

Environmental Management Plan, Mutton Cove, SA

Environmental Management Plan

Mutton Cove, South Australia

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17 December 2003

LIMITATIONS STATEMENT

The sole purpose of this report and the associated services performed by Delta Environmental Consulting is to provide an environmental management plan in accordance with the scope of services set out in the contract between Delta Environmental Consulting ('Delta') and the Department for Environment and Heritage, Coastal Protection Branch ('the Client'). That scope of services was defined by the requests of the Client, by the time and budgetary constraints imposed by the Client, and by the availability of access to the site.

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Table of Contents

1. INTRODUCTION	8
2. CONSULTANTS	9
3. MANAGEMENT FRAMEWORK	10
3.1 Land tenure	10
3.2 Current zoning	12
3.3 Current land management	12
3.4 Policy and legislation	13
4. MANAGEMENT CONTEXT	14
4.1 Purpose of Conservation Reserve	14
4.2 Location and general description	14
4.3 Natural resources of the site	15
4.3.1 Climate	15
4.3.2 Geology, soils and landform	16
4.3.2.1 Evolution of the landscape	16
4.3.2.2 Current topography	17
4.3.3 Hydrology	20
4.3.3.1 Surface and groundwater	20
4.3.3.2 Tidal flows	23
4.3.4 Vegetation and habitat	30
4.3.4.1 Historic vegetation	30
4.3.4.2 Current vegetation	31
4.3.4.3 Other flora records	38
4.3.4.4 Introduced plants	38
4.3.4.5 Threats to salt marsh habitats	39
4.3.5 Fauna	44
4.3.5.1 Birds	44
4.3.5.2 Mammals	47
4.3.5.3 Reptiles	48
4.3.5.4 Terrestrial invertebrates	48
4.3.5.5 Marine fish and invertebrates	48
4.3.5.6 Marine mammals	50
4.4 Cultural heritage of the site	51
4.4.1 Aboriginal heritage	51
4.4.2 European heritage	52
4.5 Previous and current management	54
4.5.1 EDA & DELM, Le Fevre Peninsula rehabilitation, 1993	57
4.5.2 Maunsell, Outer Harbor site development study, 1995	58
4.5.3 Maunsell, Pelican Point core site - Site history investigations, 1995	59



4.5.4	Local community in conjunction with CPAE, Our Patch, Coastcare, KESAB, & DEH, Mutton Cove Buffer Zone, 1998 - 2001	61
4.5.5	Coast and Marine Branch, Mutton Cove Coastal Reserve, November 2002	62
4.5.6	Davies, Pelican Point environmental development plan, July 2003	62
4.5.7	Project Dolphin Safe, Pelican Point – Mutton Cove clean-up, September 2003	62
4.6	Risk assessment of on-site contamination	63
4.7	Existing cooperative arrangements	66
4.8	Stakeholder aspirations for the site	66
4.8.1	Department for Business, Manufacturing and Trade	67
4.8.2	Office for Infrastructure Development	67
4.8.3	Australian Track and Rail	69
4.8.4	Port Adelaide Bicycle Users Group and Coast Park	70
4.8.5	City of Port Adelaide-Enfield	70
4.8.6	CPB and the TCWMB	70
4.8.7	Urban Forest Biodiversity Program	70
4.8.8	Community environment groups and individuals	71
4.8.9	Environment Protection Authority	71
5.	MANAGEMENT PRESCRIPTION	72
5.1	Management philosophy and strategic directions	72
5.2	Management arrangements	72
5.2.1	Partnerships and cooperative management	72
5.2.2	Community and volunteer involvement	72
5.2.3	Relationship with other environmental activities in the area	73
5.3	Management of the natural resources of the site	73
5.3.1	Contaminated soils	73
5.3.2	Hydrology and water quality	74
5.3.3	Native flora	75
5.3.4	Native fauna	76
5.3.5	Introduced species of plants and animals	76
5.3.6	Minimising ‘edge’ effects	77
5.3.7	Dealing with pollutant spills	77
5.4	Management of cultural heritage	78
5.5	Access and visitation	78
5.6	Future directions	80
5.6.1	Possible handover of the site to Council	80
5.6.2	Linkage to Biodiversity Park	80
5.6.2.1	Biodiversity issues to consider	81
5.6.2.2	Assessment of neighbouring blocks that may be used in any linkage	82
5.6.3	Further eco-tourism possibilities	83
5.7	Action table and costings	83
6.	MONITORING PROGRAM	85
6.1	Sample locations	87
6.2	Data quality	88



6.3	Sample site observations	88
6.4	Temperature, pH, alkalinity, salinity and clarity	88
6.5	Dissolved oxygen	89
6.6	Orthophosphate and ammonium	89
6.7	Plankton bloom observations	90
6.8	Recording wading birds and raptors	90
6.9	Recording invasive species	90
6.10	Mapping the salinity gradient	90
6.11	Monitoring tidal gauges	91
6.12	Measuring sulfide	91
6.13	Monitoring an intertidal SAM bed	92
6.14	Monitoring mangrove expansion	92
6.15	Studying saltmarsh plants	93
6.16	Using aerial photographs to map habitat change	94
6.17	Monitoring program trigger levels	94
REFERENCES AND BIBLIOGRAPHY		97
APPENDICES		100
Mangrove and saltmarsh zonation		100
Original survey of Mutton Cove		101
Tidal restriction data		102
Inundation hydrology		104
Flora records		105
Flora permit		111
The story of Tjilbruke		113
Shipwrecks in the Cove		121
Signage at Mangrove Cove, Bunbury WA.		123
Soil cores in filled areas of Pelican Point		127
Neighbouring blocks – matrix		128
Details of the consultants		131



Figures

Figure 1 - Location map showing Mutton Cove (copyright SA Government, Atlas SA)	8
Figure 2 - Cadastral details of the Mutton Cove area.....	11
Figure 3 - Zoning map modified from Atlas SA	12
Figure 4 – Aerial photograph of Mutton Cove	14
Figure 5 - Drainage at Mutton Cove.....	15
Figure 6 - Le Fevre Peninsula in 1954, 1977 and 1991 (copyright Gov't SA, Mapland).....	16
Figure 7 - Surface topography, Mutton Cove.....	17
Figure 8 - Small patch of soil showing oxidised products.....	18
Figure 9 - Surface levels at Mutton Cove, across the seawall	19
Figure 10 - Model of actual acid sulfate soil formation at Gillman (CPB, 2003)	19
Figure 11 - Tidal data collected at Mutton Cove on 11 September 2003.....	23
Figure 12 - Saltmarsh gauge at Mutton Cove.....	26
Figure 13 - Inundation regimes at Mutton Cove and Barker Inlet	27
Figure 14 – Wilsonia, a high marsh specialist.....	28
Figure 15 - 1963 aerial photograph of the Mutton Cove (copyright SA Gov't, Mapland)	30
Figure 16 - Supervised classification of the tidal area of Mutton Cove.	31
Figure 17 - Sarcocornia seedlings in the low marsh.....	33
Figure 18 - Sampling locations in Mutton Cove	34
Figure 19 - Sampling adequacy graph for all species.....	35
Figure 20 - Native species sampling adequacy graph.	35
Figure 21 - Effects of tidal restrictions.....	40
Figure 22 - Bait diggers on the foreshore outside Mutton Cove	44
Figure 23 - Mangroves undercut from shipping wash.....	49
Figure 24 - A baitworm hunting	50
Figure 25 - Saltmarshes near Mutton Cove and St German in Devon	53
Figure 26 - Drawing of Mutton Cove by Cawthorne, 1845 (copyright State Library of SA)	54
Figure 27 - The Greater Port Adelaide Plan (photograph courtesy the SA Maritime Museum)	55
Figure 28 - Most recent layers of fill, Pelican Point.....	57
Figure 29 - Area studied in Maunsell Outer Harbour Study (coloured blue).....	58
Figure 30 - Maunsell study area for the Pelican Point core site	59
Figure 31 - Sampling locations for previous site contamination studies.....	63
Figure 32 - Office for Infrastructure and Development projections for the Peninsula.....	67
Figure 33 - Proposed rail modifications	68
Figure 34 - Proposed road modification	69
Figure 35 - Map of track rationalisation and revegetation areas	79
Figure 36 - Sample site locations.	87
Figure 37 - Map of transect and photo point locations.....	93
Figure 38 - Base map of the blocks itemised in the neighbouring land matrix	130



Tables

Table 1 - Weather details.....	16
Table 2 - Water analysis results from North West drain	22
Table 3 – Current approximate areas of vegetation types at Mutton Cove	32
Table 4 – Plant species collected on site on 29 th September 2003	36
Table 5 - Conservation information.....	37
Table 6 – Proclaimed weeds occurring on the site and in the vicinity	39
Table 7 - Birds observed in October 2003 (* denotes an exotic species).....	44
Table 8 – Birds list supplied by J Thompsons.....	45
Table 9 - Feral mammal species present on the National Power site	47
Table 10 - Mud flat invertebrates	50
Table 11 – Five-year action plan summary	84
Table 12 - Suggested monitoring program	86
Table 13 – Physical water quality ranges	89
Table 14 - Tidal difference table	91
Table 15 - Ideal habitat percentage ranges	94



1. Introduction

The area known as Mutton Cove has been significantly degraded since European settlement. It is last remaining biodiverse area of samphire and mangrove woodland on the Le Fevre Peninsula and there is considerable interest within the community and the State government to see that this important piece of land is protected.

The land is also identified with the Commonwealth government's Environment Protection and Biodiversity Conservation Act (1999), as an important migratory bird habitat.

The location of Mutton Cove is indicated with a red dot on Figure 1.



Figure 1 - Location map showing Mutton Cove (copyright SA Government, Atlas SA)



2. Consultants

Delta Environmental Consulting is an independent South Australian consulting business. The company provides services in the areas of: biological survey work, environmental education programs, saltfield technology and saline wetland ecology, scientific illustration & desktop publishing, preparation of herbarium and museum specimens, taxonomy and classification, revegetation and rehabilitation, and computer application development.

The company is a member of Standards Australia, and its quality assurance management system has been third party certified to the international Q-base standard by NATA Certification Services International. A copy of the scope of certification is available on request.

Delta Environmental Consulting has a policy of continuous improvement in the areas of:

- providing a quality service to our clients
- providing ongoing training and educational opportunities for our consultants
- maintaining high standards in the areas of health, safety and environment both within Delta and while working with our clients

A description of the consultants undertaking this project is attached in the Appendices as *Details of Consultants*.



Document History:

19 September 2003: Outline draft provided to CMB for approval
20 October 2003: Progress draft
28 October 2003: Complete draft provided to stakeholders to review
15 December 2003: Edited draft provided to CMB
17 December 2003: Final report released.



3. Management framework

Management plans provide a framework for future management of a site and are developed to accommodate anticipated commercial, government and community trends over a period of five to ten years.

This management plan is not intended to be a comprehensive manuscript of resource information or to be a heavily prescriptive action statement. The aim of this management plan is to identify the values of the land in question and identify ways that Mutton Cove may be restored to a state that supports the highest biodiversity possible in the limited area available.

The management plan is also designed to reflect the aspirations of the local community and governmental stakeholders who have an interest in the area. The plan contains suggestions on how to promote community awareness, reduce the impacts of increased visitation and tie the Cove in to other areas of natural interest in the vicinity. It is hoped that this will provide the management committee with sufficient flexibility in day-to-day decision-making, yet also prevent inappropriate development or actions.

3.1 Land tenure

This land is held under freehold title by the Minister for Environment and Conservation, but in the past has been managed as a port asset, for future industrial development, urban development or as open space.

The land comprises:

- Allotment 48 in Deposited Plan 28143 (Certificate of Title 5898/167)
- Allotment 4 in Deposited Plan 28143 (CT 5660/241)
- portion of Allotment 23 in DP 52266 (CT 5898/168) and
- portion of Allotment 40 of DP 28143 (CT 5898/162)

The land forming the Cove, marked “A” in Figure 2 is to be returned to the Crown as unallocated Crown Land and to be dedicated as a ‘Conservation Reserve’ under the care, control and management of the Minister for Environment and Conservation under Section 5(f1) of the Crown Lands Act, 1929.



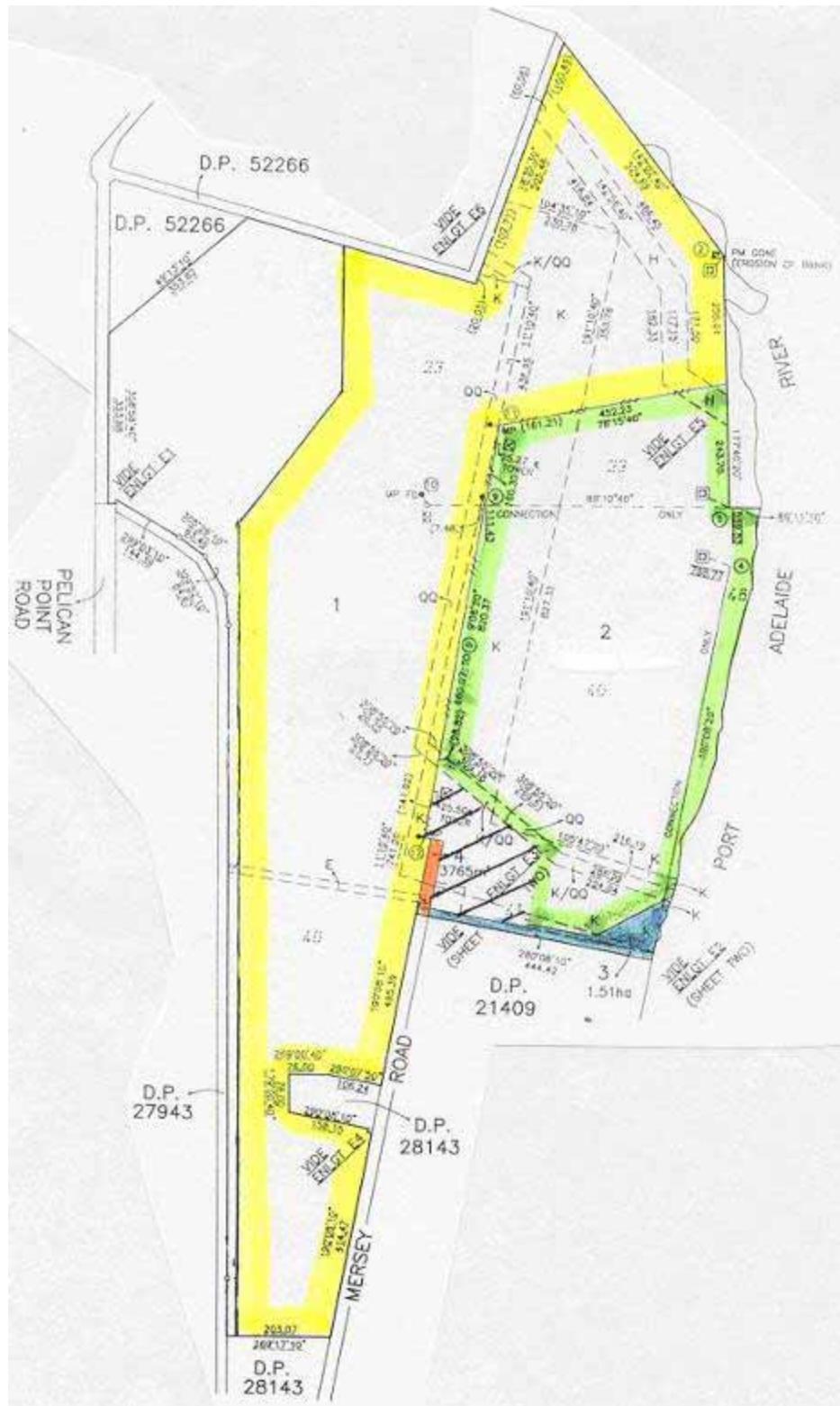


Figure 2 - Cadastral details of the Mutton Cove area

Key:	Green:	Mutton Cove reserve boundary
	Yellow:	Balance of DEH land (Industry (Port) & General Industry (2))
	Blue:	Crown Land under care of MEC (Recreation & Car Park)
	Orange:	DEH land (future public road purposes)



3.2 Current zoning

The City of Port Adelaide-Enfield has zoned Mutton Cove as MOSS (Conservation). MOSS (Conservation) is an appropriate zoning for a conservation reserve.

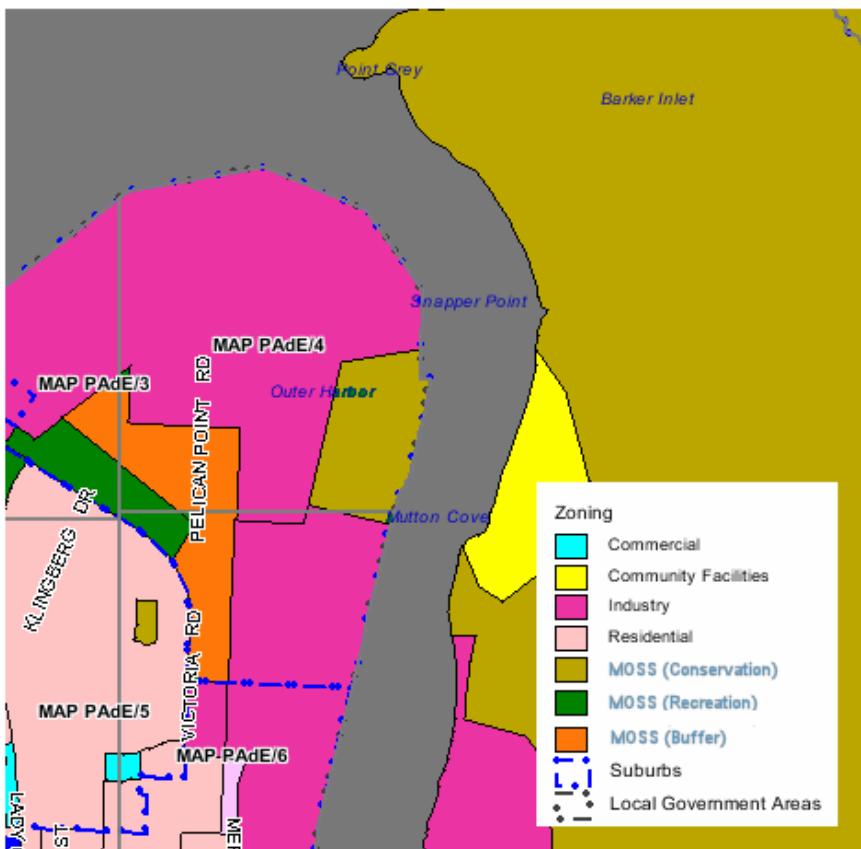


Figure 3 - Zoning map modified from Atlas SA

3.3 Current land management

The Coastal Protection Branch of the Department for Environment and Heritage is currently managing the block of land locally referred to as Mutton Cove, on the Le Fevre Peninsula on behalf of the Minister for Environment and Conservation.

Following to the formation of the steering committee the Coast Protection Board allocated \$59,000 towards the future management, protection and improvement of Mutton Cove. The Coastal Protection Branch funds were allocated to a number of essential works to achieve the Board's objectives, being

- rubbish removal,
- fencing and access,
- perimeter earthworks, and
- improvement of the hydrological regime

A Development Application was prepared for these works and planning approval was received on 2 May 2003. Details of the works completed to date are discussed further in the section entitled *Previous and current management*.



Considerable funding or in-kind support has been sourced by the steering committee for the restoration and protection of the Cove. Financial donors included the Torrens Catchment Management Board, the Coast Protection Board, Project Dolphin Safe, the Pelican Point Power Station, Crown Lands SA (CLSA) and Waterwatch SA. Many community groups have provided volunteer assistance toward rehabilitating remnant salt marsh areas and rubbish removal.

While there is still some funding available to continue the ongoing management of the Cove, certain suggested actions outlined in this plan may require the sourcing of further funding, or may be delayed until further support can be obtained.

3.4 Policy and legislation

The Department for Environment and Heritage is currently seeking Ministerial approval to have the land dedicated as a ‘Conservation Reserve’ under the Crown Lands Act (1929), under the care, control and management of the Minister for Environment and Conservation.

Further legislative support to help protect the area will be available under,

- the Fisheries Act (1982), as the area is a fish breeding area,
- the Coast Protection Act (1972),
- the Environment Protection and Biodiversity Conservation Act (1999),
- the Adelaide Dolphin Sanctuary Act (once proclaimed),
- the Native vegetation Act (1991),
- the Local Government Act (1934 & 1999). The City of Port Adelaide-Enfield also has an interest in the area, and has the option of creating council by-laws and planning changes appropriate to the site.

Community groups such as the Barker Inlet and Port Estuary Committee, Project Dolphin Safe, Waterwatch, Our Patch, Port Adelaide Environmental Forum and Friends of Biodiversity Park also have considerable interest in the area, however they have no legislative powers.



4. Management Context

4.1 Purpose of Conservation Reserve

The area known as Mutton Cove has been significantly degraded since European settlement. The purpose of the Mutton Cove Conservation Reserve is to enrich, restore and conserve the last remaining biodiverse area of samphire and mangrove woodland on the Le Fevre Peninsula, while encouraging ecologically sensitive uses of the area.

4.2 Location and general description

Mutton Cove is in the Port Adelaide Enfield Council, less than 20km from the Adelaide CBD. The site is situated at the south-eastern border of the proposed grain terminal head-works on the Peninsula and just to the north of the Australian Submarine Corporation. The site boundary is outlined in red on Figure 4 shown below.



Figure 4 – Aerial photograph of Mutton Cove

The land is to be dedicated to the care and control of the Minister for Environment and Conservation. It was initially decided to place the reserve under the care, control and management of the Coast Protection Board, but this was later changed due to the possible expansion of the reserve to include the adjoining Biodiversity Park and the interlinking corridor.

There are three branches of the Mutton Cove creek, as indicated in both Figures 4 and 5. The extent of these branches obviously extended beyond the proposed Mutton Cove area as shown in Figure 4. However, the outer limits of these branches have been blocked with earth levee banks and land fill. Currently no stormwater runoff actually enters Mutton Cove proper.



There is also a single council maintained stormwater drain that runs underground along the southern border of the site, within the proposed Recreation and Carpark Reserve. This stormwater drain discharges stormwater from the surrounding roads into the Port River.

Electranet and SEAGas both have easements over the southern portion of Mutton Cove for the overhead high tension powerlines and gas pipeline respectively.

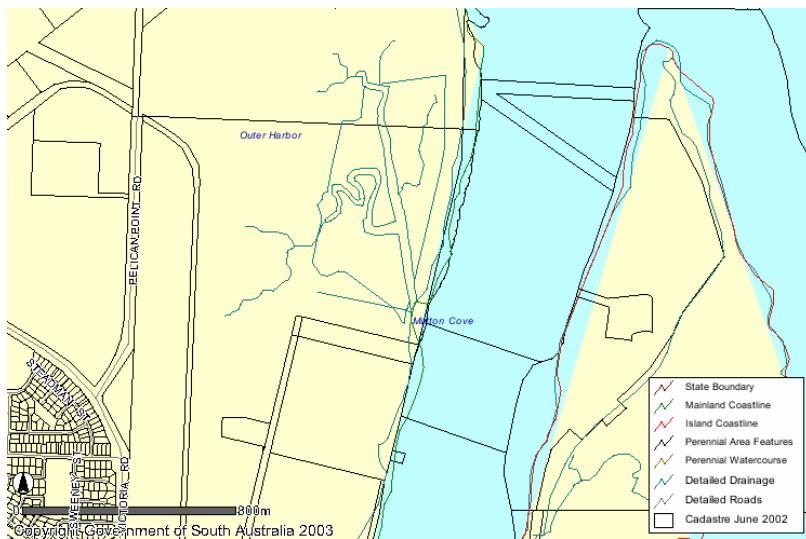


Figure 5 - Drainage at Mutton Cove

4.3 Natural resources of the site

Mutton Cove lies on the Northern Adelaide Plains within the Flinders Lofty Block IBRA region (Interim Biogeographic Regionalisation for Australia, version 5.1). IBRA regions are a landscape-based classification of the land surface into 85 bioregions Australia-wide. Each bioregion represents a unified set of major environmental influences that define the occurrence flora and fauna. Descriptions of the IBRA regions were published by Environment Australia (2000).

4.3.1 Climate

The climate on the Northern Adelaide Plains is described as Mediterranean, with cold, wet winters and hot dry summers. The Dry Creek weather station (located in the supratidal areas at Penrice Soda Products Dry Creek Saltfields) records an average of 420 mm of rain annually. This rainfall mainly occurs between May and September. Strong south-westerly winds regularly occur during autumn and spring, with hot northerly winds often occurring during summer. In winter a light northerly breeze blows in the early mornings. Lightning storms occasionally occur though out the year, but with higher intensity in mid to late spring.



Table 1 - Weather details

Weather Aspect	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total	Annual Daily Average
Av Monthly Rain (56 years)(mm)	19.3	20.8	20.7	36.9	53.9	52.7	57.1	48.7	22.6	40.4	23.7	23.6	420.4	
Av Daily Maximum Temp (10 yrs) (°C)	26.0	27.8	26.1	21.6	18.5	15.6	14.5	15.5	17.9	20.9	23.6	25.6		21.1
Av Daily Minimum Temp (10 yrs) (°C)	15.9	15.6	15.0	11.8	9.6	8.4	7.1	7.6	8.9	11.1	13.2	15.0		11.6
Av Daily Vapour Pressure (10 yrs) (mm Hg)	12.0	11.3	10.7	9.7	9.1	8.4	7.9	8.1	8.6	8.9	10.1	11.2		9.7
Av Daily Wind Speed (7 yrs) km/hr	5.7	4.3	4.0	3.5	3.4	4.1	4.4	4.7	5.6	5.7	5.1	5.3		4.6
Av Monthly Gross Evap. (56 yrs) (mm)	302	217	217	133	82	56	56	76	109	164.9	274	273	1960	
Av Monthly Nett Evap. (56 yrs) (mm)	283	197	196	97	28	3	-1	27	86	125	250	2500	1539	

4.3.2 Geology, soils and landform

The underlying soils in the area are historic estuarine muds and sands of an area that was until recent times part of the extensive tidal flats bordering Barker Inlet. The site was under the ocean until the area surfaced approximately 7500 years ago (Edmonds, 1990) during the period of Holocene marine regression. Many of the sediments on the site come from this period of inundation, particularly as much of the site appears to be the natural surface sediment with very little introduced fill (except in the border areas of the site) compared to other nearby areas.

4.3.2.1 Evolution of the landscape

The Le Fevre Peninsula was considerably smaller when Europeans first settled the area. The original soil on the Peninsula followed the approximate line of Victoria Road and Lady Gowrie Drive. Most land to the east, west and north of these two roads was originally intertidal swamp, mudflats, dunes, chenier ridges and subtidal seabed, which has been raised and levelled with hydraulic fill or industrial dumping. Most of this fill was placed between the early 1940's and 1992, when dumping ceased. The area of Mutton Cove is one of the few areas along the edges of the Peninsula that remains at natural surface level. Parts of the 1954, 1977 and 1991 aerials have been scanned and included below to illustrate these changes.

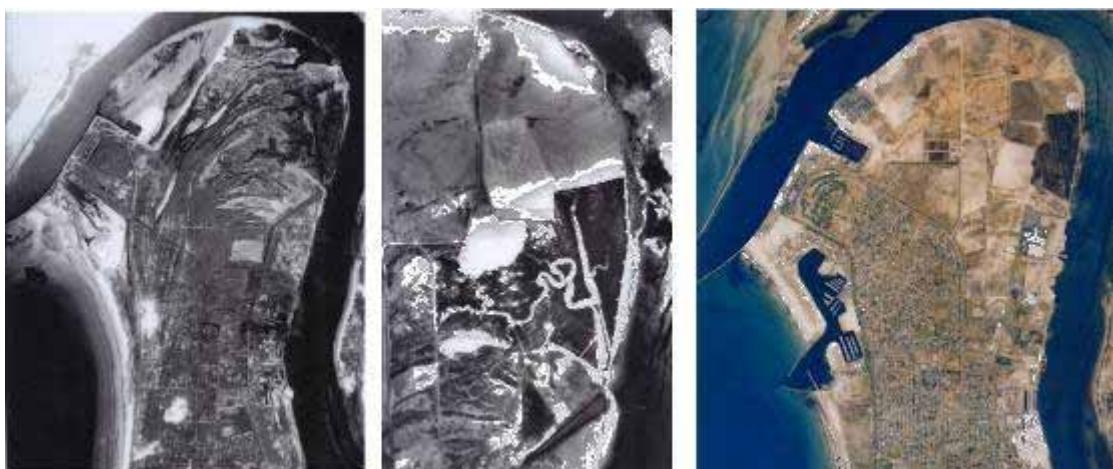


Figure 6 - Le Fevre Peninsula in 1954, 1977 and 1991 (copyright Gov't SA, Mapland)



The early photograph shows clearly the curved dunes built up from the littoral drift of sand north along the western side of the Peninsula. These dunes swept long fingers of sand into the mud flats that supported intertidal saltmarshes and mangroves on the eastern side of the Peninsula. The photo shows the new land that was being reclaimed for the Outer Harbor port facilities, and the beginning of the sand accumulation near the training walls that would ultimately become the suburb of North Haven.

By the 1970's land accumulation was proceeding apace, with dredging and waste disposal occurring in bunded blocks across the entire Pelican Point area. Mutton Cove's bunding is also evident, and it is likely that filling was probably the fate envisaged for the Cove also, at that time.

The final photograph shows the landscape in 1991, when the filling activity was starting to slow. Some white patches that represent waste disposal ponds from soda ash production are visible between Biodiversity Park and Mutton Cove. The new suburb of North Haven, with its marinas, is starting to take shape.

4.3.2.2 Current topography

The Department of Marine and Harbours flew aerial photography, combined with surveying spot levels, over the northern part of Le Fevre Peninsula in 1982 to establish land surface levels. Figure 7 is extracted from a map supplied from the archives of the Flinders Ports (Drawing 21994-30C), dated 1982. The levels on the map are presented as Marine & Harbours local datum, and have been converted to m AHD for the colour key, as stated in the figure. Ron Taylor of Flinders Ports, previously Marine & Harbours, supplied the diagram and the conversion details. The area of Mutton Cove is outlined.

