Macquarie Point Stormwater Management Plan - FINAL

Customer	Macquarie Point Development Corporation
Project	003353
Deliverable	001
Version	06
	26 August 2024

Document Control

Document Identification

Title	Macquarie Point Stormwater Management Plan - FINAL
Project No	003353
Deliverable No	001
Version No	06
Version Date	26 August 2024
Customer	Macquarie Point Development Corporation
Classification	BMT (UNOFFICIAL)

Author	Damion Cavanagh
Checked By	Matthew Buchanan
Project Manager	Damion Cavanagh

Amendment Record

The Amendment Record below records the history and issue status of this document.

Version	Version Date	Distribution	Record
01	02 July 2024	Macquarie Point Development Corporation	Report
02	09 July 2024	Macquarie Point Development Corporation	Report
03	22 July 2024	Macquarie Point Development Corporation	Report
04	22 July 2024	Macquarie Point Development Corporation	Report
05	24 July 2024	Macquarie Point Development Corporation	Report
06	26 August 2024	Macquarie Point Development Corporation	Report

Executive Summary

This report discusses the development and assessment of a conceptual stormwater quality system for the proposed Macquarie Point Precinct development in Hobart, Tasmania. The assessment covers the footprint of the Macquarie Point Precinct which is dominated by the proposed Stage 1 Stadium but also includes areas of commercial and residential buildings in addition to concourse areas required to service the Stadium itself.

Model for Urban Stormwater Improvement Conceptualisation (MUSIC) models were established for the Site to determine if the discharge objectives can be met with the inclusion of the proposed stormwater management controls. Selected stormwater controls include ground level bioretention systems integrated primarily as landscaping features and rainwater tanks attached to Site buildings to supply select internal water demands.

The inclusion of the rainwater tanks is in indicative and further design work is required to identify the extent to which rainwater tanks can be provided to service buildings. It may also be possible to utilise rainwater tanks to capture rainwater from the stadium roof and reuse water for internal non-potable demands, however, this has not been assessed in this report.

Pollutant export modelling indicates that discharge objectives are not fully achieved. This is largely attributed to the dominance of the stadium roof ‘source’ in the overall Site and inability to ‘treat’ or mitigate this runoff prior to off-site discharge to the River Derwent. While stadium roof runoff may be considered relatively ‘clean’ compared to some stormwater sources it has a significant influence on the modelled outcomes.

Water quantity controls are not specifically required for the Site and are unlikely to be necessary given the likely tidal discharging of stormwater from the Site to the River Derwent. Stormwater servicing assessments of existing drainage infrastructure around the Site indicate that the relevant flows can adequately be managed through existing infrastructure without further attenuation.

The stormwater controls selected for the Site may assist in achievement of Green Star Communities ratings as applicable under the ‘Integrated Water Management’ category.

Overall, the assessment outlined in this report is high-level in nature, commensurate with the available level of Site planning and specification. Sufficient space exists on Site for the integration of the bio-retention style systems and provided that the Site is being fully designed and built, the integration of these proposed controls should be achievable. Additional design and assessment will be required in relation to the potential inclusion of rainwater collection system outlined indicatively herein.

Contents

Tables

Figures

1 Introduction

The Macquarie Point Development Corporation (DPDC) is proposing to construct the Macquarie Point Multipurpose Stadium development within develop the Macquarie Point site. In February 2024 the Tasmanian Planning Commission (TPC) released final guidelines for the Macquarie Point Multipurpose Stadium development under the Project of State Significance process.

This report responds to Section 8.5 of the guidelines related to 'Water Quality and Water Management'. These guidelines require the identification and description of the potential effects of the design and operation of the proposed project (facility) on the site's and surrounds hydrology, water quality and stormwater drainage. The report is to describe management strategies for:

- water/stormwater treatment
- water/stormwater management
- environmental impacts.

This Stormwater Management Plan provides comprehensive information relevant to the assessment in the following sections:

- Project Overview and site characteristics (Section 2)
- Relevant objectives and performance requirements (Section 3)
- Stormwater Management Opportunities and Constraints (Section 4)
- Stormwater Management Options and Assessment (Section 5).

The report considers the development of the wider Macquarie Point Precinct in addition to the Multipurpose Stadium component.

2 Project Overview and Site Characteristics

2.1 Project Overview and Governance

Macquarie Point is a 9.3 hectare site (hereafter referred to as the 'Site'), comprising largely reclaimed land located between Hobart's CBD and the River Derwent. The Site connects the Hobart Central Business District with the green heart of the city on the Queens Domain, the Hobart Cenotaph and the inner-city cycleway and Tasman Bridge. Until approximately 10 years ago, the main part of the Site was formerly utilised as a railyard.

The Principal (i.e. Macquarie Point Development Corporation – MPDC) is a statutory corporation that was established through the *Macquarie Point Development Corporation Act 2012* and is responsible for the remediation, redevelopment and transition of the Site into a vibrant mixed-use precinct. The MPDC is the landowner of the Site.

The Site is a mixture of original and reclaimed land, with the original shoreline sitting to the west of the Site. This was home to the Muwinina people for many thousands of years.

The MPDC's vision is to build the Macquarie Point Precinct into a place to gather, celebrate and reflect, through the arts, culture, sport, events and entertainment. This includes the creation of a mixed-use precinct that is accessible to all people, offers vibrant experiences and destinations, and contributes to the delivery of the 30-Year Greater Hobart Plan.

The MPDC has developed a Precinct Plan that sets out the planned development and zones for the Site.

The development of the Site will consist of multiple integrated projects delivered in stages over a number of years. This includes the development of a multipurpose stadium as part of stage 1.

The MPDC has also been charged with developing the design, seeking the necessary approvals, and constructing and delivering the multipurpose stadium. It will be developed working closely with Stadiums Tasmania, a Tasmanian Government statutory authority which will be the future owner and operator of the stadium.

2.2 Site Location

The Site is bound by Davey Street to the west, Evans Street to the south, Hunter Street and Macquarie Wharf 3 and 5 to the east with Hobart Cenotaph to the north. The Site consists of the following proposed components of development as shown in Figure 2.1 below:

- Multipurpose Stadium and associated concourse zone
- Aboriginal culturally informed zone
- Antarctic facilities zone
- Complementary integrated mixed-use zone

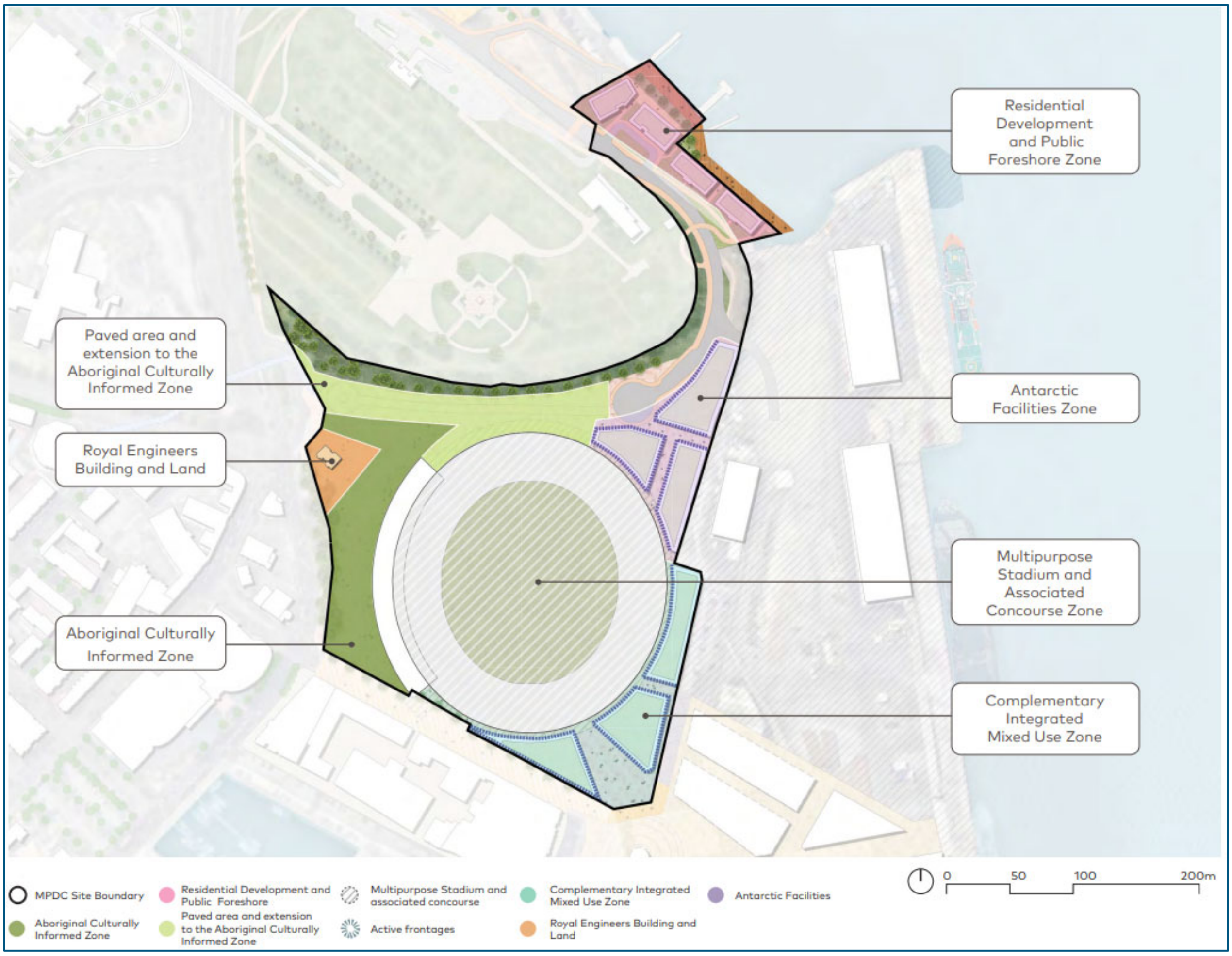


Figure 2.1 Components of Macquarie Point Precinct (Source: MPDC, 2023)

2.3 Existing Site Description

The Macquarie Point Precinct is primarily reclaimed land historically utilised for several industrial purposes and up until 1978 included the Hobart Gasworks, passenger and freight rail services and fuel storage. Following the closure of Hobart Gasworks in 1978 the Site was primarily utilised for rail services up until 2014. Since 2014 the Site has been subject to significant remediation works due to contamination resulting from previous operations. The Site is currently utilised for limited commercial use.

