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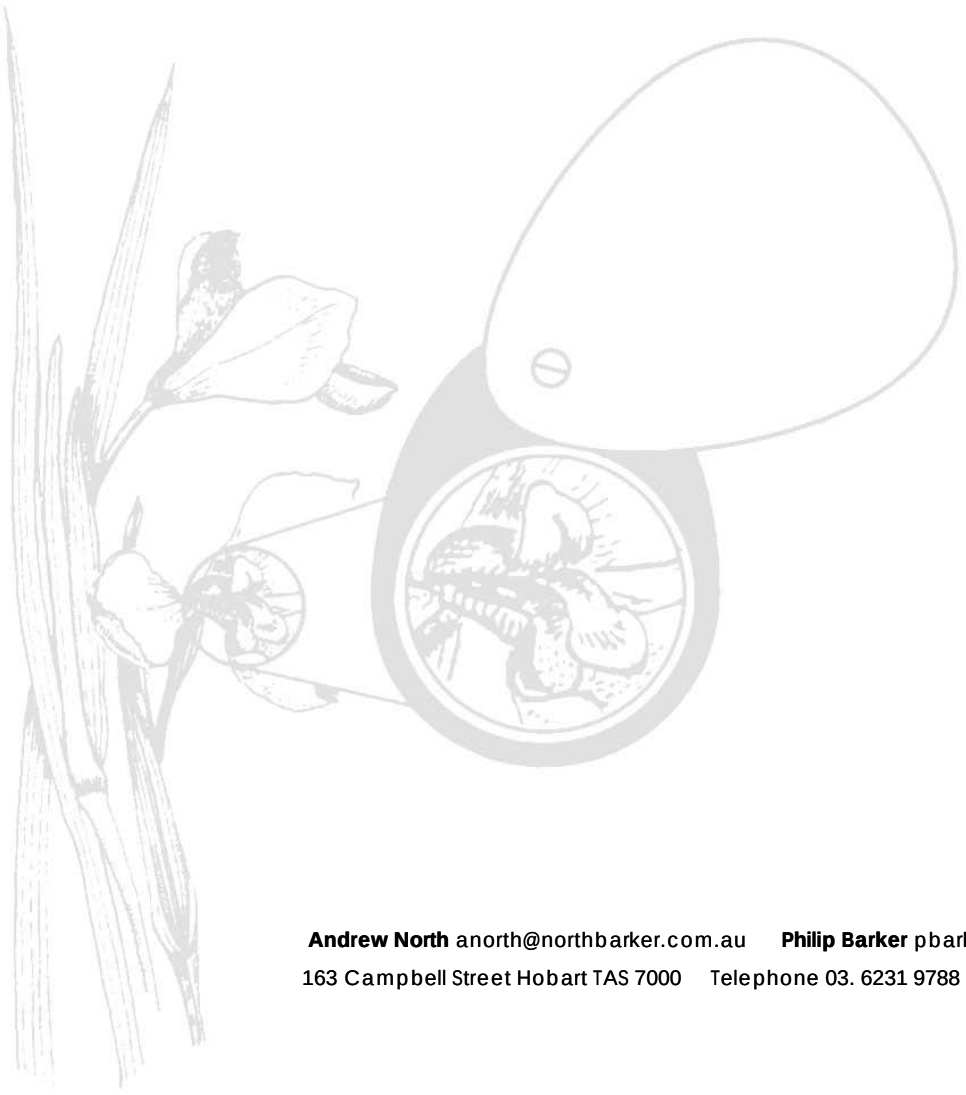
ECOSYSTEM SERVICES

BREAK O'DAY COASTAL LAGOON ASSESSMENT

December 2009

For NRM North & Break O'Day Council



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Community Consultation - Ray Murphy & Carla Mooney, Rural Development Services (RDS)

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- Lois Koehnken (TAW) - Geomorphology, hydrology, sediments, water quality sections

- Ray Murphy & Carla Mooney, (RDS) - Community engagement report

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Assistance with preliminary project decision making and administration – Emma Williams, Program Manager - Healthy Coasts and Seas, NRM North.

