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Sydney Metropolitan

Sutherland Shire
COUNCIL 

Burnum Burnum Wetland Draft Management Plan

Final Report May 2012



Burnum Burnum Wetland Management Plan

FINAL REPORT

for

**Sutherland Shire Council and Sydney Metropolitan Catchment
Management Authority**

by

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GLOSSARY

AMSL – Above Mean Sea Level

Anthropogenic – caused or produced by humans (www.dictionary.com).

AHD – Australian Height Datum: a common national surface level datum approximately corresponding to mean sea level.

ANZECC – Australian and New Zealand Environment Council

ARI – Average Recurrence Interval: is the average or expected value of the period between exceedances of a given discharge.

Catchment – an area of land from which all runoff water flows to a low point (river, creek harbour, etc). (www.stormwater.net.au/definitions)

Climate Change – is a long-term change in the statistical distribution of weather patterns over periods of time that range from decades to millions of years. (Wikipedia accessed 16/11/10).

EEC – Endangered Ecological Community: a group of species that occur together in a particular area of the landscape that are listed on Schedule 1 of the *NSW Threatened Species Conservation Act 1995*.

GPT – Gross Pollutant Traps: used to prevent large items from polluting waterways.

HAT – Highest Astronomical Tide: is the highest tide which can be predicted under any combination of astronomical conditions and average meteorological conditions. Higher tides can occur under extreme meteorological and oceanographic conditions. (*NSW Tide Charts 2009, NSW Public Works*)

Hydrology – the scientific discipline dealing with the occurrence, circulation, distribution, and properties of the waters of the earth and its atmosphere. (www.dictionary.com)

Impervious – surfaces that do not allow water to penetrate, such as roof, driveways, paths, paving etc. (adapted from “Stormwater Detention” www.stormwater.net.au/definitions)

ISLW – Indian Spring Low Water: is the lowest level to which a tide will fall under exceptional, predictable, astronomical conditions. It seldom occurs. Meteorological and oceanographical influences, which cannot be predicted, can cause the tide to fall even lower. (*NSW Tide Charts 2009, NSW Public Works*).

LAT – Lowest Astronomical Tide: is the lowest tide which can be predicted under any combination of astronomical conditions and average meteorological conditions. Lower tides can occur. (*NSW Tide Charts 2009, NSW Public Works*).

MHW – Mean High Water: The average elevation of all high waters recorded at a particular point or station over a considerable period of time, usually 19 years. For shorter periods of observation, corrections are applied to eliminate known variations and reduce the result to the equivalent of a mean 19-year value. All high water heights are included in the average where the type of tide is either semidiurnal or mixed.

MHWS – Mean High Water Springs: is the average level of the Spring high tides which occur in the New and Full Moon. (*NSW Tide Charts 2009, NSW Public Works*)

MSL – Mean Sea Level: the average height of the surface of the sea for all stages of the tide over a 19-year period, usually determined from hourly height readings.

OSD – On Site Detention: is the temporary on site storage of stormwater with a controlled release into the drainage system. (adapted from “Stormwater Detention” www.stormwater.net.au/definitions).

PMP – Probable Maximum Precipitation: the greatest depth of precipitation for a given duration meteorologically possible for a given size storm area at a particular location at a particular time of year.

PMF – Probable Maximum Flood: is the flood that occurs as a result of the runoff generated by the Probable Maximum Precipitation.

RTA – Roads and Traffic Authority, New South Wales

RAMSAR – The international convention on Wetlands, an intergovernmental treaty that embodies the commitments of its member countries to maintain the ecological character of their wetlands of international importance.

SLR – Sea Level Rise: as oceans warm, they expand and take up more space; therefore, any increase in global temperature will result in sea level rise, which relates specifically to the long term trend in movement of mean sea level.

SSC - Sutherland Shire Council.

SSDCP - Sutherland Shire Development Control Plan.

SSLEP - Sutherland Shire Local Environmental Plan.

SWaMP - Strategic Water Monitoring Program.

WSUD – Water Sensitive Urban Design: the planning and design of urban environments that is ‘sensitive’ to the issues of water sustainability and environmental protection.

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EXECUTIVE SUMMARY

Burnum Burnum Wetland is located around 40 kilometres south west of Sydney on the eastern side of the Woronora River at Woronora in the Sutherland Shire. The wetland is a small constructed wetland built by the then NSW Roads and Traffic Authority (RTA) now Roads and Maritime Services (RMS) as a spill containment basin and water pollution control pond for runoff from the Woronora bridge deck. It was opened in 2001 and drains into the Woronora River estuary immediately downstream of the Woronora bridge. The Woronora River is a tributary of the Georges River. The runoff from the bridge deck is collected within a pipe network that diverts the low flows (1 in 1-year Average Recurrence Interval) to the wetland whilst the higher flows are discharged directly to the Woronora River beneath the bridge.

Sutherland Shire Council (SSC) has care, control and management responsibilities for Burnum Burnum Sanctuary Reserve. In response to community concerns management strategies are being investigated to enable the RMS and SSC to improve the functioning of the wetland.

The objectives of the management plan have been expanded to include:

- a functioning wetland system that complements the estuarine values of the Woronora River; and
- enhanced riparian habitats and improved passive recreational activities which include bird watching, environmental educational and other leisure activities.

The wetland is highly valued by the community as an attractive area for passive and active recreation which are enjoyed by a range of user groups including families, dog walkers and sports people. Recent improvements to the adjacent parkland and playground facilities have increased the patronage of the park and its value to the local community, whilst the open water areas of the wetland are frequented by ducks and a variety of water birds which are valued by a much wider community.

Runoff from the Woronora Bridge deck is controlled by a series of individual treatment elements which together form what is commonly referred to as a “treatment train”. This particular “treatment train” consists of a low flow diversion pit; HumeGard® Gross Pollutant Trap (GPT); Humeceptor® Oil and Grit Separator; and the Wetland Treatment System (Burnum Burnum Wetland).

During the preparation of this management plan it became evident that only limited tidal flushing currently occurs within the wetland and all elements of the “treatment train” require an improved maintenance regime to increase their efficiency to function at the level for which they were designed. As a result of reduced functionality of the “treatment train” the wetland has experienced reduced water quality, increased sedimentation and algal blooms. Further, the adjacent carpark is occasionally utilised as a rubbish dump and/or to stockpile construction materials, which can be washed off the carpark into the wetland or the Woronora River during heavy rainfall. The area is isolated and often suffers from antisocial behaviour particularly after dark, especially during the summer months.

To address the reduced functionality of the wetland it became obvious that:

- The original RTA objectives had to be maintained, in particular spill containment;
- The wetland required increased inflows of both fresh and salt water; and
- The maintenance regime for the upstream treatment train required review and updating.

To achieve this, a detailed review of the upstream treatment train management regime was prepared with recommendations for repairs to and cleaning of the existing stormwater drainage system and pollution controls upstream of the wetland.

A series of management options were developed for consideration if improved upstream treatment train management failed to improve functionality of the wetland. These options included that the

highest cell (Cell 1) be retained as freshwater and that as much of the overland flows be diverted to it, whilst the lowest cell (Cell 2) be converted to a salt marsh through increased tidal inundation by lowering the outlet pipe. At the second community workshop these optional management strategies were reviewed and are now considered as stage 2 management strategies.

A variety of management actions would be required to improve maintenance of the upstream treatment train, achieve this alteration to a combined freshwater and saltmarsh system (if required) and to build the local community's capacity to care for the wetland and develop the area as an environmental education resource. The recommended management strategies to achieve and maintain these revised objectives for the Burnum Wetland include:

- Improved maintenance of the upstream treatment train;
- Concept design of proposed optional works;
- Outlet pipe reconfiguration (option);
- Wetland Cell reshaping (option);
- Wetland plantings;
- Vegetation management;
- Rubbish management;
- Divert more overland flow into the wetland using reshaping of the carpark and/or regrading of the upslope areas to divert runoff away from the box culvert and towards the wetland;
- Infrastructure renewal and maintenance;
- Education strategies; and
- Community engagement.

1 INTRODUCTION

1.1 THE MANAGEMENT PLAN

The Burnum Burnum Wetland management plan has been prepared to

“provide the RMS and Council with management options to improve the water quality and riparian habitat of the wetland and adjacent environments”.

Sutherland Shire Council (2011)

The key objectives for the management of Burnum Burnum Wetland have expanded to include:

- *a functioning wetland system that complements the estuarine values of the Woronora River;*
- *improved and enhanced riparian habitats surrounding the wetland;*
- *an efficient maintenance regime that reflects the environmentally sensitive environment and the proposed improvements to the function of the wetland;*
- *increased opportunities for recreational activities, including bird watching, environmental education and passive recreation;*
- *explore the possibility of the wetland as an educational resource demonstrating best management practices for stormwater in the estuarine zone;*
- *increased capacity of residents and users to care for and contribute to the management of the wetland.*

The management plan also acknowledges the wetland's namesake Burnum Burnum and its location adjacent to the Burnum Burnum Sanctuary, which honours the Aboriginal activist who lived in Woronora in his later life. The sanctuary was previously Jannali Reserve and was named after Burnum Burnum in 2005.

The community's concerns and aspirations for the wetland are also aimed to be reflected in the management plan.

The management plan contains a description of the wetland and an examination of its hydrology, environmental values, and social values. Relevant policies, acts and strategies are also considered. An issues analysis is presented along with management strategies to address issues and to enhance values. Management objectives and actions are prioritised and costed and potential funding sources identified. A monitoring plan for wetland management is also presented.

1.2 SCOPE OF THE PLAN

As indicated above the plan aims to identify issues around wetland management and document management options. Management strategies and actions have been developed to improve water quality and riparian habitat. The monitoring plan provides a guide for assessing the effectiveness of management actions.

The management plan should be reviewed every five years to enable the effectiveness of the recommended management actions to be considered and updated with new information or technology and community concerns. Wetland management actions should be reviewed annually.

2 SITE SETTING AND CONTEXT

2.1 LOCATION AND SETTING

Burnum Burnum Wetland is located around 40 kilometres south west of Sydney on the edge of the Woronora River at Woronora in the Sutherland Shire. The wetland is located 50 metres from the Woronora River within the foreshore recreation area between the boat ramp, car park and picnic area of Burnum Burnum Sanctuary. The location of the wetland is shown in Figure 1.

The wetland is a small constructed wetland built to serve spill containment and water quality control purposes by the Roads and Maritime Services (RMS) for the Woronora Bridge opened in 2001.

Burnum Burnum Wetland drains to the Woronora River estuary. The Woronora River is a tributary of the Georges River. The catchment of the wetland is small and associated with the Woronora Bridge. Limited tidal flushing is currently occurring in the wetland.

2.2 LAND TENURE AND ZONING

Burnum Burnum Wetland is owned by the NSW State Government with Sutherland Shire Council as trustee. The legal ownership description and zoning are presented below in Table 1. Zoning in the wetland is shown on Figure 2.

Table 1: Land Ownership Burnum Burnum Wetland

Legal Description	Owner	Zoning
Lot 7007 DP 94103	NSW State Government	SSLEP 2006 as Zone 13
Lot 7070 DP 94102	Sutherland Shire Council Trustee	Public Open Space

Burnum Burnum Sanctuary Reserve is covered by the Sutherland Shire Council Local Environment Plan 2006. The wetland is covered by zone (14) Public Open Space (Bushland). The zoning is shown in

The objectives of Zone 14—Public Open Space (Bushland) set out in SSC (2006b) include:

- (a) to enable development that facilitates recreation and preserves natural bushland areas located on publicly owned land,
- (b) to allow development that does not adversely affect natural bushland or wildlife corridors,
- (c) to protect public open space that is of environmental significance,
- (d) to ensure that flora and fauna habitats are protected and preserved for their aesthetic, educational and scientific value.

Bush fire hazard reduction work and bushland regeneration work is allowed in this zone without consent. A limited range of activities are allowed in this zone with the consent of SSC including:

- beach and foreshore protection works buildings used in association with landscaping or gardening (including vehicular access to those buildings), drainage, recreation areas, scientific research associated with native habitats, utility installations (except for gas holders or generating works).
- Demolition not included in item 2.
- Development (if authorised by a management plan under the *Local Government Act 1993*), other than development included in item 2, for the purpose of: cycle access, educational facilities (including signage), pedestrian access, roads.

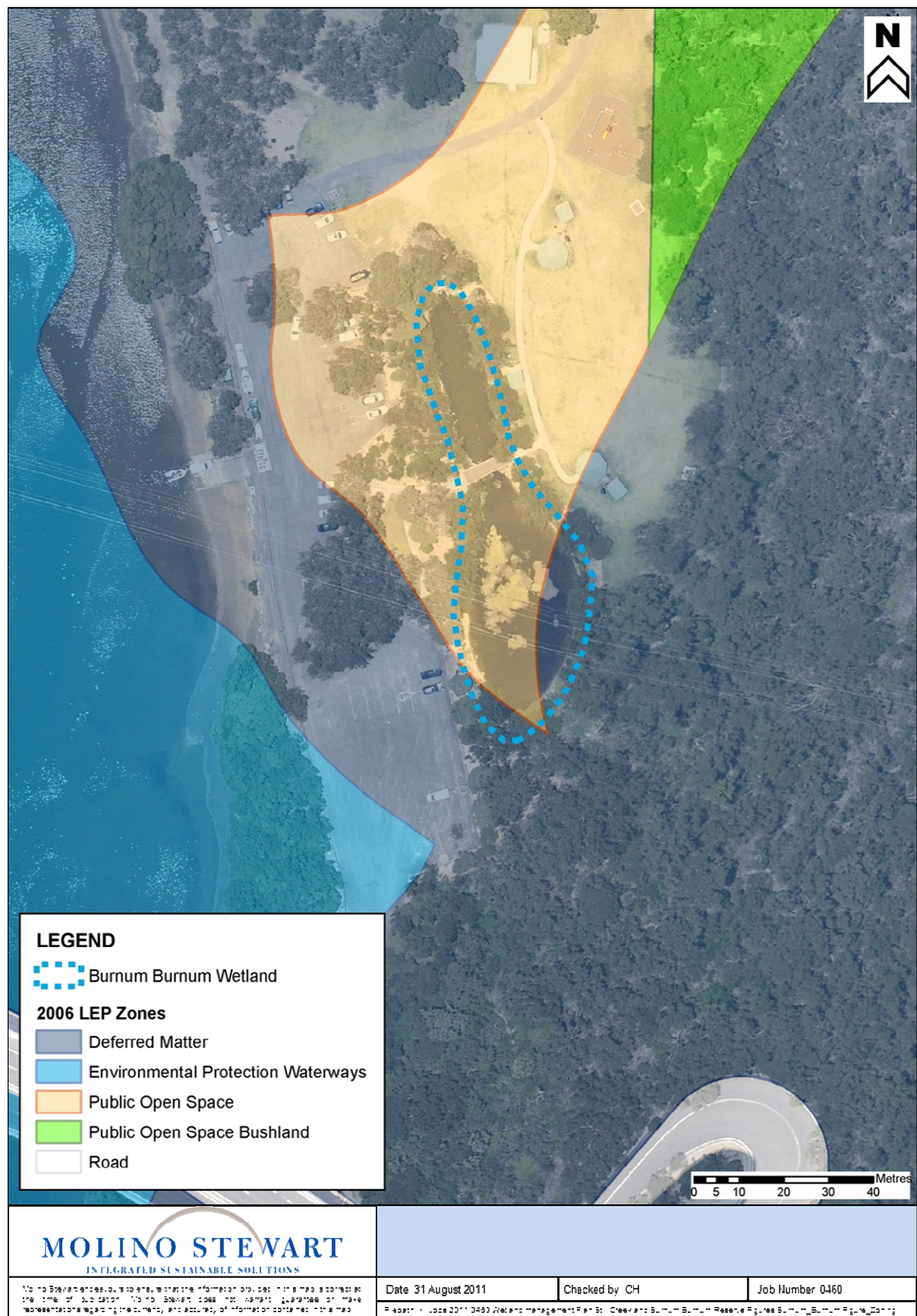


Figure 2: Burnum Burnum Wetland Zoning.

2.3 CLIMATE

The climate of Woronora is typical of the Sutherland Shire, with warm to hot summers reaching an average maximum temperature of 25 °C (Bureau of Meteorology 2011). Winter months are cool with an average maximum temperature of 16 °C (Bureau of Meteorology 2011). January and February are generally the warmest months with the majority of rain falling in March.

Refer to the following Bureau of Meteorology graphs, Figures 3, 4, 5 and 6 for the relationships between the annual and monthly averages for the Lucas Height (ANSTO) Bureau of Meteorology weather recording station (# 066078) which is approximately 6 kms south west of the Burnum Burnum Wetland. A more comprehensive set of climate and weather information is available at:

http://www.bom.gov.au/climate/averages/tables/cw_066078.shtml

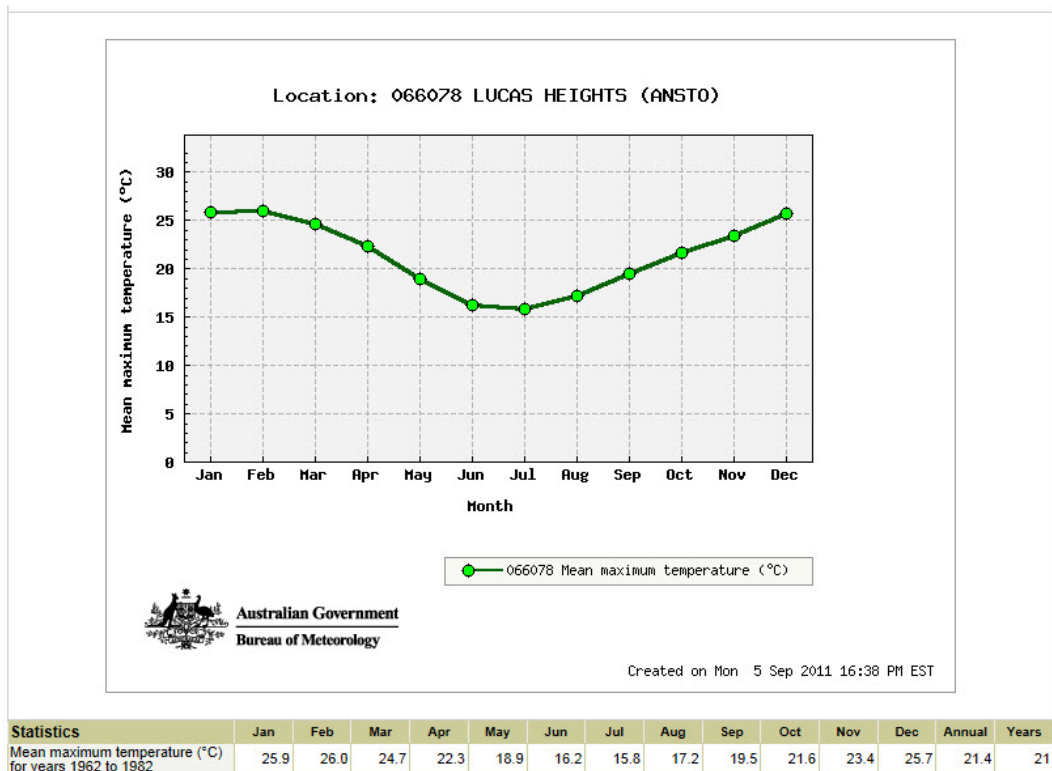


Figure 3: Mean Monthly Maximum Temperatures.