2.4 Proposed Development

The proposed development involves the remediation, redevelopment and transition of the Project Site into a mixed-use precinct. It is understood that the precinct will include:

- 23,000 seated roofed stadium acting as a multipurpose sporting, arts, events and entertainment facility. The stadium also provides facility for an additional 1,500 standing patrons.
- Public Open Space including an Aboriginal culturally informed zone;
- Mixed zoned comprising restaurants, cafes, hotels, medical facilities and commercial office space;
- Antarctic facilities including commercial spaces and connections; and
- Residential area, new public promenade and food and beverage offerings at Regatta Point.

The Project Site will be accessed via active frontages encouraging pedestrian activity, Evans Street and proposed connecting road to the north via the Residential Development and Public Foreshore Zone.

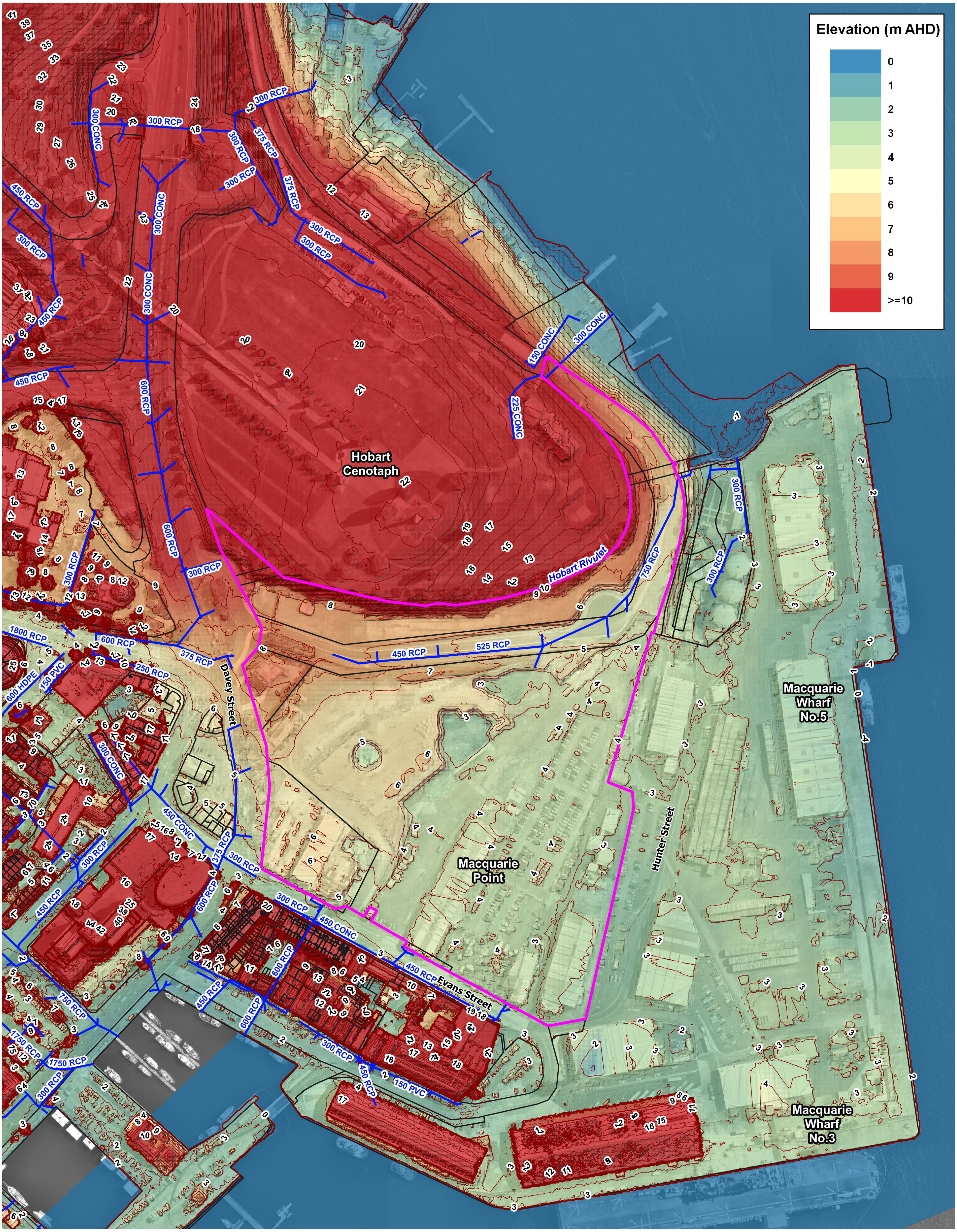
2.5 Site Topography and Drainage

Figure 2.2 below illustrates the topography of the Macquarie Point Precinct. The Site generally grades from the north-west to the south-east. Existing ground levels at the Site range from 9.3 m AHD in the north-west to 2.8 m AHD in the south-east. Runoff at the Site generally traverses the Site in a south-easterly direction with overland flow discharging to the River Derwent through the TasPorts site to the east.

Existing drainage at the Site consists of several catchments (shown in Figure 3.1) serviced by:

- A single 300mm diameter pipe increasing to a 750mm pipe towards the northern boundary of the Site. This pipe discharges to the River Derwent at the Rivulet.
- A single 300mm diameter pipe immediately west of the Site along Davey Street which discharges to Victoria Dock south of the Site.
- Two 300mm diameter pipes and one 225mm diameter pipe, servicing existing structures along the southern boundary of the Site connecting to a 450mm diameter pipe on the southern side of Evans Street and traversing beneath Sullivan Cove Apartments which also discharges to Victoria Dock.
- Existing stormwater services through the TasPorts site are being progressively investigated and refined.
- A single 300mm diameter pipe immediately west of the Site along Davey Street which discharges to Victoria Dock south of the Site.

It is expected that the existing drainage infrastructure is largely utilised for the proposed development.



Legend

- Stormwater Drainage Network
- Contours @ 1m Interval
- Cadastre

Title:

Site Topography and Stormwater Drainage Network

Drawing: 2-2

Rev: A

BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 60 120 m

BMT

www.bmt.org

Filepath: I:\003353_I_MPDC_WQ\QGIS\003353_Macquarie Point_Site Location Map.qgz

2.7 Flooding

While the Site is ultimately located within the River Derwent Catchment and Hobart City Council Local Government Area (LGA), flood conditions for the Site are contributed to by the Hobart Rivulet, a local catchment with headwaters in the Hobart hinterland and which flows through the city via a series of open channels and underground pipes.

Flood conditions at the Site are currently defined by the 'Greater Hobart Catchment Flood Hazard Study' (Cardno, December 2019) and 'Hobart Rivulet Flood Study 2013' (Entura, February 2014).

Council's online mapping indicates that the Site is subject to 1% AEP flooding across areas of its southeast boundary in the vicinity of Evans Street. An extract of this mapping is provided in Figure 2.3 below. An additional assessment being completed by BMT concurrent with this assessment that aims to update the previous flood studies with the latest underlying information and methodologies.