1 Introduction

NRM North is the regional natural resource management (NRM) body covering the north-eastern third of Tasmania. In conjunction with the Break O'Day Council, funding has been obtained to assess 22 lagoons and wetlands within the Break O'Day Council area. The purpose of this assessment is to carry out a "health check" on each wetland, identify necessary "first-aid" works and prioritise these tasks. Community consultation and landholder input is an integral part of this process. A list of the wetlands assessed and the level of assessment undertaken is provided in the following table. The distribution of the wetlands within the Break O'Day Council area is shown in Figure 1 on the following page.

Table 1.1 - Final Wetland List and Level of Assessment

Wetland Number (NRM North)	Wetland Name	Level of Assessment
2	Moriarity & Windmill Lagoons	High-level
3	Diana's Basin, Little Diana's Basin & Crockers Arm	High-level
4	Piccaninny Swamp	Mid-level
5	Grants Lagoon	Mid-level
7	Parkside Lagoon	Mid-level
8	Chimneys Lagoon	Mid-level
9	Oceana Wetland	Mid-level
10	Wrinklers Lagoon	Mid-level
11	Scamander River Mouth	Mid-level
12	Templestowe Lagoon	Mid-level
16	Lower Marsh Creek & Chain of Lagoons	Mid-level
6	Boggy Creek Wetland	Eye-ball
14	Yarmouth Creek	Eye-ball
17	Seymour Swamp	Eye-ball
19	St Helens Point (4)	Eye-ball
22	Upper Medeas Cove marshes	Eye-ball
23 & 19	Onion Creek & St Helens Pt (1)	Eye-ball
24	Dark Hollow Creek	Eye-ball
25	Four Mile Creek	Eye-ball
27	Blind Creek Marsh	Eye-ball
28	Douglas North wetland	Eye-ball
29	Douglas River & wetlands	Eye-ball

Figure 1 – Location of wetland study areas

2 Methods

2.1 Study Areas

For the purposes of this project, the study area for each wetland/lagoon that was assessed was taken to be the wetland polygon extracted from the CFEV geographic information system plus a 100m buffer around this polygon.

2.2 Levels of Site Assessment

The assessment approach used has been divided into three levels due to funding and time constraints for this project. Three levels of assessment - high-level, mid-level and eye-ball assessments were carried out, with different levels of assessment occurring both in the field and in the reporting process.

High-level Assessment - this level of assessment was allocated the most amount of time in the field, during which the full amount of environmental information was collected, including a desk-top assessment against Ramsar criteria (see Sections 2.2 & 2.3).

Mid-level Assessment - this level of assessment differs from a high-level assessment in that it was allocated less time in the field, the flora species list is not as comprehensive due to being time limited in the field and was not assessed against Ramsar criteria.

Eye-ball Assessment - this level of assessment differs from a high and mid-level assessment in that it was allocated less time again in the field, a flora species list was not compiled, it was not assessed against Ramsar criteria, vegetation community and weed mapping was not carried out, and less time was spent assessing all variables.

At each wetland a geomorphology, hydrology, sediment and water quality assessment was undertaken, in addition to an assessment of the flora and fauna, and an analysis of threats and possible "first-aid" works. The following sections give a brief overview of these assessments.

2.3 Geomorphology, hydrology, sediments & water quality

A range of methods were used to evaluate the geomorphology, hydrology, sediment and water quality characteristics of each water body. Because these processes operate at several time-scales, it is difficult to determine the 'health' or 'naturalness' of these processes based on one field visit alone. It was also not possible to visit the entire catchment of each water body. For this reason, a desk-top investigation was completed prior to field work.

The desk-top analysis included reviewing topographic and geologic maps to gain an understanding of the large scale characteristics of the catchment. This information was augmented by reviewing the CFEV geomorphic mosaic layer which provides information about relief, climate and surficial processes operating in the area. Google Earth was then used to take a 'tour' of the catchment and water body, with particular attention paid to catchment activities and disturbances, and the morphology of the water body. For most of the water bodies, relatively high resolution Google Earth images were available for 2007 and 2004. Both images were examined to identify recent changes in the catchment. The 2007 images

also provided a good contrast compared to field visits, as the images were taken during the extended drought, whereas the site visits were completed following a very high rainfall period.