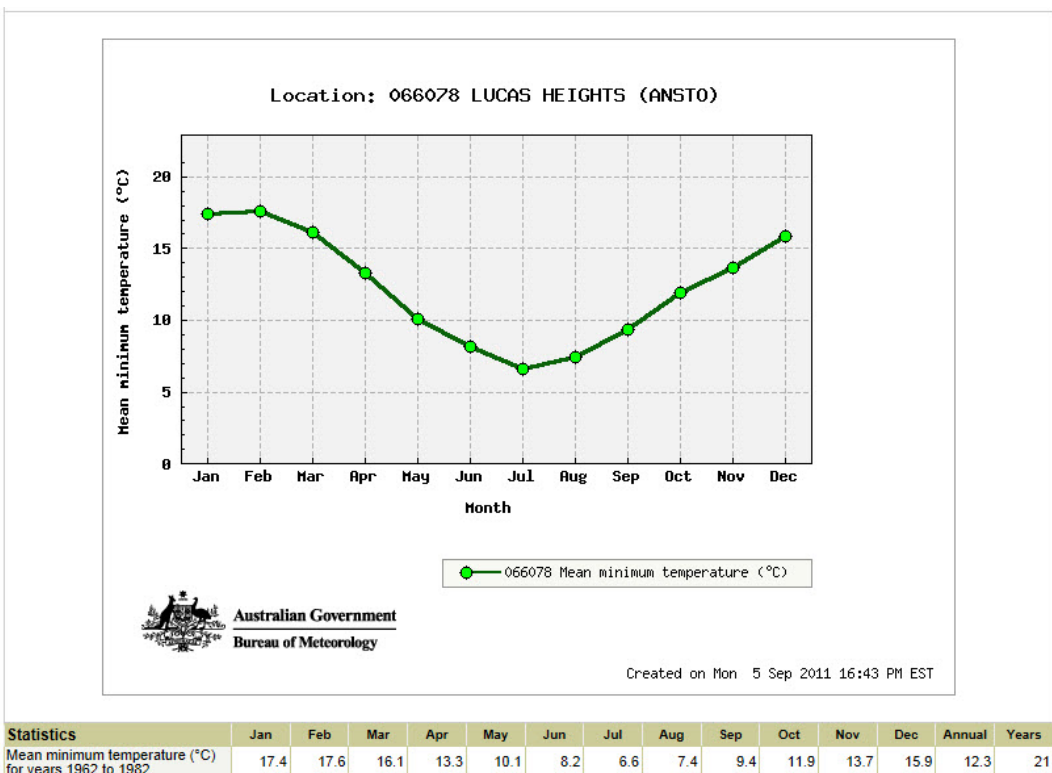


Figure 4: Mean Monthly Minimum Temperatures.

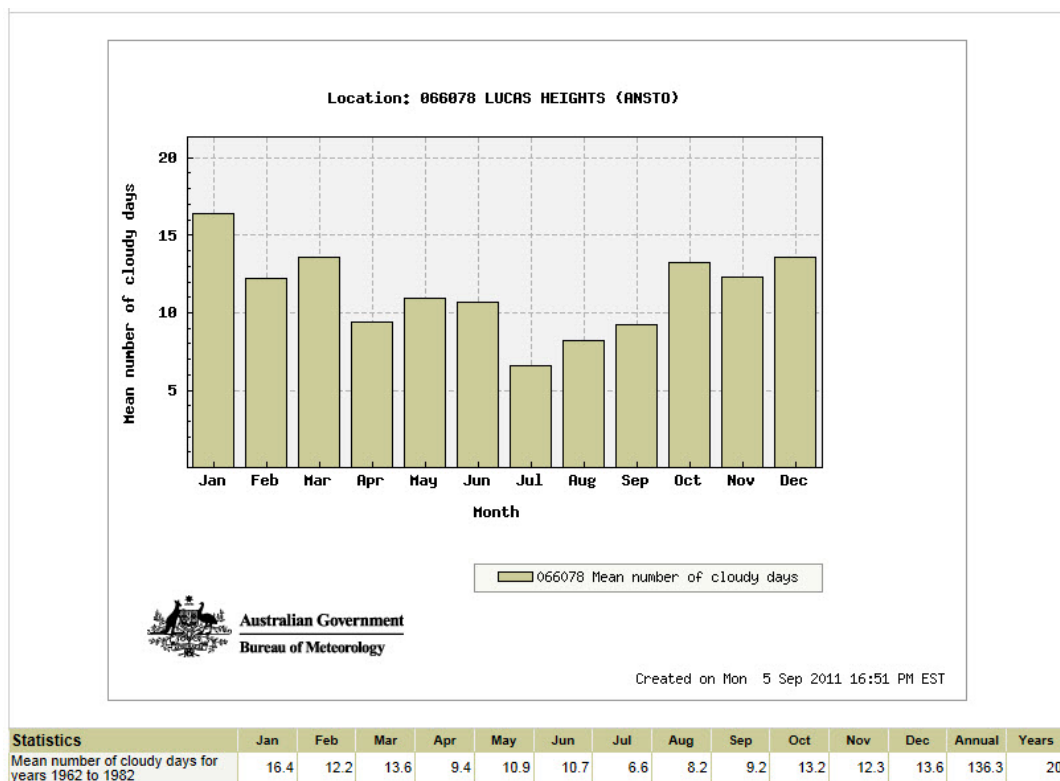


Figure 5: Mean Monthly Number of Cloudy Days.

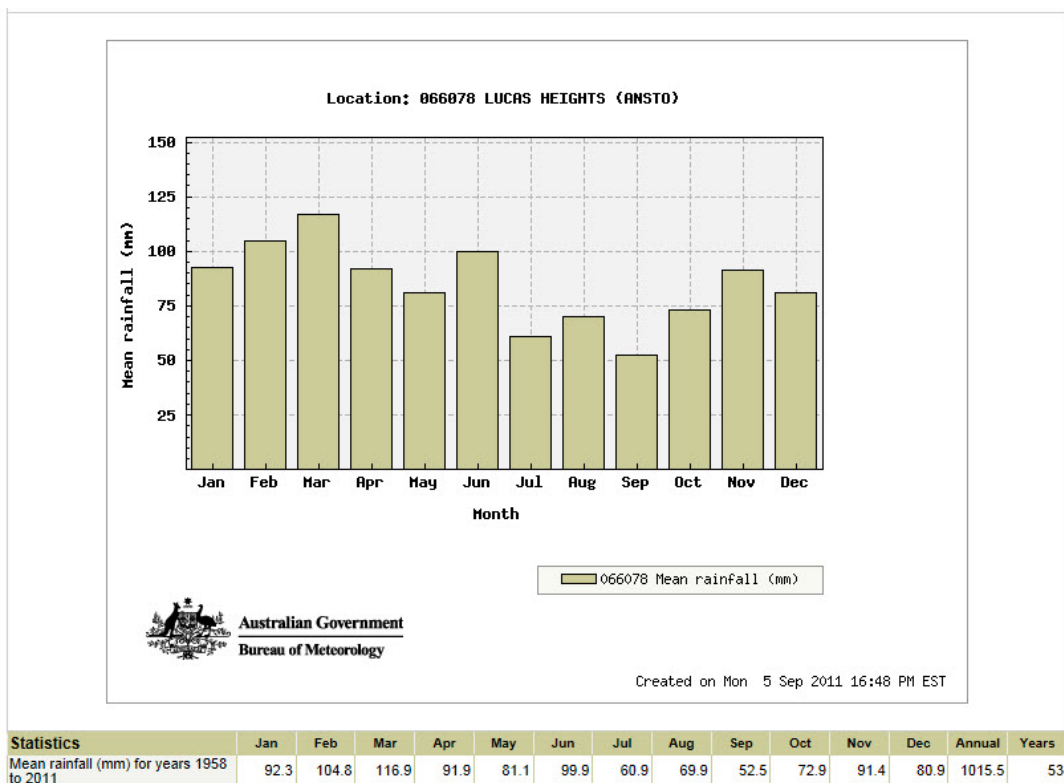


Figure 6: Mean Monthly Rainfall.

2.4 PHYSICAL GEOGRAPHY

The Woronora River originates near Helensburgh and flows north to the Woronora Dam, through Heathcote National Park, Engadine to Woronora and then onto the Georges River between Como and Illawong. Its valley is characterised by steep slopes deeply incised through the Woronora Plateau, a sandstone plateau that forms the southern edge of the Sydney Basin.

The lower catchment supports narrow river flats occupied by urban development (WBM 2006). The tidal limit of the river is upstream of Lucas Heights near an area known as the Needles around 10 kilometres upstream of the confluence with the Georges River (WBM 2006) and approximately 6 kilometres upstream of Burnum Burnum Wetland.

The Woronora River at Woronora occupies a broad, deep sandstone river valley with adjacent river flats supporting urban development. The wetland is located on the eastern side of the river flat upstream of an unnamed inlet of the Woronora River. The area is low-lying with a maximum elevation of around 8 metres above sea level. Burnum Burnum Sanctuary rises steeply to the east, reaching an elevation of approximately 47 metres above sea level.

Soils in the immediate vicinity of the wetland and park area are mapped as disturbed land (Hazelton et al 1990). This is consistent with a review of the aerial photo records (SSC undated) which show filling of the area between 1970 and 1978. Fill material was used to form Bonnet Bay and the lower areas of the Burnum Burnum Sanctuary playground, car park and boat ramp areas. Further filling occurred between 1978 and 1984 and then again in 1994 to create the playing fields located to the north east of the wetland. However SSC has identified the site as class 2 to class 3 potentially acid sulfate soil (SSC undated).

2.5 ADJACENT LAND USE

The land use adjoining Burnum Burnum wetland immediately to the west is a car park and boat ramp and the Woronora River.

Immediately to the north and east the wetland is bounded by Burnum Burnum Sanctuary Playground. The playground has recently (2011) been upgraded, the existing playground has been extended to include a new flying fox and large climbing net. The walking path has been extended to a loop bike track and a new hidden “broken heart ruins” area has been created. Additional seats around the playground and tree planting for shade have aimed to improve the amenity of the playground for recreational use (SSCa 2011).

To the south of Burnum Burnum wetland lies bushland which adjoins River Road and the eastern access to the Woronora Bridge. Further to the east lie the suburbs of Sutherland and Jannali.

2.6 WETLAND DESCRIPTION

Burnum Burnum wetland was constructed by the NSW RMS to control low flow discharges (1 in 1 year Average Recurrence Interval (ARI)) from the Woronora Bridge.

The management objectives have expanded to include:

- a functioning wetland system that complements the estuarine values of the Woronora River; and
- improved and enhanced riparian habitats and recreational activities, including bird watching, environmental educational and other recreational activities carried out at Burnum Burnum Wetland.

2.7 WETLAND FLOOD MANAGEMENT

Burnum Burnum Wetland has been mapped in the SSC Development Control Plan (2006) as being an area of medium flood risk which includes:

“Medium flood risk is defined as an area of land below the 1% AEP flood level that is either subject to a high hydraulic hazard or where there are evacuation difficulties.

There is possible danger to personal safety; evacuation by trucks would be difficult; able-bodied adults would have difficulty wading

to safety; and there is a potential for significant structural damage to buildings.”

Given the small catchment of the wetland and it's proximity to the Woronora River the opportunity of Burnum Burnum Wetland to contribute to flood mitigation is considered very limited.

2.8 WETLAND INFRASTRUCTURE

Burnum Burnum Wetland has the following infrastructure elements:

- A diversion pit in the upstream drainage system within the access road immediately below the Woronora bridge which is intended to divert low flows (1-year ARI) and spills from the bridge deck to the wetland, and high flows directly to the Woronora River;
- A HumeGard™ Gross Pollutant Trap (GPT) in the upstream drainage system;
- A HumeCeptor™ Oil and Grit Separator (OGS) in the upstream drainage system;
- A surcharge pit and bypass reinforced concrete box culvert (RCBC) immediately upstream of the wetland;
- Inlet structure including a surface skimmer and energy dissipation baffle (see Figure 7)
- Two wetland cells (southern cell No.1 and northern cell No.2)
- Oil boom separating Cell 1 and Cell 2 (located beneath the pedestrian bridge);
- The outlet structure at the northern end of Cell 2 consists of:
 - A trash rack on top of a concrete weir which is set at approximately 300 mm above the highest astronomical tide level;
 - 50 mm diameter trickle pipe set approximately 300 mm below the highest astronomical tide level;
 - 90 mm diameter UPVC pipe set approximately 400 mm below the highest astronomical tide level;
 - 90 mm diameter UPVC pipe set approximately 500 mm below the



Figure 9. Photographs of the wetland infrastructure are contained in Appendix A to this report.

The drainage system upstream of the wetland incorporates a diversion pit which was designed to divert low flows and spills, from the bridge deck, into the wetland whilst the higher flows are diverted to the Woronora River beneath the bridge. Inspection has revealed that rather than flows from the bridge deck being diverted to the junction pit, within the access road on the southern side of the Woronora Bridge, they are connected directly into the storage/treatment chamber in the HumeGard™ GPT. This results in high velocity flows entering the GPT which may affect its ability to settle sediments and retain gross pollutants, which may also result in the operation of the boom being compromised and gross pollutants being discharged downstream towards the Humeceptor™ and Surcharge Pit.

Overland flows are intercepted before they reach the wetland and directed towards a box culvert beneath the access road which discharges into the river adjacent to the car park. An oil boom separates the wetland into 2 cells, with the objective of retaining free oils within Cell 1. However, the boom is currently anchored to the base of the wetland and cannot rise and fall in unison with the fluctuations of the top water level within the wetland.

Low flows from the Woronora Bridge are directed into the wetland. The small openings in the outlet weir, connecting Cell 2 to the Woronora, restrict the outflow and increase the

hydraulic residence time within the wetland thereby promoting sedimentation. The intended uptake of nutrients, which is enhanced through contact with plants and micro-organisms, is limited due to the absence of emergent and submersed macrophytes within the wetland.

The invert of the outlet headwall at the Woronora River has been set at 0.25 m AHD (approximately 250 mm above Mean Sea Level), whilst the invert level of the lowest outlet control (90mm diameter UPVC pipe) from the wetland was set at 1.0 m AHD (approximately 1.0 m above Mean Sea Level and 400 mm above Mean High Water Springs). Consequently the wetland functions as a freshwater system for the majority of the time and is only subject to tidal inundation during king high tides in excess of 1.0 m AHD, which would allow approximately 22 hours of saltwater intrusion per year (DECCW 2009/722).

It is therefore possible that the wetland system would remain saline for extended periods until the saltwater is flushed out by stormwater inflows of sufficient volume and energy to displace the saltwater. Note saltwater is denser than freshwater and a halocline (vertical saltwater gradient) is likely to develop which could force the freshwater to flow through the wetland without mixing with or displacing the saltwater below the halocline.



Figure 7: Inlet Structure to Wetland with Surface Skimmer and Energy Dissipation Baffle.

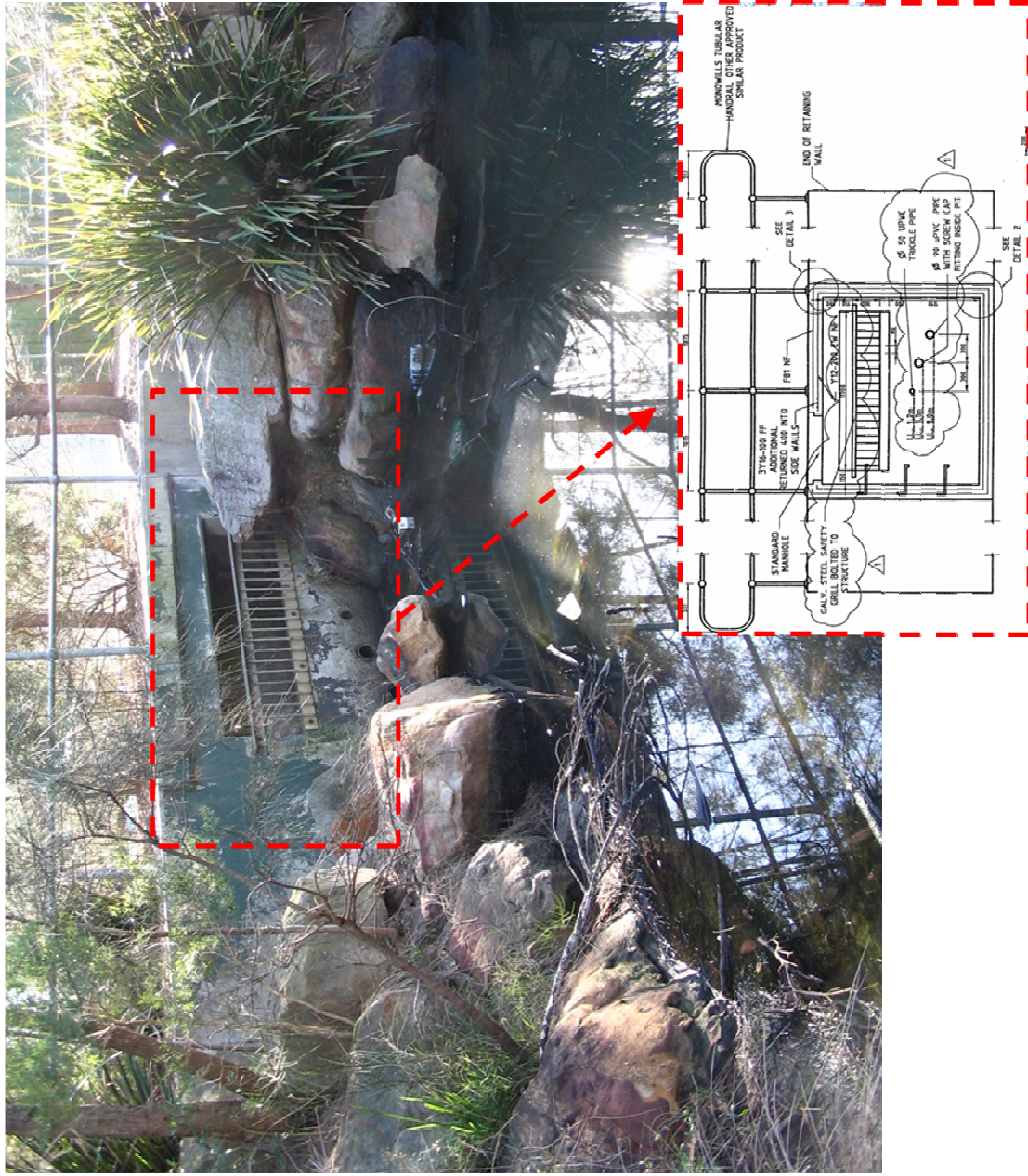


Figure 8: Restricted Outlet Structure.