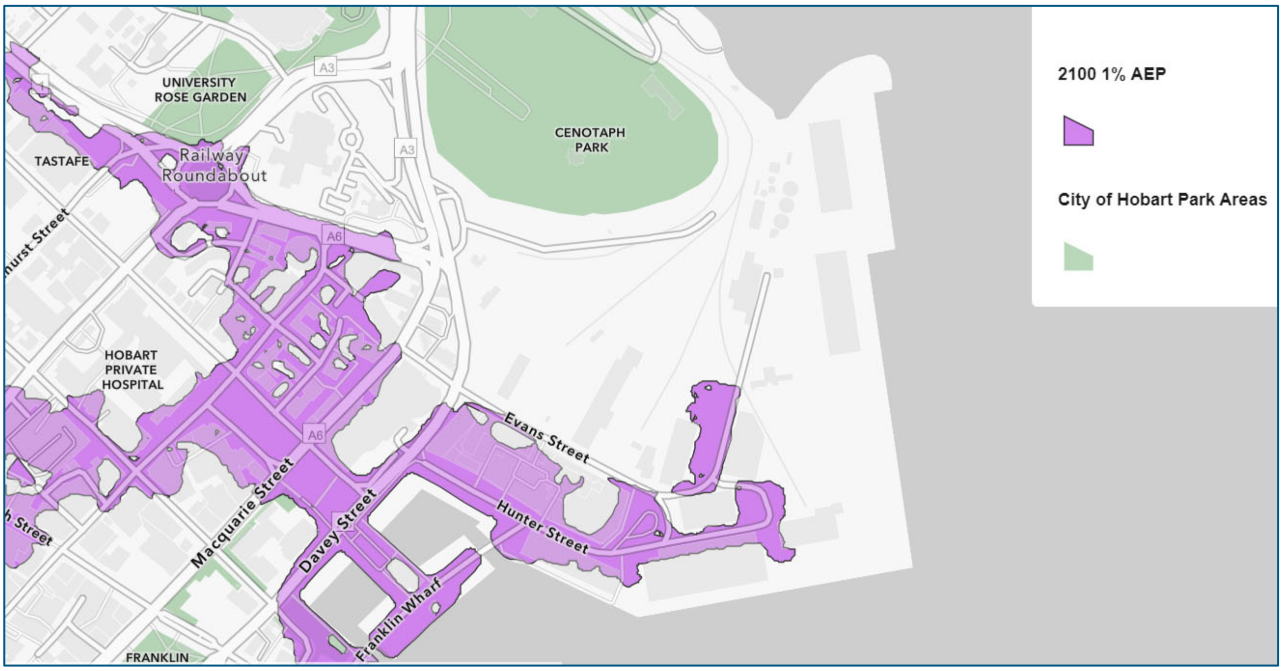


Figure 2.3 Council's Flood Mapping (Source: City of Hobart: Potential Inundation Areas)

2.8 Ecology

Previous land uses coupled with the current remediation works has resulted in significant impact to the Site. The Macquarie Point Precinct is primarily impermeable surfaces consisting of buildings, concrete and bitumen. The Site has a history of significant disturbance resulting in substantial impacts to ecological diversity and value across the Site.

Consideration to the disposal of waste produced during remediation and construction is assumed to be considered in earlier assessments.

2.9 Soils and Groundwater

Given the history of land reclamation involved in the initial development of Macquarie Point, the Site and surrounding areas are recorded to have significant fill and is described as generally *“local materials sourced from quarries (gravel, cobbles and boulders), possibly dredged deposits (Sands, silts and clays), including some anthropological waste (Bricks, concrete blocks, metal, timber, glass, coal and pottery)”* (WSP, 2024). The depth of fill increases as distance from the natural shoreline increases, consistent with reclamation activities.

Beneath the existing reclaimed land, the natural soil types are predominantly silty sands and dolerite. The WSP study refers to estuarine (typically silts and clays) and alluvial (gravels, cobbles and boulders) deposits above a layer of dolerite and states *“The thickness of estuarine and alluvial deposits has a maximum value of 18 m at the southern extent of the site. These natural soils are absent over the Northern part of the site”*.

Excavation activities conducted on the Site has had to contend with groundwater in fill primarily across the Site. The WSP study indicates *“Groundwater has been observed in boreholes across the site typically 2 m to 3 m below ground level – inferred to be at or about 1 m above mean sea level”.*

2.10 Contamination

The Macquarie Point precinct has been subject to extensive investigation considering contamination of the Site. Given the historic activities conducted at the Site it is well documented that the potential for subsurface contamination is high. As a result, operations at the Site have involved significant remediation works generally involving the removal and disposal of contaminated material.

The potential for ‘liquid emissions’ to stormwater at the Site are presently unknown and have not been considered in this report. The report focuses on only a few key stormwater pollutants (total nitrogen, total phosphorus and total suspended solids) that are commonly found in urban stormwater runoff and are quantifiable for the purposes of the assessment. It is expected that other ‘liquid emissions’ will be managed via separate systems, e.g. trade waste discharge or other on-site management and control approaches and will not enter the Site’s stormwater management system.

2.11 Receiving Water Environment

Water quality within the state of Tasmania is governed through application of two legislative controls, the State Policy on Water Quality Management 1997 (referred to as State Policy) and *Environmental Management and Pollution Control Act* 1994 (EMPCA).

In consideration of the Macquarie Point precinct, the River Derwent defines the receiving water body, specifically the lower River Derwent.

A primary objective of the State Policy is to define protected environmental values (PEVs), including current uses and values, for all Tasmanian surface waters. PEVs for the Derwent Estuary are defined in ‘Protected Environmental Values for the Derwent Estuary’ (Environment Protection Authority Tasmania, December 2003). Table 2.1 below defines the PEVs for the River Derwent between Tasman Bridge and Tinderbox/South Arm.

Table 2.1 Protected Environmental Values for the River Derwent

PEVS for Lower Derwent	Description of PEV
Protection of Aquatic Ecosystems	Protection of modified (not pristine) ecosystems from which edible fish, crustaceans and abalone, but not other shellfish, are harvested, and having particular regard to various ecological values (EPA Tasmania, December 2003)
Recreational Water Quality and Aesthetics	Primary contact water quality Secondary contact water quality Aesthetic water quality

Physical (discarded debris, temperature, turbidity), chemical (pH, dissolved oxygen, heavy metals, hydrocarbons) and microbial (E. coli and enterococci) contaminants can significantly influence the quality of River Derwent and contributing waterways in regard to the PEVs. Monitoring of such water quality characteristics provides insights to the health of the river system.

The City of Hobart conducts frequent testing to assess the health of contributing waterways, including the Hobart Rivulet. Published results[1] of the testing conducted has determined a grading of Poor for the Hobart Rivulet suitable for either primary or secondary contact.

[1] Stormwater quality data - City of Hobart, Tasmania Australia (hobartcity.com.au)

3 Stormwater Objectives and Modelling Overview

3.1 Statutory Setting

The Macquarie Point Multipurpose Stadium has been declared a Tasmanian Project of State significance. Developments of this nature are assessed under the *State Policies and Projects Act 1993*. As such, the independent Tasmanian Planning Commission oversees the assessment and approvals process.

Under s20(5) of the *State Policies and Projects Act 1993*, the assessment of a project of State significance must, amongst other things, 'be undertaken in accordance with State Policies'. Several State Policies have been made under the State Policies and Projects Act 1993 to further strategic policy direction on matters of State significance. These are typically related to environmental and planning matters and are implemented through the planning, development and regulatory systems.

One such State Policy, called the State Policy on Water Quality Management (1997) establishes a framework for the development of ambient water quality objectives and the management and regulation of point and diffuse sources of emissions to surface waters (including coastal waters) and groundwater.

Within the State Policy on Water Quality Management (1997) stormwater discharges (from development) are regarded only as diffuse (i.e. non-point) source discharges. Both point and diffuse source emissions to water should enable the achievement of WQOs for the receiving waters.

Clause 31.3 of the State Policy on Water Quality Management (1997) allows for the 'Board' to develop best practice guidelines for stormwater management. The Board is a reference to the Board of the Tasmanian Environment Protection Authority (EPA). In this regard the EPA prepared the 2010 State Stormwater Strategy, which has the following operational (discharge) targets[2]:

- 80% reduction in average annual load of TSS
- 45% reduction in average annual load of TP
- 45% reduction in average annual load of TN

It is noted that these are preferred targets and alternatives can also be set where it can be established the alternatives do not prejudice the achievement of local receiving water WQOs. There are no specific operational stormwater (discharge) quantity-based targets.

The requirements for quantitative discharge control on the Site would likely be unnecessary given that the Site will primarily discharge stormwater to a tidal waterway via piped stormwater systems. There are also no natural waterways on the Site which runoff from the Site may impact.

The State Policy on Water Quality Management (1997) does not provide specific construction quality targets; rather, the focus is on implementing best practice management techniques.

The operational discharge targets are also reflected in the Tasmanian Stormwater Policy Guidance and Standards for Development (DEP &LGAT (2021). These guidelines extend the State Policy on Water Quality Management (1997) to include a 90% reduction in average annual load of litter/gross pollutants. This document is not a guideline for the purposes of the Policy on Water Quality and is not binding.

[2] These targets are based on typical urban stormwater concentrations for TSS, TN and TP.

3.1.1 Stormwater Discharge Objectives Summary

The statutory setting of the project indicates that the following discharge objectives for the operational stage of the Site would be applicable.

- 80% reduction in average annual load of TSS
- 45% reduction in average annual load of TP
- 45% reduction in average annual load of TN
- 90% reduction in average annual load of litter/gross pollutants (non statutory)

Treated stormwater discharges from the development should also enable the achievement of WQOs for the receiving waters, i.e. the River Derwent adjacent the Site. Generally, the achievement of operational stage discharge criteria is taken as being sufficient to demonstrate compliance with receiving water WQOs (refer to Section 2.11 for further details).

There are no specific water quantity objectives applicable to the development. This requirement is likely appropriate given tidal discharge from Site will be targeted, and lack of any waterways for Site runoff to enter.

3.2 Green Star Communities Accreditation

Macquarie Point Multipurpose Stadium as part of the overall Macquarie Point Precinct will support achievement of the Green Star Communities Accreditation. This accreditation will demonstrate the Macquarie Points Development Corporation’s focus on achieving best practice development outcomes across the site.