Following this review, a site visit to the water body was completed. During the visit, the local geomorphology and hydrology was examined, including the inflows and outflows from each water body. The local sediments were investigated, and water quality measurements of pH and salinity were completed. Where possible, the adjacent coast was also visited. A field assessment was made as to the naturalness of each of the characteristics (geomorphology, hydrology, sediments, water quality).

After the field assessment, an additional desk-top analysis was completed, this time using The List to access Coastal Value databases. For the coastline bordering each water body, the condition, geo-conservation, and sensitivity attributes were interrogated. The geo-conservation data base was interrogated to identify any sites or regions of high geo-conservation status. Additional reports, where available, were also consulted.

The evaluation of most sites included a field visit of generally 1 – 2 hours in duration (longer depending on access). Exceptions to this are shown in Table . Extended site visits to Moriarty/ Windmill Lagoons and Diana's Basin/ Little Diana's Basin/ Crockers Arm were completed which involved one-half to a full day at each of the complexes. The following table details the level of assessment, information sources and variables collected at each site.

Table 1.2 - Summary of geomorphology, hydrology, sediment and water quality evaluation of wetlands.

	Geological & topographic maps	Extended site visit	Short site visit	Water Quality measurements	Google Earth investigation (2008 & 2004 images)	Coastal Geomorphology databases (LIST)	Geo-conservation database (LIST)	CFEV data base (mosaics, rivers wetlands, salt marshes estuaries)	Additional reports
Moriarity & Windmill Lagoons	✓	✓		✓	✓	✓	✓	✓	✓
Diana's Basin, Little Diana's Basin & Crockers Arm	✓	✓		✓	✓	✓	✓	✓	✓
Piccaninny Swamp	✓		✓	✓	✓	✓	✓	✓	✓
Grants Lagoon	✓		✓	✓	✓	✓	✓	✓	✓
Parkside Lagoon	✓		✓	✓	✓	✓	✓	✓	✓
Chimneys Lagoon	✓		✓	✓	✓	✓	✓	✓	✓
Oceana Wetland	✓		✓	✓	✓	✓	✓	✓	✓
Wrinklers Lagoon	✓		✓	✓	✓	✓	✓	✓	✓
Scamander River Mouth	✓		✓	✓	✓	✓	✓	✓	✓

	Geological & topographic maps	Extended site visit	Short site visit	Water Quality measurements	Google Earth investigation (2008 & 2004 images)	Coastal Geomorphology databases (LIST)	Geo-conservation database (LIST)	CFEV data base (mosaics, rivers wetlands, salt marshes estuaries)	Additional reports
Templestowe Lagoon	✓		✓	✓	✓	✓	✓	✓	✓
Lower Marsh Creek & Chain of Lagoons	✓		✓	✓	✓	✓	✓	✓	✓
Boggy Creek Wetland	✓		✓	✓	✓	✓	✓	✓	✓
Yarmouth Creek	✓				✓	✓	✓	✓	✓
Seymour Swamp	✓		✓	✓	✓	✓	✓	✓	✓
St Helens Point (4)	✓		✓		✓	✓	✓	✓	✓
Upper Medeas Cove marshes	✓		✓	✓	✓	✓	✓	✓	✓
Onion Creek & St Helens Pt (1)	✓				✓	✓	✓	✓	✓
Dark Hollow Creek	✓		✓	✓	✓	✓	✓	✓	✓
Four Mile Creek	✓				✓	✓	✓	✓	✓
Blind Creek Marsh	✓				✓	✓	✓	✓	✓
Douglas North wetland	✓				✓	✓	✓	✓	✓
Douglas River & wetlands	✓				✓	✓	✓	✓	✓

2.4 Flora and Fauna

The CFEV database was found to be more useful in assessing the attributes described above, as opposed to the assessment of the flora and fauna. The majority of data used for the flora and fauna analysis was collected during the field survey of each site. Additional data was sourced from the Natural Values Atlas database, from past reports and from discussions with landholders.