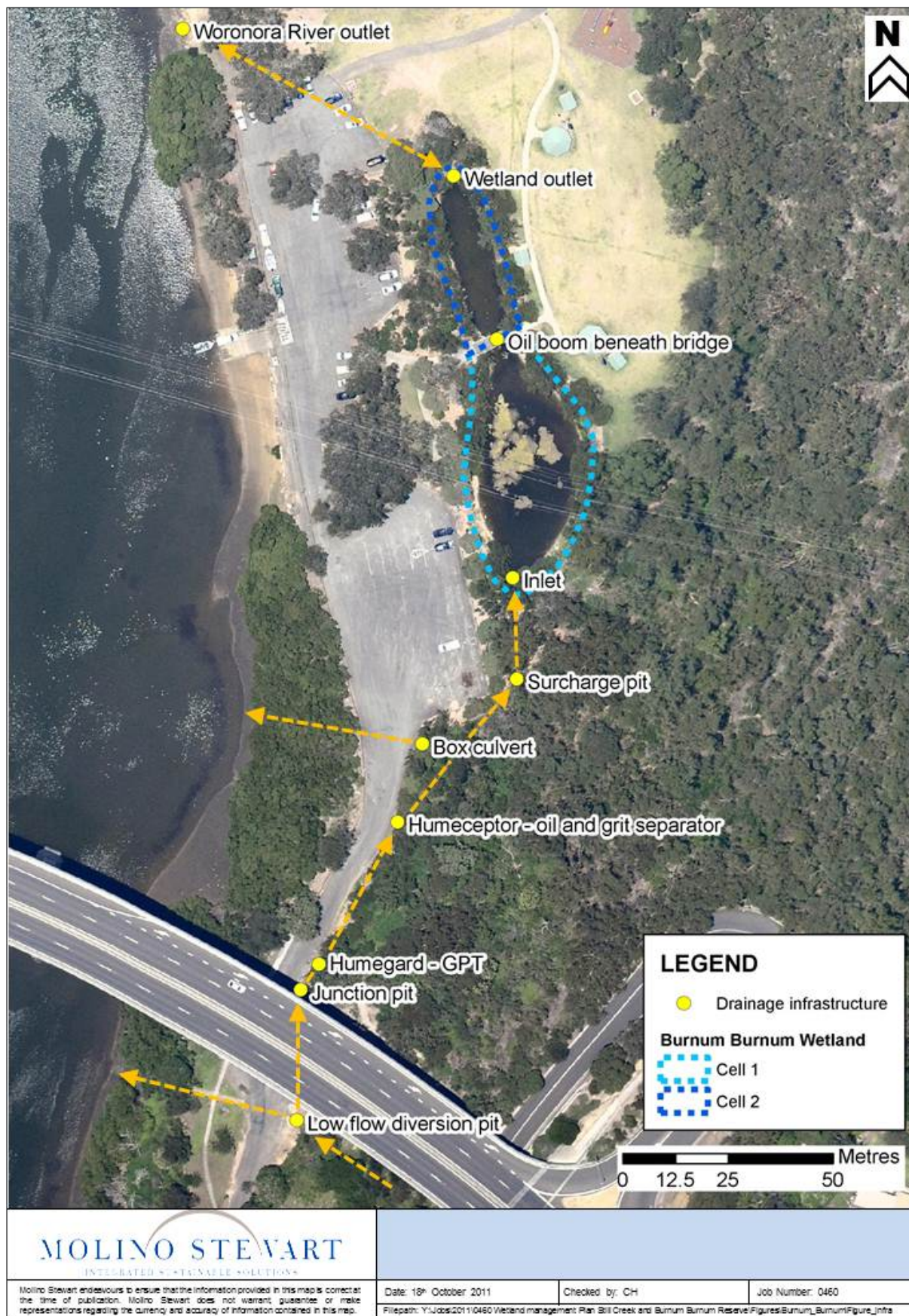


Figure 9: Burnum Burnum Wetland Infrastructure

3 PLANNING CONTEXT

A number of state and local government strategies, policies and state legislation are influential in the management of Burnum Burnum Wetland. These are outlined below.

3.1 LOCAL GOVERNMENT ACT 1993

The Management Plan has been prepared in accordance with the following requirements for specific Plans of Management detailed in Section 36 of the *Local Government Act 1993*:

- Categorising the land known as Burnum Burnum Wetland and riparian corridor;
- Defining objectives and performance targets;
- Stating the means by which objectives and performance targets will be met;
- Stating the means by which performance targets will be measured;
- Observing the requirements of any threat abatement plans and recovery plans made under the *Threatened Species Conservation Act 1995* and the *Fisheries Management Act 1994*.

3.2 ENVIRONMENTAL PLANNING AND ASSESSMENT ACT 1979

The *Environmental Planning and Assessment Act 1979 (EP&A Act)* establishes the statutory planning framework for environmental and land use planning in NSW. This is achieved through State Environmental Planning Policies (SEPPs), and Local Environmental Plans (LEPs) collectively known as Environmental Planning Instruments (EPIs). The EP&A Act 1979 allows EPIs to be made to guide the development process and to regulate competing land uses; it also sets out processes for approving development applications for structures and works.

3.3 SUTHERLAND SHIRE DEVELOPMENT CONTROL PLAN 2006

Sutherland Shire Development Control Plan (SSDCP), (SSC 2006a) applies to all land across the Sutherland Shire. It was prepared to provide more detailed provisions for the carrying out of development in lands covered by the Sutherland Shire Local Environmental Plan (SSLEP) (2006b). In particular it provides detailed objectives and controls used by SSC when determining applications under Section 79C of the *Environmental Planning and Assessment Act*. The SSDCP provides benchmarks for what is acceptable in landuse, development and environmental management decisions.

3.3.1 Wetlands

Chapter 4 of the SSDCP (SSC 2006a) deals with natural resource management and identifies that the natural resources of Sutherland Shire are a fundamental element of its character.

Wetlands are recognised as playing a critical function in ecological processes, providing breeding habitat and for wildlife and contributing to improved water quality. The SSDCP (SSC 2006a) sets out wetland buffer zone sizes for natural and non-natural wetlands.

a) Objectives

The SSDCP (SSC 2006a) sets out objectives for development on land marked on the wetlands and waterways map. The objectives include:

- to protect, restore and maintain ecological processes, natural systems and biodiversity within wetlands and waterways;
- to minimise sedimentation and pollution of wetlands and waterways;
- to restore degraded wetlands, wetland buffer areas, waterways and riparian zones;
- to ensure appropriate fire management regimes and hazard reduction techniques

for wetlands, wetland buffer areas, waterways and riparian zones.

- to encourage best practice environmental design measures so that the sustainability of wetlands and waterways is maintained or improved.

b) Controls

The SSDCP (SSC 2006a) sets out controls for all development on land marked on the wetlands and waterways map. Controls include:

- all development shall minimise changes to the local surface runoff and groundwater flows to ensure that appropriate water flow regimes are maintained to wetlands and waterways;
- stormwater flow is to mimic natural conditions and ensure a dispersed pattern of flow, avoiding newly created centralised or concentrated discharge points into wetland or waterway;
- disturbance to stream and wetland sediments is to be minimised by regulated discharge of stormwater and dissipation of flows at discharge locations;
- development shall not result in detrimental changes to temperature, salinity, chemical makeup and sediment loads of water entering the wetland or waterway;
- where stormwater is proposed to be discharged to a wetland or waterway, pollution is to be reduced by installation of pollution and sediment control devices. Access to and cleaning of devices shall not compromise the wetland areas function or natural attributes. The following standards are to be met:

a) Pollutant levels shall be below those outlined in the ANZECC (2000) Guidelines for the Protection of Aquatic Ecosystems.

b) Pollution control devices shall be located so that they are not within a watercourse or wetland itself.

- there shall be no clearing of indigenous vegetation within wetlands or riparian zones and clearing of indigenous vegetation within Wetland Buffer Areas shall be minimised;

- there shall be no clearing of indigenous stream bank vegetation and aquatic habitat;
- removal of woody debris from wetlands and waterways should be minimised. Where removal is required for improved navigation, consideration should be given to provision of alternative habitat;
- there shall be no in-stream blockages to fish passage;
- lateral connectivity between waterways and riparian vegetation must be maintained. To satisfy this control proposed landscaping will have to in part, reflect a natural environment in terms of finished levels and distribution of vegetation;
- bush fire asset protection zones must be located outside of the wetland buffer and riparian zone, except in the case of development or redevelopment of single dwellings and extended family units on existing lots or alterations and additions to existing dwellings.

3.4 WORONORA ESTUARY MANAGEMENT PLAN

The Woronora Estuary Management Study and Plan (WBM 2006) presents the objectives for the long term management of the Woronora River Estuary. Management strategies to meet objectives are presented and classified on the basis of perceived importance and the time frame in which they can be achieved.

The study recognises the Woronora River Estuary contains a range of high quality habitats and species of conservation and fisheries significance. The study recognises the major changes in saltmarsh and mangrove distribution over the past 70 years. The study recognises the close proximity of the internationally RAMSAR listed Towra Point wetlands and the significance of the estuary to migratory and resident water birds.

Key values of the estuary identified by the community included:

- high water quality;
- natural areas;
- access to waterways;

- views to water;
- heritage and cultural value; and
- recreational facilities.

Threats to estuary values are reduced due to:

- large areas of the greater catchment protected as National Park or catchment of Woronora Dam;
- steep topography limits future development potential;
- low key nature of existing foreshore development.

High priority management strategies for the Woronora estuary include:

- revegetation and protection of eroding foreshores;
- mapping and monitoring of ecological communities;
- hydrosurvey and monitoring;
- water quality monitoring;
- marking of key habitat areas on signs and with marker buoys;
- community education program on ecology and heritage;
- Bushcare groups revegetating areas close to ecologically sensitive areas;
- Shakels Estate bush regeneration;
- hard protection/repair of eroding foreshores (private and public) (including structures fronting Burnum Burnum Reserve);
- review and revision of stormwater policy;
- community campaign for clean-up/restoration of foreshores;
- limited navigation dredging; and
- modifications of stormwater system including end-of-pipe treatment and assessment and upgrade of sewerage system to minimise overflows.

3.5 GEORGES RIVER REGIONAL ENVIRONMENTAL PLAN

The Georges River Regional Environmental Plan (REP) (Department of urban Affairs and

Planning 1999) recognises activities undertaken on land in the catchment can adversely impact the catchment. The REP influences the land use, environmental planning and management decisions taken when land within the wider Georges River catchment is affected. The REP is to be considered in the planning and approval of development in the catchment.

The broad aims of the REP are:

- maintain and improve water quality and river flows in the Georges River and its tributaries;
- protect and enhance the environmental quality of the Catchment for the benefit of all users; and
- ensure consistency in the delivery of Ecologically Sustainable Development when assessing development.

The REP notes the following objectives:

- preservation and protection of significant environments (including mangroves, saltmarsh and seagrass), bushland and open space corridors by identification of environmentally sensitive areas and providing for appropriate land use planning and development controls;
- preservation, enhancement and protection of estuarine ecosystems;
- to ensure development is consistent with the aims of the REP;
- to identify land uses with potentially adverse environmental impacts;
- to conserve, manage and improve the aquatic environment by providing controls to reduce pollution entering the watercourses; and
- to protect the safety and well being of the local and regional community by improving water quality and river flows for health and recreation.

A range of planning principles are highlighted in the REP including 9(13) wetlands. The Rep indicates:

- Wetlands must be protected through the application of consistent land use and management decisions that take into account the potential impact of surrounding land uses, incorporate measures to mitigate adverse effects and

are in accordance with the *NSW Wetlands Management Policy*. Wetlands must also be protected by requiring adequate provisions where clearing, construction of a levee, draining or landscaping is to be undertaken.

3.6 THE NSW WETLANDS MANAGEMENT POLICY ACTION PLAN 2000/2003

This action plan (Department of Land and Water Conservation 2000) was developed by the State Wetlands Action Group to guide implementation of the NSW Wetlands Management Policy. It recognises that the majority of NSW's 4.5 million hectares of wetlands are located on private property and aims to resource and involve the community in wetland rehabilitation.

The action plan sets out four key strategies and associated actions for the NSW State Wetland Advisory Committee to promote the implementation of the policy. These strategies are:

- development of guidelines for preparing local wetland management plans;
- development of guidelines for rehabilitation as well as compensatory guidelines for situations where social and economic imperatives require wetlands be destroyed;
- consideration of wetlands in the NSW Water and Vegetation reforms; and
- administration of the NSW Wetland Action Grants Program.

3.7 A WETLAND PRIORITISATION TECHNIQUE FOR THE SYDNEY METRO CATCHMENT MANAGEMENT AREA (SMCMA)

The above report was prepared as part of the Sydney Metropolitan Catchment Management Authority (SMCMA) Wetland Management

Strategy (Stage 1) (Schaeper *et al* 2007). The report:

- compiled existing mapping data to identify the extent of wetlands in the SMCMA region;
- remapped wetlands that are listed in the Directory of Important Wetlands in Australia (DIWA);
- developed a wetland rehabilitation prioritisation technique, and;
- assessed the condition of the eight DIWA wetlands that occur in the SMCMA region.

A desktop wetland prioritisation technique was developed to prioritise wetlands for rehabilitation. The technique considers;

- wetland values and threats;
- the representation of the range of wetland types in Sydney;
- rehabilitation project development matters; and
- consideration of the feasibility of proposed projects.

Wetlands were assessed for their values and threats to produce a ranking of high, medium or low. Although this prioritisation technique is suitable to assess wetland condition, this assessment relied on the existence of information such as exists in a Plan of Management (PoM). In 2009, there were approximately 30 PoM's for wetlands within the SMCMA area.

It was determined that an alternate but complementary process was required to assess many more of the wetlands in SMCMA's area of operation using other available GIS data. Therefore a GIS database was developed and completed in 2011 in order to assess 226 wetlands using the initial prioritisation method of assessment on values and threats to produce a ranking of high, medium or low (Ecological 2011). Provision of this GIS based wetland prioritisation system is utilised by the SMCMA and wetland managers to inform investment decisions.

The appendices of the initial prioritisation that summarise threats, values and scoring templates as well as the technical report for

the Wetlands GIS Prioritisation are now available on the SMCMA website.

3.8 NSW INVASIVE SPECIES PLAN 2008-2015

The NSW Invasive Species Plan was developed through extensive consultation with a wide range of stakeholders. The NSW Invasive Species Plan aims to prevent new incursions, contain existing populations and adaptively manage widespread species. The plan aims to foster a cooperative culture where all relevant parties contribute with the aim of minimising the impacts of invasive species in NSW (Department of Primary Industries DPI 2008).

The NSW Invasive Species Plan identifies four goals:

- Exclude – prevent the establishment of new invasive species;
- Eradicate or contain – eliminate, or prevent the spread of new invasive species;
- Effectively manage – reduce the impacts of widespread invasive species; and
- Capacity building – ensure NSW has the ability and commitment to manage invasive species.

These goals aim to deliver specific measurable outcomes and actions that complement the NSW targets for natural resource management as identified in the NSW State Plan. The Plan's principles address current planning processes, efficacy and ethical issues, and is based on current commitments by the NSW Government and investment by a wide range of other stakeholders (DPI 2008).

3.9 WEED MANAGEMENT STRATEGY FOR THE SYDNEY METROPOLITAN CMA REGION 2007-2011

The Weed Management Strategy for the SMCMA aims to enhance and build on what is already being done by providing guidelines and recommending actions to improve

allocation of resources, education and coordination of on ground work between 2007 and 2011. Many of the recommended actions have been identified by Council staff, state agency staff, volunteers and professional bush regenerators who were involved in the consultation and development phases of this strategy (SMCMA 2007).

The Strategy acknowledges that effective and long-term weed management by Councils, agencies and landholders does not consist only of removing weeds. The Strategy recommends:

- a review the weed management priorities across the SMCMA region;
- directing funding and resource allocation toward the higher priorities; and
- coordinating on ground work across land management boundaries and according to the available resources and priorities.

3.10 GREEN WEB SYDNEY - A VEGETATION MANAGEMENT PLAN FOR THE SYDNEY REGION

Green Web Sydney is an initiative of the combined Sydney Regional Organisations of Councils (SROCs) that promotes the establishment of a green web of native vegetation to protect, conserve and enhance remnant bushland in the Sydney region (SROCs 2009).

Sutherland Shire Council is implementing a Greenweb program which aims to protect and enhance the Shire's native plant and animal populations by identifying key areas of bushland habitat and establishing corridors to connect them (SSC 2008).

SSC's Greenweb incorporates both public and private lands. Its main target is private property owners within the Shire's Greenweb network. Council funds various initiatives to support Greenweb. This has included a program where owners of private property in Sutherland Shire's Greenweb network were able to apply for financial assistance to support ecological restoration work on bushland in their property (SSC 2008). SSC's Bushcare program is a

complimentary program that undertakes bushland regeneration activities on public land in Sutherland Shire.

3.11 THE GEORGES RIVER COMBINED COUNCILS COMMITTEE

Although not strictly part of the planning context for Burnum Burnum Wetland, the Georges River Combined Council's Committee (GRCCC) is an important body that aims to

“advocate for the protection, conservation and enhancement of the health of the Georges River, by developing programs and partnerships, and by lobbying government organisations and other stakeholders.”

GRCCC (2011)

The GRCCC was formed in 1979 and consists of nine local councils, as well as agencies and community representatives in the Georges River Catchment. The GRCCC was revamped in 2008 following a report commissioned by the Sydney Metropolitan CMA to recommend an organisational structure and operational plan to better meet current and future demands (GRCCC 2011).

The GRCCC has since 2009 aligned its works program to meet National Resource Management objectives and has collectively brought over \$8 million worth of funding and in kind value to Councils within the catchment (GRCCC 2011).

The Georges River catchment covers an area of 960 square kilometres and is one of the most highly urbanised catchments in Australia with over 1 million residents. The catchment of the Georges River includes the Woronora River.

4 SITE HYDROLOGY AND HYDRAULICS

4.1 CATCHMENT ANALYSIS

The catchment to the wetland is restricted to the runoff from the Woronora Bridge deck. However a diversion pit within the piped drainage network diverts a maximum of 500 litres per second towards the wetland. The remainder of the runoff is diverted directly to the Woronora River beneath the bridge. Much of the diverted 500 litre per second surcharges upstream of the wetland and enters the Woronora River through a box culvert upslope of the car park (refer to Figure 9).

There is very limited tidal inflow into the wetland and that which does occur is from the highest of the high tides (refer to Figure 8).

4.2 FLOW REGIME

The low flow diverted through the pipeline to the Burnum Burnum Wetland has been designed by the RTA as equivalent to the 1 in 1 year ARI which is approximately 500 litres per second. Run off from the immediate area surrounding the wetland is the only surface run off that reaches the wetland.

A surcharge pit and a box culvert immediately upstream of the wetland (refer to Figure 9) divert flows in excess of the capacity of the pipe network, and surface runoff away from the wetland and directly into the Woronora River.