As the Precinct covers a variety of end uses, of which the Stadium is a component (albeit a significant component), the Green Star related requirements will be embedded in a set of Urban Design Principles (UDP) that will support these future developments across site.

Green Star Communities are independently verified and benchmarked by the Green Building Council of Australia. Accreditation is a way to formally recognise the achievement of best practice sustainability outcomes for developments.

3.2.1 Specific Water Related Credits

Item 24B of the Green Star Communities Accreditation deals with the Integrated Water Cycle. Three credits are available in this category as outlined below:

1. 24B.1 Alternative Water Sources - Public Open Spaces. Alternative Water Sources – Public Open Spaces: 1 point is available where all water used in public open spaces and public realm areas is sourced from alternative water sources.
2. 24B.3 Stormwater Peak Discharge - Stormwater Peak Discharge: 1 point is available where the post-development peak Average Recurrence Interval (ARI) event discharge from the project site does not exceed the pre-development peak ARI event discharge.
3. 24B.4 Stormwater Quality - Stormwater Quality: 1 point is available where receiving water quality is protected by limiting the quantity of key pollutants discharged in stormwater. This is based on a percentage reduction of sediment, phosphorus, nitrogen, and litter compared to untreated runoff.

In respect of Point 2, and as noted in Section 3.1 management of stormwater quantity including peak flow is typically not required for development discharging into a tidal waterway. The management of peak flows and quantity is most relevant where discharges from a development may affect overland flow systems, particularly hydrology of natural stream and waterways and contribute to the potential for flooding.

It is expected that the development will discharge minor flows via piped stormwater systems direct to the River Derwent. Major flows will similarly be directed towards the River Derwent via overland flow paths designed to limit potential flood impacts on building assets and human receptors.

It is noted that the inclusion of rainwater harvesting may assist in reduction of peak flows from the Site by either retaining flows within a storage for reuse and or slowing the discharge of stormwater from the Site.

3.3 Stormwater Quality Modelling Overview

3.3.1 Model Description

Stormwater quality modelling has been undertaken to estimate the hydrology and load of common stormwater pollutants (i.e. TSS, TP and TN) generated by the site using the Model for Urban Stormwater Improvement Conceptualisation (MUSIC) to allow comparison with Site performance objectives.

MUSIC includes algorithms to evaluate the hydrology and concentrations / loads in stormwater runoff from urban catchments as well as estimate the performance of selected stormwater management measures to capturing these pollutants and achieve load and/or concentration reductions in discharges of stormwater.

MUSIC was designed to continuously simulate urban stormwater systems over a range of temporal and spatial scales utilising historically representative rainfall data. MUSIC is considered within the engineering industry to be an appropriate conceptual design tool for the analysis of runoff water quality in the urban environment.

The hydrologic algorithm in MUSIC is based on the model developed by Chiew & McMahon (1997). The model simplifies the rainfall-runoff processes and requires input of the following variables to perform the hydrological assessment:

- Rainfall data (time steps varying from 6 minutes to 1 days);
- Areal potential evapotranspiration (PET) rates;
- Catchment parameters (area, % impervious and pervious areas);
- Impervious and pervious area parameters (rainfall threshold, soil and groundwater parameters); and
- Storm event and base flow stormwater pollutant concentrations.

MUSIC can be applied for comparison of alternative scenarios that adopt the same base inputs. Although the magnitude of the estimates may not be equivalent to actual site conditions (due to limitations in available data for a particular site), the relative differences between scenarios is expected to be appropriate for decision making.

The MUSIC modelling approach applied to estimate stormwater pollutant loads for the Site is described in the following sections.

It should be noted that MUSIC modelling approaches have followed those recommended within the MUSIC Guideline developed by Melbourne Water (2023). This version is expected to be used from July 2024 as the older guidelines are retired. It is referred to as the '*MUSIC guidelines'* in the following sections.

3.3.2 Rainfall and APET

The meteorological template includes the rainfall and areal potential evapotranspiration (APET) data and forms the basis for the hydrologic calculations within MUSIC.

The nearest Bureau of Meteorology (BoM) continuously recording rainfall station is located at Ellerslie Road in Hobart (Station 094029) approximately 1 km southwest of the Site. The station is elevated at 50.5m above sea level and is such has close geographic reference to the Site and is suitable for use. Within MUSIC, pluviographic rainfall data is available for this station from 1911 to 2010.

A review of daily rainfall data from the Bureau of Meteorology for this station (with daily data extending from 1882 to 2023) indicates that average annual rainfall is 611.5mm with a median annual rainfall of 595mm.

A 10-year simulation period has been adopted extending from 1/1/1991 to 1/1/2001. During this period mean annual rainfall (available in the pluviographic record) was noted at 537 mm. The equivalent 10-year daily rainfall record average from the same station was calculated 562 mm. While some difference exists between the two records it is less than 5% and is considered suitable for use in MUSIC modelling.

Average monthly areal potential evapotranspiration (PET) rates adopted for the MUSIC modelling are summarised in Table 3.1. These values are standard for Hobart in MUSIC.

A 6-minute time step has been adopted for the MUSIC modelling in accordance with the MUSIC guidelines and on account of the subject Site having a relatively small area.

Table 3.1 Adopted Average Monthly Areal PET Rates

Month	Mean daily areal PET (mm)
January	4.35
February	3.57
March	2.42
April	1.50
May	0.97
June	1.00
July	0.97
August	1.45
September	2.00
October	3.39

Month	Mean daily areal PET (mm)
November	4.00
December	3.87

3.3.3 Land Use

MUSIC modelling has been completed based on the proposed use of the Site. This includes land use proposals outlined in the Macquarie Point Precinct Plan (refer to Figure 2.1) not just the proposed stadium.

The proposed site land use will differ significantly from typical urban residential and for the purposes of MUSIC a split modelling approach will be applied which effectively considers Site land use as being either roof, road or other urban area in accordance with the MUSIC guidelines.

The allocation of the proposed Site into these categories is shown in Figure 3.1.

3.3.4 Soil Parameters

Soil (rainfall-runoff) parameters to adopt are outlined in the MUSIC guidelines. The guidelines recommend use of the default MUSIC parameters ensuring that the following are adjusted as follows:

- Soil storage capacity = 120 mm; and
- Field capacity = 50 mm.

These adjustments have been made to the MUSIC model.

3.3.5 Runoff Quality Parameters

MUSIC requires stormwater constituent concentrations for storm flow and base flow for the site's land uses. These concentrations are converted to logarithmic values for input into MUSIC. The $\log_{10}$ values recommended in the MUSIC guidelines for a split catchment modelling approach are summarised in Table 3.2.

Table 3.2 Split Land Use Concentration Parameters (mg/L-log10)

Pollutant	Surface type	Storm flow (log mg/L)		Baseflow (log mg/L)	
		Mean	**Standard Dev.**	**Mean**	**Standard Dev.**
TSS	Roof	1.301	0.333	n/a*	n/a
	Road	2.431	0.333	n/a	n/a
	All other urban areas	1.882	0.333	0.96	0.401
TP	Roof	-0.886	0.242	n/a	n/a
	Road	-0.301	0.242	n/a	n/a
	All other urban areas	-0.680	0.242	-0.731	0.360
TN	Roof	0.301	0.205	n/a	n/a
	Road	0.342	0.205	n/a	n/a
	All other urban areas	0.224	0.205	0.346	0.309

* n/a indicates that baseflow does not occur from these surfaces

Legend

- Cadastre
- Site Boundary
- Roof surface
- Road surface

Title:

Land use and Development layout

Drawing: 3.1

Rev: A

BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N 0 60 120 m

BMT
www.bmt.org

Filepath: I:\003353_I_MPDC_WQ\QGIS\003353_Macquarie Point_Landuse.qgz

4 Opportunities and Constraints

This section identifies site opportunities and constraints for stormwater management. The opportunities and constraints were identified in consideration of existing site conditions, and the intended future use of the site.

4.1 Opportunities

Some of the key opportunities identified for this Site include:

- Use of rainwater capture for reuse to offset potable water demand with compatible reuse options (aiming to match collected water quality with reuse type suitability). There may be potential to capture runoff from roof areas of buildings (subject to design configurations), capture and reuse from the stadium roof may also be possible subject to further design, but has not been included as an option in this assessment.
- The existing and proposed Site design generally has gentle gradients (e.g. 1 to 3%) across the Site which are generally favourable for application of a range of stormwater management controls. As the Site's ground surfaces are still be determined, it will be possible to work with the existing natural landform and grade finished surfaces towards stormwater at-grade infrastructure. This promotes the practice of 'treatment-at-source'.
- The Site is expected to have a high degree of human use and associated high degree of foot-traffic and as such will be dominated by hardstand areas to facilitate this. The future landscaping intent of the Site is unknown, however, it is expected that ground level surfaces (i.e. roads and pedestrian spaces) will be extensively broken-up with landscaping features. As identified above, finished Site surfaces should be able to direct runoff from hardstand towards at-grade stormwater infrastructure, which could include extensive use of bio-retention systems. These systems are ideal, due to their flexible design configurations, space efficacy and ability to be planted with attractive, yet effective planting types that assist in stormwater treatment. Bio-retention systems are also adaptable to local climatic conditions and can have multiple drainage configurations that account for subgrade and subsoil conditions (i.e. be free draining or not) and make use of submerged zones to assist in plant survival during dry periods.

