction Achieved	11.7%	2.8%	0.2%	20.4%

Parameter	Total Suspended Solids	Total Phosphorus	Total Nitrogen	Total Gross Pollutants
Target Achieved	No	No	No	No
Post-development Improvement	Yes	Yes	Yes	Yes

In summary, the preliminary WSUD and stormwater quality improvement assessment has shown that by implementing treatment measures including a green roof and rainwater harvesting facility, that the development in the operation phase will not further adversely impact the local water environment. The main control to achieving greater improvements is the siting of the main building directly under the bridge alignment. This significantly reduces the amount of rainfall onto the site, thus limiting dilution of generated runoff. Due to space constraints there is limited opportunity to implement widespread treatment measures and therefore the target reductions were not able to be achieved. However nett quality improvement will be achieved for all four water quality determinants. The green roof will ultimately enhance the local catchment in terms of water quality and encourage bio-diversity.

6.5 Cost

It is envisaged that the capital, operation and maintenance cost estimates for the proposed WSUD measures will be undertaken during the detailed design phase.

6.6 Maintenance Plan

A maintenance plan outlining how the WSUD elements will be maintained should be undertaken as part of the detailed design phase following discussions with relevant land owners and those parties who will adopt elements of the water quality treatment and drainage system.

7 CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

The aim of the assessment was to address the Director-General's Requirements and undertake a preliminary Water Sensitive Urban Design appraisal for Masterplanning purposes with reference to the Crawford Architects Masterplan, Sep 2010 (Dwg No. SK10) and associated building drawings.

The assessment considers the potential impact of the proposed development on the stormwater, groundwater and flood risk characteristics of the site and identifies potential stormwater management devices to either maintain or improve the quality of stormwater being discharged from the site post-development.

This report also assesses potential options for water conservation and re-use appropriate for the proposed site uses and associated operations. There are opportunities to re-use roof water for purposes such as toilet flushing and irrigation, thus reducing the use of potable water.

The site and particularly the proposed ground floor level (1.6mAHD FFL) is at risk of flooding as a result of rising waters in Blackwattle Bay during a 100 year Average Recurrence Interval (ARI) flood event. A residual flood risk also exists from rising sea levels. The 100 year ARI still water level in Blackwattle Bay was predicted to currently be 1.435m AHD which could potentially rise to 1.835m AHD by 2050 and 2.335m AHD by 2100. No allowance for freeboard (recommended to be at least 300mm to 500mm above the 100 year ARI still water level) or the impact of waves/surging was made within the predicted still water level assessment.

The site is also at risk of flooding from excess stormwater runoff, unable to drain via the existing drainage network (expected to reach full capacity at between a 1 in 2 year and 1 in 10 year ARI storm event), flowing overland from Bank Street into the north-west of the site and potentially impacting on the workshop and entry forecourt. It is proposed to implement a form of boundary treatment to divert overland flow around the building to the eastern access way. The eastern access way would need to be designed to convey the excess stormwater flow unable to be conveyed within the in-ground drainage network for events up to and including the 100 year ARI storm flow.

As the site fronts Blackwattle Bay, the City of Sydney Drainage Engineers advised that there is no requirement for OSD at the site or any restriction on the rate of stormwater discharge from the site. However some restrictions may need to be implemented if new drainage connections are to be established to the existing drainage network.

A stormwater quality assessment has been undertaken to ensure the proposed development in operation does not lead to an increase in the concentration of pollutants being discharged from the site. The assessment included the concept design of water quality treatment measures to manage and treat surface water runoff and roof runoff at source prior to a controlled release to the receiving watercourse.

The Model for Urban Stormwater Improvement Conceptualisation (MUSIC) was used to size stormwater quality elements and model the Pre and Post development pollutant loading. Various water quality treatment measures were modelled independently or in combination to assess the most appropriate means of achieving the stormwater quality targets presented in **Section 6.4.1,** whilst taking account of development constraints.

Due to space constraints there is limited opportunity to implement widespread treatment measures and therefore the target reductions set out in **Section 6.4.1** were not able to be achieved.

However the Water Sensitive Urban Design (WSUD) assessment has shown that the proposed development will not adversely affect the surface water or groundwater resources.

The MUSIC modelling results show that the implementation of water quality improvement measures such as the green roof and rainwater harvesting tank will marginally improve the quality of stormwater being discharged from the site, therefore enhancing the local water environment. The provision of the green roof will also ultimately improve bio-diversity at the site.

7.2 Recommendations

It is recommended that a full survey be conducted to confirm the presence, location and size of the existing stormwater pipes.

Certain design adaptations are required to mitigate the potential coastal flood risk at the site. These adaptations are outlined in full in SLR Consulting's *Climate Change and Sea Level Rise* report.

It is recommended that a form of boundary treatment be implemented at the Bank Street side of the workshop and entry forecourt as part of the overland flow mitigation strategy.

The proposed overland flow mitigation strategy will require approval from City of Sydney Council. It is recommended that further design works, including an analysis of the Bank Street and upper catchment stormwater drainage network be undertaken in accordance with the City of Sydney requirements.

As part of the Water Sensitive Urban Design Strategy it is recommended that the following water efficient fixtures are used throughout the development:

- 4 Star water efficiency rated WCs;
- 4 Star water efficiency rated bathroom taps; and
- Waterless urinals in commercial / retail areas.

It is also recommended that a rainwater harvesting facility with a minimum capacity of $15m^3$ is installed, underground beneath the entry forecourt. The facility will store captured roof water from the green roof area for reuse in toilets in the site buildings.

8 CLOSURE

This report has been prepared by SLR Consulting Australia Pty Ltd with all reasonable skill, care and diligence, and taking account of the manpower and resources devoted to it by agreement with the client. Information reported herein is based on the interpretation of data collected and has been accepted in good faith as being accurate and valid.

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