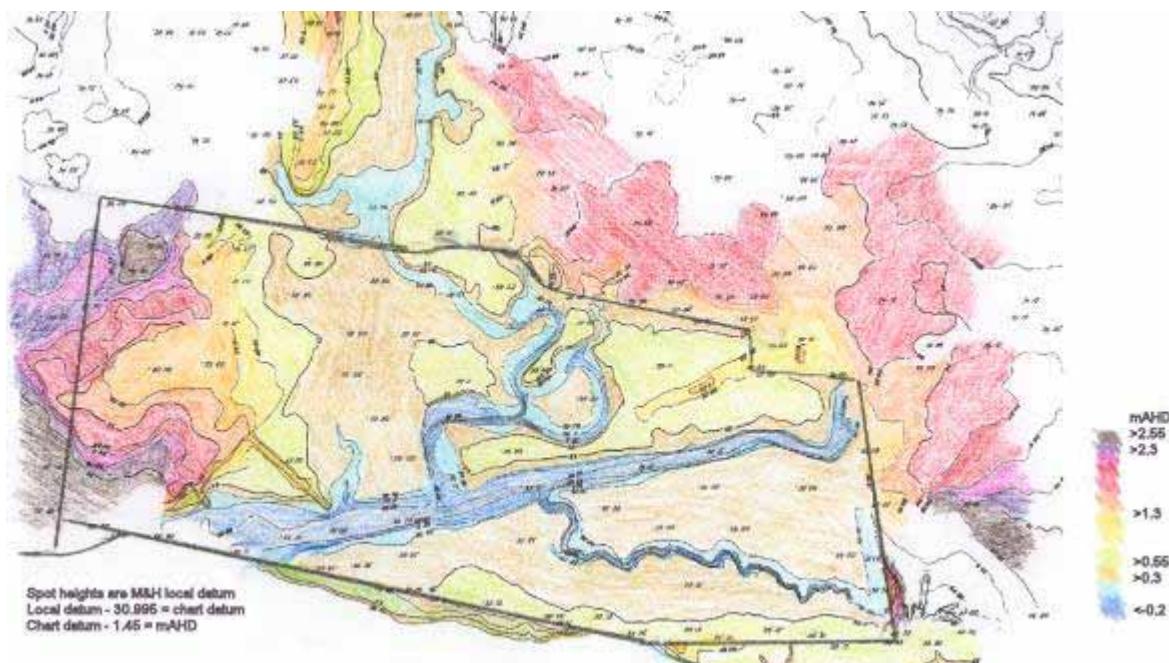


Figure 7 - Surface topography, Mutton Cove



The drawing shows quite clearly that the area is fairly flat and low-lying, and is surrounded by higher areas that mark the ‘reclaimed’ areas of Pelican Point. The reclamation consisted variously of areas of dredge spoil, caustic waste materials from the ICI Soda Ash Plant at Osborne, fly ash and cinders from the Osborne Power Station and pyritic wastes from the Acid Plant at Taperoo. Some of these filled areas may possibly contain high concentrations of the metals associated with pyrites. The specific areas of fill will be discussed in more detail in the section on historic management of the area.

Coastal acid sulfate soils (ASS) are formed during and after periods of seawater inundation, such as occurred in the Adelaide region during the Flandrian Transgression. These soils are quite stable while they remain inundated, and are usually referred to as PASS (potential acid sulfate soils). PASS soils convert to actual acid sulfate soils after they are drained.

Typical effects of ASS in areas that have been cut off from tidal inundation include soil level subsidence as a result of oxidation of carbon (both organic carbon and carbonates) in the soil profile, as well as acidification of soils. Breakdown of soil structure may also occur in stranded saline clay soils as a result of Ca:Na exchange on the surface of clay particles, which results in the formation of sodic soils once freshwater rinses the chlorides (along with calcium) from the soil. It is likely that parts of Mutton Cove are, or have been, affected by ASS, and this will need to be considered during any construction or soil works. It is recommended that the guidelines provided by the Coast Protection Board in *Coastline 33* (CPB, 2003) be adhered whenever earthworks are contemplated.



Figure 8 - Small patch of soil showing oxidised products



At Mutton Cove, there is evidence that the area has contained reactive ASS in the past, which has caused considerable sinkage, however only small patches of currently reactive areas have been observed.

The original vegetation of the area in early aerial photographs shows that Mutton Cove's vegetation was an ecotone between mangroves and saltmarsh. Observations of soil surface levels outside the Cove and in Barker Inlet show that the soil surface level for this ecotone is usually around 1m AHD. So, it would be reasonable to assume that the land surface across much of Mutton Cove prior to the placement of the seawall embankment would have also been approximately 1m AHD. At present, soil levels in the saltmarsh are between 0.4 and 0.55 m AHD, representing a reduction in level of over half a metre. A drawing showing the distribution of plant types at the different surface levels in Mutton Cove and in Barker Inlet is attached in the Appendices as *Mangrove and saltmarsh zonation*.

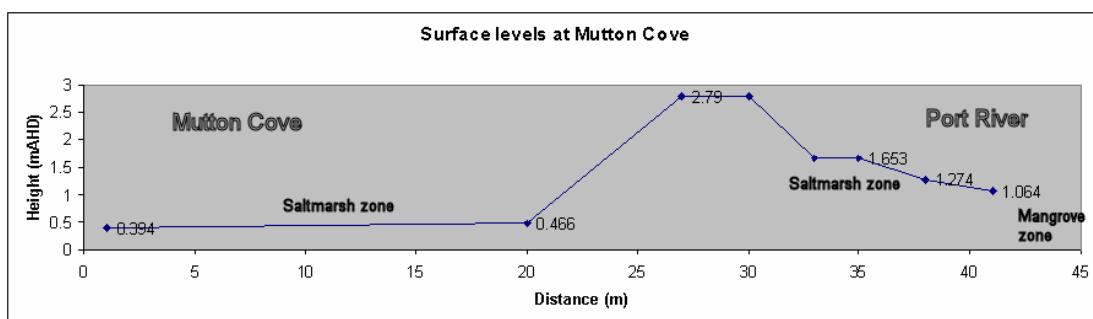


Figure 9 - Surface levels at Mutton Cove, across the seawall

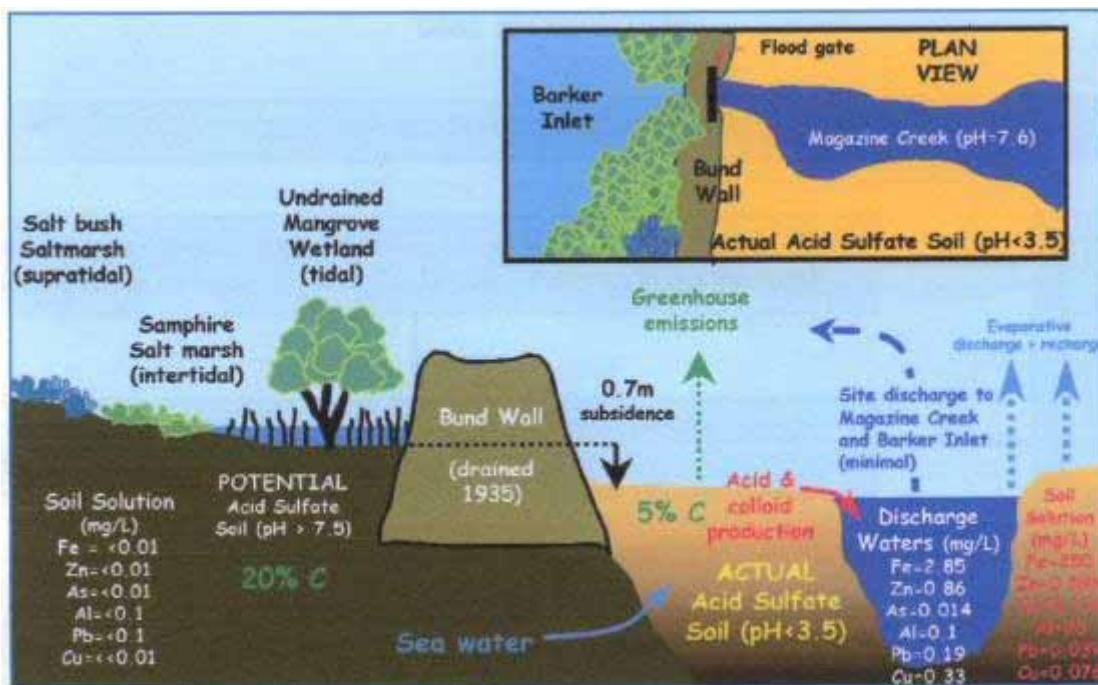


Figure 10 - Model of actual acid sulfate soil formation at Gillman (CPB, 2003)

This degree of land subsidence is not unusual in bunded saltmarsh areas. CSIRO recently undertook a study in the Gillman area, examining the acid sulfate soils that



developed after the embankments were built in the 1950's. A recent Coast Protection Board issue of *Coastline* contains mapping of the area of ASS, and diagrams (reproduced here) showing a subsidence of approximately 0.7m (CPB, 2003).

The triggering of ASS (and subsequent land subsidence) after saltmarsh tidal restriction causes some difficulties in the restoration of embanked saltmarshes. The Ramsar Convention's Scientific and Technical Review Panel formed an expert working group to look at wetland restoration issues. They found that the technique of culvert removal had to be approached with caution, as subsided land behind a tidal restriction may become too deep on reflooding to support the original vegetation (Ramsar STRP, 2002).

Locally the effects of restricting, then breaching, seawalls may be observed along the length of the old St Kilda Embankment, built in the late 1890's between Dry Creek and St Kilda along the ecotone between the samphire and the mangroves. A mere forty years later, when ICI built its first salt pond a little further inland, the St Kilda Embankment was breached in several places. The degree of subsidence that had occurred was so great that mangroves immediately started to colonise the area that once was saltmarsh. Burton noted continued rates of landward migration of mangroves in the Swan Alley region of up to 18 metres a year (Burton, 1982), half a century after the embankments were breached. An area of many hundreds of hectares of species-rich saltmarsh has been replaced by a monoculture of mangroves.

4.3.3 Hydrology

4.3.3.1 Surface and groundwater

The area of Mutton Cove would historically have been subject to freshwater input from rainfall only. As the soils of the recurved dunes inland from the site were sandy, any runoff would have been minimal. The majority of freshwater landing on the samphires and sand dunes surrounding the Cove would have evaporated or percolated directly to groundwater.

There are currently a number of freshwater inputs into the Cove and the three sections below discuss each of these and their possible impacts. In general, large freshwater inputs onto saltmarsh sediment are detrimental. The freshwater washes the chloride out of the soil, causing the sediment to become sodic, which means that the soil loses its structure and starts to repel water. This causes the soil to suspend in water, increasing erosion and decreasing the availability of water to the saltmarsh plants.

Freshwater commonly carries higher nutrients than sea-derived saltwater, and it also carries higher sediment loads, which may carry toxic chemicals or heavy metals. Saltmarshes are accumulative ecosystems, which means that the sediment is not usually a problem unless the area does not have sufficient flushing, as occurs at Mutton Cove. The nutrients may be a problem, as saltmarshes generally have low nutrient loads, and the excess nutrients may cause elevated bacterial action and cyanobacterial blooms, which result in unpleasant odours, slimy muds and polygons of cyanobacteria coating the surface.



4.3.3.1.1 Electranet runoff

The Electranet site to the south of Mutton Cove currently drains into a small pond (approximately 385m²) created to treat this water before discharge. This pond discharges directly to the low-lying land to the north of Electranet, which is part of Mutton Cove. The area contains a wide range of dumped by-products, including iron pyrites, possibly from the sulphuric acid plant at Snowden's Beach. Discharge of freshwater to this area is a concern, as the water quality may deteriorate on passing through the dumped fill. Additionally, the Environment Protection Authority has asked that the southern portion of the site should not be used to channel stormwater.

The options are twofold:

- 1) block the seawater outlet, drain the wetland water onto Mutton Cove's high land south of the saltmarshes and let it soak into the soil, or
- 2) block the seawater inlet and divert the Electranet water from the wetland into the council's stormwater drain that runs along the south side of the Electranet substation.

The first option raises the issues of flooding, ponding of stagnant water, mosquito breeding and possible contamination of groundwater.

The Electranet site includes a sealed area of concrete surface and an adjoining gravelled area of approximately 9840 m² and 2800 m² respectively. The gravelled surface may have some degree of permeability. On an average year with around 400mm of rain this area could generate between 4488 and 4782 kilolitres (cubic metres) of water. Initially this flows into a settling pond on the eastern side of the substation, and overflow during peak period will flow into the reserve and pond along the southern levee bank. Some of this water will soak into the permeable layers of soil and exit to sea via the groundwater and the remainder will evaporate during the summer months. The southern portion of Mutton Cove may contain contaminants, therefore seawater inundation of this area is not recommended by the Environment Protection Authority (EPA). Maintaining the levee bank along the entire southern edge of the filled area will ensure that none of this stormwater can flow into Mutton Cove.

A pipe has been discovered through the Port River levee bank and while seawater can flow into this area during extreme tidal events, it is unlikely that stormwater can flow back into the Port River from this site due to the high invert level of the pipe

It is proposed that this drain be blocked and the stormwater runoff from the Electranet site be redirected into the Council's stormwater pipe that runs along the southern boundary.

4.3.3.1.2 Excavated channel along the north-western levee bank.

A man-made channel exists adjacent to the levee bank in the north-west of Mutton Cove. A water sample was taken from the drain in the west of the Cove at 10:30 am on the 9th of September 2003. This drain receives water from the areas of deposited fill to the north and west of the Cove. The water in the drain was dark reddish brown in colour.



The results of tests on the sample are provided in the table below. The iron concentration in the water is higher than the Environmental Protection (Water Quality) Policy 2003 criterion for freshwater aquatic ecosystems, however no criterion is provided in the guidelines for marine ecosystems. Seawater generally contains less than 0.01 mg/L iron. Groundwater and surface water draining from areas containing acid sulfate soils may have iron concentrations approaching 3 mg/L, however this is usually accompanied by a lower pH than was in evidence here. The turbidity was particularly high, however full spectrum analysis has suggested that this could have been caused by the highly saturated colour rather than high particulate levels.

The pH of waters in estuaries is generally high, due to the concentrations of carbonates contained in seawater. An acceptable pH range for water with this salinity is between 8 and 9. As pH is a logarithmic scale, the sample had a pH of well outside this range. This is not surprising, given that the sample was collected from an area that drained from land described on DMH Drawing 21892-12E as being an ‘area of dumping’ containing ‘grey caustic, pink caustic, brown caustic and black caustic’ layers in test holes.

The dissolved oxygen concentration in the water in the drain is very low, mainly due to high salinity and low movement of the water body. No nutrient or BOD tests were conducted, however spectrum analysis revealed a high absorbance in the UV end of the scale, suggesting that tannins or lignins may be present in the water, possibly from decomposing seagrass.

Table 2 - Water analysis results from North West drain

Attribute	Reading
Iron (Fe)	1.27 mg/L
Arsenic (As)	less than 10 ppb
pH	9.49
EC	71,600 uS
Turbidity	337 NTU
Dissolved Oxygen	0.05 mg/L
Temperature	13.5°C

It is recommended that this channel be filled with spoil from the abutting levee bank, at the same time reshaping the levee bank to stop stormwater inflows and encourage native plant regeneration.

4.3.3.1.3 Drains in the northern embankment

There are three stormwater pipes running through the embankment north of the Excelsior wreck. These three pipes stick out from the embankment quite a distance, so that the erosion basin created from their discharge does not erode the embankment. The erosion basin is visible to the naked eye, so stormwater flows into Mutton Cove must have occurred in the past. However, given the current landfill and the extent of revegetation in the erosion basin it is unlikely that this has occurred for many years.

It is recommended that these pipes be either blocked or removed.



4.3.3.2 Tidal flows

The main hydrological issue in the Cove is tidal restriction. This is the issue that has led to the change in plant species dominance from mangrove to saltmarsh species, and is the most likely primary cause of the land subsidence in the Cove. To restore the Cove to a more natural regime, it is important to understand the altered flow regime in the Cove, as well as the more typical flow regime found outside the Cove.

4.3.3.2.1 Tidal restriction study

Two tide staffs have been placed at Mutton Cove, one inside the Cove itself, and the other in the Port River just outside the Cove. On September 11, during a spring tide, a series of observations was recorded, in order to assess the degree of tidal restriction occurring in Mutton Cove.

While one day of observations is a minimal data set, it is sufficient to provide an indication of the magnitude of the restriction and the time lag that is involved. For further reference, data were also obtained from the Outer Harbor tide station and from published tide predictions. The information has been plotted on the figure below, and the data attached in the Appendices as *Tidal restriction data*.

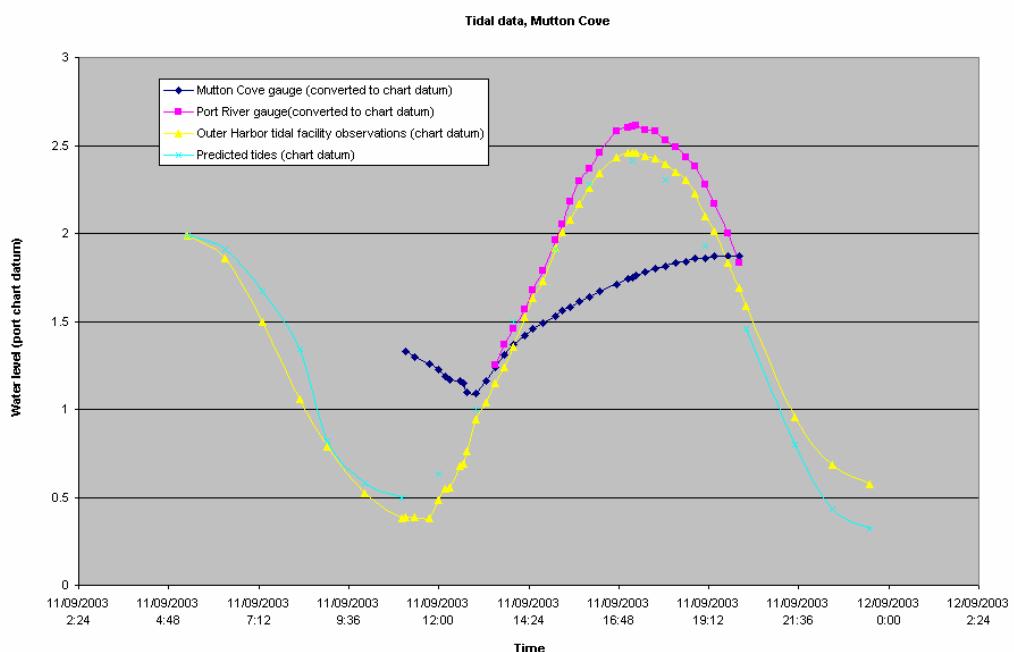


Figure 11 - Tidal data collected at Mutton Cove on 11 September 2003.

The graph shows that the predicted tide for the day reasonably closely matched the tide recorded at the official tidal station. In the Port River at Mutton Cove there was a lag of approximately 5 minutes, compared to the tide station. While the wind speed was low (around mid-tide) the tide staff in the river provided water level readings that were very similar to the readings at the tide station. However as the wind increased in the afternoon the water level in the river rose higher than at the tidal station – this is likely to be because the wind was pushing water into the narrowing river channel.



In comparison to these relatively small variations, the difference in water levels inside Mutton Cove provided a marked contrast. The high tide inside the Cove occurred about two hours later than it did in the river. Additionally, both the top and bottom levels of the tide have been truncated – the low tide is about 0.6m higher inside the Cove than outside, while high tide is about 0.75m lower than high tide in the river. This tide was a relatively small spring tide – the water in the Cove was restrained within the main creek channels. With higher tides, the water spills across the saltmarsh, and it can be expected that the rate of rise inside the Cove would slow dramatically at that point, and the final variation in the high water mark between the river gauge and the Cove gauge may be very large when river tides are very high.

The implications of this type of change in the tidal regime are wide ranging. After the embankment was built in the 1970's it is likely that the higher low tides would have caused the gradual drowning of mangroves growing inside the Cove.

Avicennia marina, the mangrove that occurs in South Australia, has a specific adaptation that allows the species to inhabit a range of hydrological conditions. As a juvenile, the propagule establishes in any area where the water is calm and below a certain depth (McMillan, 1971). The young trees have no pneumatophores, the 'fingers' on the roots that allow the adult trees to obtain enough oxygen. Instead, they have long cells that occur at all along their stems that allow them to extract enough oxygen from the air to keep them alive when submerged (Ashford and Allaway, 1995). Depending on the conditions they find themselves in, the juveniles start to grow pneumatophores as they mature. Those trees in deeper water or that are permanently ponded (such as those that occur in saltfields or in the landlocked gorges, now freshwater, of the Pilbara) will have longer pneumatophores. Those that occur where the tide comes and goes daily will have short pneumatophores, and those that grow in gardens or on shingle ridges rarely have any pneumatophores at all.

Once a tree has grown its particular array of pneumatophores, any very rapid change in conditions can cause death to the tree. Ponded trees will dehydrate within days and die, if their pond is opened to the tides. This occurred in Dry Creek, when the Dry Creek Drainage Authority widened some drainage channels in 1994. Trees that have a daily ebb and flow of water will drown if they are suddenly permanently inundated. This is the most likely cause of the sudden loss of mangroves from Mutton Cove after the area was landlocked.

Still, the next generation of propagules would have washed into the Cove – but they did not establish. This may be the fault of the other tidal restriction – the water was now not deep enough, often enough. Even today many of the saltmarsh plants are dry and struggling. This aspect is slowly changing – the settlement of the soil as a result of drying out and acid development has gradually reduced the marsh surface height. This settlement along with the opening of some of the blocked pipes a few years ago has seen a few young mangroves establish along the creek line. This is a promising sign, as it indicates that only a relatively small increase in water volume may be required to start the area regenerating.

A final impact of the tidal restriction relates to the lag time of the tide. As the tide rises in the main river, bait diggers who work the extensive river flats retreat to the Cove, knowing that they may have at least another hour or so of exposed mud. The



Cove is too small an area to support such intensive activity for long. The issue of bait digging is discussed further in the management prescription section of this plan.

4.3.3.2.1.1 Impact of pipe clearing (October 2003)

In early October heavy machinery removed rocks from both sides of the inlet pipes. The Cove tide gauge developed a lean during the operations, and on resurvey was found to have sunk a further 9cm into the mud. This is not surprising, as the area is very soft. A longer tide gauge that can be driven down to firmer substrate will probably need installing prior to the start of regular monitoring.

Observations on two days when only moderate tides were experienced (11th and 28th October) suggest that for smaller tides, where the water is restrained inside the main creek lines, the lag time between the peaks of the tides has been reduced from approximately 2 hours to 1 hour. The variation in the high water mark for these smaller tides has been reduced from 75cm to 28cm. This is a dramatic improvement.

Once the spreading out of water across the saltmarsh occurs, for example during very high storm tides such as occurred on 29 October, the lag in tidal peak is still nearly 2 hours, while the variations in the high water marks between the river and the Cove on that day was over 90 centimetres.

This is a very good result, as it confirms that the area that now receives a greatly increased frequency of flooding will be restricted to the edges of the creek lines, while the areas of high marsh will receive only a small increase in flooding frequency. This should ensure an increased population of mangroves, while retaining the small areas of high marsh that currently exist.

4.3.3.2.2 Saltmarsh-mangrove interface: inundation regime study

How much water is needed to develop open mangrove woodland along tidal creeks, with a backing of saltmarsh and then higher land? There is little published information on Australian conditions. Adam (1995) has published some transects through the mangrove-saltmarsh areas of Georges River in NSW and the Peel Preservation Group (McComb *et al*, 1995) have also published information on the surface elevations and tidal flooding regime of saltmarshes near Mandurah in Western Australia. Both these papers cite low marsh as receiving some flooding on an almost daily basis, while high marsh is only flooded at about fortnightly intervals.

Information on the actual land elevation and tidal flooding frequency from other areas may not be relevant to any local study. This is because tidal heights against the land vary depending on location. For example, Derby in WA has an 8m tidal variation each day, while Adelaide has less than 2m. Additionally, the plants are affected by salinity and water temperature, and a given frequency of flooding may result in different salinities depending on the evaporation:precipitation ratio. This will affect the amount of tidal flushing required at any location.

What was evident from the two studies was that the entire range of habitats, from low marsh through to high marsh occurred between elevations that were only about 60cm apart. Thus a quite small increase in depth and frequency of tidal flooding many have a large impact on the type of habitat present.



To discover the tidal regime in the saltmarsh-mangrove ecotone area in Barker Inlet a tide staff was placed in the saltmarsh-mangrove ecotone near St Kilda, and another staff was placed in an area that historically supported a saltmarsh-mangrove ecotone in Mutton Cove. This area now has only quite dry stranded saltmarsh. These staffs were placed to allow the consultants to compare the amount of flooding each area received to assist in developing a restoration strategy.

At each site, the level reached at the highest point of the tide was measured and recorded as mAHD. This was converted to chart datum by adding 1.45 metres to the AHD reading. This allows a comparison to be made with the tidal data provided by the Flinders Ports tidal station. From this comparison, the tidal height necessary to flood the saltmarsh at the ecotone was calculated for each site. In Barker Inlet, a tide of 2.4m chart datum will flood the ecotone, whereas in Mutton Cove (in September) inundation of the ecotone required a tide of at least 2.65m chart datum, due to the restrictions provided by the inlet pipes into the Cove.



Figure 12 - Saltmarsh gauge at Mutton Cove

Next, the tidal predictions for 2003-2004 were entered into a spreadsheet. The events that would cause inundation were isolated for each site, and histograms were produced for each location (see below). The data sets for these histograms are attached in the Appendices as *Inundation hydrology*.



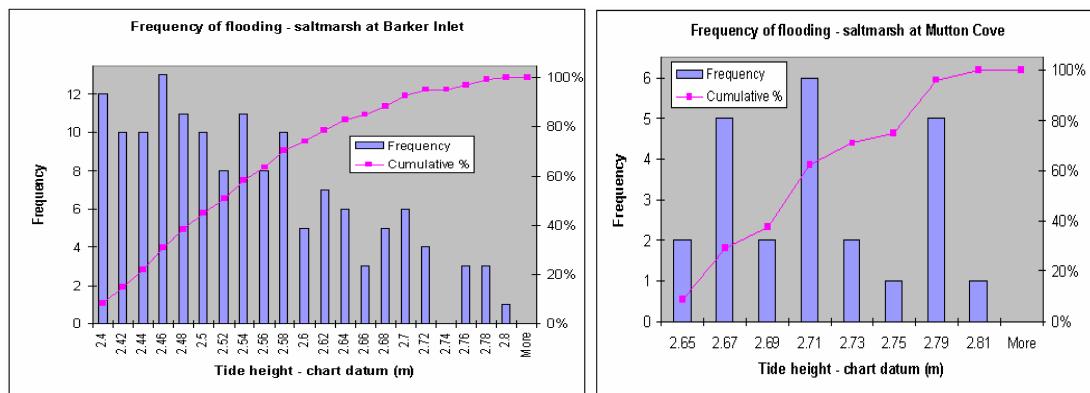


Figure 13 - Inundation regimes at Mutton Cove and Barker Inlet

The histograms reveal the magnitude of the difference in the inundation regimes. In Barker Inlet, the ecotone between mangroves and saltmarsh receives a fresh influx of tidal water on at least 146 occasions over the year. The maximum depth these inundations are predicted to reach is about 40 centimetres. As tide charts do not take into account the effect of storm surges, it is possible that the depth of water could be up to another metre deeper again during storm events.

In Mutton Cove, the area that formed the ecotone between mangroves and samphires in the 1963 aerial photography now only receives inundation on a maximum of 25 occasions over a year, to a maximum depth of 14 centimetres. The effects of any storm tides are also attenuated behind the entrance restrictions to Mutton Cove.

When observing the tide in Mutton Cove, it was noted that the tide is contained within the channel system of the creeks for a considerable time. Once the creek beds have filled up, the water spills out across the marsh surface. At this point the rate of rise slows considerably, as the increase in area is significant. This reflects the flat nature of the land surface. As the pipes forming the inlet to the Cove are partially blocked, calculating the flow through them was not possible using conduit formulas. Instead, an approximation of the flow through the inlet pipes was made using data obtained from the tidal records of 11 September.

Once most of the channel bed was wet, the tide rose inside Mutton Cove at a relatively constant rate until the head differential started to reduce as the outside tide began to fall. The tide did not rise sufficiently high inside Mutton Cove on that day to spill out of the main channel, simplifying the calculation. A set of observations from the period of fastest rise was examined. When plotted the data points approximated a straight line, so these observations were used to provide an average rate of rise. The rate was approximately 1.89 mm per minute.

As the creek channels occupy an approximate area of 5.4 ha of Mutton Cove, roughly 102 kilolitres per minute must be entering the Cove through the pipes during the four hours of maximum flow each tide. This rate will vary depending on the head differential over the period of the tide, but can be used to make approximations of the types of flow required for different flooding scenarios. Details of these further approximations are contained in the management prescription portion of this plan, which deals with the consultants' recommendations for the hydraulic modifications to the site.



4.3.3.2.2.1 Impact of pipe clearing (October 2003)

The lowered land surface inside the Cove and the increased water flows from the pipe cleaning have combined to result in a flooding regime that just overtops the edges of the creeks, about 256 times a year. The sudden drop in the rate of rise that occurs after that point as the small pipes cannot keep up with the water spilling out across the saltmarsh on higher tides does not allow this increase in flooding frequency to translate right across the site. This means there is a bigger impact from the increased flow during smaller tides than there is during larger tides.

In fact, with the three existing pipes maintained in their newly open state, it appears that the higher marsh areas will flood only slightly more often than they currently flood. What is most likely to occur is a vigorous growth of mangroves along the creek edges, with a very healthy low marsh that would receive frequent very shallow flooding, just landward of the mangrove belt. The mid marsh would flood slightly more frequently than currently, and the high marsh would flood in a similar pattern to the current flooding regime. As a result, the high marsh may remain in its current location, while the mid marsh boundary with low marsh is the most likely to change. Overall, this would see an increase in mangrove area, a slight migration landward of the low marsh, a squeeze of the mid marsh and the high marsh remaining in its current location. This is probably an ideal result for the high marsh, which is the area where a number of plant species with conservation significance occur.



Figure 14 – *Wilsonia*, a high marsh specialist

4.3.3.2.3 Storm surge and sea-level rise

The Coastal Protection Branch of the Department for Environment and Heritage recently provided a paper to the South Australia Greenhouse Committee (Deans, 2004) that examined the likely ramifications of sea level rise and increased storm



tides. Best estimates, internationally, for sea-level rise over the next century vary from 0.1m to 0.88m, with the average for all the models being 0.5m over the 100 years.

This degree of increased inundation would cause a large change in vegetation types across Mutton Cove. Unfortunately, the Cove is surrounded by high land made up of coarse fill materials, and these types of areas do not make useful retreat areas for saltmarsh, which prefers fine grained clay-rich sediments. Therefore, if any saltmarsh habitat within Mutton Cove is to be maintained in the long-term, it will be important to be able to regulate the degree of flow into the Cove. Regulation does not need to be an onerous duty – it may be as simple as periodically increasing the degree of blockage on the inlet pipes, should there be evidence that the degree of inundation is increasing beyond that suitable for supporting the desired vegetation types. Regular (annual) monitoring of the vegetation would provide ample warning of the need to add restrictions to the pipes.

The impacts of storm events are less easy to quantify. Where a storm surge is of short duration, an area inside a restriction (such as Mutton Cove) has a smaller additional rise than the unrestricted area outside. If, however, a storm surge is accompanied by a wind that holds water against the restriction (in the case of Mutton Cove, a northerly) for a longer period than a normal tide, then the restricted area will gradually approach the level of the unrestricted area.

If the land backing Mutton Cove is of sufficient height, then any flooding will be contained within the Cove, and no control would be necessary. If, on the other hand, the land surrounding Mutton Cove is of insufficient height, it would be necessary to prevent the extreme event from overfilling the Cove. Storm tides do not arrive unannounced, and providing the seawall is high enough to prevent overtopping, the inlet pipes may be temporarily blocked using sheets of conveyor belting or tethered sandbags placed in the pipes to slow the flow. The issue of overtopping is addressed below.

The current 100 year ARI (average return interval) event for Port Adelaide is considered to be an extreme water level of between 2.45m to 2.58m AHD. The two benchmarks on the seawall at Mutton Cove are flush with the roadway, and stand at 2.74m and 2.79m AHD. There are several areas of the seawall that are a little lower. In the event of a 100 year risk event, there would only be 20-35 centimetres of freeboard. This is a very small margin, if there are any waves present.