4.2 Constraints

Some of the key constraints identified for this Site include:

- Avoidance of water management infrastructure in sensitive use areas of the Site such as the Aboriginal culturally informed zone. This zone is an extent of land to the immediate west of the Stadium.
- Observation of below ground conditions and potential constraints provided current and ongoing Site remediation.
- Previous studies have identified the presence of variable fill and rock in the sub-ground may be a possible constraint to the placement of some infrastructure types (i.e. construction of infrastructure in the ground that may require new excavation) and those that relay of the use of infiltration into subsoils.
- Minor flows will primarily be discharged from the Site via existing stormwater infrastructure to the tidal River Derwent. Existing stormwater infrastructure exists within and adjoining the Site. Capacity constraints of this existing infrastructure will need to be observed during progressive Site design stage. New or augmented piped stormwater systems may be required to convey stormwater from the Site. This is not necessarily a constraint, but an ongoing design consideration and requirement.

5 Stormwater Assessments

The following sections provide the stormwater quality assessments.

5.1 Model Preparation

The process for preparing data for models has included:

- review of Site investigation data and proposed Site development.
- preparation and review of GIS data for the existing site and the post-developed site, particularly topographic, drainage and land use information.
- consideration of potential sites for placement of stormwater quality devices based on proposed future land use and knowledge of areas to avoid.

It is noted that the development concept is at the Master Plan conceptual stage and associated with this, commensurate assumptions regarding aspects of the development outcome have been required to inform this conceptual stormwater assessment.

5.2 Developed Unmitigated Site Model

Without providing exhaustive information on the above model preparation steps, Figure 5.1 illustrates the developed (unmitigated) site catchment and land use for the purposes of modelling in accordance with the MUSIC guidelines. Ground level land use is shown in orange, roof in reds and road in grey colouring.

Limited drainage from upstream areas passes through the Site. In the north of the Site a portion of the Hobart Cenotaph drains towards the Residential Development and Public Foreshore Zone. It is unknown if these flows will drain overland through the Site or be collected and diverted via stormwater infrastructure to the River Derwent. Some of the Hobart Cenotaph is already drained to the River Derwent by underground stormwater services. For the purposes of this conceptual modelling, it has been assumed that upstream flows bypass the Site.

The Site is divided into several catchments. The catchments have been identified through the Site's Infrastructure Strategy (JMG 2024) and utilises capacity in existing drainage systems surrounding the Site. The catchments included in the MUSIC model have been extended to provide coverage across the full extent of the Macquarie Point Precinct. The external catchment within Hobart Cenotaph is shown but is excluded from MUSIC modelling currently. The receiving node is the River Derwent.

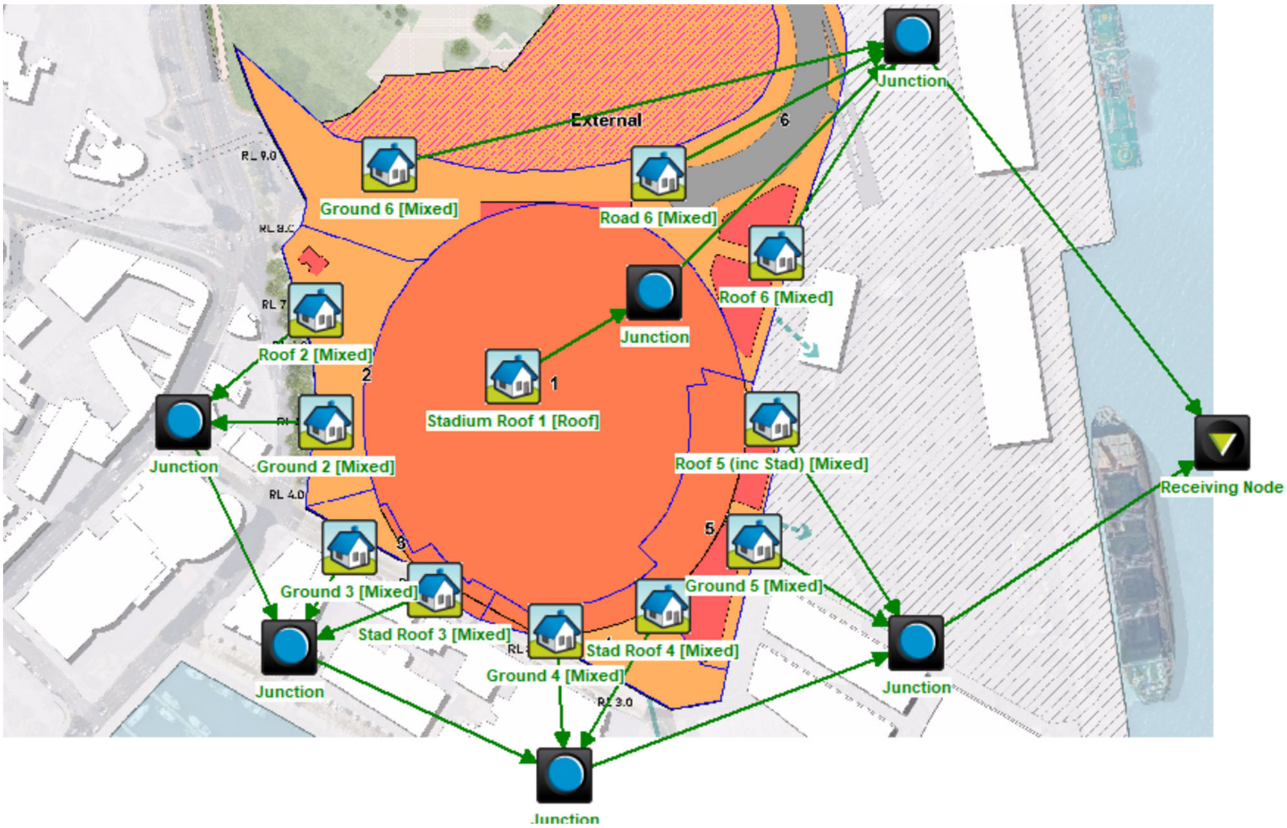


Figure 5.1 MUSIC Model Catchment (Developed Unmitigated Site)

5.2.2 Land Use Assumptions

The following division of land use and imperviousness has been applied for the developed Site as outlined in Table 5.1.

Table 5.1 Land Use Assumptions Developed Site

Land Use Category	Area (Ha)*	%Imperviousness	Notes
Roof	6.04	100	Dominated by stadium and building roofs
Road	0.61	100	Macquarie Point Road / Northern Access Road
Ground	3.54	varies	Catchment 1 – 0% (stadium roof) Catchment 2 – 20% dominated by Aboriginal Cultural Informed Area Catchment 3 – 80% Catchment 4 – 80% Catchment 5 – 80% Catchment 6 – 40% Accounts for retained existing and proposed vegetated extents

* Total modelled site area is 10.19 ha

Overall, the Site has a dominance of 'roof' land use due to incorporation of the very large impervious stadium roof. There are practical limitations in reducing pollutant loads from this large roof expanse.

5.2.3 Developed Unmitigated Site Results

Developed unmitigated modelling results are provided in Table 5.2. Loads from the stadium roof have also been included to illustrate the dominance of the stadium roof source in total site pollutant export as a total annual load and as a percentage of the total site annual load.

Table 5.2 MUSIC Modelling Results – Developed Unmitigated Site

Pollutant	Total Annual Loads Existing Site (unmitigated)	Stadium Roof Loads (unmitigated)
Flow (ML/y)	36.6	22.0 (60%)
Total Suspended Solids (kg/yr)	2,300	575 (25%)
Total Phosphorus (kg/yr)	7.46	3.33 (45%)
Total Nitrogen (kg/yr)	79.6	48.2 (60%)
Gross Pollutants (kg/yr)	1,390	827.6 (60%)

5.3 Selection of Stormwater Management Measures

The process of selecting potential stormwater management measures has been to primarily avoid known site constraints and take advantage of identified opportunities (as per Section 4). Some of the key considerations in selecting and siting potential management measures have included:

- Presence (or likely presence) of suitable gradient across the Site that will assist in Site drainage.
- Presence (or likely presence) of available space to effect treatment. Generally, there is likely to be ample space to accommodate required stormwater treatments.
- Presence (or likely presence) of subsurface features which may restrict treatment options including services, groundwater, etc. Many of these require further investigation and confirmation. Where practical options for design of stormwater systems are presented once further information is known.
- Presence of ecological, archaeological, cultural, or ecological constraints necessitating setbacks and exclusions.
- Visual appearance of the selected infrastructure in the environment and likely compatibility.
- Ability to access and ease of maintenance.

5.4 Developed Mitigated Site Model

For the purposes of MUSIC modelling the following approach and assumptions have been employed:

1. The stormwater assessment is high-level and further design and assessment stages will be required as the project progresses. The assessment aims to identify the performance of the suggested approach against the Discharge Objectives and that sufficient space is likely to be available to accommodate required infrastructure.
2. In lieu of detailed information, it has been assumed that building roof areas are fully collected and drained to treatment options such as rainwater tanks. However, this may be an unachievable or unnecessary design requirement.