Information on the following variables was collected;

- vegetation communities
- vegetation condition
- flora species list
- fauna habitat value
- weeds - abundance and distribution (declared and environmental)
- threatened flora - abundance and distribution
- threatened fauna habitat
- threats
- first aid (on-ground works)

The following table details the level of assessment and variables collected at each site.

Table 1.3 - Summary of flora and fauna evaluation of wetlands.

	Extended site visit (high-level)	Medium site visit (mid-level)	Short site visit (eye-ball)	Ramsar Assessment	Vegetation Communities	Vegetation Condition	Flora Species List	Mapping - all natural values	Fauna Habitat Value	Weeds List	Weeds - Area of Occupancy	Threatened Species	Threats	First Aid
Moriarity & Windmill Lagoons	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Diana's Basin, Little Diana's Basin & Crockers Arm	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Piccaninny Swamp		✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Grants Lagoon		✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Parkside Lagoon		✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Chimneys Lagoon		✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Oceana Wetland		✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Wrinklers Lagoon		✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Scamander River Mouth		✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Templestowe Lagoon		✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Lower Marsh Creek & Chain of Lagoons		✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Boggy Creek Wetland			✓		✓	✓			✓	✓		✓	✓	✓
Yarmouth Creek			✓		✓	✓			✓	✓		✓	✓	✓
Seymour Swamp			✓		✓	✓			✓	✓		✓	✓	✓
St Helens Point (4)			✓		✓	✓			✓	✓		✓	✓	✓
Upper Medeas Cove marshes			✓		✓	✓			✓	✓		✓	✓	✓
Onion Creek & St Helens Pt (1)			✓		✓	✓			✓	✓		✓	✓	✓
Dark Hollow Creek			✓		✓	✓			✓	✓		✓	✓	✓
Four Mile Creek			✓		✓	✓			✓	✓		✓	✓	✓
Blind Creek Marsh			✓		✓	✓			✓	✓		✓	✓	✓
Douglas North wetland			✓		✓	✓			✓	✓		✓	✓	✓
Douglas River & wetlands			✓		✓	✓			✓	✓		✓	✓	✓

2.5 Wetland Condition Rose

The approach used in this project to indicate wetland condition is based on the concept of a condition "rose". A condition rose resembles a wind rose which represents wind direction, strength and frequency using radial lines of proportionate length and thickness. The condition rose used represents each of the wetland values variables measured as a radial line with its length representing the attributes contribution to the condition of the wetland.

The scores used to determine the length of each wetland variable on the condition rose have been derived from the raw data, estimated from the knowledge gained during site visits, or derived from an analysis of CVEV values in conjunction with information obtained during the site visits. The scores are intended to be relative measures that can be compared between wetlands. In order to do this the variables have been represented in one of three ways:

1. as an absolute percentage, or
2. standardised by representation as a percentage against the maximum value recorded at any one wetland, or
3. standardised by representation as a percentage based on CFEV attribute values that were used as 'starting points' and modified accordingly based on the findings of field and desktop investigations (also see section 3.5.1 below).

The variables chosen to be represented within the condition rose are considered to be the best representatives of overall wetland health. The list below defines what these variables represent and how they have been derived (indicated by a 1, 2 or 3 as defined above);

- Catchment[3] - estimate of the overall naturalness of the catchment based on CFEV values and modified following field investigations and desk top review
- Geomorphology[3]- Estimate of level of catchment disturbance and extent of riparian vegetation in catchment based on CFEV values and modified following field investigations and desk top review
- Hydrology & Sediment[3]- Estimate of naturalness of hydrology and sediment budget of inflows to water way and outflow from water way. Based on CFEV values and modified following field investigations and desk top review
- Water Quality[3]- Estimate of water quality entering waterbody, within water body and downstream of water body. Based on CFEV values and modified following field investigations and desktop review
- Vegetation in good condition[1] - the percentage of vegetation communities within the study area at condition level 1
- Vegetation community richness[2] - the number of native vegetation communities within the study area
- Species richness[2] - the number of native flora species
- Buffer[1] - the percentage of the 100m buffer containing native vegetation communities