At best estimates (Deans, 2004) a sea-level rise of 0.3m may increase the frequency of 1:100 year extreme water events to as often as 1:2 or 1:5 years. The projected risk suggests that overtopping of the seawall may occur as frequently as every 15 years, at that point. The City of Port Adelaide-Enfield Flood Study for the Le Fevre Peninsula and Gillman will be used to assess seawall requirements for the entire extent of the coast that forms part of the Council area, including the Mutton Cove site. The management body for the Mutton Cove reserve should liaise with the CPAE and the Coast Protection Board when considering what maintenance requirements for the seawall are appropriate.



4.3.4 Vegetation and habitat

4.3.4.1 Historic vegetation

The contribution of even a small block of land (such as Mutton Cove) to conservation may be significant, particularly if the site contains rare or endangered species or habitat types. Small pockets of land often form important ‘stepping-stones’ for both native flora and fauna if maintained in an appropriate manner.

Aerial photography dating from 1963 shows the historic vegetation of the area. In this photograph the area of the Cove appears to be an ecotone between the main mangrove forest along the foreshore and the intertidal saltmarsh and dune areas backing the mangroves. Such an ecotone is usually a very biologically diverse area, containing flora and fauna belonging to each of the adjacent habitats. In 1963 the site contained 44–49% mangroves, 5-6% tidal creeks with the remainder of the site comprising both intertidal saltmarsh and dune ridges (45-50%). The mangroves occurred in scattered clumps, containing only a few trees interspersed with samphires and saltbush.



Figure 15 - 1963 aerial photograph of the Mutton Cove (copyright SA Gov't, Mapland)

In analysing the aerial photograph, the percentage of mangrove cover was calculated to include all areas that could be classified as closed forest, open forest and woodland



as pure mangroves. In areas that could be classified as open woodland, isolated trees or isolated clumps of trees, each individual tree canopy was classified and its area calculated.

The areas of tidal creek were defined as the areas that appeared darker on the aerial photography, and obviously maintained some water inundation during all but the lowest of tides. Areas of saltmarsh and dune ridges were the areas not classified as mangroves or tidal creeks.

4.3.4.2 Current vegetation

Current vegetation was assessed using three methods. Past species lists were first collected for the area. These are discussed in the section titled “Other flora records” and attached in the Appendices.

Secondly, current aerial photography was run through both supervised and unsupervised image classification, so that each habitat type present in the area was clearly delineated.

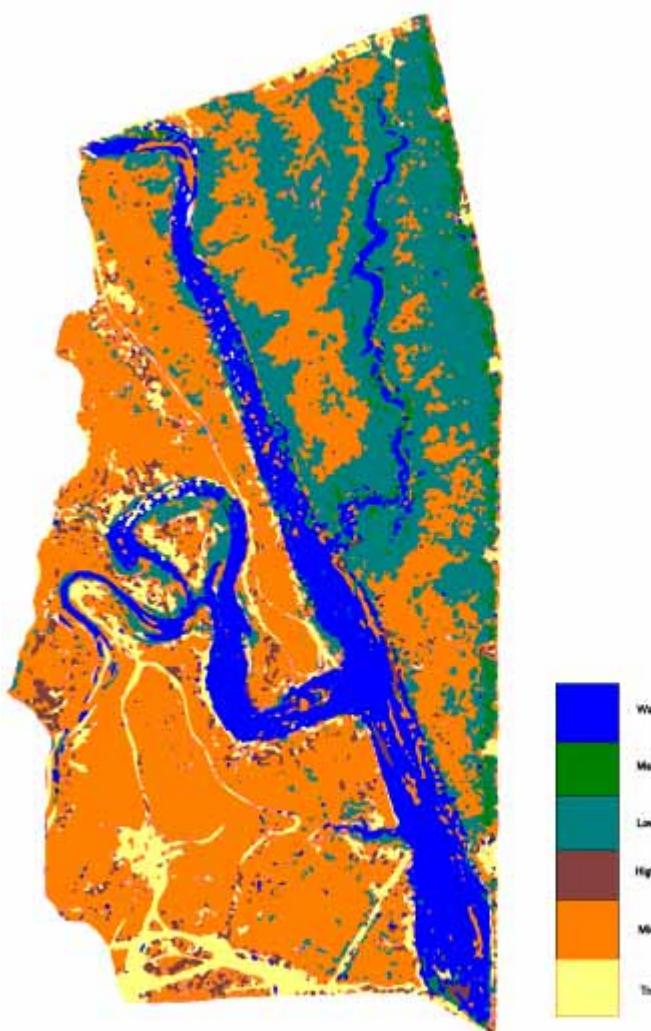


Figure 16 - Supervised classification of the tidal area of Mutton Cove.



The image includes only the land forming the Cove itself, and does not include the areas of fill surrounding and south of the low-lying land. The image was then analysed to provide percentages of cover for each habitat type. The classifications used for this photograph are slightly different than those used for the 1963 photograph, as there are now no deep areas of water, so the water areas contain those areas that are permanently flooded (very few) and those areas that flood and drain daily. A bare soil classification was added to show up the large number of vehicle tracks that have formed in the area since 1963, and the samphires are divided into further classifications depending on their tidal regime.

The approximate percentage of each classification (and its area in hectares) is reported in the table that follows.

Table 3 – Current approximate areas of vegetation types at Mutton Cove

Classification	% Cover (+/- 5%)	Ha
Water	18%	5.4
Tracks	11%	3.3
Low marsh	24%	7.1
Mid marsh	32%	9.6
High marsh	8%	2.5
Mangrove	6%	1.7
Total area	100%	29.5

Turner (2001) describes the entire area of Pelican Point as supporting a degraded *Myoporum insulare*, *Lawrenzia squamata*, *Adriana klotzschii*, *Olearia axillaris* shrubland. This was probably the vegetation association that dominated the original recurved dune areas of the Point, prior to the intensive filling activity of the 1960's to 1990's. Very little of the original surface now remains, although areas supporting small numbers of these species are starting to colonise the higher, sandy fill areas.

In Mutton Cove itself, some members of the above plant association are found on the southern areas of fill and along some of the embankments. These areas are, however, devoid of many of the other species one would expect to find: *Adriana klotzschii*, *Olearia axillaris*, *Lomandra collina*, *Alyxia buxifolia*, *Comesperma volubile*, *Atriplex cinerea*, *Atriplex semibaccata*, *Lotus australis* and *Distichlis distichophylla*.

The majority of Mutton Cove is saltmarsh. The low marsh supports a *Sarcocornia quinqueflora*, *Suaeda australis* low shrubland. Some of this area has evidence of mass recruitment of young *Sarcocornia*, probably a result of the increased inundation experienced since the first attempts to clear the pipes by hand, a few years ago.





Figure 17 - *Sarcocornia* seedlings in the low marsh

The mid marsh supports a chenopod low closed shrubland dominated by *Halosarcia halocnemoides* and *Sclerostegia arbuscula*. Much of the mid marsh contains the skeletons of samphires that died some years ago, possibly from overly dry conditions. Good stands of healthier samphire and *Frankenia* (sea-heath) were in flower when the consultants visited the site. Small areas of high marsh are scattered through the marshland, and these support an *Apium annuum*, *Puccinellia stricta* grassland.

The third part of the vegetation assessment was a field collection undertaken by Delta personnel in late September to identify and evaluate the plant associations present on the site.

While no single collection ever succeeds in collecting all the plant species present on a site, the surveyors collected a representative sample of most habitat types present within the cove. Samples were not collected from the planted species on the southern section of the site, due to their small size and immaturity. Species lists provided in the “Our Patch” (Sharn Lucas) revegetation management plan should be relied on for these species.

A sampling adequacy graph was constructed to ensure sufficient sampling of the site had been undertaken to provide a representative species list. A sampling adequacy graph was also constructed for native species only, showing that the later sampling locations, in the southern part of the Cove, contained mainly new weed species.





Figure 18 - Sampling locations in Mutton Cove



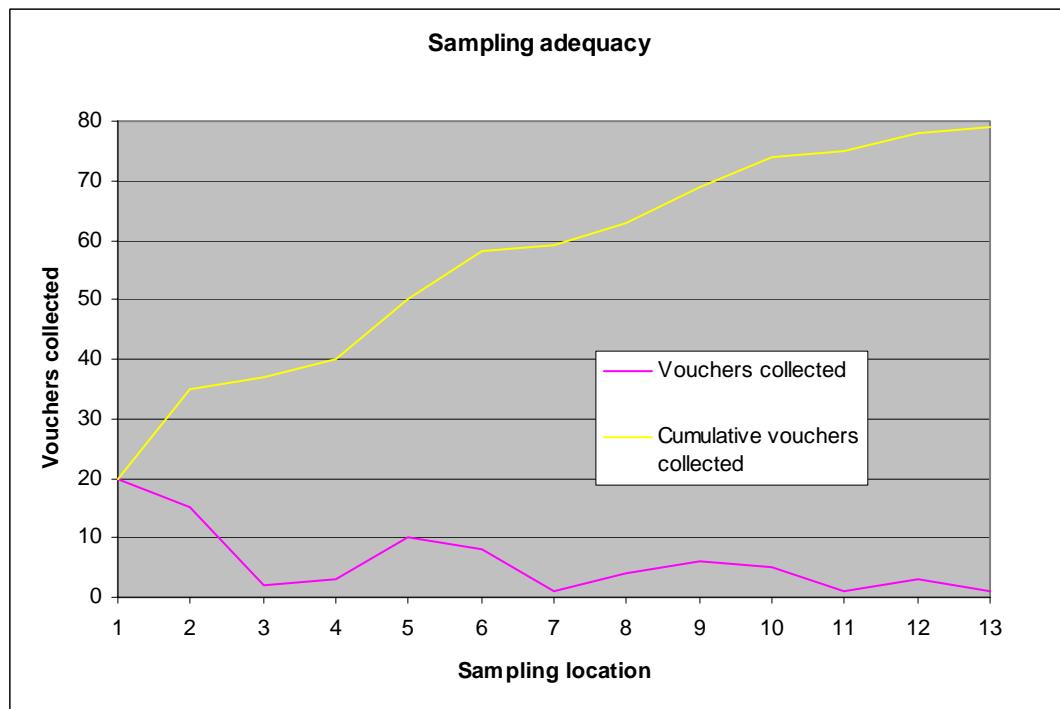


Figure 19 - Sampling adequacy graph for all species.

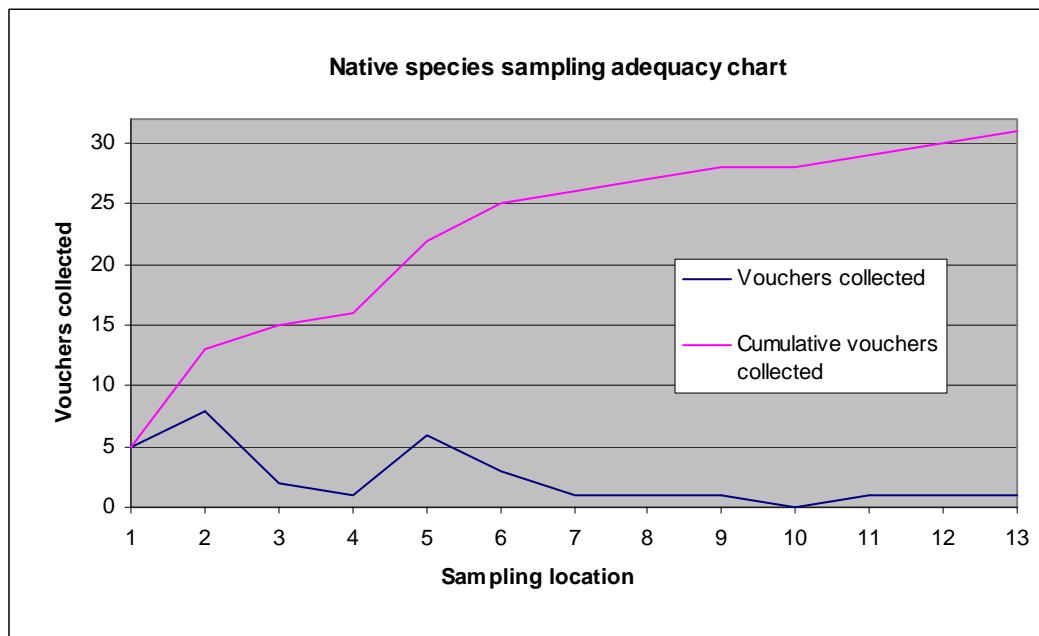


Figure 20 - Native species sampling adequacy graph.



Table 4 – Plant species collected on site on 29th September 2003

Family	Species	Common name	Exotic Conservation significance
Agavaceae	<i>Agave americana</i>	Century Plant	*
Aizoaceae	<i>Galenia pubescens</i>	Blanket Weed / Coastal Galenia	*
Aizoaceae	<i>Carpobrotus rossii</i>	Ross's Noon-flower	
Aizoaceae	<i>Disphyma crassifolium</i>	Round-leaved Pigface	
Aizoaceae	<i>Mesembryanthemum crystallinum</i>	Common Iceplant	*
Aizoaceae	<i>Mesembryanthemum nodiflorum</i>	Slender Iceplant	*
Aizoaceae	<i>Tetragonia implexicoma</i>	Bower Spinach	
Amaryllidaceae	<i>Narcissus tazetta</i>	Jonquil / Narcissus	*
Asclepiadaceae	<i>Asclepias rotundifolia</i>	Broad-leaved Cotton Bush	*
Avicenniaceae	<i>Avicennia marina</i>	White or Grey Mangrove	
Boraginaceae	<i>Echium plantagineum</i>	Salvation Jane / Patterson's Curse	* Control / notification required in some areas
Bryaceae	<i>Bryum</i> sp.	Moss	
Cactaceae	<i>Opuntia</i> sp.	Prickly Pear	* Proclaimed weed
Carophyllaceae	<i>Spergularia marina</i>	Salt Sand-spurrey	*
Chenopodiaceae	<i>Atriplex paludosa</i>	Marsh Saltbush	
Chenopodiaceae	<i>Enchydraea tomentosa</i>	Ruby Saltbush	
Chenopodiaceae	<i>Halosarcia halocnemoides</i>	Grey Samphire	
Chenopodiaceae	<i>Maireana oppositifolia</i>	Heathy Bluebush	
Chenopodiaceae	<i>Rhagodia candolleana</i>	Sea berry Saltbush	
Chenopodiaceae	<i>Salsola kali</i>	Buck bush Roly-poly	
Chenopodiaceae	<i>Sarcocornia quinqueflora</i>	Bearded Samphire	
Chenopodiaceae	<i>Sclerostegia arbuscula</i>	Shrubby Glasswort	
Chenopodiaceae	<i>Suaeda australis</i>	Austral Sea-blite	
Chenopodiaceae	<i>Threlkeldia diffusa</i>	Coast Bone Fruit	
Compositae	<i>Arctotheca calendula</i>	Cape Weed	*
Compositae	<i>Cotula bipinnata</i>	Ferny Cotula	*
Compositae	<i>Cynara cardunculus</i>	Artichoke Thistle	* Control required in some areas
Compositae	<i>Gnaphalium indutum</i>	Tiny Cudweed	Rare for SL
Compositae	<i>Hypochoeris glabra</i>	Smooth Cats Ear	*
Compositae	<i>Reichardia tingitana</i>	False Sow Thistle	*
Compositae	<i>Senecio lautus</i>	Variable Groundsel	
Compositae	<i>Vittadinia gracilis</i>	Woolly New Holland Daisy	
Convolvulaceae	<i>Wilsonia humilis</i>	Silky Wilsonia	Uncommon in SA and SL
Cruciferae	<i>Brassica tournefortii</i>	Long-Fruited Wild Turnip	*
Cruciferae	<i>Cakile maritima</i>	Sea Rocket	*
Cyperaceae	<i>Isolepis nodosa</i>	Knobby Club-rush	
Compositae	<i>Cynara cardunculus</i>	Artichoke Thistle	* Control required in some areas
Frankeniaceae	<i>Frankenia pauciflora</i>	Common Sea-heath	
Gramineae	<i>Avena barbata</i>	Bearded Oats	*
Gramineae	<i>Bromus diandrus</i>	Great Brome	*
Gramineae	<i>Bromus rubens</i>	Red Brome	*
Gramineae	<i>Critesion murinum</i>	Barley Grass	*
Gramineae	<i>Cynodon dactylon</i>	Couch Grass	*
Gramineae	<i>Danthonia caespitosa</i>	Common Wallaby Grass	
Gramineae	<i>Ehrharta longiflora</i>	Annual Veldt Grass	*
Gramineae	<i>Lagurus ovatus</i>	Hare's Tail Grass	*
Gramineae	<i>Lolium perenne</i>	Perennial Rye Grass	*
Gramineae	<i>Parapholis incurva</i>	Curly Rye	*
Gramineae	<i>Piptatherum miliaceum</i>	Rice Millet	*
Gramineae	<i>Puccinellia stricta</i>	Australian Salt-marsh Grass	



Family	Species	Common name	Exotic Conservation significance
Gramineae	<i>Rostraria cristata</i>	Annual Cat's-tail	*
Gramineae	<i>Sphenopus divaricatus</i>	False Hair Grass	*
Gramineae	<i>Stipa nitida</i>	Balcarra Grass	
Gramineae	<i>Vulpia myuros</i>	Rat's tail Fescue	*
Iridaceae	<i>Freesia</i> sp.	Garden Freesia	*
Iridaceae	<i>Romulea minutiflora</i>	Guildford Grass	*
Labiatae	<i>Marrubium vulgare</i>	Horehound	
	<i>Acacia cupularis</i> aff. <i>Acacia ligulata</i>	Coastal Umbrella Bush	* Control required in some areas <i>A. cupularis</i> : Rare in SL, <i>A. ligulata</i> : Poorly known
Leguminosae	<i>Medicago polymorpha</i>	Burr Medic	*
Leguminosae	<i>Melilotus indica</i>	King Island Melilot	*
Leguminosae	<i>Retama raetam</i>	White Weeping Broom	*
Leguminosae	<i>Vicia sativa</i>	Common Vetch	*
Liliaceae	<i>Aloe saponaria</i>	Broad-leaved Aloe	*
Liliaceae	<i>Asphodelus fistulosus</i>	Onion Weed	*
Liliaceae	<i>Dianella brevicaulis</i>	Black-anther Flax Lily	
Liliaceae	<i>Myrsiphyllum asparagoides</i>	Bridal Creeper	*
Limoniaceae	<i>Limonium</i> sp	Sea Lavender	*
Malvaceae	<i>Lawrenzia squamata</i> (female)	Thorny Lawrenzia / Fan-leaved Lawrenzia	Poorly known in SL
Malvaceae	<i>Malva parviflora</i>	Small Flowered Marshmallow	*
Myoporaceae	<i>Myoporum insulare</i>	Native Juniper, or Boobialla	
Oleaceae	<i>Olea europaea</i>	Olive	*
Oxalidaceae	<i>Oxalis pes-caprae</i>	Sour Sobs	*
Plantaginaceae	<i>Plantago coronopus</i>	Buckshorn Plantain	*
Plantaginaceae	<i>Plantago lanceolata</i>	Ribwort	*
Rubiaceae	<i>Galium murale</i>	Small Bedstraw / Small Goosegrass	*
Solanaceae	<i>Lycium ferocissimum</i>	Boxthorn	*
Umbelliferae	<i>Apium annuum</i>	Coast Celery	Rare for SL
Umbelliferae	<i>Foeniculum vulgare</i>	Fennel	*
Zygophyllaceae	<i>Nitraria billardierei</i>	Nitre Bush, Dillon Berry or Sea Grapes	

A total of 82 vouchers were collected, representing 79 separate species. The conservation significance information for the site is outlined below. Information on conservation significance and interest was obtained from Turner (2001).

Table 5 - Conservation information

Number of species found during survey:	79
Number of exotic species:	49
Number of native species (Southern Lofty region):	30
Number of species of conservation significance:	3
Number of species of conservation interest:	2
Weeds as % biodiversity:	62%

The plants of interest or significance include *Apium annuum* (rare locally), *Lawrenzia squamata* (poorly known locally), *Acacia cupularis* aff. *Acacia ligulata* (rare - poorly known locally), *Wilsonia humilis* (uncommon in the state and locally) and *Gnaphalium indutum* (rare locally).

The sea-celery, *Apium annuum*, occurs on small patches of high marsh within Mutton Cove (sampling locations 12 and 13).



Thorny lawrenzia (*Lawrenzia squamata*) and silky wilsonia (*Wilsonia humilis*) occur on dunes such as those found at location 5 and on patches of high marsh (locations 12 and 13). They also occur (and have been planted) in the filled area south of the Cove itself. *Gnaphalium indutum*, the tiny cudweed, is found on similar dune areas (location 6).

The acacia found at two locations on the site (locations 2 and 7) posed some difficulty in identification. The plants have characteristics of both *Acacia cupularis* and *Acacia ligulata*. Martin O'Leary of the State Herbarium has suggested that the plants may be an intermediate form (hybrid or cline) as the two species' ranges abut in the northern Adelaide Plains.

4.3.4.3 Other flora records

A considerable quantity of flora work has already been undertaken in the surrounding areas by various workers. Species lists from these surveys are included in the Appendices.

The Native Vegetation Branch of the Department for Environment, Heritage and Aboriginal Affairs surveyed several areas at Pelican Point on the 17 December 1997. The surveyed areas included Mutton Cove, an area north and west of Mutton Cove (Site 1), Biodiversity Park between the railway and Pelican Point Road and Crown Land west of Pelican Point Road (Site 2), Biodiversity Park west of Pelican Point Road (Site 3) and a smaller area within the southern part of Site 2 (Site 4). Mutton Cove itself, along with Site 3 and Site 4 were considered to be areas of biological value, containing remnant vegetation, quality regrowth and recently formed wetlands. Site 1 and the fill area south of Mutton Cove were considered to have moderate value and to be a useful buffer area around the higher value areas. Site 2 was considered to be of low biodiversity value and to be suitable for the storing of calcium wastes.

In all, 85 species were recorded of which 36 were indigenous.

Rosemary Ferguson undertook a survey on 26 June 1999, at the northern end of Mersey Road. She recorded 25 indigenous species, two of which had conservation significance.

On 30 May 2002, Jerry Smith surveyed the "Pelican Point Corridor", being the land between Mutton Cove and Pelican Point Road. A total of 31 indigenous species was recorded, with 6 having conservation interest or significance.

These surveys of the surrounding area have established that some of the species not recorded in the Mutton Cove site in this latest survey do exist locally. *Adriana klotzschii*, *Lotus australis*, *Melaleuca halmaturorum*, *Atriplex semibaccata*, *Halosarcia pergranulata*, *Pelagonium australe*, *Distichlis distichophylla*, *Dodonaea viscosa* and *Muehlenbeckia gunnii* have all been found in the wider area.

4.3.4.4 Introduced plants

A range of introduced plants is present on the site. These plants are listed in the results of the flora survey that was provided in an earlier section of this plan, however special reference is given here to those species that are proclaimed weeds. Some of these



species require control under the Animal and Plant Control (Agricultural Protection and Other Purposes) Act 1986, however controlling all proclaimed weeds is a sensible management action.

Table 6 – Proclaimed weeds occurring on the site and in the vicinity

Scientific name	Common name	Comments
<i>Lycium ferocissimum</i>	African boxthorn	Proclaimed weed
<i>Asphodelus fistulosus</i>	Onion weed	Control required in some areas
<i>Euphorbia terracina</i>	Carnation weed	Proclaimed weed
<i>Oxalis pes-caprae</i>	Sour sob	Control required in some areas
<i>Marrubium vulgare</i>	Horehound	Control required in some areas
<i>Myrsiphyllum asparagoides</i>	Bridal creeper	Proclaimed weed
<i>Cynara cardunculus</i>	Artichoke	Control required in some areas
<i>Echium plantagineum</i>	Salvation Jane	Control/notification required in some areas
<i>Olea europaea</i>	Olive	Proclaimed weed
<i>Opuntia</i> sp.	Prickly pear	Proclaimed weed

4.3.4.5 Threats to salt marsh habitats

Salt marshes are a particularly threatened habitat. Tidal restrictions, coastal acid sulphate soils, sea level rise, nitrification, increased sedimentation, off-road vehicle use, grazing, weed invasion, urban sprawl, land reclamation and freshwater flooding all threaten saltmarsh ecosystems. Many of these threats have impacted Mutton Cove, and the effects of any one specific threat influences the effects of others. The interconnected nature of these impacts means that managing an area for salt marsh biodiversity may be a complicated and changeable affair.

4.3.4.5.1 Weeds

Salinity levels in salt marsh habitats need to be maintained above 20g/L (2%) to prevent the invasion of brackish or freshwater plants, such as *Phragmites australis*, the Common Reed, and a wide range of detrimental agricultural weeds. To this end, no freshwater in excess of ‘natural’ flows should be allowed to enter a salt marsh area until the salinity of the input water is at or above 20g/L total dissolved salts.

Weed invasion is not generally a problem in areas that receive sufficient tidal inundation, however there are salt marsh specialists, such as *Spartina* sp. that may invade saline areas. This plant has become a weed of saltmarshes in Victoria.

Areas of salt marsh that do not get sufficient tidal inundation, and become leached free of salt by the rain will rapidly be colonised by weed species, which generally need controlling. Areas that are subject to stormwater inundation also are regularly subject to weed invasion, so preventing stormwater entering the Cove will reduce weed control costs.

Prior to European settlement, much of the Adelaide Plains were covered with freshwater wetlands, which became progressively more saline as they neared the coast. Unfortunately the area required for this form of salinity cline, depending on the volume of freshwater, could be considerably greater than the area currently within the Cove.



4.3.4.5.2 Alteration of tidal inundation range

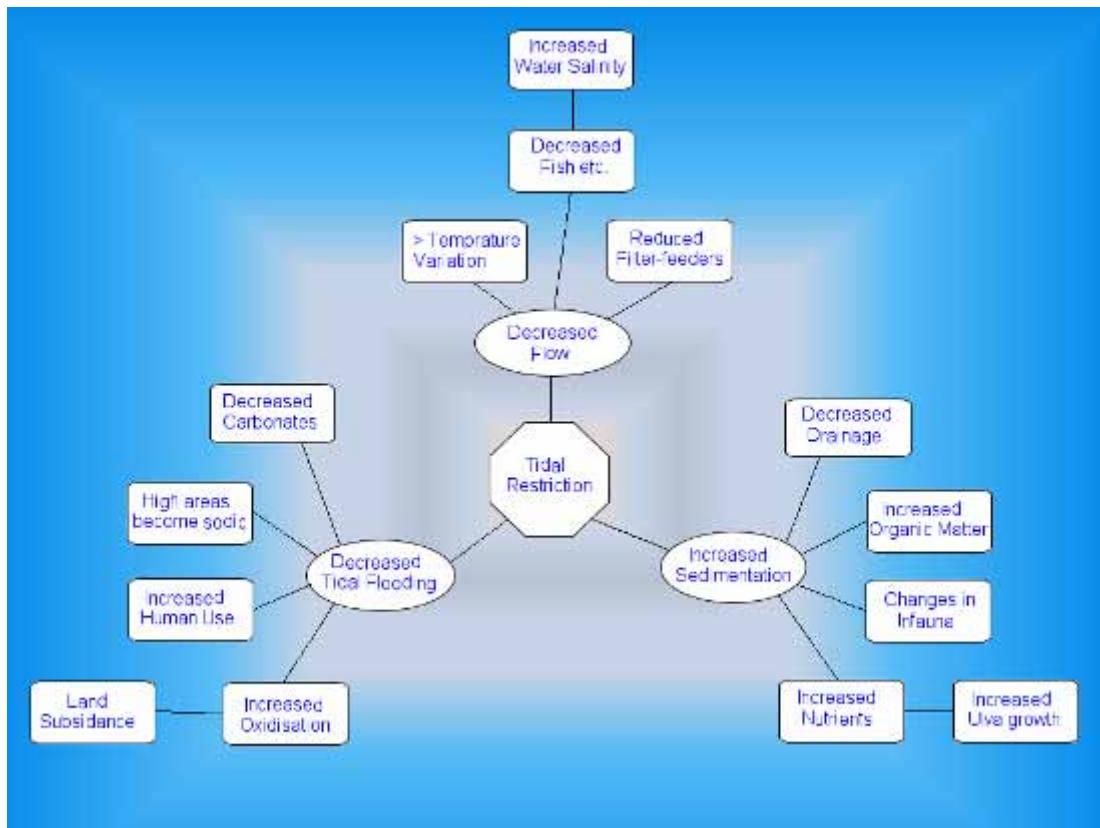


Figure 21 - Effects of tidal restrictions

Tidal restrictions cause a range of effects that can be clearly seen within Mutton Cove. These effects include the ecological impacts shown in the preceding diagram, however these are only some of the observable effects. Other effects are case specific, and need to be managed as they are identified. Some impacts are aesthetic - tidal restrictions are not desirable, as they cause unpleasant odours and black sediment.

While tidal restrictions obviously impact adversely on saltmarshes, the impacts of increased tidal inundation may not always be beneficial for the ecosystem, either. Ramsar (2003) guidelines discuss the potential effects of over-inundation. A very fine balance needs to be achieved between too much tidal inundation and too little. McComb *et al* (1995) in their study of the Peel Harvey Inlet, south of Perth in Western Australia, found alterations in inundation levels as small as 10 centimetres could cause the obliteration of mid level marsh and its replacement with low marsh.

Sea level rise and land subsidence are currently issues facing coastal ecosystems near metropolitan areas. Coastal real estate is highly valuable, so salt marsh and mangrove ecosystems have been encroached upon, forcing the remnant habitats into small and specific areas, surrounded by levee banks. As the Adelaide Plains are sinking by about a millimetre a year, so areas of samphire are quickly becoming mangroves.

Before European settlement, saltmarsh species would retreat landward, leaving room for mangrove expansion. Now, with levee banks, roads and houses backing the coastal area, they can't retreat, and are being replaced by monocultures of mangal (Harty, 2002), which will eventually face a similar problem.



Coastal acid sulphate soils (ASS) and potential acid sulphate soils (PASS) are aspects of salt marsh and mangrove ecosystems, that may pose problems in areas that are no longer inundated with carbonate-rich seawater. Left alone, these soils are a natural part of our coastal ecosystems.

4.3.4.5.3 Excess nutrients

Eutrophication refers to the presence of excess nutrients in an ecosystem. Coastal wetlands are the lowest part of our catchments, so their nutrient loads are increased exponentially by fertilisation of farmlands and gardens. This is aggravated by the practice of disposing of industrial waste into coastal areas. Ammonia concentrations are high in the Port River and therefore potentially in Mutton Cove, as a result of these practices.

Excess nutrients, generally in the form of phosphates, nitrogen or ammonia, cause adverse reactions in low-nutrient ecosystems. They promote excessive algal growth, which is often at the expense of slower growing vegetation.

In their study of the Peel estuary, McComb *et al* (1995) found that Australian saltmarshes are generally nitrogen limited, so nitrogen (N) and ammonia (NH_4) may have a greater potential for ecological disturbance than phosphorus (P). Phosphorus may, however, encourage blue green algae blooms and the formation of surface cyanobacterial mats, so the ecological significance of phosphorus pollution should not be discounted.

Large algal blooms in water bodies often have secondary effects, which include depletion of oxygen from the water, increasing water temperature and release of toxins into the water body. These types of blooms need to be avoided wherever possible. Monitoring of ammonia and phosphate is recommended to allow preventative actions to be taken when needed.

4.3.4.5.4 Changes in sedimentation rate

Increased sedimentation occurs in many salt marsh habitats due to either increased erosion up-stream or decreased flow within the marsh, or sometimes a combination of both. Examining the size of the particles being deposited, and comparing them to the original sediment in the area may quantify the type of sedimentation occurring.