3. While smaller distributed treatment systems may be required to manage Site runoff, these have been aggregated into larger combined treatment systems for ease of modelling. The design is insufficiently progressed to allow suitable representation of small distributed systems and associated sub-catchments. Additionally, various 'good' design attributes have not been included in the assessment at this conceptual level, such as high flow diversion and coarse sediment pre-treatment for bio-retention systems. The inclusion of these features would occur at a later detailed design phase (if they are required based on adopted designs) and would be expected to improve stormwater system performance, reduce maintenance and increase longevity.
4. Access to all treatment systems will be required for maintenance. Allowance for this access will be determined during detailed site design and it is not considered in detail in this assessment.

5.4.1 Stormwater Quality Measures

A variety of stormwater management measures have been integrated into the existing case MUSIC model as treatment nodes. Selected measures include:

- Bio-retention systems; and
- Rainwater storages for reuse (included for buildings).

The stormwater management measures selected for the developed site are described further in the following sections.

5.4.2 Rainwater Harvesting

The ability for the development to effectively integrate rainwater collection and reuse systems (for Site buildings and potentially the stadium roof) cannot be fully determined at this early design phase of the Site. It is a recommendation of this assessment that so far as practicable rainwater collection and reuse does occur to assist in meeting Discharge Objectives for water quality, as well as offsetting potable water demands from regional supplies. Achievement of these criteria should further the Green Star credentials of the proposed development.

Stadium

This has been excluded from assessment at this time, however, it is noted that collection and reuse of rainwater from stadium roofs is relatively common practice, and several stadiums across Australia, e.g. Bankwest Stadium, Marvel Stadium, Stadium Australian, People First Stadium (also known as Carrara Stadium) utilise rainwater collection and reuse systems. These stadiums appear to have generally larger collection tanks ranging from several hundred thousand litres to a couple of megalitres. Reuse types include toilet flushing, and or field irrigation for example.

Future stadium use is being determined, however expected stadium usage is for around 36 to 38 events per year comprising sporting, music and other community events. The future stadium capacity is expected to be around 24,500 persons (23,000 seated with another 1,500 persons standing). Harvested rainwater could be used to supply some of these demands, e.g. potentially non-potable uses such as toilet/urinal flushing where collected water quality should be sufficiently high to avoid need for significant pre-treatment prior to reuse (water may require filtration to remove any entrained sediment).

Further data is required to inform stadium water demands, and if possible, this should be generated from data from other relatively new stadiums of similar size (e.g. People First / Carrara Stadium on the Gold Coast, capacity 27,500) and verified against a first principles consideration of expected water use that considers the number and efficiency of water fixtures provided on the new stadium. Additionally, it will be important to ensure that any excess outflows from the rainwater collection tanks (i.e. overflows) does not generate damaging overland flow opportunities through the Site.

Other Buildings
Rainwater collection tanks have been included in the assessment. Rainwater thanks been applied to capture runoff from all buildings across the Site. Buildings to be provided east of the stadium are generally commercial (not residential) in nature and are expected to be built up to 5 levels.

Residential Buildings

In the north of the Site up to around 4 (waterfront) residential towers are proposed, each also are expected to have up to 5 levels. It is expected that each tower may have up to 4 units per level with lower-level commercial use. For the purposes of this report, it has been assumed that each residential tower will have 20 units (5 levels and 4 units per level) with each unit consisting of 2 bedrooms.

Residential and commercial building water use characteristics vary considerably. Average Water Use Information published by Sydney Water for apartment buildings indicates that 90% of total water use is internal (i.e. less than 10% is used for outdoor uses), and of the remainder of internal water use could be apportioned as follows:

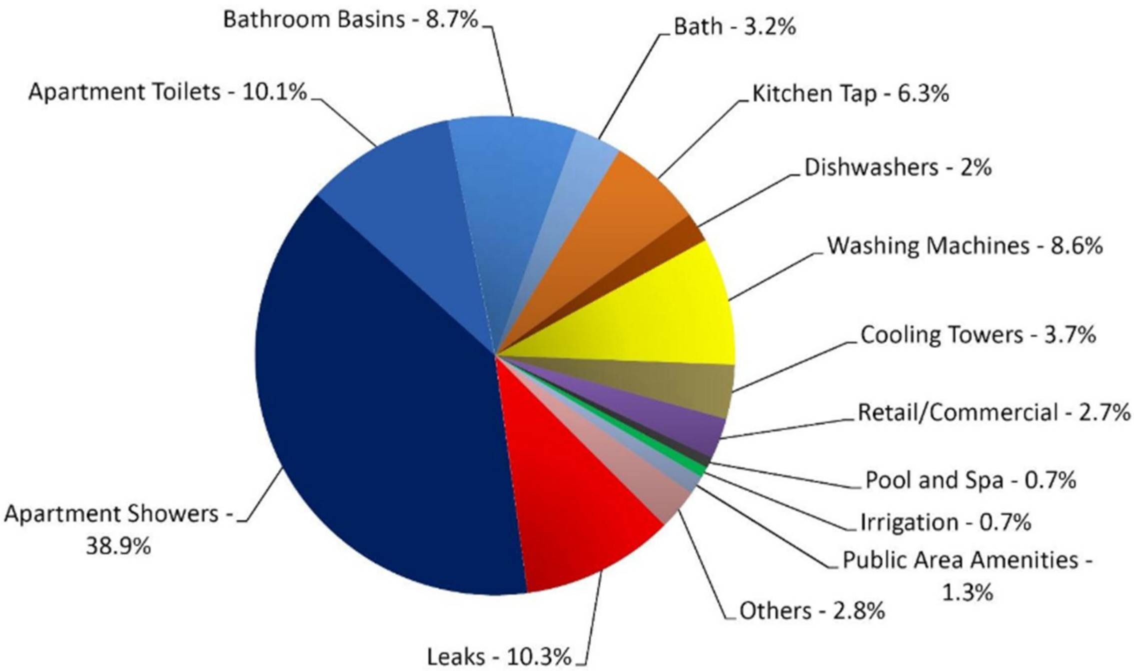


Figure 5.2 Average Water Use Information for Apartment Buildings (Source: BMT, 2011)

Through these investigations, overall water usage benchmarks were established as:

- Higher Use – 300L and higher per bedroom
- Typical – 200 to 300L per bedroom
- Best Practice – Less than 200L per bedroom
- Unachieved Target – Less than 130L per bedroom

Assuming close to best practice water usage is achieved at around 200L/bedroom, this provides a total estimated internal water demand of 8kL/d, or approximately 3,000kL/yr per residential tower. Hence, the estimated combined residential use in Catchment 6 (which has four towers) is 12,000 kL/yr.

Of this total use, it is assumed that as a minimum rainwater could be reused for washing machines and toilets, which is noted to account for approximately 20% of the total water usage. As such annual demand for these two reuse types would amount to 2,400kL/yr combined for all towers.

For the purposes of assessment each 1,000m^2 of roof area of each tower has been assumed to be connected to 20kL of connected rainwater storage and the residential towers have an approximate roof area of 2,500m^2. Reuse rates have been set at constant during the year.

If the rainwater tank runs dry provision for filling the tank or switching supply to town water will be required.

Commercial

Buildings adjacent to the stadium are for commercial usage and are also expected to be 5 storeys. Commercial water usage benchmarks have been developed by Sydney Water (Sydney Water, 2007). While generally applicable to Syndey, it is expected that water usage rates would be similar in Tasmania. The benchmarking values were derived through water use audits of buildings in Sydney, with usage estimates being divided into three classes as shown in Table 5.3.

At this stage it is not known what HVAC systems would be employed for the proposed commercial buildings. It has been assumed that no cooling towers are included. It has also been assumed that the proposed buildings will meet the definition of a 'Very Well Managed Building', which is defined as:

> *"A very well managed building demonstrates an exceptionally low level of water consumption. To achieve this, you will probably need a building with good design, strong management attention to water and the use of long-term technical measures, some of which may not be financially viable on water savings alone"*

Table 5.3 Benchmarks for water efficiency in Sydney office buildings (Syndey Water, 2007)

Benchmark	Offices with cooling towers (kL/m^2/yr)	Offices without cooling towers (kL/m^2/yr)
Median market practice with no leaks	1.01	0.64
Economic best practice (median of implementing water saving projects with two year paybacks)	0.84	0.47
Very well managed building	0.77	0.40

In terms of building size, Catchment 6 has three commercial buildings with a total area of around 3,350m^2 and Catchment 5 has two buildings with around 3,350m^2 total roof area. Based on each being 5 storeys, this provides a total of around 17,000m^2 gross floor area for commercial buildings in Catchments 5 and 6, respectively. Using the water usage rate of 0.4 kL/m^2/yr the commercial building water use in Catchment 5 and 6 is estimated at 6,700kL/yr, respectively. The inclusion of retail tenancies on the ground floor of the building may modify these usage estimates.

Of the total usage demand the benchmarking study identified that the total usage could be broken down as shown in Figure 5.3.