Tidal inflows to the wetland are controlled by a 450 mm diameter pipe which is set at mean high water level and 3 trickle flow pipes which are set at various levels between MHWS and HAT (see Figure 8). Consequently tidal flushing of the wetland is negligible and limited to only the highest of the high tides.

4.3 IMPACTS OF CLIMATE CHANGE

4.3.1 General

Research conducted by the United Nations Intergovernmental Panel on Climate Change (IPCC) (Solomon *et al.*, 2007), has shown that there has been an observable change in global climatic conditions over the last 100 years. Observed changes include an increase in global surface temperature of 0.74°C between 1906 and 2005, and a global sea level rise of 1.8 mm/yr on average (a total of 0.08m) between 1961 and 2003. Solomon *et al.* (2007) also found long term changes in precipitation for a number of continents. Based on IPCC research, ignoring ice flow melt, global sea levels are predicted to rise between 0.18 and 0.59m by 2100.

The NSW Government Department of Environment and Climate Change (DECC) has produced a *Draft Sea Level Rise Policy Statement* (DECC, 2009) which outlines state government policy in relation to sea level rise. When the influence of ice melt and the predicted higher than global average sea level rise on the east coast of Australia are included, the projected sea level rise on the NSW coast is between 0.40m by 2050 and 0.90m by 2100 (NSW DECC, 2009). These projections are based on global greenhouse gas emissions, and the uncertainties associated with their estimates lead to uncertainties in sea level rise projections for the NSW coast. Consequently constant updates of the projections are required as new information becomes available.

The effects of climate change are also anticipated to result in a change in average and seasonal rainfall patterns, including flood producing rainfall events. These changes have the potential to increase the frequency and severity of flooding. However, there is still much uncertainty about the specific nature of such changes on a regional basis and research continues.

4.4 WATER QUALITY

Run off from the Woronora Bridge deck is controlled by a series of individual treatment elements which together form what is commonly called a “treatment train”, consisting of:

- Low flow diversion pit;
- HumeGard® Gross Pollutant Trap (GPT);
- Humeceptor® Oil and Grit Separator; and
- Wetland treatment system (Burnum Burnum Wetland).

4.4.1 Diffuse Pollution

Diffuse sources of pollution refer to those pollutant inputs which occur over a wide area and are associated with a particular land use. In urban catchments these inputs are generally related to runoff from roads, houses, commercial developments and landscaped areas as well as seepage into and from groundwater.

Solid pollutants such as organic matter, sediment and light litter, which have been washed off the upstream catchment, are either retained in the upstream GPT and oil and grit separator or trapped within the wetland.

4.4.2 Point Source Pollution

Point source pollution refers to those inputs which have a readily identifiable source. They are generally related to a particular industry with a single discharge point or to a specific overflow from a wastewater treatment plant or containment facility.

There are no industrial developments, chemical storages, wastewater treatment plants or petrol stations within the catchment and apart from unplanned spills on the Woronora Bridge deck, point source pollution is not expected to be an issue.

4.4.3 Water Quality Monitoring

SSC have invested in a Strategic Water Monitoring Program (SWaMP) throughout the Shire. Burnum Burnum Wetland does not

feature in the current water quality monitoring program. The variables included in the current water quality monitoring program conducted at other sites in the shire include:

- Ammonia ;
- Biological oxygen demand (BOD);
- Metals (Copper, Lead, Zinc);
- Enterococci;
- Grease;
- Total Nitrogen;
- Total Phosphorus; and
- Suspended solids.

It is recommended that Burnum Burnum Wetland be included in the SWaMP.

4.5 CONCLUSIONS

For recommendations regarding each of the following actions see chapter 8.

4.5.1 Flood Management and Climate Change

The design inflows into the wetland are based on diverting the 1 in 1 year ARI flows into the wetland and flood management generally refers to controlling the larger storm events, in particular the 1 in 100 year ARI event. Consequently flood management as an objective for this wetland treatment system is not considered to be appropriate.

4.5.2 Gross Pollutant Trap

A Humegard® gross pollutant trap (GPT) has been constructed on line with the local pipe network. It is assumed that it was installed to remove light litter and coarse sediment from the low flows from the Woronora Bridge before they entered the wetland.

An inspection of the GPT during preparation of the plan revealed a pipe is located on the western side of the storage/treatment chamber that appears to be the outlet for the Woronora bridge deck drainage system. This pipeline was originally intended to be connected to junction pit immediately upstream of the

Humegard™ (see Figure 9) where its energy would be dissipated before entry to the Humegard™. The flows from this pipe are likely to impact adversely on the ability of the storage/treatment chamber to retain light litter and sediment and should be re-constructed to connect to junction pit as originally intended.

Inspection also revealed a large sediment plume downstream of the boom that may hamper the boom's efficient operation. According to information provided by SSC this device has been cleaned infrequently and is possibly full to capacity and in bypass. This GPT must be cleaned and made operational before work commences on retrofitting the wetland, and a regular cleaning regime implemented to ensure it remains in an operational condition.

4.5.3 Oil and Fine Sediment Removal

A Humeceptor® Oil and Grit Separator (OGS) has been constructed online with the local pipe network, downstream of the Humegard®. Its function is to remove free oil and fine particulates which have bypassed the Humegard®.

Inspection of this OGS revealed that the joint between the inlet pipe and the OGS had been compromised, allowing the ingress of tree roots which had subsequently blocked the orifice to the inlet drop pipe, which appears to have resulted in the inflows surcharging the diversion weir and by-passing the treatment chamber altogether. Internal structural failures were also observed around the surround for the access lid.

According to information provided by SSC this device has been cleaned infrequently and is possibly full to capacity and in bypass. This Oil and Grit Separator must be repaired, cleaned and made operational and a regular cleaning regime implemented to ensure it remains in an operational condition.

4.5.4 Water Quality

The lack of vegetation within the wetland limits its functionality to one of a sediment control and spill containment basin only. The existing boom (located between Cell 1 and Cell 2

beneath the pedestrian bridge) was originally installed as free oil control but has not been operational for some time. The trash rack on top of the outlet weir is intended to prevent light litter from being discharged to the Woronora River; however it results in light litter accumulating in the wetland, which is considered to be an eyesore by regular visitors to the wetland.

The wetland is regularly subjected to filamentous algal blooms, low dissolved oxygen and odour. The reported low water quality in the wetland may be exacerbated by the decomposition of organic matter that has accumulated on the bottom of the wetland and the subsequent release of nutrients into the water column. Consequently it is recommended that Burnum Burnum Wetland be included in the SWaMP and that the results of the monitoring inform the maintenance frequency and practices within the wetland.

A further recommendation includes the introduction of macrophytes to the Cell 1 as a formal wetland treatment system or in the form of a floating reed bed. Both systems have the potential to improve water quality although the floating reed bed could be used in conjunction with open water to provide additional habitat for water birds.

4.5.5 Tidal Inundation

The 450 mm diameter outlet pipe connecting Cell 2 to the Woronora River doubles as an outlet for freshwater from the wetland and as a conduit for saltwater inflows during very high tides. The opportunity exists to construct a second pipe connection at a lower level to allow more frequent tidal inundation of Cell 2.

A further option is available to improve Cell 2 if improvements to the upstream treatment train do not result in improved wetland function. Regrading Cell 2 and planting it with salt marsh plant species, common to the Woronora estuary (mangroves are to be excluded), would convert Cell 2 from a stagnant freshwater pond into a salt marsh with regular tidal inundation.

5 ENVIRONMENTAL VALUES

5.1 EXISTING VEGETATION

In order to document the vegetation communities and fauna habitats present at Burnum Burnum Wetland a desktop and field assessment were undertaken. The desktop assessment included consideration of existing mapping and an online search of matters of National Environmental Significance and a search of the NSW Wildlife Atlas as described below.

a) Existing Mapping

The vegetation at Burnum Burnum wetland is mapped by Sutherland Shire Council in their broad scale Vegetation Communities map as non-natural wetland (Sutherland Shire undated). Vegetation around the wetland was planted as part of construction and includes primarily species indigenous to the local area. The canopy includes swamp oak *Casuarina glauca* and paperbark *Melaleuca linearifolia*, with an understorey of grasses and mat rush *Lomandra longifolia* and blue flax lily *Dianella caerulea*. A number of native species that are not indigenous to the local area have also been planted as part of the wetland landscaping including cedar wattle *Acacia elata*.

b) Environment Protection and Biodiversity Conservation Act 1999

An online search of matters of National Environmental Significance (NES) or other matters protected by the EPBC Act was undertaken for a five kilometre radius of the site.

The online search revealed a number of matters relevant to this management plan:

- Towra Point Nature Reserve, classified as a RAMSAR wetland if International significance is located in Botany Bay within 10 kilometres of the Burnum Burnum Wetland Site;
- Turpentine-Ironbark Forest in the Sydney Basin Bioregion (listed as Critically

endangered on the EPBC Act 1999) may occur in the area.

Suitable habitat is present for species listed at the State (TSC Act 1995) and National level (EPBC Act 1999) and as migratory (Japan Australia Migratory Bird Agreement JAMBA) and (China Australia Migratory Bird Agreement CAMBA) include:

Birds

- regent honeyeater *Anthochaera phrygia* listed as Endangered at the national level and as migratory (JAMBA);
- swift parrot *Lathamus discolor* listed as Endangered at the national level and at the State level 1995;
- orange-bellied parrot *Neophema chrysogaster* listed as Critically Endangered at the national level and Endangered at the State level;
- Australian painted snipe *Rostratula australis* listed as Vulnerable at the national level and as migratory (CAMBA);

Frogs

- giant burrowing frog *Heleioporus australiacus* listed as Vulnerable at the national level;
- green and golden bell frog *Litoria aurea* listed as Vulnerable at the national level and Endangered at the state level;
- little john's tree frog *Litoria littlejohni* listed as Vulnerable at the national and state level;
- growling grass frog *Litoria raniformis* listed as Vulnerable at the state level;
- stuttering frog *Mixophyes balbus* listed as vulnerable at the national level and endangered at the state level;

Mammals

- large-eared pied bat *Chalinolobus dwyeri* listed as Vulnerable at the national and state level;
- spotted-tail quoll *Dasyurus maculatus* the south east population listed as endangered at the national level and the species listed as vulnerable at the state level;
- southern brown bandicoot *Isodon obesulus obesulus* listed as Endangered at the national and state level;

- brush-tailed rock wallaby *Petrogale penicillata* listed as Vulnerable at the national level and Endangered at the state level;
- long-nosed potoroo *Potorous tridactylus* south east mainland population listed as Vulnerable at the national level;
- new holland mouse *Pseudomys novaehollandiae* listed as Vulnerable at the national level;
- grey-headed flying fox *Pteropus poliocephalus* listed as Vulnerable at the national level;

Plants

- Bynoe's Wattle *Acacia bynoeana* listed as Vulnerable at the national and state level;
- downy wattle *Acacia pubescens* listed as vulnerable at the national and state level;
- thick-leaf star hair *Astrotricha crassifolia* listed as vulnerable at the national and state level;
- thick lipped spider orchid *Caladenia tessellata* listed as Vulnerable at the national level and Endangered at the state Level;
- leafless tongue orchid *Cryptostylis hunteriana* listed as Vulnerable at the national and national level;
- Camfield's stringybark *Eucalyptus camfieldii* listed as Vulnerable at the national and state level;
- small flower grevillea *Grevillea parviflora* subsp. *parviflora* listed as Vulnerable at the national and state level;
- biconvex paperbark *Melaleuca biconvexa* listed as vulnerable at the national and state level;
- Deane's melaleuca *Melaleuca deanei* listed as Vulnerable at the national and state level;
- *Pimelea curviflora* var. *curviflora* listed as Vulnerable at the national and state level;
- Sydney plains greenhood *Pterostylis saxicola* listed as endangered at the national level;
- Kangaloon sun-orchid *Thelymitra* sp. *Kangaloon* (D.L. Jones 18108) listed as Critically Endangered at the national level;

- austral toadflax *Thesium australe* listed as Vulnerable at the national level;

Reptiles

- broad-headed snake listed as *Hoplocephalus bungaroides* as Vulnerable at the national level and Endangered at the state level.

Migratory Marine Birds

- fork-tailed swift *Apus pacificus*;
- great egret *Ardea alba*;
- cattle egret *Ardea ibis*.

Migratory Terrestrial Birds

- white-bellied sea eagle *Haliaeetus leucogaster*;
- white-throated needletail *Hirundapus caudacutus*;
- rainbow bee-eater *Merops ornatus*;
- black-faced monarch *Monarcha melanopsis*;
- satin flycatcher *Myiagra cyanoleuca*;
- orange-bellied parrot *Neophema chrysogaster*;
- rufous fantail *Rhipidura rufifrons*;
- regent honeyeater *Anthochaera phrygia*.

Migratory Wetland Birds

- great egret *Ardea alba*;
- cattle egret *Ardea ibis*;
- Latham's snipe *Gallinago hardwickii*; and
- painted snipe *Rostratula australis*.

c) Threatened Species Conservation Act 1995

A spatial analysis was undertaken utilising the Office of Environment and Heritage (OEH) Wildlife Atlas of threatened species records in a ten kilometre radius of the site (the locality).

The search revealed a variety of species associated with ocean or coastal habitats. The search indicated that species of interest considered likely to utilise Burnum Burnum Wetland as part of a larger home range included:

- varied sittella *Daphoenositta chrysoptera* Vulnerable. This species was recorded from Barden Ridge in 2007;
- koala *Phascolarctos cinereus* Vulnerable. This species was recorded from River Road at Woronora in 1998 (this species has been recorded more recently west of Menai and this record may represent a young male wandering from an existing population;
- grey-headed flying fox *Pteropus poliocephalus* Vulnerable. This species was recorded from Jannali Reserve in 2007;
- powerful owl *Ninox strenua* Vulnerable. This species has been recorded repeatedly in the Forbes Creek valley (another tributary of the Woronora River) and from the Woronora River;
- sooty owl *Tyto tenebricosa* Vulnerable has also been recorded from the Forbes Creek Valley and along the Woronora River;
- greater broad nosed bat *Scoteanax rueppellii* Vulnerable, southern myotis *Myotis macropus* Vulnerable and eastern bentwing-bat *Miniopterus schreibersii oceanensis* Vulnerable have all been recorded along the Woronora River south west of the site at the Needles.

The threatened species recorded from a 10 kilometre radius of the site between 2001 and 2011 during the database search and potentially occurring in Burnum Burnum wetland are illustrated in Appendix B.

Given that the wetland is constructed and the adjoining vegetation is landscaped planting threatened flora species occurring in the wetland or adjoining vegetation is considered unlikely. However a variety of threatened flora species are known or likely to occur in Burnum Burnum Sanctuary upslope of the wetland.

5.1.2 Field Assessment

The wetland was visited on two occasions by an ecologist on the 27th May 2011. The weather was cool and sunny reaching 16 degrees Celsius. The wetland was visited again on the 18th August 2011. The weather was mild and still and there was no cloud. The temperature reached 17 degrees celsius.

The field assessment involved a traverse around the edge of the wetland and the adjoining terrestrial vegetation.

The structure of the vegetation communities around the wetland and dominant plant species were recorded. The density of weeds in various vegetation communities and areas adjacent to the wetland were also noted. A list of flora species recorded during the field assessment is contained in Appendix C to this report. Photos of vegetation communities are contained in Appendix A.

Fauna habitats of the wetland and surrounding area were identified on the basis of vegetation structure and available habitat attributes. Threatened fauna species indicated as potentially present in the study area on the basis of wildlife database analysis were considered when searching the wetland and the existence of specific habitat for these species was assessed. A diurnal search of the wetland was undertaken on the above occasion. Records of fauna species from the Woronora River riparian corridor and the adjoining Burnum Burnum Sanctuary were accessed from the Atlas of Living Australia. These records were used to generate a species list of fauna species for the Burnum Burnum wetland locality.

Field investigation reveals three vegetation communities at Burnum Burnum Wetland:

- Upslope weed community;
- Landscape plantings;
- Open water.

The distribution of vegetation communities in and around the wetland is shown in Figure 10.

a) Upslope Weed Community

This community is located upslope of the wetland between the wetland and the access road. It occupies the area immediately below the sandstone bench that is occupied by dense native vegetation and forms the western edge of Burnum Burnum Sanctuary.

This community forms an open woodland with a canopy of swamp she oak *Casuarina glauca* and paperbark *Melaleuca lineariifolia*. The shrub layer is open and supports a sporadic covering of matt rush *Lomandra longifolia*.

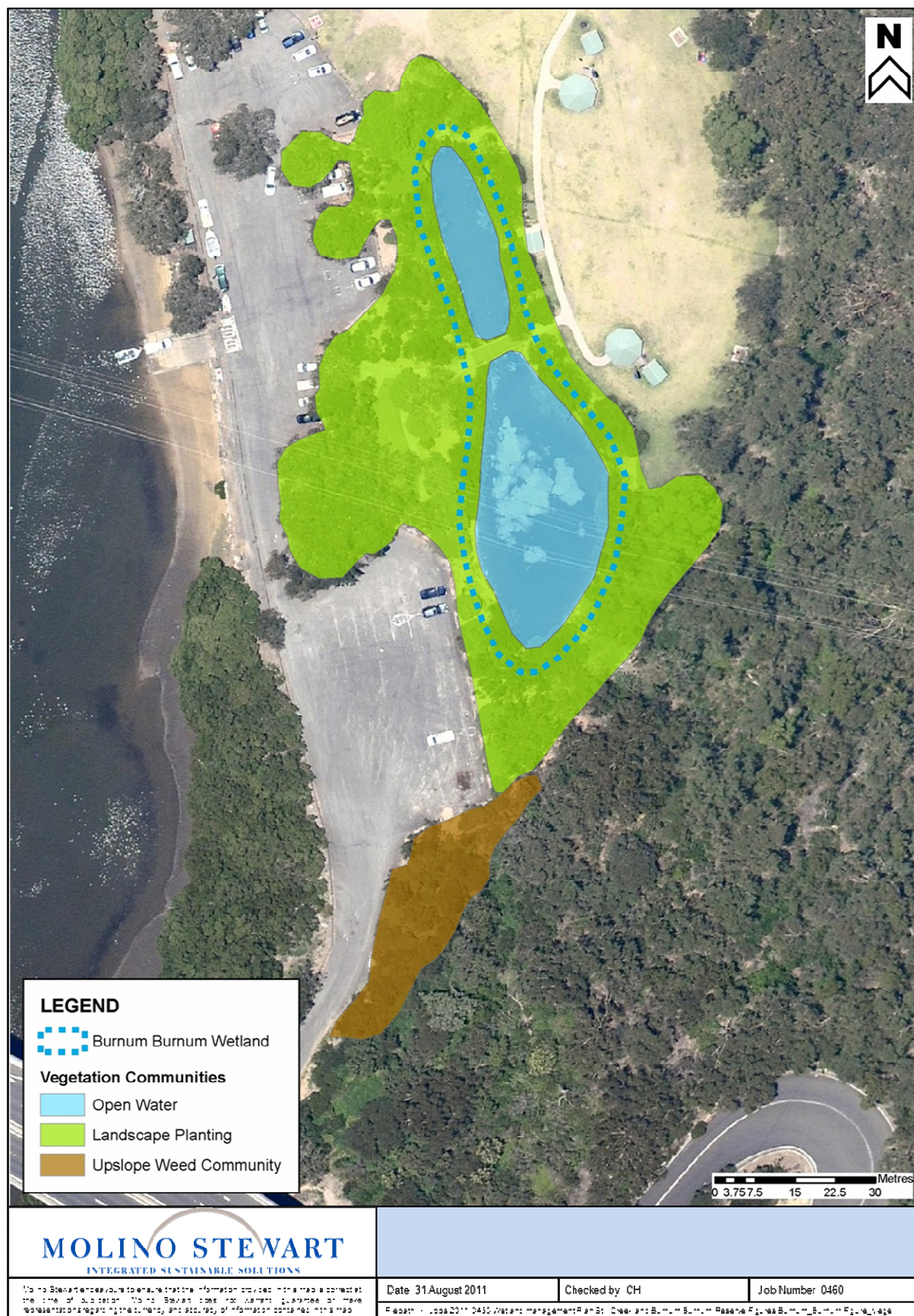


Figure 10: Burnum Burnum Wetland Vegetation Communities.