Mutton Cove has experienced both kinds of sedimentation change. Originally it experienced increased sedimentation from upstream as the surrounding lands were filled with hydraulic fill. The Cove was used as the drain for the turbid supernatant waters from the hydraulic fill ponds. Meanwhile an embankment was constructed across the mouth of the Cove, and the pipes that ran through it gradually filled in, causing slower and slower flow rates within the Cove and increasing the deposition of fine marine sediments, or muds, within the Cove.

4.3.4.5.5 Off-road vehicle use

A management issue facing all conservation efforts close to urban areas is the use of off-road vehicles. The damage done by this recreational use of the land is well



demonstrated, particularly in the salt marshes and sand dunes north of Adelaide and around Port Pirie. This damage is particularly pronounced in areas of salt marsh, which grow slowly, have delicate soil structures and are under pressure from other sources already. Off-road vehicle use results in a graffiti of large tracts of compacted, disturbed soil, which are hard to revegetate. The simplest approach to repairing such large areas of degradation is to fence them off and allow them to recover naturally. An alternative approach is to use the most impacted areas as access tracks, while fencing off the remaining tracks. This avoids damaging the area further, however it may reduce the potential for the area to recover. At Mutton Cove, the number of tracks through the site should be rationalised and regeneration of the others encouraged. This is discussed more fully in the management prescription section of this plan.

4.3.4.5.6 Grazing pressures

Many salt marshes are used as summer grazing areas, as green cover can be found on them year round. Sheep often feed on *Atriplex* species during summer, which allows them to be sold at a premium during the harder parts of the year. Many areas through Dry Creek and on the lower parts of the Peninsula were originally fenced off for this purpose. Hoofed animals cause significant damage to the soil structure in these areas, and the pools left in the hoof prints may provide mosquitos with breeding areas.

Since urbanisation has occurred around many saltmarsh areas, grazing has happened in an unintended way, with rabbits and deer mowing some areas so flat that they resemble a lawn more than a salt marsh. The consultants have found no record of Mutton Cove being used officially for grazing, however hares and rabbits are common on the site.

4.3.4.5.7 Land reclamation

The spread of urban areas is a management issue for both agricultural areas and conservation concerns. As the metropolitan area spreads, housing covers good fertile soils and removes habitat areas for rare species. Housing also brings increased visitation to areas that were once only visited by those who were willing to travel considerable distances. Three approaches need to be taken to prevent urban sprawl adversely effecting salt marsh ecosystems. These are: preventing houses or industry building on top of salt marsh in the first place, preventing runoff from built-up areas entering areas of conservation interest and building facilities or implementing policies to reduce the impacts of increased visitation.

Land reclamation is the name given to filling salt marsh, mangrove or seagrass areas in the name of progress. This is what has happened to most of the coastal fringe habitats on the Le Fevre Peninsula. It results in complete extirpation of these habitats from the affected area, and changes the hydrology in the areas surrounding the reclaimed land. This is a major cause of habitat loss on the Peninsula. There are very few feasible ways of reversing the effects of this threat, however preventing it happening to the small remaining patches of habitat is an important management issue.



4.3.4.5.8 Spills

A threat that tends to be overlooked for salt marsh ecosystems is the effect of spilling industry-sized amounts of contaminants into them. As salt marshes often occur near ports they are regularly subject to oil spills, hazardous waste dumping and effluent discharge. A salt marsh is designed to filter out pollutants and bind them up in the soil, however large quantities of these products may cause huge amounts of damage to these relatively fragile ecosystems and the animals that depend upon them.

A study done by the International Petroleum Industry Environmental Conservation Association (1994) found that clean-up efforts after the *Amoco Cadiz* petroleum spill in 1978 caused greater damage in some areas than just leaving the oil in place. A petroleum spill in Mutton Cove is unlikely, as the inlet pipes are usually below the surface of the incoming tide, except for a small period at the turn of low tide. A summary of some appropriate clean-up methods is discussed further in the *Management prescription* section of this plan.

Other potential spills into the Cove include alkalies, acids, cleaning products, grains and anything else used by the surrounding industries, or transported through the area. Creating bunds around the perimeter of the Cove would reduce the potential for these pollutants to enter the Cove. It would also reduce noise pollution within the bird habitat area, which would increase bird breeding in the area.

4.3.4.5.9 Bait digging

Bait digging is one of the major recreational uses of Mutton Cove. The consultants made several field trips to the site during the process of writing the management plan. On each visit there were (on average) seven or eight diggers out on the mudflats, only leaving when the tide became too high for them to dig. One bait digger has been observed digging inside the Cove, after the tide became too high outside the Cove, and he is there most days. The area inside the Cove is small and the population of worms may not receive sufficient recruitment to sustain regular digging. As a number of the bait diggers are older people with limited English, multilingual signs will be needed if bait digging is to be banned within the Cove.

Discussions with the diggers revealed that each time they visit they take approximately an ice cream tub full of polychaete worms. Several species were observed in each catch. Most were large, many over 10 cm long. The colours of the bait worms ranged from light creamy beige through to a dark red and a rainbow coloured green. The rainbow coloured green worms were very large and had red parapodia, which waved like skirts when they swam.

The bait diggers generally use gloves, due to the fact that worms bite. There are several ways of extracting worms from the mud. The first way is to dig large holes with a shovel picking the worms up with your hands or sieving them out using a colander. This method leaves large piles of mud and holes behind the digger.

The other method of extracting worms is to walk along the surface looking for holes. A device very like a bicycle pump is then placed over the hole, and the worm sucked out using an upward motion. This gives the diggers a considerably lower yield of worms per man-hour, but leaves a less visible scar on environment.





Figure 22 - Bait diggers on the foreshore outside Mutton Cove

The issues of concern with bait digging include the over-exploitation of the bait species themselves, damage to intertidal aquatic macrophyte beds such as *Ruppia* sp., damage and disturbance to other interstitial macroinvertebrates not being collected, reduction in food source for migratory and resident shorebirds, the presence of diggers causing a disturbance in the feeding patterns for migratory and resident shorebirds and increased rates of erosion from the disturbed areas.

4.3.5 Fauna

4.3.5.1 Birds

The unprotected birds one would expect to find on the site are ravens, crows and introduced species. All other birds occurring at Mutton Cove and on the adjacent lands are protected under State and Federal legislation.

During the site visit in October 2003, opportunistic sightings of birds were recorded, and are listed in the following table. The day was particularly windy, and this is likely to have had an impact on the range of birds foraging.

Table 7 - Birds observed in October 2003 (denotes an exotic species)*

Silver gull
Common pigeon*
European blackbird*
Australian pelican
Skylark*
Spur winged plover
Sacred ibis
Banded stilt
Bar tailed godwit
Grey teal
Marsh tern
White faced heron



Mrs. J. Thompson has provided a list of bird observations from Mutton Cove, collected between 1974 and 1997 with her late husband Brian Winslett. Some of the sightings were "one off" sightings. Mrs. Thompson believes that Mutton Cove Reserve has great potential for protecting birds like the Red-capped Plover which breeds there, as well as providing feeding and resting areas for summer migratory waders.

Birds listed under the EPBC Act and in Australia's international treaties (JAMBA and CAMBA) as migratory, along with wetland birds, may over-fly and visit the site. Along the shoreline outside the seawall embankment they may feed on small crustaceans. Feeding also occurs on the mud flats on either side of the creek, inside the Cove.

Table 8 – Birds list supplied by J Thompsons

Scientific name	Common name
<i>Actitis hypoleucus</i>	Common sandpiper
<i>Alauda arvensis</i>	Skylark*
<i>Anas castanea</i>	Chestnut teal
<i>Anas gibberifrons</i>	Grey teal
<i>Anas superciliosa</i>	Pacific black duck
<i>Anthus novaeseelandiae</i>	Richard's pipit
<i>Aquila audax</i>	Wedge tailed eagle
<i>Ardea novaehollandiae</i>	White-faced heron
<i>Biziura lobata</i>	Musk duck
<i>Burhinus grallarius</i>	Eastern curlew
<i>Cacatua pastinator</i>	Little corella
<i>Cacatua roseicapilla</i>	Galah
<i>Calidris acuminata</i>	Sharp-tailed sandpiper
<i>Calidris ferruginea</i>	Curlew sandpiper
<i>Calidris melanotos</i>	Pectoral sandpiper
<i>Calidris ruficollis</i>	Red-necked Stint
<i>Charadrius bicinctus</i>	Double-banded Plover
<i>Charadrius leschenaultia</i>	Large-billed Sand Plover
<i>Charadrius ruficollis</i>	Red capped plover
<i>Cheramoeca leucosternus</i>	White-backed Swallow
<i>Chlidonias hybrida</i>	Whiskered tern
<i>Chrysococcyx basalis</i>	Horsfield's bronze-cuckoo
<i>Cinclorhamphus cruralis</i>	Brown songlark
<i>Circus approximans</i>	Marsh harrier
<i>Cladorhynchus leucocephalus</i>	Banded stilt
<i>Colluricinclla harmonica</i>	Grey Shrike-thrush
<i>Columba livia</i>	Feral pigeon*
<i>Corvus mellori</i>	Little raven
<i>Cygnus atratus</i>	Black swan
<i>Egretta alba</i>	Great egret
<i>Egretta scara</i>	Eastern reef egret
<i>Elanus notatus</i>	Black shouldered kite
<i>Epthianura albifrons</i>	White fronted chat
<i>Erythrogenys cinctus</i>	Red-kneed Plover
<i>Falco berigora</i>	Brown falcon
<i>Falco cenchroides</i>	Australian kestrel
<i>Falco longipennis</i>	Australian hobby



Scientific name	Common name
<i>Fulica atra</i>	Common coot
<i>Gallinula ventralis</i>	Black tailed native hen
<i>Grallina cyanoleuca</i>	Magpie lark
<i>Haematopus fuligosus</i>	Sooty oystercatcher
<i>Haematopus longirostris</i>	Pied oystercatcher
<i>Haliaeetus leucogaster</i>	White-bellied Sea-Eagle
<i>Haliastur sphenurus</i>	Whistling kite
<i>Hieraethus morphnoides</i>	Little eagle
<i>Himantopus himantopus</i>	Black-winged Stilt
<i>Hirundo neoxena</i>	Welcome swallow
<i>Hirundo nigricans</i>	Tree martin
<i>Larus novaehollandiae</i>	Silver gull
<i>Larus pacificus</i>	Pacific gull
<i>Leucocarbo fuscescens</i>	Black-faced shag
<i>Lichenostomus penicillatus</i>	White plumed honey eater
<i>Lichenostomus virescens</i>	Singing honeyeater
<i>Limicola falcinellus</i>	Broad-billed Sandpiper
<i>Malurus cyaneus</i>	Superb Fairy-wren
<i>Neophema elegans</i>	Elegant parrot
<i>Neophema petrophila</i>	Rock parrot
<i>Nycticorax caledonicus</i>	Rufous night heron
<i>Ocyphaps lophotes</i>	Crested pigeon
<i>Paliocephalus poliocephalus</i>	Hoary headed grebe
<i>Pandion haliaetus</i>	Osprey
<i>Passer domesticus</i>	House sparrow*
<i>Pelecanus conspicillatus</i>	Australian pelican
<i>Phalacrocorax carbo</i>	Great cormorant
<i>Phalacrocorax melanoleucus</i>	Little pied cormorant
<i>Phalacrocorax sulcirostris</i>	Little black cormorant
<i>Phalacrocorax varius</i>	Pied cormorant
<i>Platalea flavipes</i>	Yellow-billed Spoonbill
<i>Platalea regia</i>	Royal spoonbill
<i>Pluvialis fulva</i>	Lesser golden plover
<i>Pluvialis squatarola</i>	Grey plover
<i>Podiceps cristatus</i>	Great crested grebe
<i>Porzana fluminea</i>	Australian crake
<i>Recurvirostra novaehollandiae</i>	Red-necked Avocet
<i>Rhipidura fuliginosa</i>	Grey Fan-tail
<i>Rhipidura leucophrys</i>	Willie wagtail
<i>Sericornis fruktakus</i>	White browed scrub wren
<i>Sterna (Hydroprogne) caspia</i>	Caspian tern
<i>Sterna bergii</i>	Crested tern
<i>Streptopelia chinensis</i>	Spotted turtle dove*
<i>Sturnus vulgaris</i>	Starling*
<i>Tadorna tadornoides</i>	Australian shelduck
<i>Threskiornis aethiopica</i>	Australian white ibis / Sacred Ibis
<i>Todiramphus sanctus</i>	Sacred kingfisher
<i>Tringa glareola</i>	Wood sandpiper
<i>Tringa nebularia</i>	Greenshank
<i>Tringa stagnatilis</i>	Marsh sandpiper
<i>Turdus merula</i>	Blackbird*
<i>Vanellus miles</i>	Masked lapwing



Additional species have been recorded by Mr. Nick Davies. These birds were sighted on the nearby National Power site. The species recorded by Mr. Davies that do not occur in Mrs Thompson's list are: *Tyto alba* (Barn owl), *Carduelis chloris* (European greenfinch*), *Falco cenchroides* (Nankeen kestrel), *Egretta garzetta* (Little egret), and *Coturnix pectoralis* (Stubble quail).

Roosting and nesting opportunities for large raptors such as the Osprey and Black-shouldered kite are not currently prevalent on the site, although this may change as mangroves recolonise the site. Some raptors may hunt lizards and small mammals on the high dry land on the site. Pelagic birds do not use the site. Seabirds and wetland birds mainly hunt over the mudflats of the Cove. Nesting and roosting colonies have not been observed on the site, although there are roosting colonies of pelicans, gulls, terns and cormorants on Torrens Island and Bird Island. Large groups of seagulls, stilts and black swans roost at night on sheltered mudflats and sandbanks edging Barker Inlet.

A study by Johansen and Manning (1996) on the MFP site at Gillman, across the river, reports approximately 50 species of birds in the immediate vicinity. Their study stated that two locally occurring species had conservation interest – the peregrine falcon and the little egret. It is not established that either species uses Mutton Cove as a breeding site, although the egrets are likely to visit the site for feeding purposes in January-March, when they are breeding at Torrens Island.

4.3.5.2 Mammals

Scats of foxes were found on the site during visits in October, along with fox tracks and domestic dog tracks. Several 'scrape' type rabbit burrows were observed. These are usually the temporary shelters built by single male rabbits. Several hares were set to flight during the site visit. Feral species also dominate the adjacent National Power site, as recorded in Table 9, provided by Mr. N. Davies.

Mr. Davies has recorded the possibility that the native water rat *Hydromys chrysogaster*, which lives in the mangrove areas along the coast, may be an occasional visitor to the Peninsula. Appropriate habitat for this mammal exists in the mangroves outside the Cove, and the areas of available habitat will increase over the next few years, as mangroves recolonise the Cove. Mr. Davies has sighted the Gould's wattled bat, *Chalinoloyx gouldii*, and records it as common. Other species of bat are known to forage in the area. However due to the absence of roosting niches such as hollows in trees and building structures there are unlikely to be any established residents.

Table 9 - Feral mammal species present on the National Power site

Scientific name	Common name	Distribution on site
<i>Oryctolagus cuniculus</i>	Rabbit	Common
<i>Lepus europaeus</i>	Hare	Common
<i>Vulpes vulpes</i>	Fox	Common
<i>Felis cattus</i>	Domestic cat	Common
<i>Mus musculus</i>	House mouse	Common
<i>Rattus rattus</i>	Black rat	Common
<i>Rattus norvegicus</i>	Brown rat	Occasional



Le Fevre Peninsula is part of Metropolitan Adelaide, and has been intensively developed over a long period. The range of mammals that currently occurs on the Peninsula is considerably curtailed in comparison to the range of mammal species that occurred in the area historically.

4.3.5.3 Reptiles

On several visits to the site, shingle-back lizards (*Teliqua rugosus*) have been sighted. It is to be expected that the other common reptiles for the area may be present: blue-tongue lizards, small skinks, and eastern brown snakes.

4.3.5.4 Terrestrial invertebrates

During site visits quite a number of insects and one arachnid were gathered in sweeps. Additionally, the introduced molluscs *Helix aspersa*, the common garden snail, and *Theba orientalis*, the Mediterranean snail, were found.

Of the insects found on the site, the following butterflies were recorded: *Delias aganippe* (the wood white or jezebel), *Theclinesthes* sp. (a small blue), *Vanessa itea* (the Australian admiral) and *Pieris rapae* (cabbage white). The latter is introduced.

The heliotrope moth (*Utetheisa pulchelloides*) was the only day-flying moth captured. No night-time sweeps were undertaken, but it is expected that many night-flying moths would be present in the warmer months when the mangrove nectar is available.

Hymenoptera were represented by various small black ants as well as the large red meat-ants, and by several ichneumon wasps. From the Diptera, crane flies, mosquitos and midges were recorded.

The arachnid recorded on site was a brown and grey jumping spider from the family Salticidae.

4.3.5.5 Marine fish and invertebrates

Discussions with Dr Simon Bryars of PIRSA have revealed that while a considerable quantity of information is known about the biodiversity and fisheries values of the tidal flats, tidal creeks, estuarine river and mangrove forest adjacent to (and in some cases within) Mutton Cove, there is little knowledge of the values of the saltmarsh areas. In his recent inventory of fisheries habitats (Bryars, 2003) the section of his report that deals with direct use of the saltmarsh by fisheries species has ‘unknown’ placed beside each category of use.

The tidal flats and creeks inside and outside the Cove are recorded in the inventory as being used by blue swimmer crabs, mud cockles, razor fish, baitworm, yellow fin whiting, western Australian salmon, tommy ruff, southern sea garfish, yellow eye mullet, black bream, flathead and flounder adults, and additionally the juveniles of sand crabs, western king prawns, King George whiting, school whiting, mulloway and leatherjackets.

The consultants have observed schools of juvenile fish swimming in the pool at the inlet pipes. They have suggested to Dr Bryars that, should he be able to obtain



funding, he may wish to investigate the use of the saltmarsh pools using minnow traps.

During site visits the consultants observed those organisms they could see inhabiting the intertidal flats and mangrove forests. The mangrove trunks inside the Cove appeared to host a larger number of snails than the trees outside the Cove, adjacent to the Port River. It may be that the strong wash from shipping is dislodging these animals from their perches. The wash is strong enough to undermine the mangroves, and cause erosion of the bank in those areas unprotected by mangroves, so it would not be unreasonable to suspect that the wash may provide more wave action than mangrove snails require.

Loss of the protection provided by the mangroves will eventually cause an increase in the costs associated with maintaining the seawall. In other harbours where mangroves grow alongside shipping channels, a strict enforcement of speed limits has been found to reduce the impact somewhat.



Figure 23 - Mangroves undercut from shipping wash





Figure 24 - A baitworm hunting

Table 10 presents the mud flat and mangrove marine invertebrates recorded at Mutton Cove in October 2003.

Table 10 - Mud flat invertebrates

	Species name	Common name
Gastropoda	<i>Bembicium melanostoma</i>	Mangrove conniwink
	<i>Bembicium nanum</i>	Striped mouth conniwink
	<i>Monodonta (Australocochlea) constricta</i>	Ribbed top shell
	<i>Nerita atramentosa</i>	Black periwinkle
	<i>Salinator fragilis</i>	Estuarine sand snail, or fragile air-breather
Bivalvia	<i>Lanternula recta</i>	Rectangular elongated lantern shell
	<i>Irus crebrellamellatus</i>	Boring venerid
	<i>Katelysia scalarina</i>	Stepped venerid
Polychaeta	<i>Neanthes vaalii</i>	Small bristle worm
	Unknown small nereid polychaete	Small bristle worm
	<i>Australonereis</i> sp.	Baitworm
Nemertea	unknown	Grey & white gordian knot worm
	unknown	Red stripy gordian knot worm
Bryozoa	<i>Bugula neritina</i>	Common fouling sea-moss
Crustacea	<i>Neosphaeroma laticauda</i>	Wide-tailed sea pill bug
	<i>Helice haswellianus</i>	Mudflat crab
	<i>Elminius modestus</i>	Purple striped barnacles

4.3.5.6 Marine mammals

The inlet pipes into Mutton Cove are quite small, and therefore dolphins have not been recorded inside the Cove since the seawall was erected. However, they are likely



to wait in the vicinity of the pipes for fish exiting the Cove into the Port River. The increased outflow will be noticed by the animals, and they will investigate it to determine whether the flow contains small fish. Should the flow contain fish of a size suitable for dolphin feed, they will visit the pipes on outgoing tides, as the fish will be easy to catch as they pass through the restriction.

4.4 Cultural heritage of the site

4.4.1 Aboriginal heritage

In South Australia, Aboriginal objects, remains or sites are protected under the South Australian Aboriginal Heritage Act (1988). This Act states that,

“ ... a person must not, without the authority of the Minister, damage, disturb or interfere with an Aboriginal site. It is also an offence to damage any Aboriginal object, or where an Aboriginal object or remains are found, to disturb, interfere with, or remove the object or remains.”

The site covered by this management plan has been disturbed mainly by vehicular use, so the natural surface is relatively intact. The location is close to marine and estuarine areas, which were used extensively by the local Aboriginal people.

A local Kaurna elder, Mr. Lewis O'Brien, was consulted about the importance of Mutton Cove to the original peoples. The meeting started with a brief description of the project, followed by discussion of the importance of trading stories, and the fragile nature of this planet.

Mr. O'Brien provided the consultants with a paper retelling the Tjilbruke story. The paper is reproduced in the Appendices. It was originally recorded in 1934 (and published in 1987) by Norman Tindale, who had been studying the local groups of aborigines since 1929. He had recorded the Tjilbruke story as it was related by the people who live down near Victor Harbour. The story as recounted in the paper would be very similar to that recounted by Kaurna elders.

The Tjilbruke story is a long one, and covers the landscape from Outer Harbor to Cape Jervis. Many coastal features are included in this story. In part of the story there is a description of how the people crossed the Mikawoma, or the Adelaide Plains, and chased emus up to the tip of the Mudlang, or the place of the nose, which is now known as Outer Harbor. On older aerial photographs of Mutton Cove, the triangle of land to the north of the Cove looks very like a nose, and would have made a good place to trap the fleeing birds.

Mr. O'Brien went on to say that he believes the story to be 6000 years old due to the dating of the middens at Moana. He also commented that the Peninsula is only 7000 years old so the story cannot be any older than that.

He then discussed the importance of maintaining Biodiversity Park and any other areas of natural surface or natural vegetation towards the tip of Outer Harbor. As he said, “the rounding up of the emus is an important part of the story and you need somewhere to do that.”



The importance of having open spaces and areas of significance, even though they may not be any more or less significant than neighbouring areas, was also discussed. This is a similar principle to that used when selecting representative conservation parks. Choosing to conserve the area that the emus were rounded up into is an obvious choice for preservation.

The conversation turned back to the meaning of the story - to many people a story about catching emus is merely that - a story. To the Kaurna people the story provides an outline of their morals and discusses the proper order of things. The story is equivalent to a fable or parable, such those told by Aesop, or in the Bible. The morals include not killing any more than you need to eat, leaving the female creatures to reproduce, not having any more children than you need to support you in old age, not taking anybody else's things and not interfering with the order of life.

Mr. O'Brien felt that these were important lessons, and that if Biodiversity Park and Mutton Cove could be maintained as open space they would provide a good place for educating young people in these aspects of life.

4.4.2 European heritage

The earliest recorded European to see the Port River (and presumably Mutton Cove) was Captain Collet Barker, who was sent by Governor Darling of New South Wales to find the Murray Mouth. From the top of Mount Lofty on 19 April 1831 he spotted the river and thought it would make an excellent harbour.

Sturt read his reports, and considered that Outer Harbor (as it is now known) would make a good location for the South Australian capital. Colonel Light, who examined Barker Inlet more thoroughly, may have recognised that the land forming the Peninsula was ephemeral, and recommended the Port be located further up the estuary, and the capital be located on the more solid land of the Adelaide Block.

Most areas are associated with a family that has, in some way or another, made the area their own, often over several generations. The Germein family was one early family associated with the Mutton Cove area.

John Germein arrived from Devonport, a suburb of Plymouth in 1837. He became a pilot in the Port River. When he retired he established a block and pump manufacturing business on a 40ha block of land at Mutton Cove, alongside the Port River (Couper-Smartt & Courtney, 2003, pers. comm. S. Morton). John continued working on his business until shortly before his death at 99 years of age.

Mutton Cove was named after Mutton Cove in Devonport, a location that looks quite similar to the South Australian Mutton Cove, but which has a considerably larger area. The Devonport Mutton Cove is a saltmarsh estuary near a busy port. Photos of the St German River that flows into it, and pictures of Mutton Cove (estuary and township) show a landscape of saltmarshes and wandering creeks backed by higher land. The Rivers Tamar and Tyver flow into the Devonport Mutton Cove.

Captain Benjamin Germein, one of John's three sons, went on to follow his father into work as a pilot in the Port, then at the Murray Mouth before manning a lighthouse



near Carpenter Rocks in the South-East, where he played a major part during the rescue of the survivors from the *Admella*, when it was smashed apart at that location. Using a boat patched together with soap and paper, he and a couple of others rescued 4 people from the boat, although one drowned on the way to shore. He also played a major part in coordinating the rest of the rescue from the shore (Mudie, 1966).



Figure 25 - Saltmarshes near Mutton Cove and St German in Devon

Only two years after the wreck of the *Admella*, Benjamin and his men rescued the three survivors from the wreck of the *John Ormerod*, when it went down nearby. His final years of employment were as a customs officer at Semaphore. He retired in either 1888 or 1889.

Benjamin received a medal for his involvement in the *Admella* rescue, and a memorial was erected at Cape Northumberland in commemoration of his efforts during the two shipping disasters (Mudie, 1966).

Benjamin's retired years were unfortunately not as pleasant or rewarding as his working years. His wife died so he went to live with his daughter, Pheobe Davey, and her family in Largs for 4-5 years. During this period he was in the habit of wandering around the Peninsula visiting family and camping in the sand dunes for weeks at a time. Pheobe reported him as "more reserved in late years than he used to be formerly". She thought his "want of employment" had something to do with it.

Semaphore police found the Captain's body under a large mangrove in Mutton Cove on the 19th September 1893. He was 68 years of age. His feet ankles were tied together, a bag of stones tied to his legs, a winch handle tied to his waist and a bottle of sand tied to his neck. Benjamin Germein (Jr) identified the body and discussed his father's wandering habit and previous messages that he had left suggesting that he may commit suicide. The coroner concluded that Benjamin had "came to his death at Snapper Point on or around the 3rd of July 1893, by drowning himself whilst in a state of temporary insanity". He also reported that the body was taken to its final resting point by the movement of the tides.





Figure 26 - Drawing of Mutton Cove by Cawthorne, 1845 (copyright State Library of SA)

The Germein family were not the only settlers to make Mutton Cove a part of their lives. A drawing by William Anderson Cawthorne is the earliest illustration of the Cove that the consultants have found. Cawthorne produced copious illustrations of the Aboriginal peoples of South Australia going about their daily lives, but few of Europeans. The drawing here shows a fishing party, and suggests that Mutton Cove was an important area for recreation from the earliest settlement of Port Adelaide by Europeans.

Ships graveyards, or areas where old ships were abandoned, are very common in the Port area, with 5 sites recorded and possibly others undiscovered. These sites are of some historic significance, particularly to those investigating maritime archaeology. They provide a glimpse into what was one of early Australia's main forms of transport.

Mutton Cove contains two shipwrecks (*Excelsior* and *Jupiter*), which were both dumped around 1945. The *Excelsior* was a huge ship; some 7.2m in breadth, 3.3m in depth and weighing 310 gross tonnes. An idea of how deep the original Mutton Cove creek was may be gained from the fact that *Excelsior* was floated right up the Cove to its current position, even if only gradually on the spring tides. More details relating to these ships are provided in the appendices, in the section *Shipwrecks in the Cove*.

4.5 Previous and current management

The Cove was first surveyed in September of 1854 by Michael O'Reilly. A copy of the original diagram for the site is included in the Appendices to this report.



The area of the Cove appears in early aerial photographs (see Figure 6, earlier in this plan) to be relatively unused. In the earliest photographs (1949), regularly spaced narrow tracks can be seen passing through the mangroves, perpendicular to the river. Similar markings are visible on Torrens Island in the same photograph. It is unknown what these lines were, but they may indicate the start of work on the seawall. What appears to be a small quantity of fill is visible just south of the mouth of the Cove. The wreck of the Jupiter is clearly visible in this photograph.

The area would have continued to be used for recreational purposes, similar to those illustrated in Cawthorne's drawing of 1845.

By 1963 there was evidence of a structure on the foreshore just south of the mouth of the Cove, with a small groyne or jetty in the River. A larger area of fill had been placed south of this area. Both the Excelsior and the Jupiter are clearly visible in the extremely detailed aerial photographs that were taken in 1963.

The Greater Port Adelaide Plan was developed by the Department of Marine and Harbours in the 1960's. The photograph, reproduced here, of the proposed development of the tip of the Peninsula shows the region to be fully filled, with Port activities covering all the land fronting the water. Mutton Cove appears as an area of warehouses. To realise this development would require a considerable quantity of both fill and seawalls, and an immediate start was made on raising the land surface to a level that would enable the development to occur.



Figure 27 - The Greater Port Adelaide Plan (photograph courtesy the SA Maritime Museum)



In the 1977 aerial photograph the newly constructed seawall can be clearly seen and the Cove was cut off from the main Port River estuary. Three pipes in the seawall allowed a limited amount of tidal flushing to occur, and also allowed the escape of drainage water from the areas of fluvial filling. Large areas of fluvial fill were being deposited north and west of Mutton Cove and this continued to increase into the 1980's.

Mangrove deaths in the Cove are clearly visible in the photograph taken in 1983. This was probably a result of the truncation of the tidal range, with lower high water and higher low water. The latter condition could have caused drowning of many of the trees. Reduced flushing and calmer water conditions appear to have also resulted in a narrowing of the deepest part of the Mutton Cove creek, mainly through the deposition of silt alongside the banks.

Placement of fill around Mutton Cove appears to have been continued throughout this period. Marine & Harbours records (Drawing 21892-12E) of 1983 detail the locations of the different types of filling present at Pelican Point, surrounding Mutton Cove. A copy of the drawing is attached in the Appendices as *Soil cores in filled areas of Pelican Point*. The drawing shows that the layers of fill were quite deep in parts. For example, core 1, north of Mutton Cove has 2.4 metres of various fill above its 'organic virgin material'. Most fill immediately north of the Cove and around the northern coastline of Pelican Point appears to be sand, various clays and organic fibrous material (possibly seagrass wrack). It may have been sourced from beach cleaning activities and river dredging.

To the west and north-west the fill is described as 'caustic' of various colours (pink, grey, green, brown and black) and is deposited in layers that total, in some areas, over 1.8 metres deep. This material is likely to have been a mixture of calcium carbonate and calcium hydroxide, a waste material from the soda ash plant at Osborne.

The fill placed on the south-western border of Mutton Cove includes fly-ash and caustic materials. It is not unreasonable to suppose that the fly-ash may have come from the Osborne power station or from the cement works at Birkenhead.

South of the Cove the fill material includes cinders, sands, clays and one core (number 68, between Mutton Cove and Biodiversity Park) was listed as containing pyritic material. If the pyrites were sourced from the acid plant at Taperoo, it would be reasonable to suspect that the soil in this area may be contaminated with metals that co-existed with the sulfides being used in the manufacture of acid. The most usual ions associated with sulfides as pyrites are iron and copper, however a blend of minerals such as silver, lead, zinc and arsenic may also form sulfides. These are known to occur in the southern Mt Lofty Ranges, for example silver-lead-arsenopyrites are found at Talisker and deposits of other metal sulfides are found at Brukunga in the Adelaide Hills.