- Threatened flora[2] - the number of threatened flora species currently (during the current survey) or previously recorded within the study area
- Threatened vegetation communities[1] - the percentage of the study area containing threatened native vegetation communities
- Threatened fauna habitat[1] - the percentage of the study area containing potential threatened fauna habitat
- Weeds[2] - the number of declared and environmental weeds (as listed in Appendix 2) within the study area
- Weeds AO[2] - the area of occupancy of declared and environmental weeds within the study area

2.5.1 Geomorphology, hydrology, sediment and water quality values

A two-step process was used to derive the condition rose scores for these variables. Firstly, the CFEV data base was interrogated, with relevant attributes for each wetland extracted. This included extracting information for wetlands, estuaries, rivers and salt marshes. The extracted CFEV wetland values were used to derive catchment, geomorphology, hydrology & sediment, and water quality 'scores' which were used as a starting point for the condition rose. Then, the scores were modified based on evidence found during the site visit, or during the desk-top analysis. Some of the water bodies did not have CFEV 'wetland' information. Where this occurred, similar scores for corresponding rivers, estuary and/ or salt marsh were used in conjunction with field observations.

It should be stressed that the condition rose scores reflect the condition of the water body with respect to natural conditions. Some of the water bodies are in very good condition with respect to the present hydrology of the catchment or geomorphology of the lagoon outlet, but because the Condition Score uses 'natural' as the reference point, these scores may be somewhat low even though the present health of the water way is good.

Table .4 summarises how theses 'starting points' were calculated using CFEV attribute scores. In the CFEV database all scores vary from 0 to 1 with '1' reflecting natural conditions. The CFEV scores were compared with the findings of the field and desktop investigations and varied accordingly. The final scores are presented as percentages.

Table 1.4 - Derivation of condition rose scores based on CFEV attributes for wetlands. These scores were used as 'starting points' and modified accordingly based on the findings of field and desktop investigations.

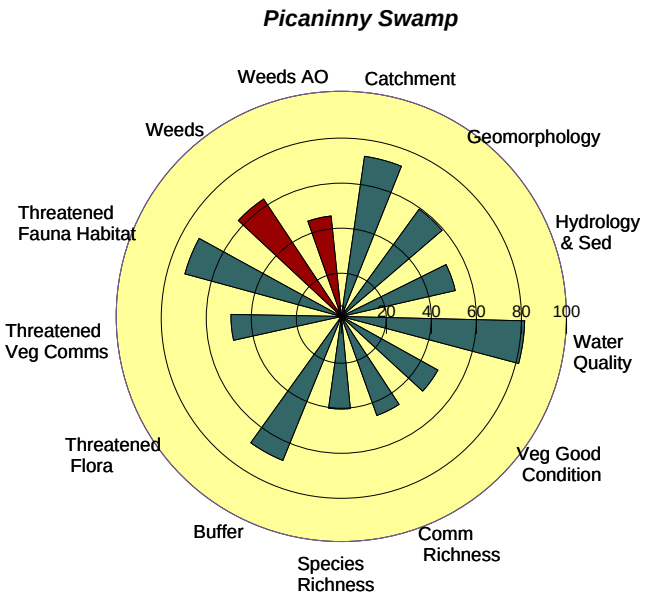
Condition Rose Characteristic	CFEV Score 'Starting Point'	Comment	Reasons to modify CFEV score for condition rose
Catchment	Naturalness (NSCORE) * 100	Reflects overall characteristic of the catchment which will affect naturalness of wetland.	Some CFEV scores did not reflect recent clearing or damming of inflows.
Geomorphology	(Catchment Disturbance + Riparian Veg)/2*100	These attributes exert large scale control over the geomorphic processes operating in a water body.	CFEV geomorphology scores did not reflect impact of modification to lagoon mouths on

Condition Rose Characteristic	CFEV Score 'Starting Point'	Comment	Reasons to modify CFEV score for condition rose
		The link between the riparian vegetation and geomorphology is very strong .	geomorphology of water bodies.
Hydrology & Sediments	(Hydrology + Sediment_in)/ 2*100	These attributes reflect changes from natural for the hydrology and sediments affecting the wetland.	CFEV scores did not reflect impact of modification to lagoon mouths on hydrology of water bodies.
Water quality	(Water Quality + Nutrient Input)/2*100	Scores reflect estimated water quality and sediment input from accumulated upstream catchment to wetland.	Some scores did not reflect current conditions.