The ground layer is a mixture of bare soil, litter and kikyu *Pennisetum clandestinum*. This community is heavily weed infested. Moth vine *Araujia sericifera* and balloon vine *Cardiospermum grandiflorum* have infested the canopy of the swamp she oaks and are smothering small and large trees. The vines are progressing toward the sandstone rock shelf of Burnum Burnum Sanctuary.

The shrub and ground layer are covered in litter that has been channelled to the area from the Woronora Bridge. The noxious weed lantana *Lantana camara* is becoming established in the shrub layer along with narrow-leaf privet *Ligustrum sinense* (also noxious in the Sutherland Shire) asparagus fern *Asparagus aethiopicus* and bridal creeper *Asparagus asparagoides*, cobblers peg *Biddens pilosa* is also common. This area is very low lying with patches of standing water and bare soil deposited after water flows.

The edges of this community at the car park have been subject to rubbish dumping with piles of electrical cable and builder's rubble evident at the time of field assessment.

b) Landscape Plantings

This community occupies the terrestrial area surrounding the wetland between the wetland and the adjoining park and Burnum Burnum Sanctuary.

It supports an open tree layer ranging from 10 to over twenty metres in height that includes paperbarks *Melaleuca lineariifolia* swamp she oak *Casuarina glauca*, Eucalypts and Sydney red gum *Angophora costata*. The small tree layer consists of Casuarinas and cedar wattle *Acacia elata*, coast banksia *Banksia integrifolia* subsp. *integrifolia* and old man banksia *Banksia serrata* and pittosporum *Pittosporum undulatum*. Native rosemary *Westringia fruticosa* has been planted throughout this community and occurs as a small and large shrub. Matt rush *Lomandra longifolia* has been planted adjacent to the pedestrian bridge and blue flax lily *Dianella caerulea* has been planted in patches on the western side of wetland under swamp she oaks between the wetland and the river.

An area of landscape plantings located in shallow circular dip is located between the

wetland and the Woronora River. This consists of a dense canopy of swamp she oak *Casuarina glauca* and an understorey of blue flax lily *Dianella caerulea*.

There has been little colonisation of the landscaped community by native species from the adjoining Burnum Burnum Reserve and although weed invasion in this area is minor, little regeneration of landscapes plantings is occurring. Supplementary planting of this area with locally indigenous native species would increase the floristic diversity and habitat values of this community.

c) Open Water

The open water in the wetland in both Cell 1 and Cell 2 is heavily infested with filamentous algae. There is a high proportion of organic matter within the open water including logs and branches along with litter including plastic bottles.

d) Fauna Habitat Values

The wetland including the open water and adjoining terrestrial vegetation provides a variety of habitat resources for water birds including the ducks and dusky moorhens using the wetland. Migratory birds known to occur in the locality may also be seasonal visitors to the wetland. A family of Australian wood ducks *Chenonetta jubata* including 5 immature ducklings were observed during the field assessment.

Only one emergent macrophyte *Schoenoplectus* sp. was observed on the edge of the open water habitat in Cell 2. The lack of emergent macrophytes reduces the habitat values of this community to reptiles and amphibians due to the lack of shelter and foraging resources although the bare sandstone boulders could be used for basking.

The landscape plantings community provides suitable habitat for nectivorous arboreal mammals and birds due to the presence of flowering canopy species including *Eucalypt* spp and *Melaleuca* spp. This habitat does not support an intact shrub layer and so shelter and cover resources for small mammals and birds are limited. This habitat would form a buffer to the much larger and more intact

habitat present upslope in Burnum Burnum Sanctuary.

The open water habitat and presence of permanent water (although variable in quality) would provide a resource for a variety of native fauna species utilising Burnum Burnum Reserve and the Woronora River corridor that may use the wetland as part of a wider home range. A list of fauna species recorded from the Atlas of Living Australia adjacent to Burnum Burnum wetland is contained in Appendix D to this report.

Table 2: Summary of Vegetation Communities and Fauna Habitat Values

Vegetation Community	EEC	Biometric Vegetation Type (DEC 2005)	Dominant Species	Condition	Habitat Values
Upslope weed community;	No	N/A	swamp she oak <i>Casuarina glauca</i> , paperbark <i>Melaleuca linearifolia</i> , kikuyu <i>Pennisetum clandestinum</i> moth vine <i>Araujia sericifera</i> , balloon vine <i>Cardiospermum grandiflorum</i> lantana <i>Lantana camara</i>	low	Habitat values are limited by heavy weed infestation but the community does provide a buffer between the Burnum Burnum Sanctuary and the access road to the Burnum Burnum Reserve boat ramp.
Landscape plantings;	No	N/A	swamp she oak <i>Casuarina glauca</i> , paperbark <i>Melaleuca linearifolia</i> native rosemary <i>Westringia fruticosa</i>	moderate	Suitable habitat resources for nectar feeding arboreal mammals and birds due to the presence of flowering canopy species including <i>Eucalypt spp.</i> and <i>Melaleuca spp.</i>
Open water.	No	N/A		moderate	Open water is infested with filamentous algae but does provide habitat resources for water birds and a variety of native fauna.

e) Noxious Weeds

Two weeds listed as noxious in the Sutherland Shire (DPI undated) were observed in the upslope weed community:

- lantana *Lantana camara*; and
- narrow-leaf privet *Ligustrum sinense*.

These weeds are only just becoming established upslope of the wetland; timely and ongoing management could see them effectively controlled and reduce the likelihood of them becoming established in Burnum Burnum Sanctuary.

Lantana is also a weed of national significance (WoNs). A National Priority Action Framework (Weeds Australia 2009) and priority actions for each natural resource management area including the Sydney Metropolitan Catchment Management Area are available to guide the management of this weed.

A variety of other weeds of concern were observed upslope of the wetland including:

- kikuyu *Pennisetum clandestinum*;
- moth vine *Araujia sericifera*; and
- balloon vine *Cardiospermum grandiflorum*.

Although not considered noxious in the Sutherland Shire these weeds are rapidly becoming established upstream of the wetland and could invade Burnum Burnum Sanctuary.

5.2 BUFFER ZONE AND CONNECTIVITY

Sutherland Shire Council has a Greenweb strategy to conserve and enhance bushland and biodiversity by identifying and appropriately managing key areas of bushland habitat and establishing and maintaining interconnecting linkages and corridors (SSC 2010).

Burnum Burnum Wetland has been mapped by the Greenweb strategy as restoration. This is defined by SSC (2010) as:

- Restoration — areas provide opportunities for the establishment and

vegetation of corridors between core areas.

other definitions under Greenweb are:

- Core — areas containing key habitat areas, linkages and threatened species, or endangered ecological communities (usually greater than 3.5 hectares).
- Support — areas containing ancillary habitat areas, secondary linkages between habitats, or lands that form a buffer between developments adjacent key habitats and corridors.

Burnum Burnum wetland forms part of a larger core Greenweb corridor that extends east through Burnum Burnum Sanctuary upslope to Jannali and across to a core corridor that extends along Oyster Creek to Oyster Bay and the Georges River.

The wetland is also connected by core corridor north to Bonnet Bay Reserve and further north to Glen Reserve which extends into areas of restoration corridor along the eastern bank of the Woronora River to its confluence with the Georges River.

The wetland is also connected to core corridor areas that extend south to Prince Edward Park and then join extensive core areas within Royal and Heathcote National Parks and the Holsworthy Military Reserve. The location of Burnum Burnum wetland in the Greenweb network is shown in Figure 11.

5.3 FAUNA HABITAT EVALUATION

The fauna habitats provided by Burnum Burnum Wetland are summarised in Table 2. They range from low to moderate. The landscape plantings provide habitat resources for nectar feeding arboreal mammals and birds due to the presence of flowering canopy species including *Eucalypt spp* and *Melaleuca spp*. The open water provides habitat resources for water birds and a variety of species that may utilise the area from Burnum Burnum Sanctuary. The upslope weed community habitat values are considered low due to the heavy levels of weed infestation and presence of litter and the disturbed nature of this community.

5.4 FISH PASSAGE ASSESSMENT

Currently fish passage between the Burnum Burnum Wetland and the Woronora River is restricted by the outlet from the wetland (see section 2.8). The current configuration of the outlet structure allows tidal inundation of the wetland only during king high tides (High Water Springs). Consequently, even though there are anecdotal reports of mullet in the wetland, the opportunity for fish to regularly enter and exit the wetland from the Woronora River is severely restricted.

6 SOCIAL VALUES

Burnum Burnum Wetland is located in the suburb of Woronora in the Sutherland Shire on the southern outskirts of Sydney. Woronora is a small suburb of just over 2000 residents and residential development has occurred on both the eastern and western side of the Woronora River.

6.1 EXISTING AND POTENTIAL USERS

The Burnum Burnum Wetland, adjoining playground and boat ramp are very popular recreational locations that experience high levels of use during the week and especially on weekends with local residents reporting the car park is often at capacity on the weekend during summer.

The parklands adjoining the wetland include passive and active recreational areas and are well patronised by families with young children, dog walkers, fisherman, bird watchers and users of the adjacent Burnum Burnum Sanctuary.

The area immediately surrounding the wetland is a known 'hot spot' for anti-social behaviour especially at night. The access gate is locked at sunset in the winter and at 10pm in the summer to allow fishermen access to the boat ramp.

The wetland and the adjacent sanctuary were renamed in 2005 in honour of Burnum Burnum, the Aboriginal activist who lived in Woronora in his later life

Burnum Burnum passed away at his Woronora home on 18 August 1997 aged 61. He was a respected member of the community who fought tirelessly for the rights of Aboriginal people and became the most recognised indigenous person in this region and well known throughout Australia. The last thirty years of his life were predominantly spent in the Sutherland Shire, the last ten at Woronora.

Following his death The Aboriginal Advisory Committee in consultation with the family of Burnum Burnum recommended to SSC that the area known as Jannali Reserve, be

renamed Burnum Burnum Reserve in recognition of the significant contribution Burnum Burnum made to Australia, his strong connection to the Sutherland Shire and his particular affinity with the land and people of the Woronora Valley.

The following groups were interviewed in regards to their use of the wetland:

- Sutherland Shire Council;
- Sutherland Shire Council Bushcare;
- Sutherland Shire Canoe Club.

An active Sutherland Shire Bushcare Group works in Burnum Burnum Sanctuary, their area of activity is in the bushland part of the sanctuary and around the artificial wetland on Tudar Road, Sutherland. Currently the Bushcare group have no activity in Burnum Burnum Wetland.

6.2 VALUE OF BURNUM BURNUM WETLAND TO THE COMMUNITY

The value of Burnum Burnum Wetland to the community has been gauged by the responses at the community consultation workshop (see section 6.3).

In summary the wetland is highly valued by the community as:

- An attractive area for passive and active recreation that is enjoyed by a range of user groups including families, dog walkers and sports people.

6.3 COMMUNITY CONSULTATION

6.3.1 Approach

A community consultation program was undertaken as part of this management plan. The objectives of the program were to:

- identify values of the wetland to the community

- gain an understanding of community attitudes towards the wetland; their likes and dislikes; and
- provide an opportunity for community members to offer suggestions on how the wetland could be improved.

Involving the community in the preparation of the management plan ensures the plan reflects the needs and concerns of those who have an interest in the future of Burnum Burnum Wetland.

A number of techniques were used to facilitate communication between the community and the study team during the preparation of the management plan. These included:

- phone interviews with known user groups;
- distribution of a newsletter to the residents of the surrounding residential area of Woronora;
- erection of a sign at the wetland providing details about the management plan process and contact details for the project team
- day to day contact through the provision of a contact name, phone number and email address; and
- two community workshops at the Sutherland Shire Council Chambers.

The first workshop was held in August 2011 during the preparation of the draft management plan so the community could directly indicate their likes and dislikes to the study team and provide input into the management strategies by identifying how they thought the wetland could be improved.

The second workshop was held after the preparation of the draft management plan to provide the community with an opportunity to comment on the draft document.

6.3.2 Results

A total of two residents attended the first workshop along with 4 Council officers, a representative from SMCMA and two consultants.

A short presentation on the management plan process and studies being undertaken was provided by Molino Stewart and J Wyndham

Prince. A series of historical aerial photos of Burnum Burnum Wetland were also presented, dating as far back as 1930. The community members then addressed the following questions:

- what they liked most about the wetland;
- what they liked least about the wetland;
- how they thought the wetland could be improved.

Participants were asked to list these things and, where possible, rank them in order of priority.

Specific features people liked about Burnum Burnum Wetland were:

- the wetland is a nice pond with a bridge;
- the wetland is nicely set up;
- the recent improvement works to the park facilities;
- the presence of birds and ducks;
- the high levels of human use for recreation.

The community members also identified things they did not like about the wetland:

- the garden around the edge is not maintained;
- a decline in bird numbers;
- flooding near the canoe club clubhouse;
- lack of flushing of the wetland;
- lack of response from Council on calls about rubbish dumping (common in the car park);
- fallen logs and rubbish;
- vandalism and lack of security for canoe clubhouse;
- nylon line left by fisherman that kills birds and wildlife;
- unsupervised youth in the reserve at night; and
- car park is at capacity during the weekends in summer.

The community members also had a number of ideas on how the wetland could be improved:

- use tidal flushing to improve water quality in the wetland;
- better and more regular rubbish collection (address the demarcation dispute within Council about who is responsible);
- more shrubs in the adjoining vegetation for birds;
- Educational signage to assist in bird identification for the wetland and the Woronora River;
- Resurfacing of the car park.

A total of three residents attended the second workshop along with 2 Council officers, a representative from SMCMA and two consultants.

A short presentation on the management plan process, strategies and actions proposed in the plan was provided by Molino Stewart. J Wyndham Prince provided a presentation on the upstream treatment train repair and maintenance requirements. A general discussion was then facilitated by the consultants on the management strategies proposed in the plan. A number of additional management measures were identified by community members at the workshop, these included:

- renaming the optional management strategies as essential;
- improving pedestrian access from Woronora bridge, Burnum Burnum Sanctuary and the wetland; and
- restoring the natural vegetation in the vicinity of the wetland, through establishment of a temporary Bushcare group and a one off Bushcare working bee.

7 ISSUES ANALYSIS

7.1 ORIGINAL DESIGN OBJECTIVES

Burnum Burnum Wetland was designed and built by the NSW RMS with two primary management objectives, both of which were to control discharges from the Woronora Bridge.

Spill containment – the upstream drainage system utilises a diversion pit to divert low flows and any spills, from the Woronora bridge deck, into Burnum Burnum Wetland whilst the higher flows are diverted to the Woronora River beneath the bridge. Overland flows are intercepted before they reach the wetland and directed towards a box culvert beneath the access road which discharges into the river adjacent to the adjoining car park. An oil boom separates the 2 cells and is intended to retain free oils within Cell 1. However the bottom of the skirt appears to be attached to the substrate of the wetland and its ability to rise and fall with changing water levels and retain free oils is questionable.

Inspection of the upstream treatment train during preparation of the management plan revealed the constructed treatment train differed from the plans resulting in reduced operational performance and this combined with a lack of maintenance may have contributed to reduced functionality of the wetland system.

Stormwater control – low flows directed into the wetland are retained within the wetland by a weir containing 2 x 90 mm diameter and 1 x 50 mm diameter trickle pipes, set 100 mm in height, apart. These restrict the outflow of freshwater from the wetland and the inflow of saltwater from the Woronora River. Whilst the restriction to the outflows safeguards the water quality of the Woronora River, it increases the hydraulic residence time within the wetland thereby promoting sedimentation and uptake of nutrients through contact with plants and micro-organisms. The height of the invert of the outlet (described in detail in chapter 4) reduces saltwater flowing back from the Woronora River into the wetland which results

in negligible tidal flushing occurring within the wetland.

Consequently the wetland is currently a freshwater system with infrequent, limited saltwater inflows. Tidal inundation only occurs during king high tides in excess of 1.0 metres AHD, which allows around 22 hours of saltwater intrusion per year (DECCW 2009/722). During these rare occasions the wetland system could remain saline for extended periods until the saltwater is flushed out by stormwater inflows of sufficient volume and energy to displace the saltwater. Note saltwater is denser than freshwater and a halocline (vertical gradient) is likely to develop which could force the freshwater to flow through the wetland without mixing with or displacing the saltwater below the halocline.

7.2 LOW WATER QUALITY AND ALGAL BLOOMS

The factors discussed above combined with the small catchment contributing to the wetland result in a lack of regular flushing of the wetland by fresh water inflows. Opportunities for tidal flushing of the wetland are limited by the high level of the trickle flow outlet pipes. The combination of these 2 infrastructure issues results in stagnant conditions within the wetland and minimal mixing of the stored water, both of which enhance the opportunity for low water quality and the likelihood of algal blooms.

The design and function of the wetland to achieve the original spill containment and stormwater management goals along with irregular maintenance of the upstream treatment train has resulted in a number of negative impacts on Burnum Burnum Wetland. These include:

- presence of filamentous algae on the surface of Cell 1 and Cell 2;
- lack of emergent vegetation;
- debris accumulation on the bottom of both wetland cells the anaerobic decomposition of which could promote low Dissolved Oxygen.

These negative impacts are compounded by:

- the faecal contamination and nutrient enrichment from waterbirds; which is exacerbated by
- community feeding of ducks.

Further, the existing trash rack on top of the outlet weir prevents light litter escaping to the Woronora River and allows it to accumulate in the wetland, thereby impacting adversely on the visual amenity.

7.3 RUBBISH DUMPING

The wetland parking area is used for dumping builder's rubbish. This detracts from the recreational and visual amenity of the wetland and surrounding area and may in some cases pose health and safety risks. Builders' rubbish could contain material that is toxic or linked to human health issues such as asbestos. Unregulated dumping in the area has not to date been addressed in a timely or regular manner.

In order to limit Council's liabilities, to protect the health and safety of wetland area users and the health of the Woronora River, a regular and effective rubbish collection system is required. Ongoing education of fisherman on the dangers posed by nylon fishing line to aquatic fauna and wildlife should also be undertaken as part of a broader environmental education program.