During the period of filling, Mutton Cove itself avoided having fill placed within it, as it was the main discharge channel for the supernatant waters that drained from the hydraulic fill materials. Eventually, should filling have continued, even the Cove would have had materials placed on its surface.



The period from 1993 onwards saw the cessation of waste dumping and fluvial filling in the Pelican Point area, and the start of efforts to rehabilitate the region. All recent deposits of fill have occurred at the northernmost extremity of the Point, on a block referred to as "Title C" that lies adjacent to the existing container terminal.

4.5.1 EDA & DELM, Le Fevre Peninsula rehabilitation, 1993

In 1993 the Economic Development Authority and Department of Environment and Land Management commissioned works to rehabilitate the Pelican Point area and reduce dust issues for the neighbouring housing divisions. The map provided at the beginning of the report on the project shows the main part of Biodiversity Park as a future transport hub and the areas to the east of Pelican Point Road as being filled by Penrice dumping materials between 1990 and 1992. The north-eastern section was topsoiled and sown, whereas the eastern section, level to the Victoria Road intersection, was covered with seagrass. The areas south of this were bare areas of cinder from the Osborne Power Station with a shell grit cover. A full map of these areas, and others surrounding Mutton Cove, is provided here.

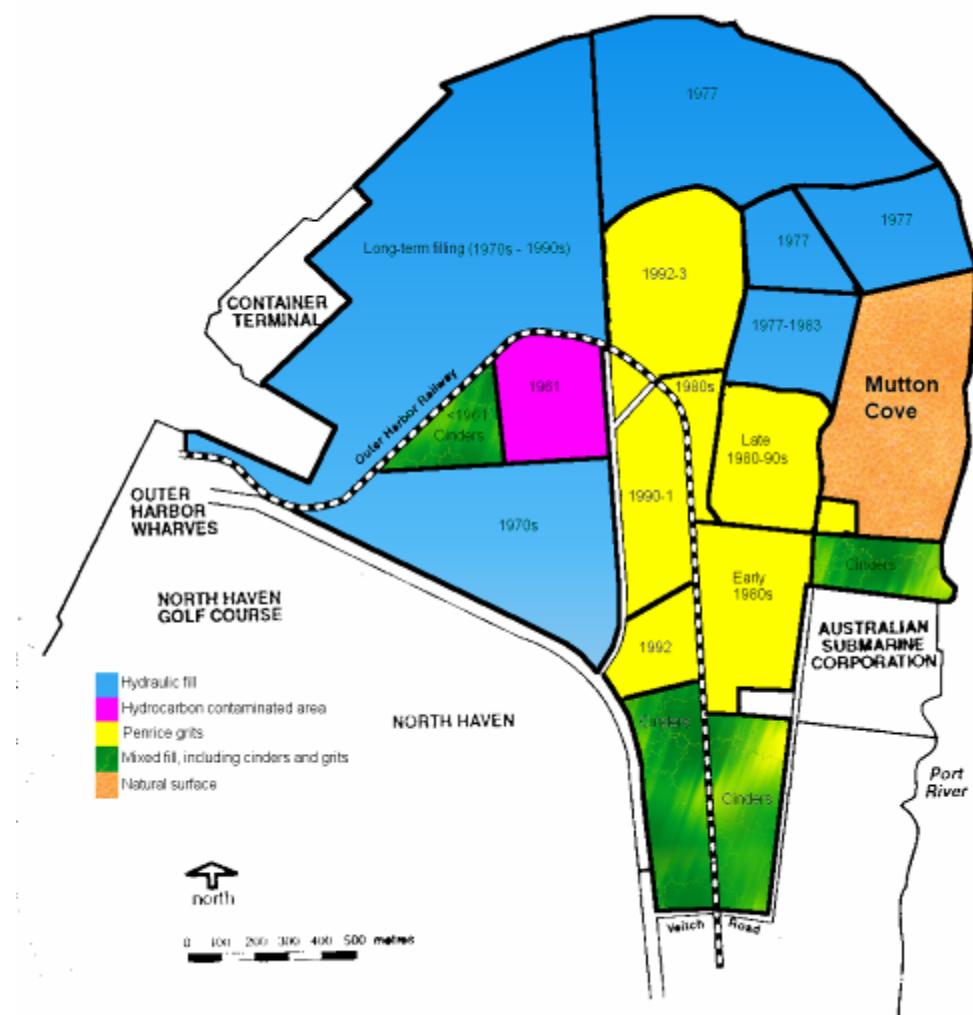


Figure 28 - Most recent layers of fill, Pelican Point



The areas identified as ‘problem areas’ were further filled with Penrice grits, and these were overlaid with seaweed from the Largs – Semaphore coastline and shell-grit from Port Gawler. There are a number of photographs of these areas being filled and revegetated, including ‘before and after’ shots.

The revegetation was not restricted to locally endemic species. A large number of weed species were introduced or encouraged at this time, including *Galenia secunda*, *Gazoul crystallinum* (now *Mesembryanthemum crystallinum*) *Cakile maritima*, *Mesembryanthemum aequilaterale* (now *Carobrotus aequilaterale*), *Limonium companyonis* and *Sonchus oleraceus*, which were all volunteer species. *Atriplex isatidea* and *Atriplex nummularia* were both seeded into the area. *Acacia cyclops* and *Casuarina cunninghamiana* were both planted as tube stock. None of these species are locally endemic, and some of them may have established as weeds in the area.

4.5.2 Maunsell, Outer Harbor site development study, 1995

The Maunsell group was hired by the SA Ports Corporation to determine the feasibility of developing a container facility with land for associated activities in close proximity to the Intermodal Adelaide container terminal and Outer Harbor.

The site examined in the report is the area surrounding the current location of the aquaculture farm. It is a 65 ha block, bounded by Pelican Point Road on the East and Coghlan Road to the West. The study site included the western portion of Biodiversity Park and some of the area around the park. The site contains areas of hydraulic fill and organic layers (1970’s), calcareous sand overlying stiff sandy clay at approximately –10m AHD, caustic grits and cinders.



Figure 29 - Area studied in Maunsell Outer Harbour Study (coloured blue)



The report states that the land underlying the aquaculture farm once had a petroleum storage terminal on it. Amoco built this in 1961 and it first became operational in 1962. The terminal had a pipeline running along the eastern side of Pelican Point Road that connected it to Largs Bay. This was constructed in 1984, but it is unknown if it was removed when the terminal was closed down in 1987. According to the data Maunsell obtained from the council, this line was left in place but filled with cement slurry.

The groundwater was located at 0.5m AHD in 1961. Current regional aquifer contours show the groundwater in the area to be approximately 1m AHD. Regional groundwater salinities are between 2500 and 5000 mg/L. Groundwater flows locally are towards the north, with micro flows along the original sand dune formations. This means that any petroleum spills from the old petroleum terminal are unlikely to drain towards Mutton Cove, and it is a low probability that the plume extends into the northern parts of Biodiversity Park. It does mean that areas to the north of the aquaculture farm may have petroleum contaminated groundwater underlying them.

The report documents the soil and groundwater monitoring results obtained from the site in 1995. The results show gross petroleum contamination of the area where the Amoco terminal was, to the point were working on the site was considered hazardous, particularly construction works with welders and other spark-producing equipment. The northern triangle of Biodiversity Park (next to the aquaculture farm) was found to have moderate contamination with heavy metals, rendering some of it unsuitable for use as a park, but still suitable for industrial use.

4.5.3 Maunsell, Pelican Point core site - Site history investigations, 1995



Figure 30 - Maunsell study area for the Pelican Point core site



This later investigation divided the area up into six separate areas. Mutton Cove and its surrounds were addressed as Area 1 and Area 2. The old Council flower farm (now aquaculture farm) and the main part of Biodiversity Park were denoted Area 3, the former Steel Mains plant was in Area 4, the golf course in Area 5 and the railway corridors were all included in Area 6.

The report contains quite a detailed survey of site-specific fill across the Peninsula. The report found that filling commenced prior to 1909 in the vicinity of parcels 10 and 28. The end date of filling is considered to be in the early 1990's. Most of the fill was a combination of marine dredging and industrial wastes.

Reclaiming of land in Area 1 (Mutton Cove and surrounds) started in the early 1960's. The fill present on the southern part of Mutton Cove is coarse, black and grey suggesting that the original dump material was cinder. The filling of this area did not cease into the late 1980's or early 1990's.

Studies after filling ceased, by the Marine and Harbours Board, revealed an area containing pyritic wastes associated with waste from the Acid Plant at Taperoo. This area was between Mutton Cove and Biodiversity Park and is reported again by Maunsell. Maunsell report that the MFP commissioned a test bore in that location in 1991, for the study of soils and groundwater (Bore OH2, soil sample MP3). Both groundwater and soil samples were collected and analysed. The Maunsell report provides copies of information provided in a Kinhill Delfin (1991) report to the MFP, and states that the groundwater was slightly contaminated with a range of metals, however the page of groundwater results provided by them refers to test hole numbers that the original Kinhill Delfin (1991) report applied to samples from Gillman. The original Kinhill Delfin (1991) report makes no reference to groundwater exceedances from the bore at OH2. The soil sample (MP3) results revealed no metals with concentrations above the Interim Urban Ecological Investigation limits or above the Health Investigation Limits for Recreational Areas (NEPC, 1999)

Area 2, which consists of parcels 6, 7 and 8, was not reclaimed until 1975, when levy banks were constructed. Filling these parcels ceased in the late 1980's. The central and southern sections of Area 2 contain some caustic materials, however no caustic materials were detected in the western, eastern or northern sections. One sample of groundwater was taken from Area 2, directly to the west of the Submarine Corporation, toward the northern end of the area. According to the Maunsell report, analysis of this water showed that above background levels of nickel were observed. Soil bore logs from a sampling location near the northwest corner of Mutton Cove, indicated the presence of industrial waste products, possibly Penrice grits.

Anecdotal information suggests that levies in Area 2 were constructed using building and demolition waste materials. A 1909 map of the area suggest that an explosives berth was located at, or proposed for, the north-eastern extremity of the Peninsula. There is also some suggestion that there was an ammunition depot on site.

Some discussion of the potential contaminants in Area 3 (in the area of the aquaculture farm) is provided within Maunsell's report, however these are outside the scope of this management plan. Aerial photography shows filling of parcels 3, 33 and 34 occurred between 1965 and 1975.



A total of 12 soil samples were recovered from 6 investigation trenches on parcel 3, which is currently known as Biodiversity Park. Most of the surface materials consisted of silty sands and clay, however caustic muds, ash, cinders and slag were encountered in some trenches. These were mainly in the northern triangle. The groundwater level (in m AHD) ranged between 1.49 and 2.17 m.

The filling and potential contaminants present in Area 4 (steel mains and facility) are also covered in the Maunsell report, however these are outside the range of this management plan. It is interesting to note this pipe manufacturing plant was established between 1910 and 1920.

Very little information is provided about the potential contamination in Area 6, or the railway reserves. Considerable amounts of fill (ballast) were imported to raise the rail beds, and this is generally considered fairly clean. There is the potential for inorganic pesticides or hydrocarbon contamination.

All areas contained some amount of marine fluvial fill obtained from deepening activities in the Port River. Other unknown sources of commercial and industrial wastes cover most blocks to some degree or another.

4.5.4 Local community in conjunction with CPAE, Our Patch, Coastcare, KESAB, & DEH, Mutton Cove Buffer Zone, 1998 - 2001

During this period, key local community members in conjunction with Council and the Our Patch, Coastcare and KESAB programs, lobbied to elevate the profile of Mutton Cove and establish it as a site that should be retained for conservation purposes and rehabilitated. Efforts included:

- local media articles on the need to protect shorebird habitat, the value of the area for reptiles and other fauna, the blight created by rubbish dumping, illegal disposal of cars and the need for the creation of this management plan;
- letters to various ministers and key state government agencies;
- facilitating visits to the site with senior environment managers from state and local government;
- involvement in the rezoning of the area;
- seeking advice and involvement from key representatives of the local Kaurna community;
- establishing a multi-stakeholder Steering Committee comprising interested individuals, non-government groups and local and state government representatives; and
- public education including writing newsletter articles for numerous publications, conducting tours of the site for interested local community members and conducting public presentations for the Port Adelaide Environment Forum.

In addition, on-ground works included rubbish removal, clearing the intake pipes of debris and improving the flow, establishing water quality monitoring sites and records, vegetation surveys and initial revegetation and compiling information of relevance to the area such as anecdotal bird lists etc.



In 2001 the local community undertook to revegetate the southern (filled) portion of Mutton Cove. The plan was to grow and plant 250 plants in the area by July 2002. Vit and Cheryl Karnaitis were the main participants. The Torrens CWMB provided funding and the City of Port Adelaide Enfield managed the funds.

Twelve species were proposed for the planting, and these included *Adriana klotzschii* and *Lotus australis* as well as other local species. Photo points were established, but the consultants have not been supplied with the photographs or details on survival rates.

4.5.5 Coast and Marine Branch, Mutton Cove Coastal Reserve, November 2002

In November 2002 the Coast and Marine Branch of the Department for Environment and Heritage assumed a coordinating role for the environmental improvements at Mutton Cove. In April 2003 the Coast Protection Board approved funding for the project.

Over the next few months, a CMB staff member (Mr Sam Penney) organised the dedication of the land as a Conservation Reserve and prepared a Development Application for the works at the site. On approval of the DA, a contract was called to undertake the work, but responses were very disappointing and initially only the fencing contract was let. Minor earthworks were undertaken on an hourly hire to prepare the fence line around the three landward boundaries. The fencing contract was funded jointly by the Board, TCWMB, and CLSA.

The fencing has proved very successful and to date has restricted all off road vehicle activity. Only minor vandalism has been experienced since its construction.

4.5.6 Davies, Pelican Point environmental development plan, July 2003

Nick Davies provided the Mutton Cove Steering Committee with this outline in July 2003. It discusses the possibility of a linkage zone between Biodiversity Park and the Mutton Cove Reserve. Mr Davies' preferred linkage zone runs due east from Biodiversity Park to Mutton Cove, linking up with Mutton Cove in the region of the Electranet transformer station. He would also like to see a buffer zone surrounding Mutton Cove on the north and western sides.

4.5.7 Project Dolphin Safe, Pelican Point – Mutton Cove clean-up, September 2003

The aim of the Project Dolphin Safe community group is to enhance the environment to make it safe and more appealing for local dolphin populations. On April 22, 2003 they planned and sourced funding for the removal of 16 cars in and around Mutton Cove. A further 35 cars were removed at a later date, and a clean-up day removed 11.7 tonnes of rubbish. The group has also held tree planting days, using the species list developed by "Our Patch".



4.6 Risk assessment of on-site contamination

In South Australia, historically occurring contamination is managed by treatment, containment, removal or management, taking into account the current and intended uses of the site. This involves a risk assessment process. The process is driven by the intended use of a site, which allows the assessor to select an appropriate assessment regime, using guidance from the National Environment Protection (Assessment of Site Contamination) Measure 1999.

The intended use of the Mutton Cove site is as a conservation reserve, incorporating public open space. This management plan was restricted to examining existing studies on possible site contamination, and therefore the data selected for examination is that provided in the Kinhill Delfin Joint Venture studies of the MFP site (1991), reported again by Maunsell Pty Ltd in 1995, and an earlier diagram showing boreholes placed by the Marine and Harbours Board.

As far as could be ascertained, no physical sampling was conducted by Maunsell Pty Ltd inside the current boundaries of the Mutton Cove reserve or in the immediate vicinity. The 1991 Kinhill Delfin study also undertook no physical studies inside the area of the Mutton Cove reserve, however two locations in the immediate vicinity had boreholes installed, and these are reported in this section.

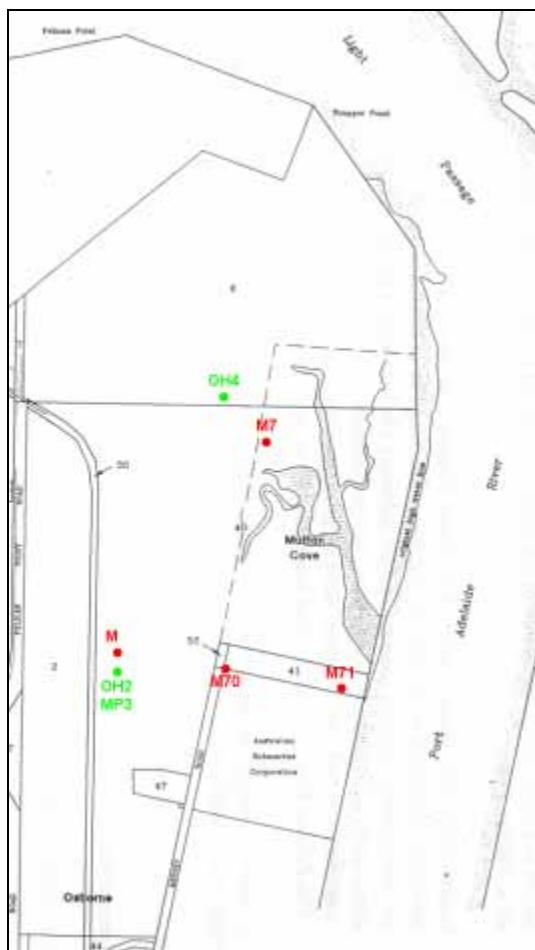


Figure 31 - Sampling locations for previous site contamination studies



Earlier boreholes installed by the Marine and Harbours Board were placed on areas of fill along the western and southern boundaries of the site. These reveal physical information about the fill, however no chemical analyses have been sighted by the consultants. The approximate location of these bores are marked with red letter M's in the sampling diagram (Figure 31).

The M&H borehole on the western boundary of the site (M7) was placed slightly north of where the fluvial fill drain enters the site. It revealed that the area had been filled with fluvial fill and 'caustic' waste – possibly limestone grits. This type of contaminant (limestone grits) has implications for pH in the vicinity, however it is not usually considered a metals hazard, as most caustic-metal complexes are insoluble. Over time, these compounds will revert to a type of limestone that is virtually indistinguishable from natural limestone (Kinhill Delfin, 1995). The fluvial fill material comprises sand and seaweed, with clays and lumps of kunkar (local calcrete) derived during deepening operations for the port waterways.

The M&H borehole on the south-western fill area (M70) revealed cinders, sand and seaweed while the borehole on the south-eastern fill area (M71) revealed cinders, organic materials (possibly seagrass debris), sand and a red-brown clay. Deposits of cinders allow a more rapid penetration of rainwater through the fill, and may contribute PAH's, tar-like and phenolic chemicals to the groundwater. In some parts of the world, cinders from coal have been found to contain elevated zinc and mercury concentrations. On the surface, cinders may produce a fine, irritant dust if crushed by being worked by heavy machinery.

The M&H bore lying between Mutton Cove and Biodiversity Park (M) revealed red sand, caustic grit, caustic mud and clay, red crumbly pyrites, soft clay and seaweed.

The bores for the Kinhill Delfin site were located north-west of Mutton Cove (OH4 on the diagram) and west-south-west of Mutton Cove (OH2 on the diagram). The latter was placed to approximate the location of the earlier M&H borehole.

OH2 revealed waste from cement production, fluvial fill, then the natural surface, with St Kilda formation sands overlying the Glanville formation. No pyritic wastes were found in this hole, suggesting that the area of pyritic material may be relatively small.

OH4 revealed fluvial fill, industrial waste products that comprised a white sandy silt with a low liquid limit, then below that a peat overlying organic shelly sand.

Kinhill Delfin tested a soil sample (MP3 on the diagram) from the OH2 site for a suite of metals, inorganic and organic chemical parameters. These included all those parameters where investigation levels are specified in the NEPM (NEPC, 1999) and a further range of more unusual contaminants.

Investigation levels in the NEPM vary, depending on the proposed use of a site. The aim of investigation levels is to allow a preliminary evaluation of whether a site needs a more exhaustive study, before using it for the purpose planned. Should a site exceed the investigation levels for its specific planned use, further testing will be needed to determine the site's suitability for use.



This approach is similar to the Dutch approach, which has a series of concentrations that are considered normal background concentrations, then has investigation levels that trigger the need for further investigation, and ‘clean-up’ levels that indicate the need for remediation.

The soil sample that was tested from OH2 borehole (MP3) revealed no metals or other contaminants in concentrations above the Interim Urban Ecological Investigation limits or above the Health Investigation Limits for Recreational Areas (NEPC, 1999). These limits were selected for application to this site as they reflect the two main uses of the Mutton Cove area – the Cove itself is a conservation reserve, and the areas of surrounding fill are planned to be recreational areas.

The soil sample was a judgemental sample – it was collected from the area that was considered most likely to return concentrations of concern. While the results do not indicate any exceedances, the borehole log also suggests that the sample did not intercept any layers of materials that would be likely to cause elevated metals concentrations, such as cinders or pyrites. This suggests that the area of pyrites may be quite small.

While the majority of the filled areas north of the site are fluvial fill, and the fill along the western boundary is mainly caustic materials that will revert to limestone if left alone for a sufficient time, in the southern filled area of Mutton Cove reserve there are cinders visible on the surface. No chemical testing has been conducted in this area. Its planned use is recreational. As this contract specified a review of existing information only, it is not known to what degree the cinders may have caused any contamination of the site.

As the filled land is not proposed for residential use, or other sensitive uses, the most appropriate method of dealing with possible contamination would be containment and management. The aims should be to reduce the risk of contaminating groundwaters and the estuary with any solutes from the cinders, as well as reducing the risk of crushed cinders becoming airborne.

The filled area is surrounded on its seaward and northern sides by embankments. These have a relatively low permeability, providing large quantities of water are not left to sit adjacent to the landward side of the embankments. To ensure that any metals or other chemicals in the cinders remain in-situ, it is important to reduce water movement through the area that contains cinders. The following actions are recommended to contain any water-borne solutes:

- runoff from the Electranet substation should not be allowed to enter the site, but should be redirected south to the CPAE stormwater drains,
- any drains through the seawall or into the Cove proper should be sealed, so that the small amount of water from direct rainfall that enters the filled area of the site cannot drain to the river,
- penetration of rainwater into cinder beds should be slowed by mulching the surface with either sand or seaweed, and



- revegetation of the mulched areas should be conducted to encourage evapotranspiration to occur, so that much of the rain that falls on to the site is used by plants and returned to the atmosphere.

Containing any fugitive dust that could escape from crushed cinders would require management actions such as the following:

- demarcate pathways through the southern fill area and ensure they are sandy or topped with clean material so that no cinders are on the surface,
- as a first priority, mulch the areas immediately adjacent to the paths and revegetate them, as the resulting rows of plants will make it less convenient for people to leave the path,
- gradually extend the mulched areas, concentrating first on areas where cinders are visible, then gradually filling in the areas between,
- avoid the use of heavy machinery in cinder areas where possible, and
- if heavy machinery will be working on areas where cinders are present, choose still days, preferably when the surface is a little damp, and ensure that operators use an appropriate dust mask.

4.7 Existing cooperative arrangements

In addition to the day-to-day management arrangements for the site, there are easement arrangements over parts of Mutton Cove that allow the easement owners the right to access the site and maintain their assets. Copies of easement documentation should be requested from the easement owners and should be filed with this management plan.

Electranet has an easement that covers the site of their transformer station and a strip of land under the high voltage lines. They require access to these areas at all times, so that they may maintain their assets.

SEAGas has an easement for their gas pipeline, from the river across the southern portion of the site to the western boundary. The pipeline is underground. In some areas it was placed by drilling, and in other areas by trenching. These latter areas will require revegetation. SEAGas should be requested to provide an ‘as-built’ survey of their gas pipeline, to ensure future activities do not impact on this buried infrastructure.

Future management arrangements may include passing over the day-to-day management of the site to the Port Adelaide Enfield Council. The actions suggested in this management plan should be taken into account when drafting any future management arrangements.

4.8 Stakeholder aspirations for the site

Stakeholder aspirations for a site are always a complex issue, and something that needs investigating in any management plan. If a management plan does not fulfil stakeholder aspirations, then those stakeholders will often not participate in the progress of that plan. This plan has tried to take into account all the aspirations of the



stakeholders, and many comments have been included in the main sections of the document. Some specific stakeholder aspirations are documented below for the purpose of clarity.

4.8.1 Department for Business, Manufacturing and Trade

Mr. Louis Mourtzios from the Department for Business, Manufacturing and Trade met with the consultants in September 2003. He discussed the value of the area for industrial development and port related activities. Potential land trading, the value of industrial land and the need for a buffer between heavy industry and light industry or housing were discussed. Stormwater was also an issue of concern, as some form of stormwater discharge area may be needed in the southern end of the development, as well as the northern end.

4.8.2 Office for Infrastructure Development

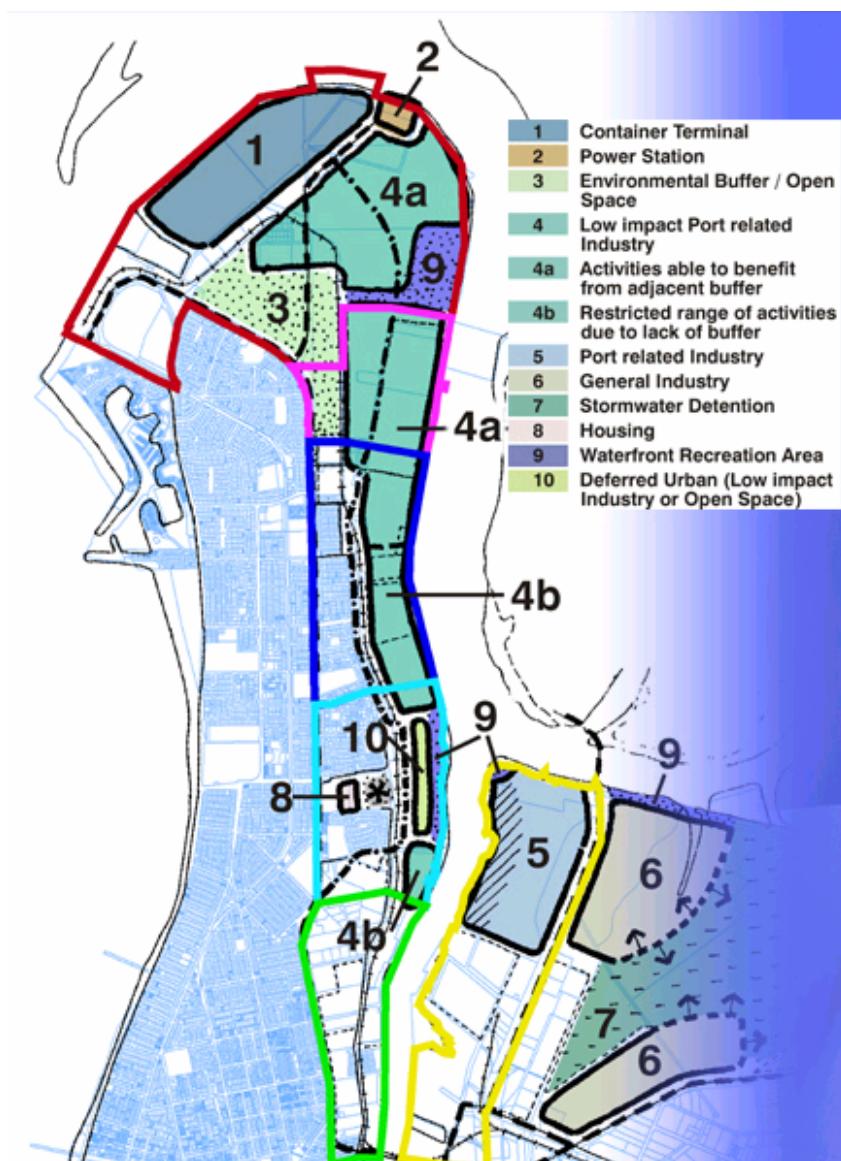


Figure 32 - Office for Infrastructure and Development projections for the Peninsula.



Mr. Lino Di Lernia from the Office for Infrastructure Development met with the consultants in September 2003. He provided them with the greater Port of Adelaide Master Plan on CDROM, which contained images of planned future developments for the Outer Harbor area, as shown in Figure 32.

Stormwater infrastructure was not shown in the maps, however the CDROM stated that the stormwater was to be treated on-site.

An examination of the figure, reveals that the purpose of an ‘environmental buffer’ may be different for different users. The ‘environmental buffer’ outlined in the OFID diagram serves to allow a wider range of noisy or dusty industries to use the area, than would be the case were no buffer available. That is, the ‘environmental buffer’ is a buffer between two sets of human activities – residential activities and industrial activities. Hence the plan shows unrestricted industrial activities alongside Mutton Cove, Biodiversity Park and the interlinking buffer zone, whereas further south where no ‘environmental buffer’ exists, only ‘restricted’ industrial activity is planned.

From a biodiversity point of view, a buffer zone protects a very sensitive environmental area from all types of human activities. As such, reserves such as Mutton Cove that support migratory birdlife, would require ‘buffering’ from the types of industry that are very noisy or otherwise intrusive.



Figure 33 - Proposed rail modifications





Figure 34 - Proposed road modification

4.8.3 Australian Track and Rail

Australian Track and Rail have one main objective for the northern part of the Peninsula – reducing the number of uncontrolled rail crossings to the minimum number possible, so that speed and number of tracks can be safely increased. The Port of Adelaide Master Plan, supplied by OFID, shows three tracks between Mutton Cove and Biodiversity Park. This is required to service the types of developments planned for the Outer Harbor area.

The reduced number of crossings is envisaged to be restricted to a crossing controlled with boom gates at Veitch Road, and another on the northern section of Pelican Point Road. Either of these may be the best location for a bicycle path or biodiversity corridor crossing. Another option would be a pedestrian crossing level with Mutton Cove, however this suggestion was not met with enthusiasm, as ATR plan to have three rail lines in parallel at that point. A pedestrian crossing of the appropriate standard to be safe for the increased distance across three lines and the increased speed of trains would require considerable funding. Any proposed animal underpasses would face similar problems.



4.8.4 Port Adelaide Bicycle Users Group and Coast Park

The Port Adelaide Bicycle Users Group would love to see Mutton Cove as a stop on a loop section of the Coast Park. Mr. Dave Hemmings sent an email to the consultants, requesting that safe and convenient cyclist access was ensured to the entry of the Cove, and the provision of bicycle parking was included so that cyclists could leave their bikes and explore the Cove on foot.

Mr. Hemmings expressed a desire that the access to the Cove be tied into the off-road cycle/pedestrian path that PABUG is hoping will be developed from Outer Harbor to the eastern bank of the Port River. The desired route would pass next to, or through, Biodiversity Park and Mutton Cove, although this route may be affected by the location of the buffer zones, the biodiversity corridor linking the Biodiversity Park and Mutton Cove, and new rail and road corridors.

4.8.5 City of Port Adelaide-Enfield

City of Port Adelaide-Enfield held a meeting with the consultants in mid September 2003. They expressed their desire that the area have appropriate visitor facilities, that all tidal flooding be contained within the Cove and that the contaminated area in the south of the site should be addressed within the management plan.

A suggestion was made that informational signage be made consistent with those along the Coast Park and that public access to the Cove be made more obvious.

4.8.6 CPB and the TCWMB

The Coast Protection Board and the Torrens Catchment Water Management Board have been the major funding partners for this management plan and other works being completed at the Cove. Both bodies have as their main priority for the site the conservation and enhancement of the biodiversity within the Cove precinct. Mutton Cove is the largest remaining area of saltmarsh on the Le Fevre Peninsula, so is an important coastal wetland and estuarine area.