An example of a wetland condition rose is shown below in Figure 2. Variables represented in green are considered to be "goods", where a high value or longer radial line, is considered to be a positive for the wetland, in other words, the higher the better. Variables represented in red are considered to be "bads", where a high value or longer radial line, is considered to be a negative for the wetland, in other words, the lower the better.

Condition roses for the eye-ball assessments differ from the high and mid-level assessments. This is due to the difference in time available for the assessment, some of the variables have had to be estimated rather than be more accurately measured or determined from a more comprehensive survey. Some variables - species richness, threatened flora, area of occupancy of weeds, were not able to be accurately estimated for the eye-ball assessments and have therefore been left off these roses. This needs to be considered when looking at these condition roses.

Figure 2 - Example of wetland condition rose



2.6 Wetland Health Score

Following on from the condition rose, the concept of a "wetland health score" is also being used to give another indication of wetland health. The wetland health score is an unweighted addition of the variables that make up the condition rose to give an assessment out of a possible 100 points. These variables represent the current condition and natural values recorded historically and during the current survey. Due to the different levels of survey undertaken at each site, this score should not be used as a comparative value between wetlands. It is likely to be most useful in monitoring the condition change within a wetland over time. Due to incomplete data sets for the eye-ball sites, wetland health scores are only given for the high and mid-level sites.

2.7 Community Consultation

The community consultation phase of this project involved several phases. Key landholders for each wetland were initially identified and subsequently engaged through a mail out. This was followed by a telephone survey of those willing to participate, where a pre-prepared list of questions (see Appendix 25) was discussed with each landholder. A spreadsheet of the results (see Appendix 26) of the telephone survey and the initial mail out, and a summary report of the community consultation process and results (see Appendix 27) were prepared. The key threats and issues identified within the interview process have also been extracted and included for each wetland within this report.

16 Seymour Swamp (#17)

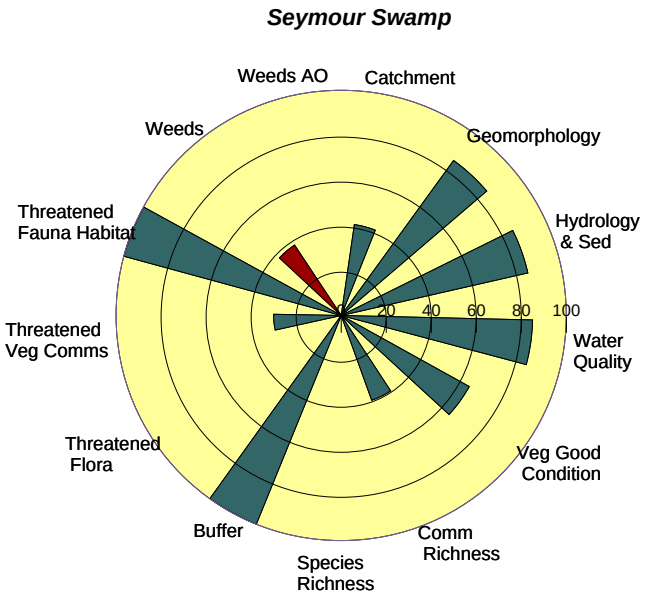


Photo 16.21. Seymour Swamp looking east across wetland

Photo 16.2. Google Earth aerial photo of Seymour Swamp study area.