The wetland also receives rubbish from overland flows from the Woronora Bridge. A net style GPT on the end of the inlet pipe would improve light litter, gross pollutant and sediment volumes entering the wetland. A regular maintenance regime to remove captured debris would be required.

7.4 WEED MANAGEMENT

A variety of weeds are becoming established immediately upstream of Burnum Burnum Wetland and include lantana and small leaf privet, noxious weeds in the Sutherland Shire. The area that has been infested is small and contained. An ongoing and regular weed management program is required to address these weeds and replace them with dense plantings of suitable locally indigenous native

species that will address the purpose of the uptake of nutrient enriched run off and contribute to local fauna habitat values.

7.5 EXPANDED MANAGEMENT OBJECTIVES

Sutherland Shire Council now has care, control and management responsibilities for Burnum Burnum Wetland, and its management objectives for the wetland have expanded to include:

- A functioning wetland system that complements the recreational values of the Burnum Burnum Sanctuary.

This expansion of the wetland objectives requires that:

- reasonable levels of water quality are achieved within the wetland;
- there is a reduction in algal blooms;
- water quality is enhanced through mixing of the water.

An additional provisional objective includes:

- an increase in tidal flushing to assist with mixing and provide a saltmarsh/estuarine habitat free of mangroves.

The original RTA spill containment objective for the wetland must be maintained to protect the Woronora River estuary. An innovative approach is required to address the water quality issues in the wetland while maintaining the original design objectives.

7.6 MANAGEMENT OPPORTUNITIES

7.6.1 Repair and Maintenance of the Upstream Treatment Train

During the preparation of the management plan the treatment train upstream of the wetland was subject to an inspection and audit that revealed due to design, construction and in some cases failure of structural elements the operation of the treatment train was not optimal. This combined with an irregular

maintenance regime has contributed to reduced functionality of the wetland.

Recommend repairs to and cleaning of the existing stormwater drainage system and pollution controls upstream of the wetland were developed as part of this plan and are detailed in Appendix E to this report. In summary corrective actions included:

- streamlining within pits to enhance their flow characteristics;
- the relocation of the pipe line draining the bridge deck to the design intended junction pit at the top of the treatment train;
- raising the surcharge pit;
- raising the inlet to the bypass reinforced concrete box culvert (RCBC) adjacent to the car park;
- localised site regrading to create an overland flow path between the existing surcharge pit and the wetland and provide maintenance access to the headwall;
- Preparation of maintenance manuals for the existing diversion pit and weir, Humegard gross pollutant trap (GPT) and HumeCeptor oil and grease separator (OGS).

7.6.2 Freshwater and Saltmarsh Wetland

A broad management approach was developed during the wetland management plan process to address the management issues identified above. Key ideas included:

- Altering the wetland from essentially a freshwater system, to include Cell 1 as a freshwater wetland treatment and spill containment system with dense emergent macrophytes, and Cell 2 as a salt marsh containing examples of high, mid and low saltmarsh zones.

Following the inspection and audit of the treatment train the alteration of Cell 2 to a saltmarsh system has been retained as a management option for consideration if recommended repairs and increased maintenance do not improve wetland function.

A variety of management actions would be required to achieve this optional alteration to a combined freshwater and saltmarsh system. These are outlined in detail in chapter 8. Ongoing monitoring and adaptive management would also be required to manage the successful transition. This is detailed in Chapter 9.

7.6.3 Improving Vegetation Communities and Fauna Habitat Values

Currently the condition of vegetation communities and fauna habitats in and around Burnum Burnum Wetland is considered moderate. The alterations to the wetland and the introduction of emergent macrophytes and salt marsh to the wetland itself will contribute significantly to increased floristic diversity and habitat values for a variety of species. It is considered likely that the variety of bird species utilising the wetland may alter with the introduction of salt marsh and emergent macrophytes.

The ecological values of the adjoining landscape planting and weed communities could also be improved through the progressive removal and ongoing control of weeds. Supplementary planting in the landscaped area and upslope weed community with locally indigenous native species in the shrub layer would increase diversity and habitat values in these communities particularly for small birds, a key concern of community members.

Sutherland Shire Council has released a guide to indigenous plant species suitable for landscape and revegetation projects (SSC 2005). This guide provides information on plant selection criteria for bird attracting and information on specific landscaping considerations. This guide also provides a list of plant descriptions often with notes on distribution in the Sutherland Shire. A number of plants are highlighted as occurring in Jannali Reserve, now Burnum Burnum Sanctuary that may be suitable for use at this site.

7.6.4 Education

The creation of a freshwater through to a saltmarsh wetland in this contained environment would present a unique education environment for a variety of participants. The constructed wetland with an improved upstream treatment train would also provide an opportunity for environmental education. Participants would range from school children through to post graduate university students and include wetland management and construction practitioners. Burnum Burnum Wetland could be used as a demonstration site for professional groups such as the Stormwater Industry Association and Engineers Australia.

The community has also expressed an interest in the development of educational signage for the identification of birds using the wetland and the Woronora River and on the function of the wetland. The high levels of usage of the wetland and adjoining park, its proximity to the Woronora River and the Burnum Burnum Sanctuary provide opportunities for environmental education. The use of signage to identify birds and native wildlife and wetland function is an effective environmental education tool.

There is also a need to initiate and continue education for local fisherman on the dangers posed to wildlife by nylon fishing line. Regular fishing line “clean up days for wildlife” could be undertaken as part of a wider community engagement program.

7.6.5 Community Engagement

Burnum Burnum Wetland and the adjacent Burnum Burnum Sanctuary represent areas named in memory of an important Indigenous activist and as such exhibit indigenous cultural heritage sensitivity that should be acknowledged and incorporated into the wetland management plan.

Liaison with Indigenous representatives in the local area and Burnum Burnum’s widow regarding the proposed management changes and the potential use of the wetland as an educational resource are appropriate.

The initiatives proposed in this management plan provide opportunities for community engagement through programs and signage with a focus on:

- Native bird and wildlife identification;
- Protection of wildlife and the Woronora River by collecting and removing nylon fishing line;
- Undertaking clean up days in the wetland and surrounding park lead by Council to increase the capacity of community members that use the area to take action.

7.6.6 Improved Access and Pedestrian Links

The pedestrian access from Menai Road (the old Woronora bridge) to Burnum Burnum Sanctuary and the wetland is currently considered by the community as very poor and dangerous. There is currently no defined pedestrian access link between Menai Road and the wetland despite the popularity of the area for recreational walks.

Community feedback indicates a pedestrian path (or shared path/cycleway):

- would improve access for sustainable means of transport (eg cycling and walking) and improve safety for users; and
- could be designated over the top of the drainage pits and access points to ensure that vehicles do not drive over the lids and reduce the potential for further damage.

Information and education signs about the operation of the complex stormwater system and the natural environment could be provided along the pedestrian path to increase information for users of the area. Tiled mosaics of natural or interesting features of the area (eg birds, animals, kayaks, fishing etc) could be embedded into the surface of the concrete as informative signage.

The community has indicated that improving pedestrian access would contribute to the social value of the wetland, and allow greater understanding of the wetland and environment.

8 MANAGEMENT STRATEGIES

8.1 MANAGEMENT STRATEGIES

A variety of management strategies and actions have been developed to take into account the issues analysis and to provide clear and specific management objectives. It is suggested that these management strategies be undertaken in two stages. Strategies include:

- Upstream Treatment Train Repairs and Maintenance;
- Vegetation management;
- Rubbish management;
- Increased catchment size;
- Infrastructure renewal;
- Education strategies; and
- Community engagement.

A number of stage two management strategies have also been developed

- Concept design of proposed works;
- Outlet pipe reconfiguration;
- Cell reshaping; and
- Wetland plantings.

The strategies are presented below. The strategies have been prioritised and costed and this is presented in Appendix E to this report.

8.2 UPSTREAM TREATMENT TRAIN REPAIRS AND MAINTENANCE

8.2.1 Objectives

To repair and maintain the upstream treatment train to improve wetland function and access.

8.2.2 Actions

- Remove accumulated sediment from the diversion pit,
- Streamlining of the diversion pit, upstream and downstream of the weir, to reduce hydraulic losses, improve flow characteristic and prevent sediment buildup. Streamlining should also occur within the kerb inlet pit and the Junction pit (See detailed recommendations in Appendix E).
- Repair the GPT lid and frame. Clean out the sediment accumulated around the boom. Remove the pipe from the Woronora bridge deck out of the storage/treatment chamber and re-connect it to the upstream junction pit (See detailed recommendations in Appendix E).
- Repair the HumeCeptor™. Oil and Grit Separator (OGS) lid surround, remove the tree roots from within the OGS and repair the joint between the inflow pipe and the HumeCeptor™ (See detailed recommendations in Appendix E).
- Install a raised letter box pit in front of the culvert and existing surcharge pit and undertake localised site regrading to allow surcharge flows to enter the wetland (See detailed recommendations in Appendix E).
- Implement a maintenance schedule as per the maintenance manual provided in Appendix E for each element of the stormwater pollution control treatment train.
- Undertake water quality monitoring in the wetland over a minimum of four seasons to determine if there is a measurable increase in water quality and flushing in the wetland.
- Install a raised concrete pedestrian or shared pathway on the eastern edge of the access road from the old Woronora bridge (Menai Road) that would include raising the lids on the existing pits to fit flush with the finished surface of the pathway and exclude vehicular traffic due to the application of 100 mm of concrete over the existing pavement.

8.2.3 Performance Targets

- Improved water quality within the wetland;

- Reduced algae in the wetland;
- Improved water balance (the flow of water in and out of the wetland) in the wetland system.
- Installation of pedestrian pathway.

8.2.4 Funding Sources

- NSW Roads and Maritime Services.
- Sutherland Shire Council.

8.3 VEGETATION MANAGEMENT

8.3.1 Objectives

Increase the structural and floristic diversity of the native vegetation buffer zone to Burnum Burnum Wetland.

8.3.2 Actions

- Undertake supplementary planting with locally indigenous native plant species including groundcovers, low shrubs, medium and tall shrubs on the terrestrial edge of the wetland (refer to SSC 2005);
- Remove and undertake ongoing control of weeds upstream of the wetland;
- Monitor revegetation and undertake supplementary planting and weeding as required.

8.3.3 Performance Targets

- Increased floristic and structural diversity in the shrub layer of the wetland buffer vegetation;
- Reduced weed levels in the vegetation upstream of the wetland in particular removal of vines and noxious weeds.

8.3.4 Funding Sources

- Water Sensitive Urban Design (WSUD) Program - www.wsud.org Sydney metropolitan Catchment Management Authority has funding WSUD projects for next year (11-12) and the year after that.

Projects need to be in Botany Bay Catchment and improve water quality. Projects require co-funding from land manager. Catchment area treated needs to be 2 hectares or greater.

- Office of Environment and Heritage Environmental Restoration and Rehabilitation Grants (as part of a broader grant application) <http://www.environment.nsw.gov.au/grants/envtrust.htm> <http://www.environment.nsw.gov.au/grants/restoration.htm>.
- SCC's Bushcare program.
- Georges River Combined Councils Committee River Keeper Program.

8.4 RUBBISH MANAGEMENT

8.4.1 Objectives

Reduce the time that dumped rubbish stays in the wetland car park, reduce rubbish entering the wetland, reduce the volume of nylon fishing line in and around the wetland, boat ramp and surrounding area.

8.4.2 Actions

- Determine who has responsibility for responding to residents calls regarding dumped rubbish at Burnum Burnum Wetland car park;
- Develop a regular and effective dumped rubbish investigation and collection service for the wetland;
- Investigate the existing GPT between the Woronora Bridge and the wetland, identify how this may be changed, upgraded or altered to reduce rubbish entering the wetland;
- Until the GPT investigation can be acted upon, institute a regular rubbish collection from the wetland and undertake rubbish collection following rainfall events;
- Develop an environmental education initiative aimed at reducing the volume of nylon fishing line dumped at the wetland, boat ramp and surrounding area;
- Celebrate events like 'Clean Up Australia Day' and "World Wetlands Day" at the

wetland and assist the local community to become involved in cleaning up the surrounding area;

- Explore the opportunity to develop corporate sponsorship for these events at Burnum Burnum Wetland.

8.4.1 Performance Targets

- Determination of Council Officer responsible for responding to residents calls regarding rubbish dumping at the wetland identified;
- A regular and effective rubbish investigation and collection service established;
- Installation of net style GPT on the wetland inlet pipe;
- Environmental education program to address nylon fishing line dumping developed and implemented;
- Clean Up Australia day celebrated at Burnum Burnum Wetland;
- World Wetlands Day celebrated at Burnum Burnum Wetland.

8.4.2 Funding Sources

- Georges River Combined Councils Committee River Keeper Program;
- SCC's maintenance budget;
- SCCs Bushcare program;
- Corporate sponsorship.

8.5 INCREASED CATCHMENT SIZE

8.5.1 Objectives

Increased flushing of the wetland by increased volume of freshwater entering the wetland

8.5.2 Actions

- Upstream site re-grading, between the existing box culvert under the access road and Cell 1, and possibly re-shaping of the carpark to allow surface runoff to

be directed to the wetland instead of the Woronora River;

- a diversion weir placed across the entry into the box culvert under the access road, upstream of the wetland, to direct as much as possible of the the overland flow and surcharged runoff into the wetland. High flows must be allowed to overtop the weir and flow to the river without flooding the carpark;
- Re-shaping and resurfacing of the carpark to force surface runoff towards a perimeter bioswale to be filtered and treated before it discharges into Cell 1.

8.5.3 Performance Targets

- Improved water quality within the wetland;
- Reduced algae in the wetland;
- Improved water balance (the flow of water in and out of the wetland) in the wetland system.

8.5.4 Funding Sources

- Water Sensitive Urban Design (WSUD) Program - www.wsud.org Sydney metropolitan Catchment Management Authority has funding WSUD projects for next year (11-12) and the year after that. Projects need to be in Botany Bay Catchment and improve water quality. Projects require co-funding from council or land manager. Catchment area treated needs to be 2 hectares or greater.
- Office of Environment and Heritage Environmental Restoration and Rehabilitation Grants (as part of a broader grant application) <http://www.environment.nsw.gov.au/grants/envtrust.htm> <http://www.environment.nsw.gov.au/grants/restoration.htm>

8.6 INFRASTRUCTURE RENEWAL

8.6.1 Objectives

- Restrict the establishment of mangroves in Cell 2;
- Reduce litter volume in the wetland; and

- Improve retention of free oil in Cell 1.

8.6.2 Actions

- Installation of a hooded or grated control on the outlet pipe at the Woronora River to prevent buoyant mangrove propagules from entering the saltmarsh in Cell 2.
- A net style GPT on the end of the inlet pipe;
- Replacement of the oil boom separating Cell 1 and Cell 2 with a new one that floats and will retain any free oil within Cell 1 without letting it bypass into Cell 2 and the Woronora River.
- Maintain the operational efficiency of the existing Humegard® GPT and Humeceptor® Oil and Grit Separator, or replace them with a Baramy® vane style GPT between the existing surcharge pit and Cell 1.

8.6.3 Performance Targets

- No establishment of mangroves in Cell 2 of the wetland in the short or long term;
- No light litter entering the wetland from the upstream pipe network;
- Free oil retained in Cell 1 of the wetland. Thereby retaining the original RTA spill basin objective.

8.6.4 Funding Sources

- NSW RMS.

8.7 EDUCATION STRATEGIES

8.7.1 Objectives

Utilise the renewed wetland for environmental educational purposes.

8.7.2 Actions

- Identify appropriate education partners who may develop education programs using the wetland (for example local public and high schools, local TAFE colleges, relevant Universities, wetland

managers and builders of constructed wetlands);

- Build partnerships through measures including but not limited to information sharing and e-newsletters;
- Disseminate information on the proposed changes of the wetland to these partners, prior to and following the changes;
- Develop appropriate signage to display at the wetland showing the changes;
- Liaise directly with key educational partners to encourage the development of educational material based around Burnum Burnum Wetland;
- Develop partnerships to widen educational opportunities at Burnum Burnum Wetland in particular with Burnum Burnum Sanctuary;
- Develop appropriate signage for the identification of birds and wildlife using the wetland and the Woronora River and wetland function;
- Develop an environmental education program specifically focussed on reducing nylon fishing line being left at the boat ramp and surrounding area.

8.7.3 Performance Targets

- Educational programs delivered on site at the wetland;
- Use of the wetland by local school groups;
- Use of the wetland by technical and tertiary education groups;
- Use of Burnum Burnum Wetland as a demonstration site for professional groups;
- Signage for the identification of birds and wildlife and wetland function erected;
- Reduced volumes of nylon fishing line left at the boat ramps and surrounding area.

8.7.4 Funding Sources

- Office of Environment and Heritage Environmental Trust grant programs, Environmental Education – Community <http://www.environment.nsw.gov.au/grants/education.htm>
- Corporate sponsorship.

8.8 COMMUNITY ENGAGEMENT

8.8.1 Objectives

To engage the local community and users of Burnum Burnum Wetland to undertake measures that will contribute to the long term management of the wetland.

8.8.2 Actions

- Identify and engage with local community user groups;
- Identify and engage with broader community user groups;
- Ensure local and broader community groups are kept informed of the progress of changes proposed to be made to the wetland;
- Provide a point of contact within Council for user groups (for example Bushcare or Greenweb Officer);
- Provide information to local groups, residents and the community in how they can become involved in management and monitoring in the wetland, for example Birds in Backyards surveys, Clean Up Australia Day, World Wetlands Day, remove nylon line program activities;
- Provide signage that reflects the new management measures at the wetland and encourages monitoring native species;
- Provide environmental education signage for the identification of birds and wildlife using the wetland and the Woronora River;
- Assist the Burnum Burnum Sanctuary Bushcare group to consider how they might contribute to the ongoing management of Burnum Burnum Wetland, with a view to developing a sub group focussed on the wetland;
- Consider the use of the Community Biodiversity Survey Project approach to train Bushcare members on collecting monitoring data for the wetland.
- Develop incentives for the local community to utilise the wetland for educational and recreational purposes (for example providing free seedlings and

a bbq on world wetlands day and clean up Australia day weekend.

- Explore opportunities for corporate sponsorship for activities and or programs around the wetland.

8.8.3 Performance Targets

- Ongoing community use of Burnum Burnum Wetland and the adjacent park;
- Engagement of local and broader community groups in programs that contribute to management and monitoring in the wetland.

8.8.4 Funding Sources

- Office of Environment and Heritage Environmental Trust grant programs, Environmental Education – Community <http://www.environment.nsw.gov.au/grant/s/education.htm>
- Office of Environment and Heritage Environmental Restoration and Rehabilitation Grants (as part of a broader grant application) <http://www.environment.nsw.gov.au/grant/s/envtrust.htm> <http://www.environment.nsw.gov.au/grant/s/restoration.htm>

8.9 STAGE 2 WETLAND MANAGEMENT STRATEGIES

A range of wetland management strategies were developed during the preparation of the management plan that can be implemented as a second stage. Consideration of the success of the repairs and improved maintenance regime of the upstream treatment train in achieving a measurable increase in water quality and flushing of the wetland within a 12 month period should be considered in the implementation of the stage 2 strategies and actions.