Additionally, the Torrens Catchment Water Management Board has similar objectives for the neighbouring Biodiversity Park.

4.8.7 Urban Forest Biodiversity Program

The Urban Forest Biodiversity Program is keen to see Mutton Cove restored. Ms. Penny Paton wrote a letter to the consultants (dated 13/10/03) offering assistance with funding towards biodiversity conservation and enhancement within Mutton Cove, its buffers, the linkage corridor, or the wider Pelican Point area.

The letter raised some concerns, including the width of the linkage corridor and the size of buffer zones to protect the more sensitive core area of the Cove from edge effects that may result from neighbouring industries. The UFBP believes that the area of environmental buffers zones should be maximised, as the buffers will become important habitat areas in their own right and that large buffer zones will provide the largest distance between Mutton Cove and a potentially noisy, dusty industrial zone. Similar concerns were raised regarding the linkage corridor, which Ms. Paton suggested should be at least 200m wide.



The difficulty of a linkage corridor crossing several major railways and roads was discussed in the letter. The use of underpasses was suggested, although it was understood that these would need to be installed in future road and rail upgrades, not immediately.

4.8.8 Community environment groups and individuals

The consultants advertised the development of this management plan in the local Port Adelaide newspaper. Community environment groups and individuals were asked to provide comment, in particular about their hopes for the future of Mutton Cove.

Mr. Dave Kirner, of Community Action for Port and Peninsula mentioned that his organisation had a number of interested members who wished to be involved in tree planting. The need for a linkage corridor between Mutton Cove and Biodiversity Park, integration with the Dolphin Sanctuary and appropriate signage were also mentioned in Mr. Kirner's comments.

Mr. Jon Emmett, who is a community member on the steering committee, pointed out the serious erosion occurring on the seaward fringe of mangroves just outside the seawall of the Cove, but within the 'Conservation Reserve'. The effect of bait digging on the Cove was another issue he brought to the consultants' attention.

Mr. Emmett also described a good quality patch of vegetation that exists south east of the Pelican Point Road and Victoria Road intersection, which he believes should be preserved as part of a linkage between Biodiversity Park and Mutton Cove.

4.8.9 Environment Protection Authority

Mr. Mike Fanning and Mr. Luke Cattlin from the EPA both visited the site in April 2003. In an email Mr. Fanning wrote to Mr. Sam Penney of the Coastal Protection Branch, he discussed the EPA's concerns about the site and general approval of increasing tidal inundation within Mutton Cove. Their concerns centre around inundation of the areas of cinders and iron pyrites present in the southern areas of fill and within some of the embankments, which could cause the release of contaminated leachate into the Port River. The email suggested that the southern filled area be contained by a suitable levee and not inundated with the tide. Removal of rubbish and the hiring of a consultant to write a management plan were also advised. Mr. Fanning recommended that the management plan address the issues of contamination, acid sulphate soils and the effect of increased tidal inundation.



5. Management prescription

5.1 Management philosophy and strategic directions

The aim of this management plan is to restore the salt marsh and mangrove wetlands of Mutton Cove and conserve the biodiversity values of the site while encouraging the wider community to experience the site in an environmentally acceptable manner.

5.2 Management arrangements

5.2.1 Partnerships and cooperative management

The Coastal Protection Branch currently manages Mutton Cove with advice from the Steering Committee. Mr. Sam Penney of the Coastal Protection Branch of the Department for Environment and Heritage acts as chairperson to the committee.

This large management body is important, particularly during the initial period of establishing the Reserve, as it gives the management of the Cove a larger base of expertise, participation and funding. The consultants recommend that this steering group be maintained for the first 5 years after the initiation of this plan. This group should consist of no less than 8 people, with at least one representative from each of the categories below and extra members as the Committee feels the requirement;

- City of Port Adelaide Enfield
- Coastal Protection Branch
- Local environmental action groups
- The Torrens Catchment Water Management Board
- National Parks and Wildlife Service (Port Adelaide Dolphin Sanctuary)
- Representative/s of the local Kaurna people
- Local landowners / developers (including Crown Lands SA)
- Saltmarsh botanist / ecologist

Additional representatives should be added as required, by a vote within the committee.

5.2.2 Community and volunteer involvement

Community involvement is a key factor of this management plan. Many of the tasks are costly if undertaken commercially, however may be economically feasible if supported by enough volunteers. Use of community members also raises the public face of a Reserve and provides participants with a sense of achievement and belonging.

The consultants recommend the use of volunteers in whichever role the volunteers feel they are capable of fulfilling. Full support should be given to actions that may involve community members. These actions involve many of the tasks within the monitoring program, as well as revegetation efforts, weed removal and the occasional guided walk for other community groups.



5.2.3 Relationship with other environmental activities in the area

Environmental activities as recreation are becoming more common within Australian society, particularly along the coast. Other sites supporting environmental activities in the area include Biodiversity Park, the St Kilda Mangrove Trail, dune plantings along the foreshore, the Port Adelaide Dolphin Sanctuary and the Adelaide Metropolitan Coast Park.

Involvement with other environmental activities on either a management or practical level is always a positive move. Forming a relationship with groups or areas that have similar goals and issues can facilitate the exchange of expertise and sharing some of the practical work, for example weed control, and reduce costs for both parties.

5.3 Management of the natural resources of the site

5.3.1 Contaminated soils

The southern filled area of the site is surrounded on its seaward and northern sides by embankments. These have a relatively low permeability, providing large quantities of water are not left to sit adjacent to the landward side of the embankments. To ensure that any metals or other chemicals in the cinders remain in-situ, it is important to reduce water movement through the area. The following actions are recommended to contain any water-borne solutes:

- runoff from the Electranet substation should not be allowed to enter the site, but should be redirected south to the CPAE stormwater drains,
- any drains through the seawall or into the Cove proper should be sealed, so that the small amount of water from direct rainfall that enters the filled area of the site cannot drain to the river,
- penetration of rainwater into cinder beds should be slowed by mulching the surface with either sand or seaweed, and
- revegetation of the mulched areas should be conducted to encourage evapotranspiration to occur, so that much of the rain that falls on to the site is used by plants and returned to the atmosphere.

Containing any fugitive dust that could escape from crushed cinders would require management actions such as the following:

- demarcate pathways through the southern fill area and ensure they are sandy or topped with clean material so no cinders are on the surface,
- as a first priority, mulch the areas immediately adjacent to the paths and revegetate them, as the resulting rows of plants will make it less convenient for people to leave the path,
- gradually extend the mulched areas, concentrating first on areas where cinders are visible, then gradually filling in the areas between,
- avoid the use of heavy machinery in cinder areas where possible, and
- if heavy machinery will be working on areas where cinders are present, choose still days, preferably when the surface is a little damp, and operators should use a dust mask.



The poor quality of the fill in the southern area, which contains many cinders, has slowed revegetation efforts. The consultants recommend that, should any local authorities conduct beach-cleaning exercises, the removed seagrass could be spread onto the southern fill areas. After an area is covered, then revegetation may proceed in that area. Prior to planting tube stock, broadcasting seed of appropriate groundcover and pioneer species is advisable. Seed of *Atriplex semibaccata*, *Atriplex paludosa*, *Isolepis nodosa*, and *Stipa* grasses are recommended.

5.3.2 Hydrology and water quality

The entire surface of Mutton Cove has not been surveyed for height since 1983. Given that the amount of surface subsidence since the embankments were placed in the 1970's amounts to some half a metre, some of this subsidence is likely to have occurred since 1983. As a result, an accurate map of the topographic levels of the site is not available. However, it is likely that the overall surface topography has remained similar to that mapped in 1983. The vegetation associations occurring on the site currently provide a reasonable approximation of the underlying surface level, and will be used here to estimate the various areas of the Cove that are likely to be flooded to different depths with different volumes of water.

Creeks cover about 5.4 ha of the site. Low marsh and a few scattered mangroves form the lowest of the terrestrial height classes, and occupy about 8.8 ha of the vegetated area of Mutton Cove at present. The mid-level marsh occupies a further 9.6 ha, while the high marsh occupies 2.5 ha. All these vegetation types occur within a topography that varies by no more than 60 centimetres in height. Even very small changes in the depth of flooding will produce startling changes in the vegetation (McComb *et al*, 1995).

In 1963, Mutton Cove contained about 44–49% mangroves and 5–6% tidal creeks with the remainder of the site comprising both intertidal saltmarsh and dune ridges (45–50%). To obtain vegetation associations more similar to those found in Mutton Cove in 1963, the current mangrove and low marsh area needs to be flooded frequently enough for mangroves to colonise the area. The lower edge of the mid marsh would become the mangrove-saltmarsh ecotone, with mainly low and marsh occupying what is now the mid marsh. The current area of high marsh would become two bands – mid marsh and high marsh. Dune species will colonise the filled areas.

In order for an appropriate flooding regime to develop that would allow the habitats to modify themselves in this way, it is necessary to replicate the flooding depths and frequencies found in similar habitats in the neighbouring Barker Inlet. To replicate the flooding regime found in the mangrove-saltmarsh ecotone in Barker Inlet over the areas outlined above, the following scenario is suggested.

In general the creek line is between 0.5m and 0.75m deep. It would therefore require a volume of between 27,000 and 40,500 kL to fill the creeks to the point where the water starts to inundate the saltmarsh. To provide another 40 cm depth across the channel area and the existing mangrove-low marsh at the highest predicted tides for the year, and up to 15 cm depth across the existing mid-level marsh would require a further 71,200 kL of water. This suggests that the amount of tidal water needed at the



highest tide of the season would be between 98,200 kL and 111,700 kL over the six hours of flow. This volume is between 2.7 and 3.6 times the estimated volume that entered Mutton Cove on September 11.

It appears that the three existing pipes are more than large enough to supply such a volume over a large incoming tide, but the inlet pipes, until late September 2003, were restricted by material wedged inside the pipes and by a build up of rocks in the basins surrounding them. In fact, one pipe was barely flowing at all. In October the basins around the pipes were cleared, and quantities of material were removed from the entries of the pipes. The cleaning of the existing pipes, and rock lining a basin area below them may have provided all the extra flow necessary.

One issue to keep in mind, if additional pipes are ever required, is the height of the pipes. Pipes located too high will not allow enough water to flow out at low tides, however pipes located too low may become filled with rock and sediment. If all the pipes are set at a low level, scouring may occur on the inland side of the restriction, as the head differential at high tide will cause the flow rate to increase. A reasonable solution would be to set the pipes at slightly different heights, which will provide a more natural flow pattern, while ensuring that the effects of sedimentation and scouring are kept to a minimum.

Seasonal monitoring of the internal and external tide pegs will allow the management body to determine whether rocks and sediment are re-blocking the pipes, and will also provide advance warning of whether the effects of sea-level rise are reaching the point where the pipes need some restricting, or the seawall requires maintenance.

The hydrological changes should bring about beneficial changes in the water quality. Water quality should be monitored as outlined in the monitoring program.

5.3.3 Native flora

Monitoring the change in areas covered by the different types of habitat on site will provide warning should any class of vegetation be placed under threat by the altered hydrological regime. McComb *et al* (1995) found that while decreased inundation causes species change to occur in less than a year, increased inundation took at least two years to cause changes in vegetation patterns. This is because the adult plants often cope with the increased saltwater inundation, but germination of seedlings is impaired.

To minimise the chance of mid and high level marsh species being extirpated on site, the following two approaches are recommended:

- shaping the bordering embankments to a much lower slope, to allow mid and high marsh species an ‘escape route’ to higher land,
- collection of seed and/or propagation material from the mid and high marsh species for use in revegetation activities, both on the site and in the buffer areas, and
- annual vegetation monitoring of a transect that includes all marsh types.



The latter two actions are particularly important for species that have conservation significance or interest, such as *Apium annuum*, *Lawrenzia squamata*, *Wilsonia humilis* and *Gnaphalium indutum*.

5.3.4 Native fauna

Mutton Cove is an excellent shorebird feeding ground. Activities that disturb the feeding and roosting of shorebirds need to be minimised. The fencing of the site has restricted access to foot traffic, and this is a benefit to noise-sensitive birds. Early growth of mangroves is likely to occur along the seawall, and this will provide visiting walkers with some screening and will allow the birds to continue feeding undisturbed. The ‘nodes’ along the seawall may provide an excellent location to build bird hides, as the approach routes to the hides could be hidden by the mangroves.

The consultants recommend that, as a minimum, bait digging be banned inside the Cove to avoid disturbing migratory bird feeding habits and because the Cove contains too small an area of flats to support intensive bait digging. The Steering Committee may wish to consider whether they also wish to ban bait digging in those parts of the river that are included in the Reserve.

Most of the dogs observed in the Cove and foreshore area by the consultants have been reasonably behaved and have not chased birds or lizards. As the Cove becomes more popular, or if large numbers of noisy or marauding dogs are brought to the site, the Steering Committee may wish to consider an ‘on leash only’ policy. The Steering Committee may wish to consider the supply of a rubbish bin specifically for receiving dog-waste bags.

Most of the reptile fauna in the reserve is found in the mid-high marsh areas and the filled land. Revegetation efforts on the filled land should include a range of prickly shrubs such as *Nitraria billardierei* and *Lawrenzia squamata* that provide the type of habitat reptiles like to shelter in.

5.3.5 Introduced species of plants and animals

Control of foxes and rabbits every 3 to 5 years is recommended. Any baits that could be attractive to raptors and pelicans need to be buried. If baits are used the site needs signage and dogs would need to be banned during the baiting program. All untaken baits need to be collected at the end of the program. Any dead animals should also be removed from site.

Hares rarely take bait and are difficult to trap, so controlling them is probably not feasible. Hares frequently damage revegetation plots, by snapping the tops off quite large plants. The only practical method of preventing this is the use of tree guards on plants that hares find particularly attractive, or placing temporary rabbit fencing around planted areas. Work undertaken in the Barker Inlet Wetlands by Coleman and Valamanesh (1998) revealed that hares have a strong preference for *Allocasuarina verticillata*, followed by *Myoporum insulare* then *Nitraria billardierei*.

Control of noxious weeds is recommended annually.



5.3.6 Minimising ‘edge’ effects

Mutton Cove is a relatively small conservation area, and most of it is currently subject to edge effects. These effects include off-road vehicle use, noise, dust, introduction of weeds, stormwater run-off and a range of other impacts that affect the edges of conservation reserves.

The Coastal Protection Branch has addressed some of the immediate issues by providing fencing and by the blocking of stormwater access to the north-western part of the site. The fencing has incorporated higher, filled land along the western side of the Cove into the Reserve, and it is intended to revegetate this land with a wide variety of local dune species. The inclusion of bushy plants such as *Acacia cupularis/ligulata*, *Melaleuca halmaturorum* and *Nitraria billardierei* should provide a visual screen and reduce noise from the neighbouring industrial and off-road activities. The filled land to the south of the Cove, which is also included in the Reserve, will fill a similar function.

To reduce the invasion of weeds, it is recommended that revegetation be preceded by mulching the land. The most useful mulch for sandy dune soils is seagrass wrack/ While the consultants are not recommending the raiding of beaches for this resource, any wrack that has been removed from metropolitan beaches under existing beach-cleaning agreements should be used at Mutton Cove. Seagrass wrack carries only a small range of weed seeds, it mats down quite quickly and has proven to be an excellent aid to revegetation on neighbouring blocks.

The consultants do not recommend the use of ryegrass as a cover crop at Mutton Cove, suggesting that direct seeding with a range of *Atriplex* and *Isolepis* species be undertaken instead.

Should additional land be available for incorporation into the Reserve as a buffer, then the consultants would suggest that the Steering Committee examine the matrix that is attached in the Appendices, *Neighbouring blocks – matrix*. The matrix outlines the value of the neighbouring blocks, including those that form part of Biodiversity Park west and Biodiversity Park east. The value of each block is a combination of the following parameters: dates of filling, filling material, likely contaminants, revegetation treatment after filling, degree of dumping and track formation, and current biodiversity values.

5.3.7 Dealing with pollutant spills

Saltmarshes tend to trap spills such as oil, particularly along the strand line zone. The response of saltmarsh vegetation to spills, and the recovery time, is quite variable and depend on the types of vegetation present in the marsh and the variety of material that has been spilt. Light oils, which penetrate the cuticle of plants, are more damaging than heavy oils, for example (IPIECA, 1994).

Hydrocarbon spills are the most likely pollutant to enter the site, and may enter Mutton Cove from several sources:

- the Port (although the inlet pipes will restrict the entry as they are sub-surface most of the time),



- through groundwater as a plume from land based pollution,
- as direct spills from earthmoving machinery on site, and
- through stormwater

Saltmarshes do not respond well to clean-up efforts (IPIECA, 1994). Preventing the spill from reaching the surface of the saltmarsh in the first place is the best option. Blocking the inlet pipes, or using floating bunds around any spills that are in the Cove's main creek line are useful for spills that are affecting the surface waters. Redirecting all stormwater that drains from industrial zones away from the site is also a useful preventative measure.

If underground plumes are shown to be surfacing in the Cove, the place to undertake remedial works is further back along the plume, before it reaches the Cove.

Usually, spills are left to decompose naturally. Adding nitrogen and oil-degrading bacteria may encourage the breakdown of the product, but is not strictly necessary. The only times when a more interventionist approach is recommended is when there is sub-surface penetration of oil or when free oil is floating on the surface that could damage wildlife.

5.4 Management of cultural heritage

Signage is recommended that retells those parts of the Tjilbruke story that have to do with Mutton Cove. Any signage should be consistent with signs installed along the Port Adelaide Kaurna Cultural Trail. It is recommended that the Steering Committee talk to the Tauondi College, who run guided tours of the Port Adelaide Kaurna Cultural Trail, to see if they would like to extend their trail to include Mutton Cove.

Signage is also appropriate for the shipwrecks on the site. The Excelsior wreck is adjacent to an embankment, and this would make a good location for a sign that links Mutton Cove in with the other Ships' Graveyards in the Port Adelaide area.

Additional visitation may bring with it the risk that some members of the public may try to climb out onto the Excelsior. It is recommended that any signage define a 10-metre exclusion zone around the wreck. This also protects the public from any portions of the ship that may corrode and fall off.

Information on signage that deals with the post-settlement history of a similar site (Mangrove Cove) in Bunbury, WA is attached in the Appendices. The signage discusses the revegetation of areas of industrial fill on the site and the biodiversity values of the site. Such information could well be provided to visitors of Mutton Cove.

5.5 Access and visitation

Current visitation at the Cove is relatively low, with the consultants estimating that Mutton Cove receives 2,000-3,000 visitors annually. Most of these visitors are walkers and bait-diggers. There is potential for large numbers of visitors, given appropriate facilities and greater public awareness. Areas such as the Middle Beach



Samphire Trail and the St Kilda Boardwalk receive 9,000-22,000 paying visitors per annum, showing that there is an appetite for this type of ecotourism.

Immediate recommended access improvements are only minimal. The main access tracks through the site are along embankments and along tracks through the southern landfill. The recommended access points are adjacent to the Car Park Reserve between the south-eastern corner of Mutton Cove and the Submarine Corporation, and from the south-western gate next to the Electranet transformer site.

A set of bike racks in the Car Park Reserve would provide cyclists with a location where they could lock their bikes while they explored the Cove on foot.

The seawall embankment requires a small amount of fill to remove surface pot-holes and make the walking surface safer. Occasionally the river-side of the seawall will require some rocking to repair erosion.



Figure 35 - Map of track rationalisation and revegetation areas



Tracks through the samphire should be rationalised to the main tracks only, and the chosen tracks could be raised slightly and gravelled. This will make them accessible during the wetter times of the year and the cleaner, drier surface will tend to discourage people from leaving the track. Careful loosening of the soil at the accessible ends of tracks chosen for closure will allow saltmarsh species to recolonise these areas. The remaining portions of track will then revegetate over time, as the track is no longer trampled. The diagram of proposed track rationalisation (Figure 35) shows high priority paths in red, lower priority paths in pink, and revegetation areas shaded with green.

An information board, rubbish bin and shelter near either the main seawater inlet or on the southern landfill area could inform visitors of the area's significance and any management restrictions they should be aware of. Mutton Cove contains both remnant saltmarsh and land previously used for industrial disposal. Signage should reflect both the area's ecological value and its history. Examples of signage from a small reserve in Western Australia that has many similarities are attached in the Appendices as *Signage at Mangrove Cove, Bunbury WA*.

For the purposes of water quality monitoring, the existing sampling location (adjacent to the seawater inlet) requires the negotiation of a steep embankment. This is not easy when carrying sampling equipment. The consultants recommend a new location for water quality sampling, while continuing the tidal observations in the current location.

A good place to monitor water quality is the tip of the embankment that intersects the Mutton Cove creek. This location is next to the main channel of the creek, and other regular monitoring (photo points and vegetation surveys) occurs in close proximity. The main obstacle with this location is the amount of silt that has deposited along the creek bank, making access to deeper water difficult.

To address this, it is recommended that the Steering Committee consider the erection of a small landing, similar to that used in the saltmarsh at the Middle Beach Samphire Trail, at the end of the embankment. This landing would provide a good viewpoint for visitors, as well as a stable location for sampling water.

5.6 Future directions

5.6.1 Possible handover of the site to Council

Should the Conservation Reserve be placed in the care of the City of Port Adelaide Enfield at some time in the future, the Council will need to give consideration to the requirements of this management plan.

5.6.2 Linkage to Biodiversity Park

Biodiversity Park is an area of open space relatively centrally located between Mutton Cove and the western side of the Peninsula. One part of the park, Biodiversity Park west, which lies west of Pelican Point Road, has been the subject of a considerable amount of community effort in its revegetation since filling of the land ceased in the 1970's. A second part of the park, Biodiversity Park east, which lies between the railway and Pelican Point Road, has been filled more recently with alkali wastes, and then topped with seagrass and revegetated by a range of government bodies and



private companies. Since the cessation of this revegetation work the land has been again degraded, this time by dumping, weed invasion and off-road vehicle use.

The distance between this second part of Biodiversity Park and the Mutton Cove Conservation Reserve is approximately 300m. There have been requests for a ‘biodiversity’ corridor to enable movement of people, plants and animals between Biodiversity Park and the Mutton Cove Conservation Reserve. The development of such a link should consider the following points:

- in the near future Australian Track and Rail will be adding another two rail lines to their rail reserve, and do not envisage a pedestrian crossing as an appropriate option in what will be a relatively high speed area,
- underground pedestrian and animal access ways of the necessary magnitude are likely to be very costly, with no guarantee that the local reptiles will choose to use them,
- Biodiversity Park east itself is currently badly degraded with weeds and feral animals,
- the intervening land has also been subjected to filling with alkali waste and has only recovered poorly thus far as it has very little sand topping,
- the area most likely to be available for a linkage is in the area that has been shown previously to contain contaminants from pyritic wastes

5.6.2.1 Biodiversity issues to consider

Wildlife corridors are considered to have a number of positive roles in conserving biodiversity. They are often seen as providing a connected landscape for animals to move through, they may provide an area of habitat for resident and migratory populations, they may provide a route to access previously isolated patches of habitat and they may promote interchange of genetic material through the ability of groups to migrate between patches of habitat. The most effective corridors are reasonably large, and contain a range of landscape features within the corridor itself. Gullies, ridges, rocky outcrops, tall and short vegetation are all required to ensure that a range of organisms can safely negotiate corridors.

However corridors are also seen as facilitating the spread of deleterious genes, and allowing invasion by weeds, feral animals, predators and fires. Some authors (Burgman and Lindenmayer, 1998) suggest that corridors between high diversity areas and low diversity areas can allow the lower diversity areas to act as ‘sinks’. The over-dispersal of some metapopulations by this process may result in them becoming locally extinct.

Corridors have huge boundaries in relation to their area, resulting in them containing only ‘edges’. As a result, they may be very expensive to maintain. Burgman and Lindenmayer (1998) state “blind insistence on corridors may divert financial resources from other, potentially more appropriate or less costly conservation strategies”.

The use of corridors should be considered in relation to their specific purpose. What species of bird, insect, reptile or mammal is the Steering Committee encouraging to



use the corridor? Once the species being targeted is known, the types of questions that need to be answered include:

- what distance of open land, roads, rails etc can each species safely negotiate?
- what distance do these species usually travel from their home range?
- what type of habitat do they require in each habitat patch that the corridors connect?
- do they require corridor land to travel across, or do they fly from patch to patch?
- are they likely to use underpasses to negotiate intervening rails and roads, or will they prefer to travel along the surface, and
- if the latter, will a corridor expose individual animals to increased predation or risk of accident?

Should the Steering Committee decide that the biodiversity of Mutton Cove will not be negatively impacted by connecting it to Biodiversity Park east with a corridor, then choosing the appropriate land becomes the next decision.

5.6.2.2 Assessment of neighbouring blocks that may be used in any linkage

Should the Steering Committee decide on recommending to the City of Port Adelaide Enfield, or other parties, that areas be set aside as either a buffer zone or as a linkage between Biodiversity Park and Mutton Cove, then the Committee will need to choose that land carefully.

Ideally the land should have the highest biodiversity value possible, considering its recent origin as landfill, with as few contamination issues as practical. The land could also provide some linkage for people to move along, although this may be constrained by the development of very wide transportation corridors.

If any linkage is purely for habitat purposes, then the Steering Committee may need to decide whether the continuous habitat is designed to facilitate the spread of seeds, insects and birds, or whether they wish to encourage the movement of terrestrial vertebrates. If the latter, then some form of engineering (to cross a three-track railway system and upgraded roads) may be required to facilitate this movement.

The Steering Committee may wish to consider the availability of funding for such works, prior to making a decision on which type of corridor they would prefer.

An earlier section of this report that discussed historic management of the Mutton Cove area, provided a map that showed the use of neighbouring parcels of land for filling over an extended period. Further assessment of the current biodiversity of the nearby blocks and notes about development constraints that may result from the future expansion of port activities in the area, or from contamination, is summarised in a table and map attached to this document in the Appendices, as *Neighbouring blocks – Matrix*.



5.6.3 Further eco-tourism possibilities

As visitor numbers increase over several years, boardwalks along the saltmarsh tracks and disability access may both be worthwhile improvements to consider.

Tying Mutton Cove Conservation Reserve into the Coast Park is also possible. A continuous walking/cycling trail could extend from North Haven through to Biodiversity Park, and run through the Park to Veitch Road. Veitch Road will be one of the few roads to have a controlled rail crossing (most other crossings are being closed), and after passing over the crossing, the trail could continue towards Mersey Road. At the intersection, a spur trail could veer north to Mutton Cove, while the main trail could continue south along Mersey Road to Snowden's Beach.

5.7 Action table and costings

The actions outlined in the management prescription section of this plan are of several types. Some activities, such as making changes to the hydrology and revegetation are important activities for maintaining biodiversity issues on site. These activities would have a high priority and be undertaken in the short-term, along with ongoing maintenance of assets such as the seawall and inlet pipes.

Some improvement in visitor facilities is required in the short-term, but other actions will not be required unless visitor numbers increase significantly. Facilities that also serve a purpose in the monitoring program are ear-marked for undertaking in the short-term.

Monitoring activities are important when undertaking long-term environmental restoration. These need to be put in place as quickly as possible.

The following action table summarises the actions recommended in the management prescription, defines them as required in the short-term, long-term or ongoing, and provides an approximate costing. The values provided are approximate commercial costs to undertake each of the projects over a 5-year time frame. The cost of many of these tasks would be cheaper if completed with volunteer labour and in-kind donations. For example, the mulching cost is based on the use of commercial mulch and a blower, and would be more economically undertaken with donated seagrass and loaned earthmoving equipment.



Table 11 – Five-year action plan summary

Action	Priority	Value
Management		
Steering group to assist managers for first 5 years	1	
Use of volunteers in as many capacities as possible to be encouraged	2	
Co-operative management with neighbours and other environmental activities (security, weeds & feral control, joint tours, etc)	2	
Approach easement holders for copies of easement documentation and ‘as-built’ drawings/surveys of infrastructure	2	
Use Coast Protection Act to restrict bait-digging within the Cove (and possibly outside)	2	
Monitoring		
Regular monitoring of water quality parameters as discussed in the monitoring program	1	\$ 2,200.00
Monitoring vegetation changes using aerial photography, photo points and transects	1	\$ 3,500.00
Seasonal monitoring of tidal hydrology (including biannual resurveying)	1	\$ 4,500.00
Maintenance		
Weed control (once a year)	1	not calculated
Cleaning out existing pipes when needed	2	\$ 2,000.00
Upgrading and maintaining seawall	2	not calculated
Supply of rubbish bin for animal faeces, fishing line and lunch refuse	3	not calculated
Trapping or baiting feral animals (one 6 week event, every 3-5 years)	3	\$ 1,500.00
Asset Improvement		
Seagrass mulching around existing plants in the southern filled area and along western embankment	1	\$ 29,000.00
Diverting stormwater from transformer station	1	not calculated
Blocking pipe to Port River in the southern landfill area	1	not calculated
Shape surrounding embankments to give an area for retreating high marsh species	1	\$ 9,000.00
Collect seed and/or propagation materials for use in revegetation projects	1	\$ 600.00
Direct seeding of Atriplex, Stipa and Isolepis species on bare patches of landfill	2	\$ 4,400.00
Erect two signs showing where bait digging is banned	2	\$ 3,000.00
Installing gravel paths over some of the current ORV tracks	2	\$ 35,000.00
Continuing planting tube stock on the southern area and western embankment (approx 1000/year)	2	\$ 38,700.00
Landing for water quality monitoring	2	\$ 2,000.00
Signs detailing the Tjilbruke story and discussing the ship wrecks.	3	\$ 3,000.00
Bicycle racks at the most eastern car park	3	not calculated
Hexagonal permapine shelter near eastern car park containing six information signs	3	\$ 14,000.00
Installing extra pipes if required	4	\$ 60,000.00
Investigate the need for boardwalks, bird hides and biodiversity corridors	4	not calculated



6. Monitoring program

Measuring the effects of actions taken as part of a management plan is an essential element of any plan. Monitoring may be costly and needs to be undertaken over a long period of time, so requires careful planning.

When restoring tidal marsh, intensive monitoring is generally recommended for 3 to 7 years, depending on the speed of recovery. Less intensive monitoring may be informative for up to 20 years after a management action has taken place. Many of the attributes that require monitoring will depend upon commitment from members of the management committee. This commitment may be in the form of financial aid, or it may be in the form of labour.

Most of the procedures selected for this monitoring program have been selected using the criteria below;

- How useful is the data?
- Do we really need to monitor it?
- How much time or financial outlay is required to complete this action?
- Do the benefits outweigh the costs?
- Are the procedures repeatable and likely to be consistent between monitoring groups?
- If the management plan is not accessible, are the methods and justification publicly available?
- Are similar monitoring actions occurring elsewhere, so that the results may be compared?
- Is it possible for community groups to complete test actions if required?

Due to the limitations enforced by the criteria, most of the methods and justifications used in this monitoring program are selected from the *Waterwatch SA Estuarine Monitoring Guidelines* (Coleman and Cook, 2003). This handbook is available from the South Australian EPA or the State Waterwatch office.

The matrix presented over the page illustrates the monitoring program. It shows the parameters to be monitored, and the required frequency of monitoring. Monitoring may be done for a wider range of attributes than those listed in the matrix, and may be done more frequently, if there are sufficient time and resources. The suggested program provides the basic data required to quantify any changes and maintain the ecological health of the Cove. More frequent monitoring of hydrology will be needed immediately after any changes to the inlet pipes are made.