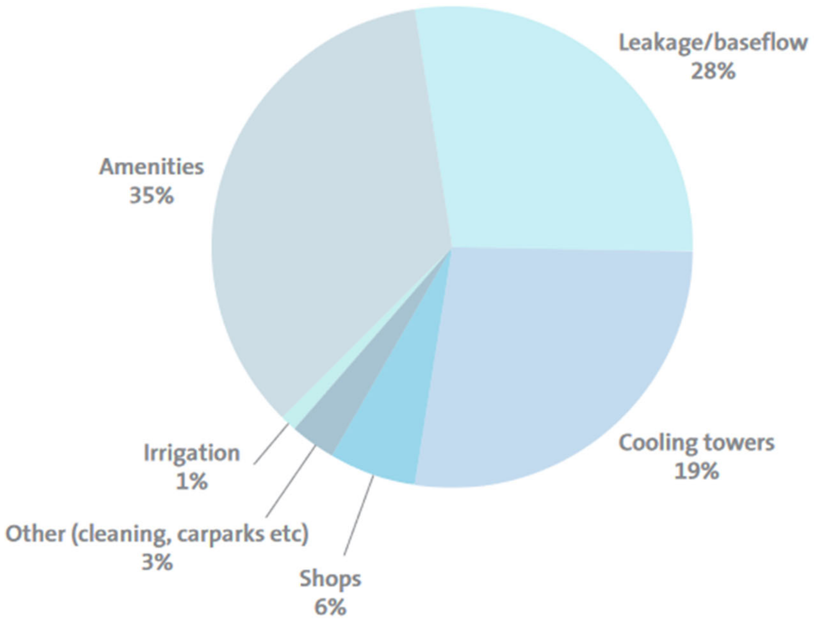


Figure 5.3 Water distribution in a commercial office building (Sydney Water, 2007)

Within MUSIC the rainwater tank has been modelled as attached to the building roof source nodes with parameters as shown in Table 5.4. The breakdown includes cooling towers and does not distinguish what usage types contribute to 'Amenities'. The amenities component of the demand for the commercial buildings in Catchment 5 and 6 is broadly estimated as 2,000 kL/yr, respectively.

For the purposes of assessment each 1000m^2 of roof area of each commercial building has been assumed to be connected to 20kL of connected rainwater storage. Reuse rates have been set at constant during the year. If the rainwater tank runs dry provision for filling the tank or switching supply to town water will be required.

Within MUSIC the rainwater tanks for residential and commercial buildings have been modelled with parameters as shown in Table 5.4.

Table 5.4 Specification for Rainwater Tank (Buildings)

Parameter	RT 5 (Commercial)	RT 6 (Residential)	RT 6 (Commercial)
Low Flow bypass (m^3/s)	0	0	0
High Flow bypass (m^3/s)	100	100	100
Volume below overflow pipe (kL)	70	50	70
Surface Area (m^2)	30	20	30
Initial Volume (kL)	10	10	10
Overflow Pipe Diameter (mm)	200	200	200
Max Drawdown height (m)	2.3	2.5	2.3
Annual Demand	2,000 kL evenly distributed	2,400 kL evenly distributed	2,000 kL evenly distributed

5.4.3 Bio-retention Basins

Landscape Integrated

It is expected that a significant number of bio-retention basins will be integrated into the Site design. The flexible design of bio-retention systems allows for them to be configured in a variety of shapes and sizes, including as linear features adjacent roads and concourses, etc and as basins receiving runoff from particular areas via a conveyance system.

As bio-retention systems can be 'designed' with a variety of shapes, sizes and looks (due to differences in the plantings) they can be integrated into areas and appear simply as landscaping.

Bio-retention systems are space effective treatment options for stormwater in that they require a minimum amount of area to achieve a relatively high degree of treatment. For the Macquarie Point site, it will likely be possible to design areas to drain effectively to integrated (adjacent) bio-retention systems providing for treatment at source which is a best management practice in water sensitive urban design.

Bio-retention systems are adaptable to Site conditions and have multiple drainage configuration options that account for subgrade and subsoil conditions (i.e. be free draining or not) and make use of submerged zones to assist in plant survival during dry periods.

Key design considerations for the bioretention systems include:

- Typically, 'high-flows' are diverted away from bioretention systems, this is done to protect plantings and reduce opportunities for scour of soil media. This is particularly important for bio-retention systems treating larger catchments which receive runoff via pipe or swale conveyance systems. However, if bio-retention systems are employed in smaller scales (i.e. smaller catchments), it is possible that runoff can be directed into the bio-retention system without high flow diversion. Examples may include linear roadway bio-retention systems that receiving runoff along their length.
- For larger basin style bio-retention systems, these should be designed to include sediment forebays to capture coarse sediment and prolong the life of the system prior to the need for system renewal. Alternatively, coarse sediments, litter and gross-pollutants can also be captured by pre-treatment systems such as gross-pollutant traps located on drainage lines (i.e. typically stormwater pipes) upstream of them.
- The bio-retention systems will necessarily have overflow pits to take water out of the basins once they reach a threshold level. The basins should also contain an overflow weir to direct excess flows out of the basin once water levels reach the weir level.
- The bio-retention basin may or may not be able to infiltrate water to subsoils. This will depend on the capacity of the subsoils at the location to infiltrate water, i.e. taking into consideration saturated hydraulic conductivity of the surrounding soils and local groundwater profile. Other practical considerations for the Macquarie Point site that may influence this design consideration include risk of infiltrated waters becoming contaminated or of the bio-retention system becoming contaminated.
- The site's stormwater systems should be free draining and not affected by tidal influences from the River Derwent.
- The bio-retention basin should be planted out in suitable species for nutrient retention and uptake. Appropriate species selection will occur during later design stages but should utilise endemic species that are suitable in the design environment and that meet aesthetic requirements. Examples of planting options are included in the Derwent Estuary Program's WSUD Procedures.
- Bio-retention systems have been provided at the typical rate of 5% of the ground level land use area in each catchment.

Properties for the bio-retention system are provided in Table 5.5.

Table 5.5 Specification for bio-retention systems

Parameter	BR 2	BR 3	BR 4	BR5	BR 6
Low Flow bypass (m^3/s)	0	0	0	0	0
High Flow bypass (m^3/s) #	100	100	100	100	100
Extended Detention Depth (m)	0.3	0.3	0.3	0.3	0.3
Surface Area (m^2) **	365	55	175	65	1,415
Filter Area (m^2)	365	55	175	65	1,415
Unlined Filter Media Perimeter (m)^	Unlined	Unlined	Unlined	Unlined	Unlined
Saturated Hydraulic Conductivity (mm/hr)	100	100	100	100	100
Filter Depth (m)	0.6	0.6	0.6	0.6	0.6
TN content of Filter Media (mg/kg)	800	800	800	800	800
Orthophosphate Content of Filter Media (mg/kg)	55	55	55	55	55
Exfiltration Rate (mm/hr) &	0	0	0	0	0
Lined ^	No	No	No	No	No
Vegetated	Effective Plants	Effective Plants	Effective Plants	Effective Plants	Effective Plants
Overflow Weir Width (m) $	5	5	5	5	5
Underdrain Present @	No	No	No	No	No
Submerged Zone (Depth m)	Yes (0.3)	Yes (0.3)	Yes (0.3)	Yes (0.3)	Yes (0.3)

Notes:
High flow not specified for this assessment
** Modelled at around 5% of contributing 'ground' land use contributing catchment area
& No infiltration into subsoils assumed
^ Not assumed to be lined – may be required to control infiltration or exfiltration.
$ Estimated and not sized for this assessment
@ May be required to manage basin outflows