The stage 2 management strategies are presented below.

8.10 CONCEPT DESIGN

8.10.1 Objectives

To prepare a concept design and construction estimate for the works required to achieve a freshwater and saltmarsh zoned wetland.

8.10.2 Actions

- Engage engineers to undertake the detailed concept design;
- Present concept design to the community;
- Gather quotations for the cost of construction of the proposed structural alterations to Burnum Burnum Wetland.

8.10.3 Performance Targets

- Review of concept design by the community, project team and Council;
- Cost quotations on the construction of proposed structural changes.

8.10.4 Funding Sources

- NSW Roads and Maritime Services.

8.11 OUTLET PIPE RECONFIGURATION

8.11.1 Objectives

Re-configuration of the outlet structure, pipeline and headwall at the Woronora River to allow more frequent saltwater inundation of Cell 2 of the Burnum Burnum Wetland.

8.11.2 Actions

- Undertake required calculations to determine the new levels for the outlet pipeline and headwall required to achieve a saltmarsh within Cell 2;
- Construct a pipeline connecting Cell 2 to the Woronora River at least 500 mm lower than the existing pipeline to allow

saltwater intrusion of Cell 2 at MSL. Provide a suitable control within this connection to prevent mangrove propagules from entering the wetland from the Woronora River;

- Reconfiguration of Cell 1 to retain its function as a spill control basin and enhance its functionality as a wetland treatment system through the incorporation of emergent macrophytes;
- Reinstatement of the spill control through the use of a floating boom and / or floating reed bed.

8.11.3 Performance Targets

- Zonation through saltmarsh in Cell 2 achieved by allowing more frequent tidal inundation;
- Grading the surface of the saltmarsh through Cell 2 to provide a low salt marsh close to the outlet and a high saltmarsh close to the pedestrian bridge. This will require a level of 0.5 m (AHD) at the outlet and 0.7 m (AHD) beneath the pedestrian bridge with the top of the weir separating Cell 1 and Cell 2 at 1.5 m (AHD);
- A functional wetland treatment system in Cell 1 with the capacity to control spills which may occur on the Woronora Bridge deck.

8.11.4 Funding Sources

- Water Sensitive Urban Design (WSUD) Program - www.wsud.org Sydney metropolitan Catchment Management Authority has funding WSUD projects for next year (11-12) and the year after that. Projects need to be in Botany Bay Catchment and improve water quality. Projects require co-funding from land manager. Catchment area treated needs to be 2 hectares or greater.
- Office of Environment and Heritage Environmental Restoration and Rehabilitation Grants (as part of a broader grant application) <http://www.environment.nsw.gov.au/grants/envtrust.htm> <http://www.environment.nsw.gov.au/grants/restoration.htm>

8.12 CELL RESHAPING

8.12.1 Objectives

Reshaping and the addition of substrate in Cell 1 and Cell 2 to enable alterations to the wetland

8.12.2 Actions

- Draining of the wetland for a short period to enable earthworks, installation of growing media and planting;
- Reconfiguration of Cell 1 to include either a wetland planted out with emergent macrophytes or a floating reed bed creating a mix of macrophytes and open water;
- Source appropriate saltmarsh substrate for Cell 2, and regrading of the substrate to form a sloping substrate (0.5 m AHD at the outlet and 0.7 m AHD beneath the pedestrian bridge);
- Addition of growing medium to Cell 2 suitable to support saltmarsh species.

8.12.3 Performance Targets

- Establishment of suitable cell shapes and interior cell heights and surfaces to establish emergent macrophytes in Cell 1 and zones of different saltmarsh species in Cell 2.

8.12.4 Funding Sources

- Water Sensitive Urban Design (WSUD) Program - www.wsud.org Sydney metropolitan Catchment Management Authority has funding WSUD projects for next year (11-12) and the year after that. Projects need to be in Botany Bay Catchment and improve water quality. Projects require co-funding from land manager. Catchment area treated needs to be 2 hectares or greater.
- Office of Environment and Heritage Environmental Restoration and Rehabilitation Grants (as part of a broader grant application) <http://www.environment.nsw.gov.au/grants/envtrust.htm>

<http://www.environment.nsw.gov.au/grants/restoration.htm>

8.13 WETLAND PLANTINGS

8.13.1 Objectives

To establish a viable saltmarsh in Cell 2 of Burnum Burnum Wetland consisting of a low, mid and high saltmarsh, minus mangroves consistent with the Woronora estuary.

8.13.2 Actions

- Trial suitable locally dredged material as saltmarsh substrate prior to its use in Cell 2 of Burnum Burnum Wetland;
- Prepare a revegetation plan for Cell 1 (emergent macrophytes) and Cell 2 (saltmarsh species) of Burnum Burnum Wetland with appropriate plant densities and planting zones.
- Select and source appropriate emergent macrophytes plants or floating reed bed for planting in Cell 1;
- Select and source appropriate saltmarsh species for planting in zones in Cell 2.

8.13.3 Performance Targets

- Establishment of emergent macrophytes or floating reed bed in Cell 1;
- Establishment of zones of saltmarsh species in Cell 2;
- Ongoing survival of revegetated areas following increased tidal flushing and increased freshwater inflows.

8.13.4 Funding Sources

- Water Sensitive Urban Design (WSUD) Program - www.wsud.org Sydney metropolitan Catchment Management Authority has funding WSUD projects for next year (11-12) and the year after that. Projects need to be in Botany Bay Catchment and improve water quality. Projects require co-funding from land manager. Catchment area treated needs to be 2 hectares or greater.

- Office of Environment and Heritage
Environmental Restoration and
Rehabilitation Grants (as part of a
broader grant application)
<http://www.environment.nsw.gov.au/grants/envtrust.htm>
<http://www.environment.nsw.gov.au/grants/restoration.htm>

9 WETLAND MONITORING PLAN

INTRODUCTION

Monitoring of Burnum Burnum Wetland will enable wetland managers to:

- Collect long term information on the success of management actions introduced as part of this management plan;
- Collect information on the quality of surface water in the wetland and trends in water quality;
- Collect information on the success of the sea grass and emergent macrophytes zones in maintaining water quality in the wetland;
- Collect information on the success of weed management actions in vegetation around the wetland;
- Provide an evaluation of management actions;
- Provide recommendations for future management actions.

9.2 WATER QUALITY MONITORING

9.2.1 Question

- How does water quality in Burnum Burnum Wetland change over time with management?

9.2.2 Objectives

- Identify the current water quality conditions;
- Monitor diffuse and point source pollution;
- Identify trends in water quality over time;
- Identify current rates of tidal exchange and record changes following alteration to inlet and outlet structures;
- Identify a measurable reduction in level of contaminants in surface water quality in the wetland.

- Identify how the wetland functions as a spill containment basin in the event of a spill on the Woronora Bridge.

Water quality monitoring should note if and when additional changes are made to the wetland, for example:

- reshaping and replanting of cells 1 and 2;
- regrading of car park to increase freshwater catchment size;

9.2.3 Monitoring

- Long term water quality sampling should be performed at Cell 1 and Cell 2 in the wetland;
- Sampling should be undertaken every six months, preferably late summer and late winter;
- Monitoring should include those variables listed in chapter 4, with an estimated cost of \$2000 per annum (including laboratory analysis);
- In the case of a spill on the Woronora Bridge implement daily monitoring for a week and then weekly monitoring until the water quality improves back to pre spill levels;
- After two years monitoring, results should be reviewed to identify trends and consider requirements for ongoing monitoring.

9.3

CELL 1 PLANTING

9.3.1 Question

- How does replanted vegetation respond over time?
- How effective is a floating reed bed at controlling water quality?

9.3.2 Objective

- Monitor the establishment and ongoing health of emergent macrophytes planted in the newly excavated and resurfaced Cell 1 of the wetland; or
- Monitor the establishment and ongoing health of emergent macrophytes planted

within the floating reed bed and the integrity of the frames.

9.3.3 Monitoring

- The wetland cell is small and a quantitative survey using a transect from the inlet to the oil boom should be undertaken in Cell 1;

Data collection should include:

- Walk /wade the transect and identify the plants along the transect
- Estimate the percentage cover of emergent macrophytes
- Record any weed species and estimate the percentage cover
- An estimate of the area of bare water in Cell 1 should also be made.

Alternatively, monitoring of the survival and growth of plants contained in the floating reed bed should be undertaken.

9.4 CELL 2 SALTMARSH PLANTING MONITORING

9.4.1 Question

How does replanted vegetation respond over time?

9.4.2 Objective

Monitor the establishment and ongoing health of saltmarsh species planted in the resurfaced Cell 2 of the wetland

9.4.3 Monitoring

A transect should be established in Cell 2 of the wetland.

The transect should run from the oil boom to the outlet

Data collection should include:

- Walk /wade the transect and identify the plants along the transect;
- Estimate the percentage cover of each zone of saltmarsh;

- Note the change in zone or location of the change in dominant saltmarsh species along the transect. The assumption is this should reflect the range of intrusion of saline water into Cell 2;
- Record any weed species and estimate the percentage cover;
- Estimate the grading of the surface of the saltmarsh across Cell 2, (performance target from around 0.5 m AHD at the outlet to about 0.7 m AHD under the pedestrian bridge.)

9.4.4 Objective

Utilise photo points to monitor long term changes in vegetation

9.4.5 Monitoring

- Establish photo points to collect a series of photographs to cover Cell 1 and Cell 2 of the wetland;
- Establish permanent photo points within the area covered by the photograph;
- Photos should be taken at higher than ground level utilising a step ladder to enable greater coverage of the wetland;
- Photo points should be established to cover vegetation in each wetland cell;

Suggested photo points are:

- the inlet point looking downstream into Cell 1;
- the foot bridge over the oil boom looking up stream into Cell 1;
- the foot bridge over the oil boom looking downstream into Cell 2;
- the footpath at the northern end of Cell 2 looking upstream into Cell 2
- The date, time and weather conditions at the time of the photograph should be recorded;
- Photographs should be taken during spring.

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APPENDIX A - WETLAND PHOTOS

APPENDIX B - THREATENED FAUNA AND FLORA SPECIES

Burnum Burnum Wetland Threatened Terrestrial Fauna recorded in a 10kilometre radius 2001-2011			
Family	Species name	Common name	Conservation status NSW TSC Act 1995
AVES			
Accipitridae	<i>Hieraaetus morphnoides</i>	Little Eagle	V
	<i>Lophoictinia isura</i>	Square-tailed Kite	V
	<i>Circus assimilis</i>	Spotted Harrier	V
	<i>Pandion haliaetus</i>	Osprey	V
Ardeidae	<i>Botaurus poiciloptilus</i>	Australasian Bittern	E1
	<i>Ixobrychus flavicollis</i>	Black Bittern	V
Burhinidae	<i>Esacus neglectus</i>	Beach Stone-curlew	E4A
Cacatuidae	<i>Callocephalon fimbriatum</i>	Gang-gang Cockatoo	V
	<i>Calyptorhynchus lathami</i>	Glossy Black-Cockatoo	V
Charadriidae	<i>Charadrius mongolus</i>	Lesser Sand-plover	V
	<i>Charadrius leschenaultii</i>	Greater Sand-plover	V
Ciconiidae	<i>Ephippiorhynchus asiaticus</i>	Black-necked Stork	E1

<i>Diomedidae</i>	<i>Diomedea exulans</i>	Wandering Albatross	E1
	<i>Diomedea gibsoni</i>	Gibson's Albatross	V
<i>Estrildidae</i>	<i>Stagonopleura guttata</i>	Diamond Firetail	V
<i>Haematopodidae</i>	<i>Haematopus longirostris</i>	Pied Oystercatcher	E1
	<i>Haematopus fuliginosus</i>	Sooty Oystercatcher	V
<i>Laridae</i>	<i>Sterna albifrons</i>	Little Tern	E1
	<i>Sterna fuscata</i>	Sooty Tern	V
<i>Meliphagidae</i>	<i>Anthochaera phrygia</i>	Regent Honeyeater	E4A
	<i>Epthianura albifrons</i>	White-fronted Chat	V
<i>Neosittidae</i>	<i>Daphoenositta chrysoptera</i>	Varied Sittella	V
<i>Petroicidae</i>	<i>Petroica boodang</i>	Scarlet Robin	V
<i>Psittacidae</i>	<i>Glossopsitta pusilla</i>	Little Lorikeet	V
	<i>Lathamus discolor</i>	Swift Parrot	E1
	<i>Neophema chrysogaster</i>	Orange-bellied Parrot	E4A
<i>Scolopacidae</i>	<i>Calidris alba</i>	Sanderling	V
	<i>Xenus cinereus</i>	Terek Sandpiper	V
	<i>Calidris tenuirostris</i>	Great Knot	V

	<i>Limosa limosa</i>	Black-tailed Godwit	V
<i>Strigidae</i>	<i>Ninox strenua</i>	Powerful Owl	V
<i>Tytonidae</i>	<i>Tyto tenebricosa</i>	Sooty Owl	V
	<i>Tyto novaehollandiae</i>	Masked Owl	V
	<i>Tyto capensis</i>	Grass Owl	V
MAMMALIA			
<i>Burramyidae</i>	<i>Cercartetus nanus</i>	Eastern Pygmy-possum	V
<i>Dasyuridae</i>	<i>Dasyurus maculatus</i>	Spotted-tailed Quoll	V
<i>Emballonuridae</i>	<i>Saccolaimus flaviventris</i>	Yellow-bellied Sheath-tail-bat	V
<i>Molossidae</i>	<i>Mormopterus norfolkensis</i>	Eastern Freetail-bat	V
<i>Phascolarctidae</i>	<i>Phascolarctos cinereus</i>	Koala	V
<i>Pteropodidae</i>	<i>Pteropus poliocephalus</i>	Grey-headed Flying-fox	V
<i>Vespertilionidae</i>	<i>Miniopterus schreibersii oceanensis</i>	Eastern Bentwing-bat	V
	<i>Scoteanax rueppellii</i>	Greater Broad-nosed Bat	V
	<i>Myotis macropus</i>	Southern Myotis	V
	<i>Chalinolobus dwyeri</i>	Large-eared Pied Bat	V

<i>Amphibia</i>			
<i>Hylidae</i>	<i>Litoria aurea</i>	Green and Golden Bell Frog	E1
	<i>Litoria littlejohni</i>	Littlejohn's Tree Frog	V
<i>Myobatrachidae</i>	<i>Pseudophryne australis</i>	Red-crowned Toadlet	V
	<i>Heleioporus australiacus</i>	Giant Burrowing Frog	V
	<i>Crinia tinnula</i>	Wallum Froglet	V
<i>Reptilia</i>			
<i>Elapidae</i>	<i>Hoplocephalus bungaroides</i>	Broad-headed Snake	E1
<i>Varanidae</i>	<i>Varanus rosenbergi</i>	Rosenberg's Goanna	V
E1 Endangered, E2 Endangered Population E4A Critically Endangered Species V Vulnerable			

Burnum Burnum wetland -Threatened Flora recorded in a 10 kilometre radius 2001-2011

<i>Family</i>	<i>Species name</i>	<i>Common name</i>	<i>Conservation status NSW TSC Act 1995</i>
<i>Anthericaceae</i>	<i>Caesia parviflora var. minor</i>	Small Pale Grass-lily	E1
<i>Araliaceae</i>	<i>Astrotricha crassifolia</i>	Thick-leaf Star-hair	V
<i>Convolvulaceae</i>	<i>Wilsonia backhousei</i>	Narrow-leafed Wilsonia	V
<i>Ericaceae</i>	<i>Leucopogon exolasius</i>	Woronora Beard-heath	V
	<i>Epacris purpurascens var. purpurascens</i>		V
<i>Fabaceae</i>	<i>Pultenaea aristata</i>	Prickly Bush-pea	V
	<i>Acacia pubescens</i>	Downy Wattle	V
	<i>Acacia prominens</i>	Gosford Wattle, Hurstville and Kogarah Local Government Areas	E2
	<i>Acacia bynoeana</i>	Bynoe's Wattle	E1
	<i>Acacia terminalis subsp. terminalis</i>	Sunshine Wattle	E1
<i>Lamiaceae</i>	<i>Prostanthera densa</i>	Villous Mint-bush	V
	<i>Prostanthera marifolia</i>	Seaforth Mintbush	E4A
<i>Monimiaceae</i>	<i>Daphnandra sp. Illawarra</i> C	Illawarra Socketwood	E1

<i>Myrtaceae</i>	<i>Melaleuca deanei</i>	Deane's Paperbark	V
	<i>Callistemon linearifolius</i>	Netted Bottle Brush	V
	<i>Syzygium paniculatum</i>	Magenta Lilly Pilly	E1
	<i>Eucalyptus camfieldii</i>	Camfield's Stringybark	V
	<i>Eucalyptus nicholii</i>	Narrow-leaved Black Peppermint	V
	<i>Eucalyptus scoparia</i>	Wallangarra White Gum	E1
<i>Rhamnaceae</i>	<i>Pomaderris adnata</i>	Sublime Point Pomaderris	E1
	<i>Pomaderris prunifolia</i>	<i>P. prunifolia</i> in the Parramatta, Auburn, Strathfield and Bankstown Local Government Areas	E2
E1 Endangered E2 Endangered Population E4A Critically Endangered Species V Vulnerable			

APPENDIX C – FLORA SPECIES LIST

Family Asteraceae

Bidens pilosa Cobblers peg*

Family Casuarinaceae

Casuarina glauca Swamp She Oak

Family Convolvulaceae

Dichondra repens

Family Fabaceae

Acacia elata Cedar Wattle

Hardenbergia violacea False

Sarsaparilla

Senna pendula var. *glabrata* Easter

Cassia*

Family Lomandraceae

Lomandra longifolia Spiny-headed

Mat-rush

Family Myrtaceae

Angophora costata Sydney Red Gum

Corymbia gummifera Red Bloodwood

Lophostemon confertus Brush Box

Melaleuca linarifolia Snow in Summer

Melaleuca stypheloides

Family Oleaceae

Ligustrum sinense small leaf privet*

Family Oxalidaceae

Oxalis sp. *

Family Pittosporaceae

Pittosporum undulatum Pittosporum

Family Proteaceae

Banksia integrifolia subsp. *integrifolia*

Banksia serrata

Grevillea sp

Family Sapindaceae

Cardiospermum grandiflorum Balloon

Vine*

Family Solanaceae

Solanum chenopodioides Blackberry

nightshade*

Family Verbenaceae

Lantana camara Lantana *

Verbena bonariensis Purpletop *

Family Vitaceae

Viola odorata Sweet violet*

Scoenoplectus mucronatus

Family Commelinaceae

Commelina cyanea

Family Liliaceae

Asparagus aethiopicus Asparagus
fern*

Asparagus asparagoides Bridal
Creeper*

Dianella caerulea var. *producta* Blue
Flax Lily

Family Poaceae

Pennisetum clandestinum Kikyu*

Family Smilacaceae

Smilax glycyphylla Native Sarsaparilla

* Denotes introduced species

MONOCOTYLEDONS**Family Cyperaceae**

APPENDIX D – FAUNA SPECIES LIST

Fauna species recorded within 5km of Burnum Burnum Wetland

BIRDS

	Atlas of Living Australia	Current assessment
PELECANIDAE		
<i>Pelecanus conspicillatus</i> Australian Pelican	*	
CHARADRIIDAE		
<i>Vanellus miles</i> Masked Lapwing		
LARIDAE		
<i>Chroicocephalus novaehollandiae</i> Silver Gull	*	
ANHINGIDAE		
<i>Anhinga novaehollandiae</i> Australasian Darter	*	
PHALACROCORACIDAE		
<i>Phalacrocorax carbo</i> Great Cormorant	*	
<i>Microcarbo melanoleucos</i> Little Pied Cormorant	*	
<i>Phalacrocorax sulcirostris</i> Little Black Cormorant	*	
<i>Phalacrocorax varius</i> Pied Cormorant	*	
ANATIDAE		
<i>Anas superciliosa</i> Pacific Black Duck	*	
<i>Chenonetta jubata</i> Australian Wood Duck		*
RALLIDAE		
<i>Gallinula tenebrosa</i> Dusky Moorhen		
ARDEIDAE		
<i>Butorides striatus</i> Striated Heron	*	
<i>Egretta novaehollandiae</i> White-faced Heron	*	
<i>Nycticorax caledonicus</i> Nankeen Night Heron	*	
SCOLOPACIDAE		
<i>Limosa lapponica</i> Bar-tailed Godwit	*	