Other attributes of interest may include bacterial monitoring, if septic-based toilets are installed near the Cove or stormwater is allowed into the site. SARDI representatives have noted that fish monitoring may be useful to determine any changes in the role of Mutton Cove as a fish nursery, however this type research may require trained personnel and external funding.

Monitoring in the Cove is currently being conducted by Waterwatch volunteers. Their monitoring results are currently reported to the KESAB Waterwatch regional



coordinators. Waterwatch has agreed to forward the results of the Mutton Cove monitoring to the Steering Committee. The Waterwatch estuarine kit currently used in Mutton Cove contains most of the equipment required for this monitoring program. Other equipment has already been installed, or may be obtained cheaply when required.

Table 12 - Suggested monitoring program

Frequency → Attribute↓	Once only	Monthly	Seasonally	Yearly	As needed, or desired
Sample site observations		X			
Water temperature		X			
pH		X			
Alkalinity		X			
Water clarity		X			
Water salinity		X			
Dissolved oxygen					X
Orthophosphate			X		
Ammonium			X		
Plankton bloom observation		X			X
Recording wading birds / raptors				X	X
Recording invasive species				X	
Mapping the salinity gradient				X	
Monitoring tidal gauges			X		
Measuring for sulphide					X
Monitoring an intertidal SAM bed					X
Monitoring mangrove expansion				X	
Studying saltmarsh plants				X	
Using aerial photographs to map habitat change					X



6.1 Sample locations

Sample locations may vary once management actions have been completed, however the current location for monitoring inside the Cove is slightly north of the inlet basin. For tidal monitoring in the Port River readings are taken from the tide gauge mounted at the outlet in the Port River.

While the current locations are appropriate for tidal monitoring, it would be advisable that a more permanent monitoring location for water quality sampling be established inside the Cove. The location should provide a stable platform for sampling, without requiring the sampler to climb steep embankments.

Once further sediment has eroded, a suitable location for water quality sampling may be a small landing or jetty built at the end of the low embankment which runs semi-perpendicular to the Cove. The end of this would need to be in water most of the time, with sufficient depth to occasionally monitor water clarity (2-5m). Measuring this parameter is currently impractical at the inlet basin.

The proposed permanent water quality monitoring site is shown as a pink dot in the aerial photograph given below. The current locations (to be retained for tidal monitoring) are shown as blue dots.



Figure 36 - Sample site locations.



6.2 Data quality

Good quality data is essential for setting milestones and trigger thresholds for the Mutton Cove management plan. It is expected that data collected for this monitoring program will comply with a Waterwatch estuarine data quality of ‘advanced’ or ‘standard’, depending to the frequency of testing and the abilities of the samplers.

Taking representative water samples is discussed in depth in the Waterwatch Estuarine Guidelines (2003) and these procedures should be followed. Additionally, chemical water samples within the Cove are best taken while the tide is ebbing, otherwise the test results reflect Port River conditions more than Cove conditions. If desired, additional samples may be taken outside the Cove, or extra sample events may be performed.

6.3 Sample site observations

Ideally, monitoring events should all be undertaken at a similar time of day on calm, sunny days that are not excessively hot, however this is not always practical. To compensate for variations in climate and other attributes, sample site observations should be recorded when any form of monitoring is undertaken. These attributes provide the analyst with some context for the monitoring results. Lower bird counts may be expected on a cold rainy day or during a school visit, and lower water clarity may occur if the day has been fairly windy.

Sample site observations are a significant part of a monitoring program. Field personnel should record the weather, tidal data, surface water conditions and any odours or observations using the Waterwatch estuarine site record sheet. In addition to the standard Waterwatch estuarine site observations, the Mutton Cove samplers should record the tide height on both the inside and outside tidal gauges, and note any oily scums on the water surface.

Events that trigger a response from the management body include the presence of extensive oil slicks on the surface (not just mangrove oils), unusually high tides, or an unexpected difference between internal and external tide heights.

6.4 Temperature, pH, alkalinity, salinity and clarity

These four attributes provide an indication of the success of the project, as they indicate the retention times, flushing and sedimentation occurring within the Cove. These attributes also interfere with some of the chemical tests, so should be measured whenever any chemical parameters are collected. They are also useful if recorded separately, without any other tests being completed.

The ranges expected for each of these parameters at the designated sample point(s) are shown in the table below. If the results fall outside these ranges, test the parameter again, then report the abnormality to the management body.



Table 13 – Physical water quality ranges

Attribute	Low	High
Temperature (°C)	10	30
pH	7	9
Alkalinity	90	No upper limit
Salinity (g/L)	30	70
Water clarity	3 events less than 2m, or 1 event less than 0.5m.	No upper limit.

Water colour and water depth are interesting parameters, and may be measured at the same time as water clarity, however there are no trigger thresholds for these readings, as they are for information only.

6.5 Dissolved oxygen

Problems with low dissolved oxygen are not envisaged at the southern end of the Cove, due to the high flow caused by the tidal restriction. If these problems occur, they are more likely in the northern end of the Cove, where there may be insufficient tidal flushing. Measuring dissolved oxygen will be required if fish kills, low water clarity or strange smells are noticed.

The dissolved oxygen test is a multi-step titration, and the test kit is provided in the Waterwatch Estuarine Kit. While there are plenty of tests in the kit, each test takes a considerable amount of time. An alternative is purchasing a DO meter, which is expensive. Due to these limitations, it is advised that these tests be done only when other readings or observation suggests that low dissolved oxygen may be a problem.

Trigger thresholds for dissolved oxygen are concentrations below 3mg/L, as this indicates that the cause of the events discussed above may be a lack of oxygen in the water (hypoxia). Increasing tidal flushing should reduce the potential for this kind of damage to occur. However, should low dissolved oxygen be a regular occurrence, the management body will need to determine the cause.

6.6 Orthophosphate and ammonium

These parameters are measures of nutrient enrichment. The Waterwatch estuarine kits include these two parameters using test kits appropriate for saline waters. Together the tests provide a good indication of eutrophication. The ammonium test is particularly relevant to Mutton Cove due to the large amounts of ammonia that enter the Port River from sewerage and industry. Orthophosphate helps characterise the sources of pollution entering the Cove and indicates the likelihood of toxic blue-green algae blooms.

Levels of orthophosphates more than 1mg/L-PO₄ or levels of ammonium greater than 0.5mg/L-NH₄ are considered high in estuarine ecosystems. Unfortunately there is little that can be done about high nutrients within the Cove, unless water quality in the Port River is improved. These tests are done for the purpose of informing the management body, and other government agencies. In this way, the results of improvement programs for Port River water quality may be measured.



In the case of very large spills of pollutants such as ammonia or superphosphate in the river, it may be possible to block the inlet pipes to the Cove until the tidal exchange renders the river water suitable to allow into the Cove again.

6.7 Plankton bloom observations

Plankton bloom observations are a simple method used for assessing the long-term health of an ecosystem, particularly during summer. Some types of blooms indicate a range of problems in an estuary, whereas others are a natural part of the nutrient cycle.

If in doubt about the type of plankton bloom you are looking at, take a 500mL water sample, chill it and take it to someone who can identify the animals or plants causing the bloom. A record of these blooms should be kept, and if any toxic blooms are identified, then the management body should be notified and access to the water in the Cove should be restricted.

6.8 Recording wading birds and raptors

Mutton Cove is considered an important wading bird habitat. It is also a good site for observing raptors. Greater plant diversity and more shelter is likely to encourage more regular hunting and nesting of both raptors and waders in the area.

Observations of the waders and raptors frequenting the site provide an indication of the species diversity and dominance of each species. Many bird species have known habitat preferences, so this is a further indication of changes happening within the Cove. If the diversity or number of birds visiting the area reduces over a period of 3 or more observations, steps should be taken by the management body to identify why this is occurring.

6.9 Recording invasive species

Invasive species of plants and animals may significantly damage a small site like Mutton Cove. There is also a legal obligation to control or report some species, and this needs to be considered by the management body. Complete lists of terrestrial invasive species are available on weed and pest control board websites, and leaflets are available from most urban councils. A list of marine pests in South Australia is provided by PIRSA at http://www.pir.sa.gov.au/pages/sus_res/mar_hab/pests.htm.

6.10 Mapping the salinity gradient

This activity shows the degree of tidal flushing occurring within the Cove, and reveals areas that may require more or less flushing to support the desired habitat ranges. This type of mapping only needs to be done occasionally, as changes will only occur to the salinity gradient with major changes to hydrology or over a long period of time. Seasonal variations occur, so it is important to record what the weather has been like over the week prior to monitoring a salinity gradient. Winter is the most stable period to monitor the salinity gradient.



A general map of the salinity gradient, using 6 monitoring sites, should be undertaken whenever changes are made to the inlet pipes, or once every couple of years. The information from this type of monitoring is used to support other data, so there is no trigger threshold for this monitoring action.

6.11 Monitoring tidal gauges

Regular monitoring of the three tidal gauges (1 outside, 2 inside) is an important part of the monitoring program. These may either be set up to measure maximum tide heights only, or they may be monitored over a 2-8 hour interval to provide lag times or tidal curve shapes. These parameters indicate the degree of tidal restriction experienced at the inlet entry and can be related to the spread of mangroves and samphire communities within Mutton Cove.

The tidal gauges will need resurveying whenever earthworks are completed in their vicinity, or every 2-4 years. Resurveying may be completed with a laser level hired from Kennard's, or sourced from members of the management body. A spirit level or plumb-line will also be required to ensure the gauges are as close as possible to vertical. The nearest reference benchmark, BM 6628-35574, is located on the seawall in the northern part of the site. It has a reduced level of 2.79m AHD.

The gauges are easily adjusted using a hammer or by removing and replacing the plastic measurement sheet. These sheets will fade over time, and may need remarking with a permanent marker or with spray paint. The marks have been etched onto the measurement sheets, so repainting the marks should be simple, and should not affect the accuracy of the gauge.

Tidal monitoring is conducted seasonally. The high water mark on the inside and outside gauges should be recorded, as well as the depth of flooding at the saltmarsh tidal peg. The outside gauge will record a higher water mark than the inside gauge.

Table 14 - Tidal difference table

High water mark on River gauge	Expected difference between River gauge and Cove gauge
Tides below 1.2m AHD	25 cm to 50 cm
Tides above 1.2m AHD	50cm to 100cm

Differences larger than the ranges specified above may occur in exceptionally high tides. Usually, however, differences larger than the ranges in the table indicate that the pipes may have become blocked, and may need unblocking. Differences less than the smallest difference provided in the table above are also undesirable, as they mean that the site may be receiving too much tidal inundation, and flow may need reducing. If a trend of larger or smaller differences is noted over three sampling events, the results should be provided to the management committee, for further investigation.

6.12 Measuring sulfide

Sulfides are present in the sediment of most waterways, however they are not usually detectable in the water, where most sulphur is present as sulfate. If sulfide is



detectable in the water, there has either been a large storm event or the site has ‘turned over’. An estuary turns over when low dissolved oxygen levels allow anaerobic bacteria to rise to the surface, bringing sediment from the bottom of the waterway with them. The sulfide test can detect that there has been an anoxic (no oxygen) event for a long time after dissolved oxygen levels start to rise again. This makes the sulfide test useful if there are fish kills, unusual odours or very dense plankton blooms.

6.13 Monitoring an intertidal SAM bed

Prior to excavations near the pipes, several small beds of either *Ruppia* or *Lepilaena* survived on the semi-solid sediment in the creek bed between 20m and 200m from the inlet pipes. These beds were not disturbed during the excavations, however some of them have been eroded due to the increased flow. It is expected that the area this vegetation covers will decrease as sediment build-up erodes; however in the longer term the habitat area should increase, due to the changes in water quality resulting from better flows.

Growth of these beds is an ecological benefit to the Cove. They decrease erosion and indicate low sedimentation rates. Loss of these plants in the long term is an undesirable thing, as it would indicate that the area was not stable, was subject to freshwater inundation or was experiencing high turbidity. There should be signs of increased areas of *Ruppia/Lepilaena* beds within the next 3-7 years.

Due to the small areas these beds cover, several methods could be used to map them, depending on the preferences of the monitoring group. Quadrats work particularly well, and could be done in a single line running up the middle of the creek at low tide. Otherwise the growth of the beds may be monitored using high-resolution aerial photography or by setting up a photo point in an appropriate location.

6.14 Monitoring mangrove expansion

Mangrove expansion is a desired part of this management plan, however expansion that extirpates the samphire community is not appropriate. The size and distribution of mangroves within the Cove are important aspects of ensuring management actions have the desired response.

A photo point has been placed at the end of the perpendicular embankment, looking northwest along the Cove. The location for the photopoint is shown on the aerial photograph in Figure 37. A wooden stake has been driven into the ground where it can be seen in the photographs; with a known amount protruding above the ground (1m). This will provide a scale in the photographs. Another short stake has been driven into the embankment so that a camera may be placed on top of it. These stakes will need painting occasionally to prevent deterioration.

Heights and breadths of the mangrove fringe should be calculated from these photographs, using the scaling stake as a gauge. A new photo point may be established as the mangrove zone expands.



6.15 Studying saltmarsh plants

There are a number of plant species of conservation significance or interest within the Cove. Most of these species occur within the saltmarshes or on the small dunes, with the *Acacia cupularis* occurring on the higher, grassy areas. The vegetation in the saltmarsh and dune areas is likely to change significantly with any hydrological changes, and these changes are unable to be modelled accurately using current scientific knowledge.



Figure 37 - Map of transect and photo point locations.

It is unlikely that large areas of adult plants will die due to the changes that have occurred in hydrology; however there will be an almost immediate effect on the number of seedlings and young plants (McComb *et al*, 1995). To identify changes in the areas of saltmarsh, samphire species need to be identified to genus level. Surveying these areas during October to November makes this considerably easier. Significant species need to be identified to species level. A herbarium folder has been supplied to the Steering Committee so that the pressings can be compared to plants in the field.

A 100m transect has been set up in the southern samphires, and its location is marked in Figure 37. These have been surveyed, and the beginning and end points have been marked with wooden pegs and orange tags. The start peg is on the embankment (0272151E, 06148603E, Australian Map Grid), and the end point is not far from the tracks left by off-road vehicles (0272229E, 6148556N).

When identifying plants, the identity and distribution of the small plants or seedlings is important, even if they are only identified to genus or family level. This is where changes will first appear. At least two years of data will be required before changes to



the vegetation will be noticed. Frequent comparisons and graphical representations of the data will be required if changes are to be noticed and acted on rapidly.

Only one transect was selected, to minimise trampling damage to the saltmarsh. Should boardwalks be constructed in place of tracks in the saltmarsh areas, these will form useful platforms for additional vegetation transects.

The area of fill south of the Cove has particularly poor vegetation in its current state, however community members have put in a large amount of work growing and planting threatened species in this area. The progress of these plantings needs to be monitored to assess the effectiveness of these plantings and to confirm methods for future planting. A grant application suggests that a photo point is already being used in this area.

6.16 Using aerial photographs to map habitat change

Aerial photography is the easiest method of identifying the extent of gross habitat change. A simple classification of georectified aerial photography into three classifications (Mangrove, samphire and creek lines) will suffice, however division of samphire into mid marsh and low marsh is desirable. High marsh will probably be restricted to the cheniers and embankments only, so does not need classifying within the tidal section. Its presence and approximate distribution will be identified in the manual vegetation surveys.

Low marsh is generally a *Sarcocornia* dominated shrubland with a smooth texture, whereas mid marsh areas are *Halosarcia* and *Sclerostegia* shrublands, which often have a rougher texture.

Table 15 - Ideal habitat percentage ranges

Habitat type	Lowest %	Highest %
Mangrove	6	40
Samphire	40 (20:20)	89 (50:39)
Creek lines	5	20

Table 15 shows the desirable ranges of the different habitat types. The samphire percentages are also presented as mid and low marsh percentages, in brackets.

6.17 Monitoring program trigger levels

In most circumstances, the volunteers undertaking the monitoring program should send a copy of their records to their local Waterwatch coordinator, who will make the results available to the Mutton Cove management body.

When observations are outside the normal range of readings, this triggers a range of actions. These are outlined below.



Parameter	Trigger	Action
Sample site observations	Large oil slicks are visible in the Cove or the Port River adjacent to the Cove.	Ring the chair of the management committee, and if they advise it, the Environment Protection Authority. It may be necessary to obtain oil booms from the Ports Corp store at the Royal Yacht Squadron, or block the Cove entry.
	Very high tides are predicted.	If overtopping of the embankment could occur, notify the chair of the management committee. Observe the tide during its rise, from a safe location. The management committee will use the information to guide their maintenance and upgrade plans for the embankment.
	Unexpected difference between the internal and external tides.	If there is a visible reason (blockage etc), notify the management body so that they may budget for repairing the problem.
Water temperature	Less than 10°C or more than 30°C	Repeat the test, and if still outside the range, mark the test sheet “for immediate copying to management body”
pH	Less than 7 or more than 9	Repeat the test, and if still outside the range, mark the test sheet “for immediate copying to management body”
Alkalinity	Less than 90 mg/L	Repeat the test, and if still outside the range, mark the test sheet “for immediate copying to management body”
Salinity	Less than 30 g/L or more than 70 g/L	Repeat the test, and if still outside the range, mark the test sheet “for immediate copying to management body”
Clarity	3 sampling events in a row of less than 2m, or a single event less than 0.5m	Repeat the test, and if still outside the range, mark the sampling sheet “for immediate copying to management body”
Water colour and depth	None – these tests help in the interpretation of other results.	
Dissolved oxygen	Less than 3 mg/L	Report on the sampling sheet the reason the test was taken (dead fish, strange coloured water) and the dissolved oxygen result. Mark the sampling sheet “for immediate copying to management body”. Should this occur more than once a year, it may be necessary to investigate the flushing patterns of the creeks in Mutton Cove, by mapping the salinity.
Orthophosphate	More than 1 mg/L PO ₄	This test helps assess the effectiveness of efforts to improve the quality of the Port’s waterways. In the event of large industrial spills, it may be wise to close the Cove’s inlets until the tidal exchange improves the river quality.
Ammonium	More than 0.5 mg/L NH ₄	This test helps assess the effectiveness of efforts to improve the quality of the Port’s waterways. In the event of large industrial spills, it may be wise to close the Cove’s inlets until the tidal exchange improves the river quality.
Plankton blooms	Toxic blooms trigger specific action	Record all algal blooms, and have ones that you are unsure about identified. If the bloom is toxic, ring the chair of the management body, and request temporary signage.
Mapping salinity gradient	This is a supporting activity, and does not have a trigger.	
Tidal monitoring	High water mark (“top of tide”) differences that are outside these ranges, over three sampling events trigger an action: For tides below 1.2m AHD the difference should be 25-50cm. For tides above 1.2m AHD the difference should be 50-100cm.	Mark the sampling sheet “for immediate copying to management body”. The committee will need to determine whether some alteration to the pipe works is required.
Sulfide	Any sulfide detectable in the water.	Report on the sampling sheet the reason the test was taken (dead fish, strange coloured water) and the sulfide result. Mark the sampling sheet “for immediate copying to management body”.



Parameter	Trigger	Action
SAM beds (optional monitoring)	Reduction in area of SAM beds over the next 2-3 years	Report the results of all SAM bed monitoring to your local Waterwatch coordinator. In the event of continued loss of area over 2-3 years, mark the sampling sheet “for immediate copying to management body”.
Monitoring mangrove expansion	No trigger. This monitors the success of increasing tidal inundation and provides data for future saltmarsh/mangrove remediation projects.	Copies of photographs should be provided for the Waterwatch regional coordinator and the management body.
Studying saltmarsh plants	Reduction of area of mid-high marsh specialist plants triggers an action.	The transect data should be examined by a saltmarsh ecologist annually. In the event of reduction in the area of mid & high marsh, the management committee may need to undertake direct seeding of appropriate areas, to establish new colonies of plants. Reduction of tidal flow may also need to be considered.
Using aerial photography (optional monitoring)	Over a 10-20 year period, the vegetation distribution and site morphology should stay within the following ranges: Mangrove 6-40% Saltmarsh 40-89% Creeklines 5-20%	Excessive colonisation with mangroves, at the expense of saltmarsh indicates that the tidal regime needs reducing.



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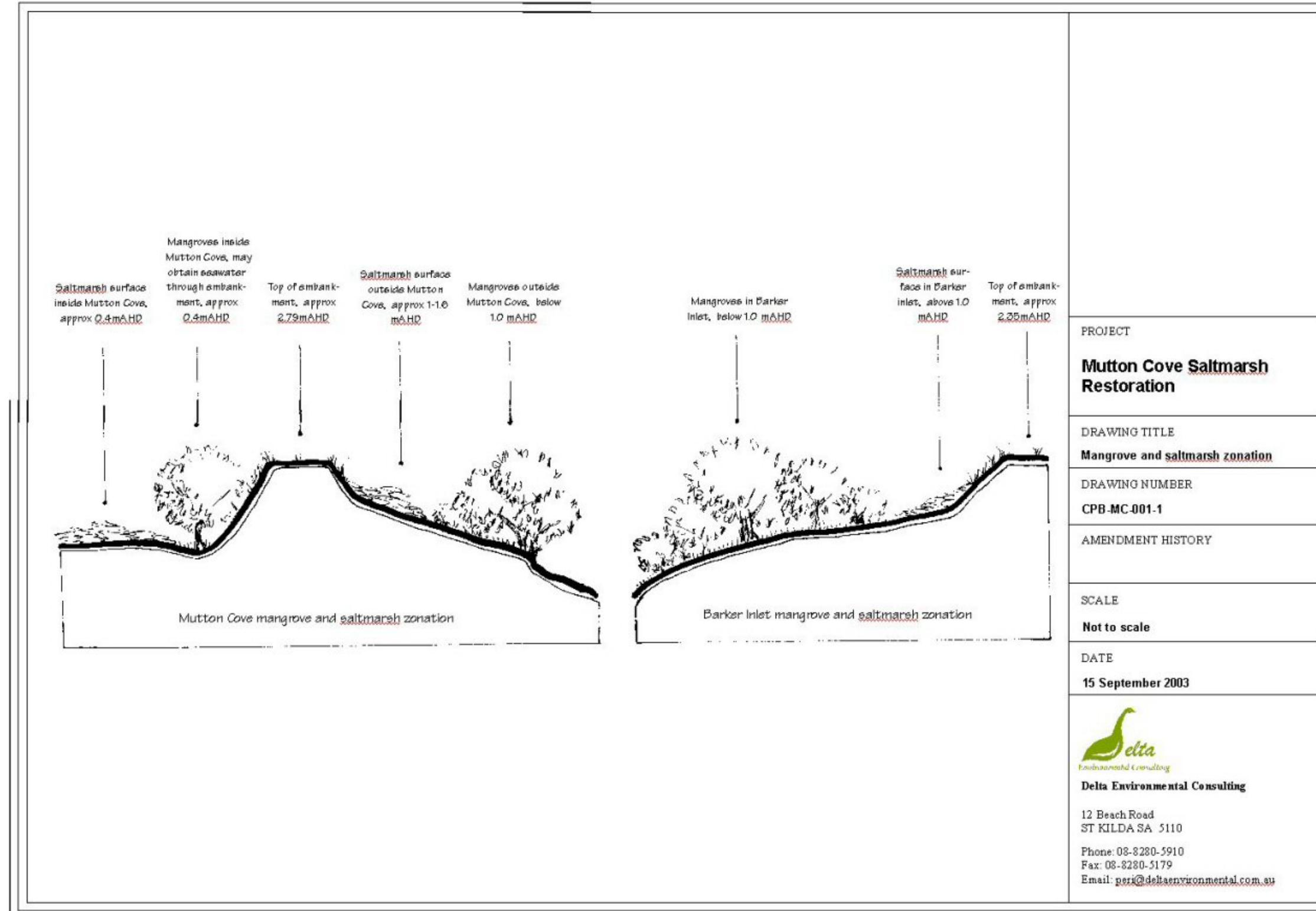
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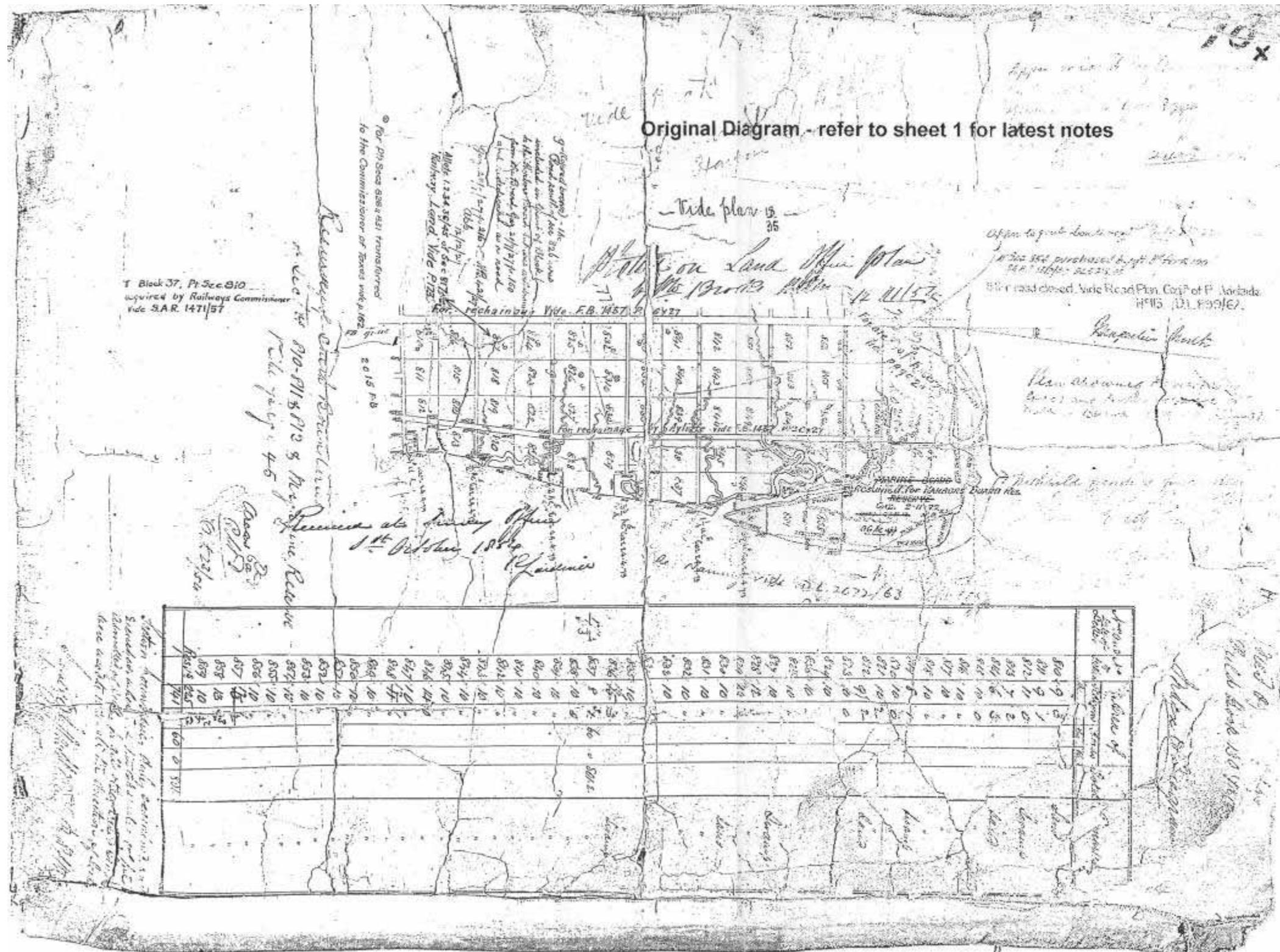


Appendices

Mangrove and saltmarsh zonation



Original survey of Mutton Cove



Tidal restriction data

Mutton Cove tide level data

11-Sep-03

Time	Mutton Cove gauge (mAHD)	Port River gauge (mAHD)	Mutton Cove gauge (converted to chart datum)	Port River gauge (converted to chart datum)	Outer Harbor tidal facility observations (chart datum)	Predicted tides (chart datum)
11/09/2003 5:19					1.99	1.99
11/09/2003 6:19					1.857	1.91
11/09/2003 7:19					1.494	1.67
11/09/2003 8:19					1.06	1.34
11/09/2003 9:02					0.79	0.82
11/09/2003 10:02					0.52	0.58
11/09/2003 11:02					0.38	0.5
11/09/2003 11:07	-0.12		1.33		0.39	
11/09/2003 11:22	-0.15		1.3		0.386	
11/09/2003 11:45	-0.19		1.26		0.379	
11/09/2003 12:00	-0.225		1.225		0.482	0.63
11/09/2003 12:10	-0.26		1.19		0.548	
11/09/2003 12:18	-0.28		1.17		0.554	
11/09/2003 12:35	-0.29		1.16		0.675	
11/09/2003 12:40	-0.3		1.15		0.691	
11/09/2003 12:45	-0.35		1.1		0.764	
11/09/2003 13:00	-0.36		1.09		0.939	1
11/09/2003 13:15	-0.29		1.16		1.038	
11/09/2003 13:30	-0.21	-0.2	1.24	1.25	1.15	
11/09/2003 13:45	-0.14	-0.08	1.31	1.37	1.239	
11/09/2003 14:00	-0.08	0.01	1.37	1.46	1.356	1.5
11/09/2003 14:17	-0.03	0.12	1.42	1.57	1.523	
11/09/2003 14:31	0.01	0.23	1.46	1.68	1.633	
11/09/2003 14:46	0.04	0.34	1.49	1.79	1.73	
11/09/2003 15:06	0.08	0.51	1.53	1.96	1.914	1.91
11/09/2003 15:18	0.11	0.6	1.56	2.05	2.008	
11/09/2003 15:31	0.13	0.73	1.58	2.18	2.075	
11/09/2003 15:45	0.16	0.85	1.61	2.3	2.169	
11/09/2003 16:02	0.19	0.92	1.64	2.37	2.26	2.28
11/09/2003 16:17	0.22	1.01	1.67	2.46	2.34	
11/09/2003 16:45	0.26	1.13	1.71	2.58	2.435	
11/09/2003 17:02	0.29	1.15	1.74	2.6	2.46	
11/09/2003 17:11	0.3	1.155	1.75	2.605	2.46	2.41
11/09/2003 17:16	0.31	1.16	1.76	2.61	2.459	
11/09/2003 17:30	0.33	1.14	1.78	2.59	2.441	
11/09/2003 17:47	0.35	1.13	1.8	2.58	2.425	
11/09/2003 18:03	0.36	1.08	1.81	2.53	2.395	2.3

Time	Mutton		Cove gauge (converted to chart datum)	Port River gauge (converted to chart datum)	Outer Harbor tidal facility observations (chart datum)	Predicted
	Mutton Cove gauge (mAHD)	Port River gauge (mAHD)				tides (chart datum)
11/09/2003 18:19	0.38	1.04	1.83	2.49	2.35	
11/09/2003 18:35	0.39	0.98	1.84	2.43	2.305	
11/09/2003 18:50	0.41	0.93	1.86	2.38	2.226	
11/09/2003 19:06	0.41	0.83	1.86	2.28	2.1	1.93
11/09/2003 19:20	0.42	0.72	1.87	2.17	2.015	
11/09/2003 19:42	0.42	0.55	1.87	2	1.835	
11/09/2003 20:00	0.42	0.38	1.87	1.83	1.691	
11/09/2003 20:11					1.585	1.46
11/09/2003 21:30					0.957	0.8
11/09/2003 22:30					0.685	0.43
11/09/2003 23:30					0.571	0.32