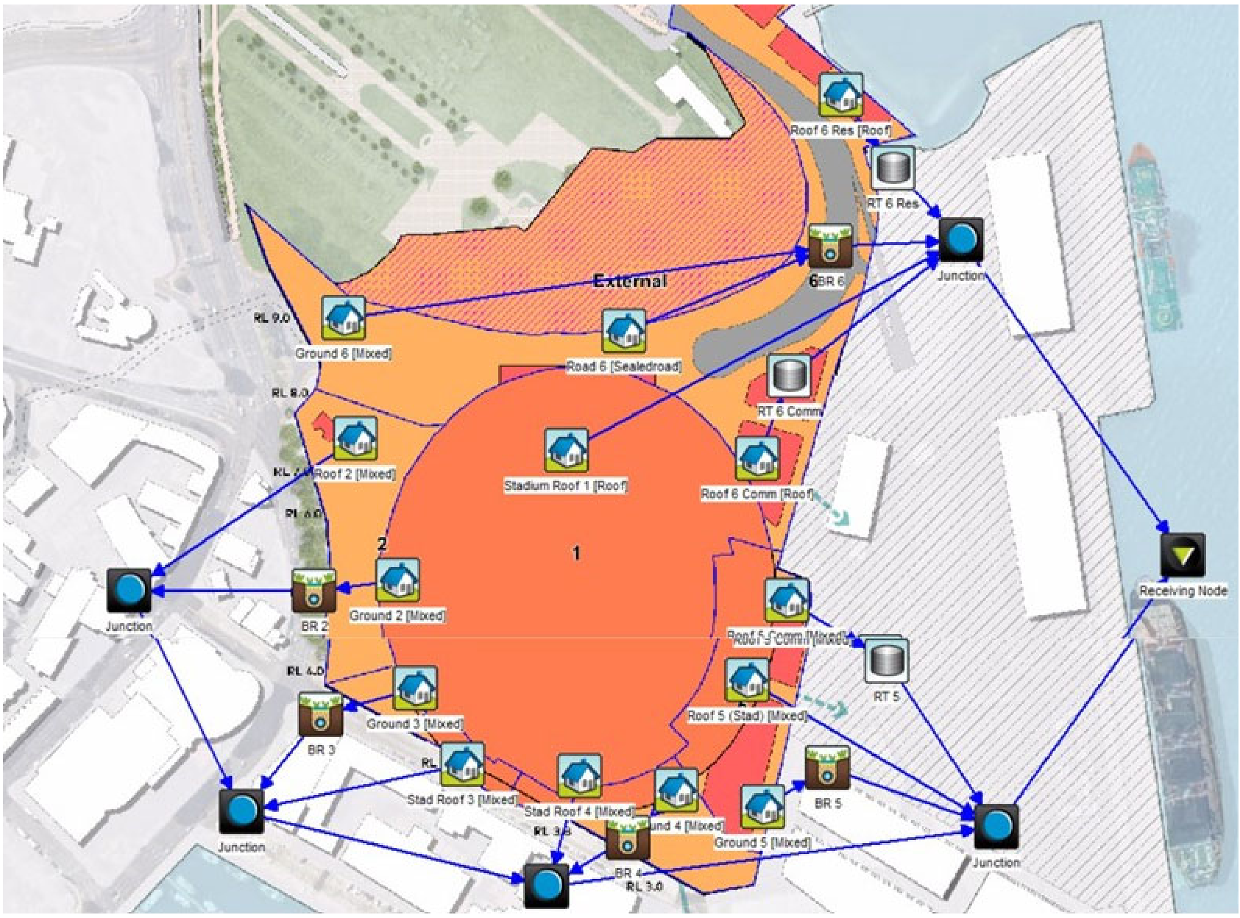


Figure 5.4 Developed Mitigated Site MUSIC Model Arrangement

5.4.4 Developed Mitigated Site Results

The modelled results of the developed mitigated site are included in Table 5.6.

Table 5.6 MUSIC Modelling Results – Developed Mitigated Site (including Stadium)

Parameter	Annual Loads Mitigated Site	% Reduction* (Objective)
Flow (ML/yr)	29.6	19
Total Suspended Solids (kg/yr)	731	68.2 (80%)
Total Phosphorus (kg/yr)	4.36	41.2 (45%)
Total Nitrogen (kg/yr)	60.5	24.2 (45%)
Gross Pollutants (kg/yr)	831	40.2 (90%)

* Compared to Development Unmitigated Site, Table 5.2

Outcomes of the MUSIC modelling indicate that the discharge objectives are not achieved with the inclusion of the proposed indicative stormwater management controls. The objectives are not able to be achieved with the inclusion of the stadium roof which as illustrated in Table 5.2 shows the dominance of the stadium roof for generation of certain pollutant loads. There are limited treatment options available for reducing pollutant loads off large roof areas, apart from capture and reuse which has been excluded from the current assessment.

It is noteworthy that if the stadium roof area was excluded from the assessment, the Site would readily achieve the nominated Discharge Objectives as shown in Table 5.7.

Table 5.7 MUSIC Modelling Results – Developed Mitigated Site (excluding Stadium)

Parameter	Annual Source Loads	Annual Loads Mitigated	% Reduction* (Objective)
Flow (ML/yr)	14.6	7.60	19
Total Suspended Solids (kg/yr)	1.73E3	157	90.9 (80%)
Total Phosphorus (kg/yr)	4.09	1.01	75.3 (45%)
Total Nitrogen (kg/yr)	31.2	11.9	61.8 (45%)
Gross Pollutants (kg/yr)	562	3.25	99.4 (90%)

* Compared to Development Unmitigated Site, Table 5.2

The assessment is high level in nature, commensurate with the available level of Site planning and specification. Sufficient space exists on Site for the integration of the required control measures, and provided that the Site is being fully designed, the integration of the proposed controls should be readily achievable.

6 Findings and Recommendations

6.1 Findings

This report has developed and assessed a conceptual stormwater quality system for the proposed Macquarie Point development in Hobart, Tasmania. The assessment covers the footprint of the Macquarie Point Precinct which is dominated by the proposed Stage 1 Stadium.

Discharge objectives were relevant for water quality discharges from the Site. Water quantity objectives were not identified as applicable to the development and are considered unlikely to be necessary given the likely discharge of stormwater directly from the Site to the tidal River Derwent adjacent the Site.

Site characteristics have been reviewed to gain an understanding of potential opportunities and constraints in terms of stormwater management. Additionally, Green Star Communities accreditation options applicable to the development were reviewed for applicability. These considerations combined to assist in the identification of a stormwater treatment system based on the following key stormwater control types:

- Rainwater tanks and reuse – to allow for water reuse and reduce potable water demands. These have indicatively been provided to all proposed buildings. The ability for tanks to be integrated effectively into Site design will be determined as design progresses.
- Bio-retention system – space effective, flexible and attractive option to treat stormwater runoff from the Site. To be targeted in suitable areas, ideally adjacent use areas (i.e. road, and pedestrian ways, which are likely to contribute a higher load of stormwater pollutants).

Adoption of these stormwater controls may assist in gaining Green Star points for the ‘Alternative Water Sources’ and ‘Stormwater Quality’ options under ‘Integrated Water Management’.

In terms of water quality, the assessment approach has been to utilise MUSIC to test the performance of the conceptual stormwater management systems and demonstrate achievement of discharge objectives.

Site based MUSIC models (excluding contributing areas of the Hobart Cenotaph) were developed. The models result indicate that the discharge objectives cannot be met with the inclusion of the proposed stormwater management controls. The stadium roof has been shown to significantly influence model results and without mitigation of rainwater pollutant loads from the stadium roof, the discharge objectives are unachievable. If the stadium roof is omitted from the assessment, the discharge objectives are achieved with proposed controls. Considering space constraints there are limited treatment options for roof runoff beyond rainwater capture and reuse (which has been excluded from assessment).

While the assessment is high level in nature, commensurate with the available level of Site planning and specification it has been determined that sufficient space exists on Site for the integration of the recommended control measures.

6.2 Recommendations

The following recommendations are identified for the proposed development:

- Complete further investigations into the viability of stormwater harvesting from the stadium roof for internal stadium reuse to offset potable water demands.
- Embed elements of the Site's proposed stormwater system in design requirements for separable development packages, such as residential and commercial buildings.
- Embed elements of the Site's proposed stormwater system into design requirements for surfaces (e.g. concourse areas, roads and accessways, pedestrian and open space area, etc) outside of the stadium itself.
- Require designers to apply locally accepted Water Sensitive Urban Design approaches to progressive stormwater system design.
- As required, revisit MUSIC modelling as design stages progress to ensure overall Site objective are being achieved.

7 References

BMT (2011) *Hirise Pilot Summary Report - Overall findings from completed Water Audits*.

DEP &LGAT (2021). *Tasmanian Stormwater Policy Guidance and Standards for Development*. A. Wilson, H. Atkins, J. Flanagan, E. Deegan, S. Jack, M. Edrich, A. Weller-Wong. Derwent Estuary Program and Local Government Association of Tasmania (Hobart, Australia).

JMG (2024) *Services Report Macquarie Point Infrastructure Strategy*. Report prepared for Macquarie Point Development Corporation, June 2024.

Macquarie Point Development Corporation (2024), *Mac Point Draft Precinct Plan*.

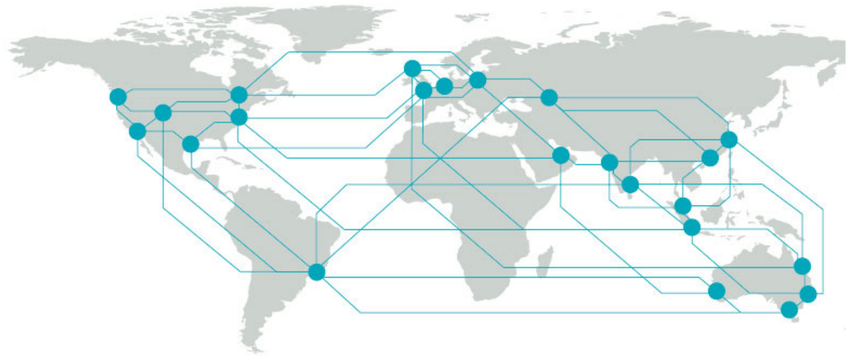
Melbourne Water (2023) *MUSIC (Model for Urban Stormwater Improvement Conceptualisation) Guideline*. Published by Melbourne Water.

Sydney Water (2007) *Best practice guidelines for water conservation in commercial office buildings and shopping centres*. Published by Sydney Water Corporation, Sydney South.

WSP (2024) *Macquarie Point Preliminary Ground Model Report*

Cardno (December 2019) *'Greater Hobart Catchment Flood Hazard Study'*

Entura (February 2014) *'Hobart Rivulet Flood Study 2013'*



BMT is a leading design, engineering, science and management consultancy with a reputation for engineering excellence. We are driven by a belief that things can always be better, safer, faster and more efficient. BMT is an independent organisation held in trust for its employees.

Contact us

enquiries@bmtglobal.com

www.bmt.org

Follow us

www.bmt.org/linkedin

www.bmt.org/youtube

www.bmt.org/twitter

www.bmt.org/facebook

12 Byron Street
Bangalow
NSW 2479
Australia
+61 2 6687 0466

Registered in Australia
Registered no. 010 830 421
Registered office
Level 5, 348 Edward Street,
Brisbane QLD 4000 Australia

For your local BMT office visit www.bmt.org