SCOLOPACIDAE		
<i>Numenius madagascariensis</i> Eastern Curlew	*	
ACCIPITRIDAE		
<i>Haliaeetus leucogaster</i> White-bellied Sea-Eagle	*	
CHARADRIIDAE		
<i>Streptopelia chinensis</i> Spotted Turtle dove	*	
<i>Geopelia cuneata</i> Diamond Dove	*	
CACATUIDAE		
<i>Cacatua galerita</i> Sulphur-crested Cockatoo	*	
<i>Calyptorhynchus funereus</i> Yellow-tailed Black Cockatoo		
<i>Cacatua sanguinea</i> Little Corella	*	
PSITTACIDAE		
<i>Trichoglossus haematodus</i> Rainbow Lorikeet	*	
<i>Platycercus elegans</i> Crimson Rosella	*	
<i>Platycercus eximius</i> Eastern Rosella		
STRIGIDAE		
<i>Ninox novaeseelandiae</i> Southern Boobook	*	
AEGOTHELIDAE		
<i>Aegotheles cristatus</i> Australian Owlet-nightjar		
ALCEDINIDAE		
<i>Dacelo novaeguineae</i> Laughing Kookaburra	*	
<i>Todiramphus sanctus</i> Sacred Kingfisher	*	
MALURIDAE		
<i>Malurus lamberti</i> Variegated Fairy-wren	*	
<i>Malurus cyaneus</i> Superb Blue Fairy-wren		
PACHYCEPHALIDAE		
<i>Pachycephala pectoralis</i> Golden Whistler	*	
<i>Colluricincla harmonica</i> Grey Shrike-thrush	*	

<i>PARDALOTIDAE</i>		
<i>Pardalotus punctatus</i> Spotted Pardalote	*	
<i>Sericornis frontalis</i> White-browed Scrubwren	*	
<i>ACANTHIZIDAE</i>		
<i>Acanthiza nana</i> Yellow Thornbill	*	
<i>Acanthiza pusilla</i> Brown Thornbill	*	
<i>PETROICIDAE</i>		
<i>Petroica rosea</i> Rose Robin	*	
<i>MELIPAGIDAE</i>		
<i>Anthochaera carunculata</i> Red Wattlebird	*	
<i>Anthochaera chrysoptera</i> Little Wattlebird	*	
<i>Manorina melanocephala</i> Noisy Miner	*	
<i>Lichenostomus chrysops</i> Yellow-faced Honeyeater	*	
<i>Meliphaga lewinii</i> Lewins Honeyeater	*	
<i>Phylidonyris novaehollandiae</i> New Holland Honeyeater	*	
<i>Acanthorhynchus tenuirostris</i> Eastern Spinebill	*	
<i>PSOPHODIDAE</i>		
<i>Psophodes olivaceus</i> Eastern Whipbird	*	
<i>Eopsaltria australis</i> Eastern Yellow Robin		*
<i>DICRURIDAE</i>		
<i>Grallina cyanoleuca</i> Magpie-lark	*	
<i>Rhipidura fuliginosa</i> Grey Fantail	*	
<i>Rhipidura leucophrys</i> Willie Wagtail	*	
<i>Myiagra rubecula</i> leaden Flycatcher		
<i>CAMPEPHAGIDAE</i>		
<i>Coracina novaehollandiae</i> Black-faced Cuckoo-shrike	*	
<i>ARTAMIDAE</i>		
<i>Cracticus torquatus</i> Grey Butcherbird	*	

<i>Gymnorhina tibicen</i> Australian Magpie	*	*
<i>Strepera graculina</i> Pied Currawong	*	
CORVIDAE		
<i>Corvus coronoides</i> Australian Raven	*	
PASSERIDAE		
<i>Neochmia temporalis</i> Red-browed Finch		
HIRUNDINIDAE		
<i>Hirundo neoxena</i> Welcome Swallow	*	
PYCNONOTIDAE		
<i>Pycnonotus jocosus</i> Red-whiskered Bulbul	*	
ZOSTEROPIDAE		
<i>Zosterops lateralis</i> Silvereye	*	
STURNIDAE		
<i>Acridotheres tristis</i> Common Mynah	*	
<i>Sturnus vulgaris</i> Common Starling	*	
<u>MAMMALS</u>		
<i>Marsupials</i>		
PSEUDOCHEIRIDAE		
<i>Pseudocheirus peregrinus</i> Common Ringtail Possum	*	
PHALANGERIDAE		
<i>Trichosurus vulpecula</i> Common Brushtail Possum	*	
<i>Eutherians</i>		
PTEROPODIDAE		
<i>Pteropus poliocephalus</i> Grey-headed Flying-fox	*	

<i>MOLOSSIDAE</i>		
<i>Mormopterus sp. 1</i> A Freetail-Bat		
<i>Mormopterus norfolkensis</i> East-coast Freetail-bat		
<i>Tadarida australis</i> White-striped Freetail-bat	*	
<i>VESPERTILIONIDAE</i>		
<i>Chalinolobus gouldii</i> Gould's Wattled Bat	*	
<i>Chalinolobus morio</i> Chocolate Wattled Bat	*	
<i>Chalinolobus dwyeri</i> Large-eared Pied Bat	WA	
<i>Falsistrellus tasmaniensis</i> Eastern False Pippistrelle	WA	
<i>Myotis macropus</i> Southern Myotis	WA	
<i>Miniopterus schreibersii oceanensis</i> Eastern Bentwing-bat	WA	
<i>Nyctophilus geoffroyi</i> Lesser Long-eared Bat	*	
<i>Scoteanax rueppellii</i> Greater Broad-nosed Bat	WA	
<u><i>AMPHIBIANS</i></u>		
<i>HYLIDAE</i>		
<i>Litoria fallax</i> Eastern Dwarf Tree Frog	*	
<i>Litoria phyllochroa</i> Leaf-green Tree Frog	*	
<i>Litoria peronii</i> Peron's Tree Frog		
<i>MYOBATRACHIDAE</i>		
<i>Crinia signifera</i> Common Eastern Froglet	*	
<i>Limnodynastes peronii</i> Striped Marsh Frog	*	
<i>Paracrinia haswelli</i> Haswell's Frog	*	
<i>Uperoleia laevigata</i> Smooth Toadlet		

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APPENDIX E - UPSTREAM DRAINAGE INVESTIGATION

APPENDIX F – COSTINGS AND PRIORITIES

Priorities have been allocated as follows:

- * Very High priority – to be completed as soon as practicable
- * High priority - to be completed within two years
- * Moderate priority - to be completed within the next five years
- * Low priority - to be completed

Draft Burnum Burnum Wetland Management Plan

Management Strategies, Actions, Cost & Priority

Management Strategy	Action	Responsibility	One off Cost	Cost per annum	Cost over 5 years	Priority
Upstream treatment train repairs and maintenance	Remove accumulated sediment from the diversion pit	NSW RMS	completed		\$0	high
	Streamlining of the diversion pit, upstream and downstream of the weir, to reduce hydraulic losses, improve flow characteristic and prevent sediment build up. Streamlining should also occur within the kerb inlet pit and the Junction pit (See detailed recommendations in Appendix E).	NSW RMS	\$2,000		\$0	high
	Repair the GPT lid and frame. Clean out the sediment accumulated around the boom.	NSW RMS	\$5,000		\$0	high
	Remove the pipe from the Woronora bridge deck out of the storage/treatment chamber and re-connect it to the upstream junction pit (See detailed recommendations in Appendix E).	NSW RMS	\$10,000		\$0	high
	Repair the HumeCeptor™ Oil and Grit Separator (OGS) lid surround, remove the tree roots from within the OGS and repair the joint between the inflow pipe and the HumeCeptor™ (See detailed recommendations in Appendix E).	NSW RMS	\$10,000		\$0	high
	Install a raised letter box pit in front of the culvert and existing surcharge pit.	NSW RMS	\$5,000		\$0	
	undertake localised site regrading to allow surcharge flows to enter the wetland (See detailed recommendations in Appendix E).	NSW RMS	\$2,000		\$0	high
	Implement a maintenance schedule as per the maintenance manual provided in Appendix E for each element of the stormwater pollution control treatment train.	NSW RMS		\$3,000	\$15,000	high

Management Strategy	Action	Responsibility	One off Cost	Cost per annum	Cost over 5 years	Priority
	Undertake water quality monitoring in the wetland over a minimum of four seasons to determine if there is a measurable increase in water quality and flushing in the wetland.	NSW RMS/SSC	\$20,000		\$0	high
	Install shared footpath Menai Road to wetland on eastern edge of access road.	SSC	\$15,000			high
Vegetation management	Undertake supplementary planting with locally indigenous plants species including groundcovers, low shrubs, medium and tall shrubs.	SSC – Parks Operations Unit	\$2,000		\$0	moderate
	Remove and undertake ongoing control of weeds upstream of the wetland.	SSC – Parks Operations Unit		\$3,000	\$15,000	moderate
	Monitor revegetation and undertake supplementary planting and weeding as required	SSC – Parks Operations Unit		\$1,000	\$5,000	moderate
	Allocate responsibility for responding to residents calls regarding dumped rubbish at Burnum Burnum Wetland car park;	SSC - Natural Areas Manager / Bushcare officers/	\$1,000		\$0	high
Rubbish management	Develop a regular and effective dumped rubbish investigation and collection service for the wetland;	SSC - Natural Areas Manager / Bushcare officers	\$1,000		\$0	high
	Clean out existing Humegard® and Humeceptor® and/or construct a Baramy® style vane GPT on the inlet pipe to Cell 1.	NSW RMS		\$10,000	\$50,000	high
	Initiate regular rubbish collection from the wetland, especially following rainfall events.	NSW RMS		\$3,000	\$15,000	high
	Develop an environmental education initiative aimed at reducing the volume of nylon fishing line dumped at the wetland, boat ramp and surrounding area;	SSC - Natural Areas Manager / Bushcare officers/ Stormwater Management	\$4,000		\$0	moderate
	Celebrate event like 'Clean Up Australia Day' and "World Wetlands Day" at the wetland and assist the local community to become involved in cleaning up the surrounding area;	NSW RMS & SSC - Natural Areas Manager / Bushcare officers		\$4,000	\$20,000	moderate

Management Strategy	Action	Responsibility	One off Cost	Cost per annum	Cost over 5 years	Priority
Increased catchment size	Explore the opportunity to develop corporate sponsorship for these events at Burnum Burnum Wetland.	NSW RMS & SSC - Natural Areas Manager / Bushcare officers	\$2,000		\$0	moderate
	Upstream site re-grading, and re-shaping of the car park to allow surface runoff to be directed to the wetland instead of the Woronora River;	NSW RMS	\$50,000		\$0	high
	Building of bioswale so re-shaped carpark surface runoff towards a perimeter bioswale and before it discharges into Cell.	NSW RMS	\$40,000		\$0	high
Infrastructure renewal	Control structure on the outlet pipe to the Woronora River to prevent buoyant mangrove propagules from entering Cell 2.	NSW RMS	\$5,000		\$0	high
	Replacement of the oil boom separating Cell 1 and Cell 2 with a new one that floats and will retain any free oil within Cell 1 without letting it bypass into Cell 2 and the Woronora River.	NSW RMS	\$5,000		\$0	Very high
Education strategies	Identify appropriate education partners who may develop education programs using the wetland (for example local public and high schools, local TAFE colleges, relevant Universities, wetland managers and builders of constructed wetlands)	NSW RMS & SSC - Natural Areas Manager/ Stormwater Management	\$3,000		\$0	high
	Disseminate information on the proposed changes of the wetland to these partners, prior to and following the changes;	NSW RMS & SSC - Natural Areas Manager/ Stormwater Management	\$5,000		\$0	high
	Develop appropriate signage to display at the wetland showing the changes;	NSW RMS & SSC - Natural Areas Manager/ Stormwater Management	\$5,000		\$0	moderate

Management Strategy	Action	Responsibility	One off Cost	Cost per annum	Cost over 5 years	Priority
	Liaise directly with key educational partners to encourage the development of educational material based around Burnum Burnum Wetland;	NSW RMS & SSC - Natural Areas Manager/ Stormwater Management		\$1,000	\$5,000	moderate
	Develop partnerships to widen educational opportunities at Burnum Burnum Wetland in particular with Burnum Burnum Sanctuary;	NSW RMS & SSC - Natural Areas Manager/ Stormwater Management		\$1,000	\$5,000	moderate
	Develop appropriate signage for the identification of birds and wildlife using the wetland and the Woronora River;	SSC - Natural Areas Manager/ Stormwater Management	\$10,000		\$0	moderate
	Develop an environmental education program specifically focussed on reducing nylon fishing line being left at the boat ramp and surrounding area	SSC - Natural Areas Manager/ Stormwater Management	\$20,000		\$0	moderate
Community engagement	Identify and engage with local community user groups;	SSC - Natural Areas Manager / Bushcare officers	\$3,000		\$0	moderate
	Identify and engage with broader community user groups	SSC - Natural Areas Manager / Bushcare officers	\$3,000		\$0	moderate
	Ensure local and broader community groups are kept informed of the progress of changes proposed to be made to the wetland	SSC - Natural Areas Manager / Bushcare officers	\$5,000		\$0	moderate
	Provide a point of contact within Council for user groups (for example Bushcare or Greenweb Officer)	SSC - Natural Areas Manager / Bushcare officers	\$3,000		\$0	moderate
	Provide information to local groups, residents and the community in how they can become involved in management and monitoring in the wetland, eg Birds in Backyards surveys, Clean Up Australia Day, World Wetlands Day, remove nylon line program activities	SSC - Natural Areas Manager / Bushcare officers	\$5,000		\$0	moderate

Management Strategy	Action	Responsibility	One off Cost	Cost per annum	Cost over 5 years	Priority
	Provide signage that reflects the new management measures at the wetland and encourages monitoring native species	SSC - Natural Areas Manager / Bushcare officers	(see above \$5000)		\$0	moderate
	Provide environmental education signage for the identification of birds and wildlife using the wetland and the Woronora River	SSC - Natural Areas Manager / Bushcare officers	(see above \$5000)		\$0	moderate
	Assist the Burnum Burnum Sanctuary Bushcare group to consider how they might contribute to the ongoing management of Burnum Burnum Wetland, with a view to developing a sub group focussed on the wetland;	SSC - Natural Areas Manager / Bushcare officers	\$5,000		\$0	moderate
	Consider the use of the Community Biodiversity Survey Project approach to train Bushcare members on collecting monitoring data for the wetland.	SSC - Natural Areas Manager / Bushcare officers	\$2,000		\$0	moderate
	Develop incentives for the local community to utilise the wetland for educational and recreational purposes (for example providing free seedlings and a BBQ on world wetlands day and clean up Australia day weekend	SSC - Natural Areas Manager / Bushcare officers	\$10,000		\$0	moderate
	Explore opportunities for corporate sponsorship for activities and or programs around the wetland	SSC - Natural Areas Manager / Bushcare officers	\$3,000		\$0	moderate
Total implementation costs		RMS	\$134,000	\$16,000	\$80,000	
Total implementation costs		SSC	\$107,000	\$10,000	\$45,000	

STAGE TWO MANAGEMENT STRATEGIES TO BE CONSIDERED FOLLOWING RESULTS OF WATER QUALITY MONITORING OVER 4 SEASONS						
Management Strategy	Action	Responsibility	One off Cost	Cost per annum	Cost over 5 years	Priority
Concept design of proposed works	Engage engineers to undertake the detailed concept design	NSW RMS	\$5,500		\$5,500	high
	Present concept design to community	NSW RMS	\$2,000		\$2,000	high
	Gather quotations for the cost of construction of the proposed structural alterations to Burnum Burnum Wetland	NSW RMS	\$5,000		\$5,000	high
Outlet pipe reconfiguration	Undertake calculations to determine saltwater inundation levels for Cell 2, required to achieve the desired zonation within the saltmarsh;	NSW RMS	\$2,000		\$2,000	high
	Construction of an additional outlet pipe, about 0.5 m lower than existing, connecting Cell 2 to the Woronora River.	NSW RMS	50000		\$50,000	high
Cell reshaping	Draining of the wetland for a short period to enable earthworks, installation of growing media and planting;	NSW RMS	\$2,000		\$2,000	moderate
	Excavation and re-shaping of Cell 1 with the addition of a suitable growing media to mix with the existing substrate;(An alternative to this option may be to make provision for and install a Floating Reed Bed - cost would be similar to a FWS wetland inclusive of source and supply macrophytes)	NSW RMS	\$50,000		\$50,000	moderate
Wetland plantings	Source appropriate saltmarsh substrate for Cell2 Regrade from 0.5 m AHD at the outlet to 0.7 m AHD beneath the pedestrian bridge	NSW RMS	\$20,000		\$20,000	moderate
	Trial suitable locally dredged material as saltmarsh substrate prior to its use in cell2 of Burnum Burnum Wetland	NSW RMS	\$2,000		\$2,000	moderate
	Prepare a revegetation plan for Cell 1 (emergent macrophytes) and Cell 2 (saltmarsh species) of Burnum Burnum Wetland with appropriate plant densities and planting zones	NSW RMS	\$5,000		\$5,000	moderate

Management Strategy	Action	Responsibility	One off Cost	Cost per annum	Cost over 5 years	Priority
	Select, source, supply and plant appropriate emergent macrophytes plants for planting in cell1	NSW RMS	\$20,000		\$20,000	moderate
	Select, source, supply and plant appropriate saltmarsh species for planting in zones in Cell 2.	NSW RMS	\$20,000		\$20,000	moderate
Total implementation costs		RMS	\$183,500		\$183,500	
All costs are approximate and ex GST						