16.1 Geomorphology

Seymour Swamp is an artificially created wetland which resulted from the excavation of clay in the mid to late 1800s. It is situated in the centre of Long Point, a bedrock point with inland dunes. Long Point is listed on the geo-conservation data base as a feature of regional significance and high sensitivity due to the presence of an active headland bypass dune field system with older stabilised beach ridges. Seymour Swamp is located within the dune field approximately 0.5 km from the northern or southern coast of the point. The swamp is bounded by well vegetated gently sloping sandy slopes which were probably modified during excavation of the pit.

16.2 Hydrology and sediments

Seymour Swamp has a small catchment and no inflowing surface drainage making direct precipitation and shallow groundwater movements the primary inflows. The (likely) presence of clay at depth suggests that the swamp could be a perched lake, with limited connection to regional groundwater. The swamp looses water through evaporation and possibly groundwater movement. It does not appear to be affected by tidal movements.

The bed of the lagoon consisted of highly organic rich material with a strong sulphide smell and are potentially acid forming (Gurung, 2001). Sand was generally absent from the top 20 cm of sediments indicating that Aeolian sand inputs are limited, probably due to the well vegetated (stable) nature of the adjacent dunes.

16.3 Water quality

The water in Seymour Swamp is fresh, dark, organic rich and has low turbidity. Following a period of high rainfall salinity in the lagoon was 0.8 ppt, presumably due to marine aerosols entering via wind and rainfall. Based on the high organic content of the nutrients, nutrient recycling within the swamp is probably an important water quality process.

16.4 Geomorphology, hydrology and water quality condition

The condition of Seymour Swamp compared to natural is poor due to the artificial nature of the geomorphology and hydrology of the swamp. It is also located within a larger catchment which has poor condition due to extensive agricultural development. If the highly modified nature of Seymour Swamp is accepted as the baseline, then the condition of Seymour Swamp is good as its processes are similar to natural lagoons operating in similar settings. The condition rose is based on accepting the modified nature of the swamp and not applying the CFEV results except for Catchment condition. The geomorphology, hydrology and water quality criteria are based on comparing the swamp with other natural small natural lagoons, such as Windmill.

Figure 16.3. Left - General view of swamp.

Figure 16.4. Right - Organic rich sediments.

16.5 Flora and Fauna

16.5.1 Overview

The Seymour Swamp study area covers approximately 17.2 hectares (including a 100m buffer), with an estimated 100% of the buffer area being native vegetation communities. A total of five native vegetation communities were recorded, covering a variety of habitats including swamp forest, coastal scrub, coastal heathland, sedgeland, grassland and fresh water aquatic habitats.

Figure 16.5. Fresh water aquatic sedgeland and rushland (ASF) and Water, sea (OAQ).

16.5.2 Vegetation Condition

The condition of the study area was good overall, with an estimated 65% being at Condition Level 1. This condition level is characterised by no or very low levels of weed invasion, with the vegetation being structurally and floristically intact. The remaining 35% was in an average condition due to weed invasion.

16.5.3 Vegetation Community Richness

Six vegetation communities were recorded in the study area, with all six being native. Of the native vegetation communities recorded two are considered to be threatened under the Tasmanian *Nature Conservation Act 2002*. Full details of vegetation communities recorded, their threatened status and their condition is provided below in Table 16.1.

Table 16.1 – Vegetation Communities recorded in the study area, including their conservation priority, reservation status and condition.

Veg Code[102]	Vegetation Community Description	State-wide Conservation Priority and Reservation Status [103], [104]	Bioregional Conservation Priority and Reservation Status[2], [3]	Condition*
ASF	Fresh water aquatic sedgeland and rushland	Threatened and inadequately reserved	Threatened and inadequately reserved	1
GHC	Coastal grass and herbfield	Not threatened	Not threatened	1
NME	*Melaleuca ericifolia* swamp forest	Threatened and inadequately reserved	Threatened and inadequately reserved	1
OAQ	Water, sea	-	-	-
SAC	*Acacia longifolia* coastal scrub	Not threatened	Not threatened	3
SCH	Coastal heathland	Not threatened	Not threatened	3

* - Refer to mid and high level assessments for descriptions of the condition levels.

16.5.4 Threatened Flora & Fauna

One threatened fauna species listed under either the Tasmanian *Threatened Species Protection Act 199*5 (TSPA) or the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBCA) has been previously recorded within the study area[105]. No threatened flora species have been recorded. No additional threatened flora or fauna species were recorded during the current survey. All species of conservation significance recorded within the study area are listed below:

- wedge-tailed eagle (*Aquila audax* ssp. *fleayi*) (e/EN)

16.5.5 Threatened Fauna Habitat

An estimated 100% of the study area is habitat that is potentially suitable for threatened fauna. Nine threatened fauna species are known to use the habitat types that are present within the study area. An additional three species listed under the JAMBA and CAMBA[106] migratory

[102] As per Tasveg 2.0 Vegetation Classification System, DPIPWE

[103] Nature Conservation Act 2002

[104] FCF 2007. Note there is no recent analysis of reservation status of non forest communities

[105] Natural Values Atlas, DPIPWE

[106] Japan Australia Migratory Bird Agreement (1974) and China Australia Migratory Bird Agreement (1986)

bird agreements also have potential habitat within the study area. Details of the species of threatened fauna and migratory birds that may occur at Seymour Swamp and their preferred habitats are in Appendix 1. The habitats within the study area that are preferred by at least one threatened fauna species include;

- *Acacia longifolia* coastal scrub (SAC)
- Coastal grass and herbfield (GHC)
- Coastal heathland (SCH)
- Fresh water aquatic sedgeland and rushland (ASF)
- *Melaleuca ericifolia* swamp forest (NME)
- Water, sea (OAQ)

16.6 Weeds

Weeds are common in patches within the study area, and are relatively abundant within those patches. Three declared or environmental weed species were recorded within the study area. "Declared" weed species are listed on the schedules of the *Tasmanian Weed Management Act 1999.* All declared and environmental weed species recorded within the study area are listed below:

- blackberry (*Rubus fruticosus*) - Declared
- gorse (*Ulex europaeus*) - Declared
- marram grass (*Ammophila arenaria*) - Environmental

16.7 Threats

The key threats identified include;

- increasing nutrient inputs is a potential threat to water quality due to the proximity of agricultural lands and lack of surface outflow
- modification of the hydrology of the system through the creation of an inflow channel could increase sedimentation and alter the organic rich nature of the underlying sediments
- Weeds

16.8 First Aid

Suggested first aid actions, listed in priority order, include the following;

1. Implement weed control program.

25 Generic comments

The major alterations to the wetlands as compared to 'natural' condition include:

- Alterations to hydrology, either through draining or regulation of inflows, and / or alteration of the mouths of the water bodies. Alterations to the mouths include constriction due to road and bridge construction, channelization due to placement of culverts, and restriction due to the stabilising effect of marram grass on the coastal fore dunes.
- The alterations to hydrology have sometimes lead to a reduction in the fluctuations of water levels within the water body which in turn have allowed vegetation to become established (which provides additional stability).
- Clearing has likely altered the hydrology and sediment budget in some wetland catchments. This combined with restrictions in lagoon outflows leads to sediment accumulation in the lagoon systems. This is especially true where the lagoon system has been altered by road / bridge / culvert construction.
- Water quality in the wetlands and lagoons is generally good, but observations and measurements were completed following a period of high rainfall and lagoon breakout events. Water quality monitoring may be warranted during the warm, dry summer period in lagoons which have residential development nearby and are used extensively for recreation, such as Diana's Basin and Grants Lagoon.

26 Generic recommendations

- Improve community understanding of lagoon systems – why they are important, why variability in flows, water levels etc are important for maintaining a dynamic, robust environment.
- Complete an historic aerial photo and map (parish plans, etc) analysis of the lagoons which have had outflows altered by roads and marram grass to get a better understanding of the 'natural' conditions of these systems. This information would be useful in evaluating whether marram grass removal is warranted in some lagoonal areas and for informing stakeholders of changes which have occurred to the systems.
- In the lagoons where outflow is controlled by culverts, try and maintain clear channels to maximise flow and exchange between lagoon and the bay or sea.
- Water quality monitoring over the summer months would provide a better indication of how recreational activities and the increase in local population are affecting the lagoons.