* red data are estimated figures

Inundation hydrology

Barker Inlet mangrove-samphire ecotone flooding frequency analysis, based on 2004 tide predictions

Tide height (chart datum m)	Frequency	Cumulative %	Flooding depth (cm)
2.4	12	8.22%	just wet
2.42	10	15.07%	< 2 cm
2.44	10	21.92%	2-4 cm
2.46	13	30.82%	4-6 cm
2.48	11	38.36%	6-8 cm
2.5	10	45.21%	8-10 cm
2.52	8	50.68%	10-12 cm
2.54	11	58.22%	12-14 cm
2.56	8	63.70%	14-16 cm
2.58	10	70.55%	16-18 cm
2.6	5	73.97%	18-20 cm
2.62	7	78.77%	20-22 cm
2.64	6	82.88%	22-24 cm
2.66	3	84.93%	24-26 cm
2.68	5	88.36%	26-28 cm
2.7	6	92.47%	28-30 cm
2.72	4	95.21%	30-32 cm
2.74	0	95.21%	32-34 cm
2.76	3	97.26%	34-36 cm
2.78	3	99.32%	36-38 cm
2.8	1	100.00%	38-40 cm
More	0	100.00%	>42 cm

Mutton Cove mangrove-samphire ecotone flooding frequency analysis, September 2003, prior to pipe cleaning, based on 2004 tide predictions

Tide height (chart datum m)	Frequency	Cumulative %	Flooding depth (cm)
2.65	2	8.33%	just wet
2.67	5	29.17%	< 2 cm
2.69	2	37.50%	2-4 cm
2.71	6	62.50%	4-6 cm
2.73	2	70.83%	6-8 cm
2.75	1	75.00%	8-10 cm
2.79	5	95.83%	10-12 cm
2.81	1	100.00%	12-14 cm
More	0	100.00%	>14 cm

Flora records

Voucher specimens collected at Mutton Cove

Mutton Cove

GPS accuracy:4m Vouchers collected: 2 of each, 1 lodged AD, 1 to client

Location Datum:Aust Geodetic 1966

Position format:UTM/UPS

Units:Metric

Collectors:Peri Coleman (COLP), Faith Cook (COOF)

DEH Permit No:

Delta code:PSC_CPB_09/03

Site ID	Voucher	Collector	Date	Easting	Northing	Family	Species	Common name	Exotic	Conservation significance
1	1COLP/COOF	September 29, 2003	272435	6149006	Compositae	<i>Arctotheca calendula</i>	Cape Weed	*		
1	2COLP/COOF	September 29, 2003	272435	6149006	Gramineae	<i>Stipa nitida</i>	Balcarra Grass			
1	3COLP/COOF	September 29, 2003	272435	6149006	Gramineae	<i>Critesion murinum</i>	Barley Grass	*		
1	4COLP/COOF	September 29, 2003	272435	6149006	Solanaceae	<i>Lycium ferocissimum</i>	Box thorn	*	Proclaimed weed	
1	5COLP/COOF	September 29, 2003	272435	6149006	Compositae	<i>Reichardia tingitana</i>	False Sow Thistle	*		
1	6COLP/COOF	September 29, 2003	272435	6149006	Liliaceae	<i>Asphodelus fistulosus</i>	Onion weed	*	Control required in some areas	
1	7COLP/COOF	September 29, 2003	272435	6149006	Euphorbiaceae	<i>Euphorbia terracina</i>	Carnation Weed	*	Proclaimed weed	
1	8COLP/COOF	September 29, 2003	272435	6149006	Chenopodiaceae	<i>Enchyalaena tomentosa</i>	Ruby saltbush			
1	9aCOLP/COOF	September 29, 2003	272435	6149006	Zygophyllaceae	<i>Nitraria billardierei</i>	Nitre Bush			
1	9bCOLP/COOF	September 29, 2003	272435	6149006	Umbelliferae	<i>Foeniculum vulgare</i>	Fennel	*		
1	10COLP/COOF	September 29, 2003	272435	6149006	Cruciferae	<i>Cakile maritima</i>	Sea Rocket	*		
1	11COLP/COOF	September 29, 2003	272435	6149006	Leguminosae	<i>Medicago polymorpha</i>	Burr Medic	*		
1	12COLP/COOF	September 29, 2003	272435	6149006	Gramineae	<i>Avena barbata</i>	Bearded Oats	*		
1	13COLP/COOF	September 29, 2003	272435	6149006	Gramineae	<i>Lolium perenne</i>	Perennial Rye Grass	*		
1	14COLP/COOF	September 29, 2003	272435	6149006	Gramineae	<i>Bromus diandrus</i>	Great brome	*		
1	15COLP/COOF	September 29, 2003	272435	6149006	Chenopodiaceae	<i>Salsola kali</i>	Buck bush Roly-poly			
1	16COLP/COOF	September 29, 2003	272435	6149006	Gramineae	<i>Parapholis incurva</i>	Curly Rye	*		
1	17COLP/COOF	September 29, 2003	272435	6149006	Gramineae	<i>Piptatherum miliaceum</i>	Rice Millet	*		
1	18COLP/COOF	September 29, 2003	272435	6149006	Aizoaceae	<i>Galenia pubescens</i>	Blanket Weed / Coastal Galenia	*		
1	19COLP/COOF	September 29, 2003	272435	6149006	Oxalidaceae	<i>Oxalis pes-caprae</i>	Sour sobs	*	Control required in some areas	
2	20COLP/COOF	September 29, 2003	272407	6148922	Compositae	<i>Cotula bipinnata</i>	Ferny Cotula	*		
2	21COLP/COOF	September 29, 2003	272407	6148922	Avicenniaceae	<i>Avicennia marina</i>	White or Grey Mangrove			
2	22COLP/COOF	September 29, 2003	272407	6148922	Chenopodiaceae	<i>Atriplex paludososa</i>	Marsh saltbush			
2	23COLP/COOF	September 29, 2003	272407	6148922	Liliaceae	<i>Dianella brevicaulis</i>	Black anther flax lily			
2	24COLP/COOF	September 29, 2003	272407	6148922	Chenopodiaceae	<i>Threlkeldia diffusa</i>	Coast Bonefruit			
2	25COLP/COOF	September 29, 2003	272407	6148922	Chenopodiaceae	<i>Rhagodia candolleana</i>	Sea berry Saltbush			
2	26COLP/COOF	September 29, 2003	272407	6148922	Aizoaceae	<i>Mesembryanthemum crystallinum</i>	Common Iceplant	*		
2	27COLP/COOF	September 29, 2003	272407	6148922	Gramineae	<i>Vulpia myuros</i>	Rat's tail Fescue	*		
2	28COLP/COOF	September 29, 2003	272407	6148922	Gramineae	<i>Ehrharta longiflora</i>	Annual Veldt Grass	*		
2	29COLP/COOF	September 29, 2003	272407	6148922	Leguminosae	<i>Melilotus indica</i>	King Island Melilot	*		
2	30COLP/COOF	September 29, 2003	272407	6148922	Aizoaceae	<i>Carpobrotus rossii</i>	Ross's Noon-flower			
2	31COLP/COOF	September 29, 2003	272407	6148922	Gramineae	<i>Rostraria cristata</i>	Annual Cat's-tail	*		
2	32COLP/COOF	September 29, 2003	272407	6148922	Cruciferae	<i>Brassica tournefortii</i>	Long-Fruited Wild Turnip	*		
2	33COLP/COOF	September 29, 2003	272407	6148922	Leguminosae	<i>Acacia cupularis</i> aff. <i>Acacia ligulata</i>	Coastal Umbrella Bush		A. cupularis: Rare in SL, A.ligulata: Poorly known	
2	34COLP/COOF	September 29, 2003	272407	6148922	Bryaceae	<i>Bryum sp.</i>	Moss			
3	35COLP/COOF	September 29, 2003	272386	6148841	Chenopodiaceae	<i>Sarcocornia quinqueflora</i>	Beared Samphire			
3	36COLP/COOF	September 29, 2003	272386	6148841	Chenopodiaceae	<i>Suaeda australis</i>	Austral sea blite			
4	37COLP/COOF	September 29, 2003	272399	6148812	Aizoaceae	<i>Tetragonia implexicoma</i>	Bower Spinach			
4	38COLP/COOF	September 29, 2003	272399	6148812	Labiatae	<i>Marrubium vulgare</i>	Horehound	*	Control required in some areas	
4	39COLP/COOF	September 29, 2003	272399	6148812	Plantaginaceae	<i>Plantago coronopus</i>	Buckshorn Plantain	*		
5	40COLP/COOF	September 29, 2003	272376	6148747	Malvaceae	<i>Lawrenzia squamata</i> (female)	Thorny Lawrenzia / Fan-leaved Lawrenzia		Poorly known in SL	
5	41COLP/COOF	September 29, 2003	272376	6148747	Frankeniaceae	<i>Frankenia pauciflora</i>	Common Sea-heath			

Site ID	Voucher	Collector	Date	Easting	Northing	Family	Species	Common name	Exotic	Conservation significance
5	42COLP/COOF		September 29, 2003	272376	6148747	Aizoaceae	<i>Disphyma crassifolium</i>	Round-leaved pigface		
5	43COLP/COOF		September 29, 2003	272376	6148747	Limoniaceae	<i>Limonium sp</i>	Sea lavender	*	
5	44COLP/COOF		September 29, 2003	272376	6148747	Compositae	<i>Senecio lautus</i>	Variable Groundsel		
5	45COLP/COOF		September 29, 2003	272376	6148747	Rubiaceae	<i>Galium murale</i>	Small Bedstraw / Small Goosegrass	*	
5	46COLP/COOF		September 29, 2003	272376	6148747	Convolvulaceae	<i>Wilsonia humilis</i>	Silky Wilsonia		Uncommon in SA and SL
5	47COLP/COOF		September 29, 2003	272376	6148747	Gramineae	<i>Lagurus ovatus</i>	Hare's tail grass	*	
5	48COLP/COOF		September 29, 2003	272376	6148747	Iridaceae	<i>Romulea minutiflora</i>	Guildford Grass	*	
5	49COLP/COOF		September 29, 2003	272376	6148747	Chenopodiaceae	<i>Halosarcia halocnemoides</i>	Grey Samphire		
6	50COLP/COOF		September 29, 2003	272203	6148494	Compositae	<i>Vittadinia gracilis</i>	Woolly New Holland Daisy		
6	51COLP/COOF		September 29, 2003	272203	6148494	Chenopodiaceae	<i>Maireana oppositifolia</i>	Heathy Bluebush		
6	52COLP/COOF		September 29, 2003	272203	6148494	Liliaceae	<i>Myrsiphyllum asparagooides</i>	Bridal creeper	*	Proclaimed weed
6	53COLP/COOF		September 29, 2003	272203	6148494	Gramineae	<i>Bromus rubens</i>	Red Brome	*	
6	54COLP/COOF		September 29, 2003	272203	6148494	Compositae	<i>Gnaphalium indutum</i>	Tiny Cudweed		Rare for SL
6	55COLP/COOF		September 29, 2003	272203	6148494	Compositae	<i>Hypochoeris glabra</i>	Smooth Cats ear	*	
6	56aCOLP/COOF		September 29, 2003	272203	6148494	Aizoaceae	<i>Mesembryanthemum nodiflorum</i>	Slender Iceplant	*	
6	56bCOLP/COOF		September 29, 2003	272203	6148494	Plantaginaceae	<i>Plantago lanceolata</i>	Ribwort	*	
7	57COLP/COOF		September 29, 2003	272121	6148349	Chenopodiaceae	<i>Halosarcia halocnemoides</i>	Grey samphire		
7	58COLP/COOF		September 29, 2003	272121	6148349	Chenopodiaceae	<i>Halosarcia halocnemoides</i>	Grey samphire		
7	59COLP/COOF		September 29, 2003	272121	6148349	Leguminosae	<i>Acacia cupularis</i> aff. <i>Acacia ligulata</i>	Coast Umbrella Bush		<i>A. cupularis</i> : Rare in SL, <i>A.ligulata</i> : Poorly known
7	60COLP/COOF		September 29, 2003	272121	6148349	Chenopodiaceae	<i>Sclerostegia arbuscula</i>	Shrubby glasswort		
8	61COLP/COOF		September 29, 2003	272220	6148323	Compositae	<i>Cynara cardunculus</i>	Artichoke Thistle	*	Control required in some areas
8	62COLP/COOF		September 29, 2003	272220	6148323	Cyperaceae	<i>Isolepis nodosa</i>	Knobby Club-rush		
8	63COLP/COOF		September 29, 2003	272220	6148323	Boranginaceae	<i>Echium plantagineum</i>	Salvation Jane / Pattersons Curse	*	Control / notification required in some areas
8	64COLP/COOF		September 29, 2003	272220	6148323	Asclepiadaceae	<i>Asclepias rotundifolia</i>	Broad-leaved Cotton bush	*	
9	65COLP/COOF		September 29, 2003	272254	6148363	Amaryllidaceae	<i>Narcissus tazetta</i>	Jonquil / Narcissus	*	
9	66COLP/COOF		September 29, 2003	272254	6148363	Iridaceae	<i>Freesia sp.</i>	Garden Freesia	*	
9	67COLP/COOF		September 29, 2003	272254	6148363	Leguminosae	<i>Retama raetam</i>	White weeping broom	*	
9	68COLP/COOF		September 29, 2003	272254	6148363	Gramineae	<i>Danthonia caespitosa</i>	Common Wallaby Grass		
9	69COLP/COOF		September 29, 2003	272254	6148363	Liliaceae	<i>Aloe saponaria</i>	Broad-leaved Aloe	*	
9	70COLP/COOF		September 29, 2003	272254	6148363	Leguminosae	<i>Vicia sativa</i>	Common Vetch	*	
10	71COLP/COOF		September 29, 2003	272240	6148391	Agavaceae	<i>Agave americana</i>	Century Plant	*	
10	72COLP/COOF		September 29, 2003	272240	6148391	Oleaceae	<i>Olea europaea</i>	Olive	*	Proclaimed weed
10	73COLP/COOF		September 29, 2003	272240	6148391	Cactaceae	<i>Opuntia sp.</i>	Prickly Pear	*	Proclaimed weed
10	74COLP/COOF		September 29, 2003	272240	6148391	Gramineae	<i>Cynodon dactylon</i>	Couch Grass	*	
10	75COLP/COOF		September 29, 2003	272240	6148391	Malvaceae	<i>Malva parviflora</i>	Small flowered marshmallow	*	
11	76COLP/COOF		October 10, 2003	272363	6148636	Myoporaceae	<i>Myoporum insulare</i>	Native juniper, or boobialla		
12	77COLP/COOF		October 10, 2003	272195	6148554	Umbelliferae	<i>Apium annuum</i>	Coast celery		
12	78COLP/COOF		October 10, 2003	272195	6148554	Gramineae	<i>Sphenopus divaricatus</i>	False hair grass	*	
12	79COLP/COOF		October 10, 2003	272195	6148554	Carophyllaceae	<i>Spergularia marina</i>	Salt sand-spurrey	*	
13	80COLP/COOF		October 10, 2003	272144	6148569	Gramineae	<i>Puccinellia stricta</i>	Australian salt-marsh grass		

Survey 30/05/02 Jerry Smith

	Common name	Common Name	SL
<i>Acacia cupularis</i>	Coast Wattle	Coast Umbrella-bush	R
<i>Acacia ligulata</i>	Umbrella Bush	Dune Wattle	K
<i>Acacia pycnantha</i>	Golden Wattle		
<i>Adriana klotzschii</i>	Coast Bitter-bush		U
<i>Atriplex paludosa</i> ssp. <i>cordata</i>	Marsh Saltbush		
<i>Atriplex semibaccata</i>	Berry Saltbush	Creeping Saltbush	
<i>Carpobrotus rossii</i>	Native Pigface	Karkalla	
<i>Danthonia setacea</i> var. <i>setacea</i>	Small-flower Wallaby-grass	Bristly Wallaby-grass	
<i>Dianella revicaulis</i>	Short-stem Flax-lily	Coast Flax-lily	
<i>Distichlis distichophylla</i>	Emu-grass	Australian Salt-grass	
<i>Dodonaea viscosa</i> ssp. <i>spathulata</i>	Sticky Hop-bush	Spoon-leaf Hop-bush	
<i>Enchylaena tomentosa</i> var. <i>tomentosa</i>	Ruby Saltbush	Barrier Saltbush	
<i>Frankenia pauciflora</i> var. <i>fruticulosa</i>	Southern Sea-heath	Common Sea-heath	
<i>Halosarcia halocnemoides</i> ssp. <i>halocnemoides</i>	Grey Samphire	Grey Glasswort	
<i>Halosarcia pergranulata</i> ssp. <i>pergranulata</i>	Black-seed Samphire	Black-seed Glasswort	
<i>Isolepis nodosa</i>	Knobby Club-rush	Knobby Club-sedge	
<i>Lawrenzia squamata</i>	Thorny Lawrenzia	Thorny Fan-leaf	K
<i>Maireana brevifolia</i>	Short-leaf Bluebush	Small-leaf Bluebush	
<i>Maireana oppositifolia</i>	Salt Bluebush	Heathy Bluebush	
<i>Melaleuca halmaturorum</i> ssp. <i>halmaturorum</i>	Swam Paper-bark	Salt Paper-bark	V
<i>Muehlenbeckia gunnii</i>	Coastal Climbing Lignum	Native Sarsaparilla	
<i>Myoporum insulare</i>	Common Boobialla	Native Juniper	
<i>Pelargonium australe</i>	Australian Pelargonium	Austral Storks-bill	U
<i>Puccinellia stricta</i> var. <i>stricta</i>	Australian Saltmarshgrass	Marsh grass	
<i>Rhagodia candolleana</i> ssp. <i>candolleana</i>	Sea-berry Saltbush		
<i>Salsola kali</i>	Buck bush	Tumbleweed	
<i>Sarcocornia quinqueflora</i>	Beaded Sam hire	Beaded Glasswort	
<i>Stipa mollis</i>	Soft Spear-grass	Supple Spear-grass	
<i>Stipa scabra</i> group	Falcate-awn Spear-grass		
<i>Suaeda australis</i>	Austral Seablite		
<i>Threlkeldia diffusa</i>	Coast Bonefruit		

Vegetation Species List for Mutton Cove Area (northern end of Mersey Road)

A compilation of reports prepared by the Department for the Environment, Heritage and Aboriginal Affairs (17/12197) and Rosemary Ferguson (2616199)

Species	Common Name	Conservation Rating
<i>Atriplex paludosa</i> ssp <i>cordata</i>	Marsh salt bush	
<i>Atriplex semibaccata</i>	Berry saltbush	
<i>Avicennia marina</i> var <i>resinifera</i>	Grey mangrove	
<i>Carpobrotus rossii</i>	Native pigface	
<i>Dianella brevicaulis</i>	Black anther flax lily	
<i>Disphyma crassifolium</i> ssp	Round leaf pigface	
<i>Enchytraea tomentosa</i> var <i>tomentosa</i>	Ruby salt bush	
<i>Frankenia pauciflora</i> var <i>fruiticulosa</i>	Sea heath	
<i>Halosarcia halocnemoides</i> ssp <i>halocnemoides</i>	Grey samphire	
<i>Halosarcia pergranulata</i> var <i>pergranulata</i>	Black seed samphire	
<i>Isolepis nodosa</i>	Knobby club rush	
<i>Maireana brevifolia</i>	Small leaved blue bush	
<i>Melaleuca halmaturorum</i> ssp <i>halmaturorum</i>	South Australian Swamp Paperbark	V
<i>Myoporum insulare</i>	Boobialla	
<i>Nitraria billardierei</i>	Nitre bush	
<i>Puccinellia stricta</i>	Australian salt marsh grass	
<i>Rhagodia candolleana</i> ssp <i>candolleana</i>	Sea berry salt bush	
<i>Sarcocornia quinqueflora</i>	Beaded samphire	
<i>Sclerostegia arbuscula</i>	shrubby samphire	
<i>Senecio lautus</i>	various groundsel	
<i>Spergularia</i> sp	Sand-spurrey	
<i>Stipa</i> sp	Spear grass	
<i>Suaeda australis</i>	Austral seablite	
<i>Threlkeldia diffusa</i>	Coast bone fruit	
<i>Wilsonia humilis</i> var <i>humilis</i>	Silky wilsonia	N, V

DEHAA LAND AT OSBORNE – PELICAN POINT, 17/12/97

Species	Common Name
<i>Acacia cupularis</i>	Cup wattle
<i>Acacia cyclops</i>	Western coast wattle
<i>Acacia pycnantha</i>	Golden wattle
<i>Adriana klotzschii</i>	Coast bitter-bush
<i>Asphodelus fistulosus</i>	Onion weed
<i>Atriplex paludosa ssp cordata</i>	Marsh salt bush
<i>Atriplex semibaccata</i>	Berry saltbush
<i>Avena sp</i>	Oat
<i>Avicennia marina var resinifera</i>	Grey mangrove
<i>Bromus sp</i>	Brome
<i>Cakile maritima</i>	Sea rocket
<i>Carpobrotus rossii</i>	Native pigface
<i>Carrichtera annua</i>	Ward's weed
<i>Centaurea melitensis</i>	Malta thistle
<i>Chondrilla juncea</i>	Skeleton weed
<i>Cirsium vulgare</i>	Spear thistle
<i>Critesion marinum</i>	Sea barley grass
<i>Cynodon dactylon</i>	Couch
<i>Danthonia caespitosa</i>	Common wallaby grass
<i>Dianella revoluta</i>	Black anther flax lily
<i>Disphyma crassifolium ssp clavellatum</i>	Round leaf pigface
<i>Distichlis distichophylla</i>	Emu grass
<i>Dittrichia graveolans</i>	Stinkweed
<i>Dodonaea viscosa</i>	Sticky hop bush
<i>Elymus elongatus</i>	Long wheat grass
<i>Enchytraea tomentosa var tomentosa</i>	Ruby salt bush
<i>Euphorbia terracina</i>	False caper
<i>Foeniculum vulgare</i>	Fennel
<i>Frankenia pauciflora var fruiticulosa</i>	Sea heath
<i>Gazania sp</i>	Gazania
<i>Galenia pubescens</i>	Blanket weed
<i>Halosarcia halocnemoides ssp halocnemoides</i>	Grey samphire
<i>Halosarcia pergranulata var pergranulata</i>	Black seed samphire
<i>Isolepis nodosa</i>	Knobby club rush
<i>Lagurus ovatus</i>	Hare tail grass
<i>Lycium ferocissimum</i>	Boxthorn
<i>Limonium sinuatum</i>	Notch leaf sea lavender
<i>Lolium perenne</i>	Perennial rye grass

<i>Lotus australis</i>	Austral trefoil
<i>Lawrenzia squamata</i>	Thorny fan-leaf
<i>Melaleuca halmaturorum</i> ssp <i>halmaturorum</i>	South Australian Swamp Paperbark
<i>Mesembryanthemum crystallinum</i>	Common iceplant
<i>Mesembryanthemum nodiflorum</i>	Slender iceplant
<i>Muehlenbeckia gunnii</i>	Coastal climbing lignum
<i>Myoporum insulare</i>	Boobialla
<i>Nicotiana glauca</i>	Tree tobacco
<i>Nitraria billardierei</i>	Nitre bush
<i>Oenothera stricta</i>	Evening primrose
<i>Olea europaea</i>	Olive
<i>Olearia axillaris</i>	Coast daisy bush
<i>Pelargonium australe</i>	Australian pelargonium
<i>Plantago coronopus</i>	Bucks horn plantain
<i>Poa labillardieri</i>	Common tussock grass
<i>Puccinellia stricta</i>	Australian salt marsh
<i>Reichardia tingitana</i>	False sow thistle
<i>Rhagodia candolleana</i> ssp <i>candolleana</i>	Sea berry salt bush
<i>Salsola kali</i>	Roly poly
<i>Sarcocornia quinqueflora</i>	Beaded samphire
<i>Sclerostegia arbuscula</i>	Shrubby samphire
<i>Senecio lautus</i>	Variable groundsel
<i>Solanum elaeagnifolium</i>	Silver leaf nightshade
<i>Spergularia</i> sp	Sand-spurrey
<i>Stipa</i> sp	Spear grass
<i>Suaeda australis</i>	Austral seablite
<i>Threlkeldia diffusa</i>	Coast bone fruit
<i>Vittadinia</i> sp	New Holland daisy

Flora permit



SOUTH AUSTRALIAN
NATIONAL PARKS AND WILDLIFE ACT, 1972

Department for Environment and Heritage
Heritage and Biodiversity Division
Biodiversity Branch
Biological Survey and Research Section
GPO Box 1047, Adelaide 5001 SA
1 Richmond Road, Keswick 5035 SA (Telephone 8124 4700 Fax 8124 4719)

PLEASE CARRY THIS PERMIT WHEN CONDUCTING RESEARCH

The SA Department for Environment and Heritage encourages scientific research both within the state's system of conservation reserves on our protected native plants and animals. It is only through increased scientific understanding that we can develop a soundly based system of conservation management for the state.

In carrying out such research projects, you should be conscious that you are manipulating a part of Australia's natural heritage and this carries certain responsibilities. Some of the more obvious responsibilities are outlined under the standard conditions listed below. In addition the Service would ask you to always conduct your research project in such a way as to have the smallest possible impact on the animals and their natural environment.

The Department for Environment and Heritage trust that this research project will be successful and looks forward to receiving a report of the results in due course.

Permit to Undertake Scientific Research

Project Title: Mutton Cove Saltmarsh and Mangrove Restoration

This permit is valid from 25/08/2003 to 31/02/2004 unless cancelled or revoked under provisions of the National Parks and Wildlife Act, 1972.

PERMIT CONDITIONS

The permit is issued subject to the following conditions

1. The permit does not authorise the collection of specimens from private property without the written consent of the landowner granted not more than six months beforehand.
2. The Ranger-in-Charge of parks listed in the permit shall be notified beforehand of the exact dates on which research will be undertaken within approved reserves. Details of any vehicles to be used in field work should also be provided. If, for some reason, dates are changed, the Ranger-in-Charge must be advised accordingly. For research in remote areas, the Ranger-in-Charge must be notified at least 14 days in advance of visiting the area.
3. Upon arrival in a reserve attended by a resident Ranger, the permit shall be shown to the Ranger before research is undertaken.
4. Samples collected shall be limited in size and taken where they will cause the least disfigurement or disturbance.
5. The number of specimens of any one species which may be taken is limited to the number specified in the permit, or where the number is not stated to the minimum required for the approved scientific research.
6. You as the permit holder are responsible for the actions of other persons who may undertake this research or collect specimens on your behalf.
7. Specimens collected shall not be exported from this State without the consent of the Director, National Parks and Wildlife.
8. Specimens or the progeny and carcasses of animals taken under the permit may not be sold or transferred without the written consent of the Director, National Parks and Wildlife and all such specimens shall be disposed of in the manner specified in this permit at the termination of the permit or a time specified by the Director.
9. Upon completion of the research, all equipment shall be removed from the reserve, unless specific approval to the contrary has been obtained.
10. Within 14 days of the expiration of the permit, the Director, National Parks and Wildlife must be given a full report (marked 'Attention: Research Permit Section'), including all collection data, on the research carried out under the permit. Numbers and locations of all specimens collected must be supplied, together with a progress report if the project is not complete.
11. If an account of the research is published, or information circulated, a copy of the account or information shall be lodged with the Research Permit Section, within 28 days of its publication or circulation.
12. Any permits involving research on vertebrates will require the approval of an official South Australian Animal Experimentation Ethics Committee as a condition of this permit.
13. When planning and conducting your research, please be aware that your work may intrude on locations or involve species with cultural significance to local Aboriginal communities. As part of your project planning it would be a courtesy, and in some cases a requirement, to consult with local Aboriginal representatives to determine any potential impacts and the means of avoiding or limiting them.
14. This permit will cease to have effect upon a determination that native title exists in any of the lands or waters covered by this permit to the extent that such determination affects those lands or waters.

Permit
Holder

Ms PSJ Coleman
Delta Environmental Consulting 12 Beach Rd
ST KILDA 5110 SA

PERMIT NO
E24706 1

Peri Coleman
Signature of Permit Holder

John Hill
John Hill, MP
MINISTER FOR ENVIRONMENT AND CONSERVATION

Additional Conditions:

GENERAL FLORA SURVEYS

Plant specimens are to be collected when validating a field identification, when a field identification cannot be reliably made, or if the specimen constitutes a new park species record, a significant range extension or an unusual form.

Advice on species likely to fall within these criteria, and recommended number of specimens is to be obtained from the appropriate specialist (eg from the Biodiversity Survey and Monitoring Section, Department for Environment and Heritage or the Plant Biodiversity Centre (State Herbarium). If such advice is not available then the specimen should be the minimum required to authenticate the record, ie one representative plant voucher specimen (representative is taken to mean a sample that includes foliage, flowers, fruits etc of sufficient quantity to meet State Herbarium standards).

In any case no more than ten percent of the visible local population (within an area of continuous habitat) is to be collected.

Collections of plant species classified as endangered, vulnerable or rare under the National Parks and Wildlife Act (SA) 1972, are to be kept to the minimum required to authenticate the record. Collection of additional material from these species must be anticipated prior to collection and specific approval sought.

MINIMUM DATASET

Researchers must collect at least a minimum set of data when carrying out biological studies under a Scientific Permit. The NPWSA Biodiversity Survey and Monitoring Group (BSM) has prepared guidelines, 'Scientific Permit Minimum Dataset', to ensure that the information collected is accurate, comprehensive and has relevance beyond the confines of the project for which it may have been originally intended.

Unless the recommended minimum dataset is collected, the information may be useless and is unlikely to be acceptable for addition into recognised, statewide environmental databases (e.g., DEH Environmental databases of SA (ESDA), South Australia Museum or Plant Biodiversity Centre). It is the responsibility of all researchers to maximise the use of the information they collect. This is especially important where studies involve the handling and interaction with animals, and the collection of plant and animal specimens.

Important Specimen

NSXCODE: 100-00000000000000000000000000000000

SPECIMEN: All plant species encountered

NUMBER/SIZE: Two individuals per species.

NUMBER
1024

LOCALITY:

Disposition:

Disposition

Vouchers w \$ 000 - 500

Affiliates

Faith Cooke

Please

Please contact these offices when going to Athelstone.

<http://www.elsevier.com/locate/jmp>

The story of Tjilbruke

THE WANDERINGS OF TJIRBRUKE

(extracted from Tindale, NB. 1987. The wanderings of Tjirbruke: a tale of the Kaurna people of Adelaide, *Records of the SA Museum*, 20:5-13.)

Tjirbruki and his fellow Pat pangga clansfolk were living at Tankulrawun near Rapid Bay. Tankulrawun (its name has the meaning of the Granite Place) was one of their summer camping places near Witawatang. Today Witawatang is known as Rapid Head.

There came an urge among some of the members of the band assembled there including some young visitors to go north and arrange a hunt for *kari* (or emus). Many *kari* were to be seen in the *ruwe* clanlands of the Tandanja people at Adelaide, because that big bird was their *naitji* or totem. They did not kill them although they feasted on their eggs.

Tjirbruki, who was a hunter skilled in kangaroo spearing did not wish to go, but his much loved *nangari* or sister's son, named Kulultuwi, who was visiting with him along with several companions did so wish. Kulultuwi called his mother's brother (*wannu* or *kawannu*) as did two other younger lads whom he persuaded to go along with him. Both Jurawi and Tetjawi bore the same relationship in Tjirbruki although they were by different mothers. They departed hastily. It may be assumed that their families accompanied them although the story, as told, often omits such details.

Tjirbruki not wishing to take part, shifted his camp more leisurely, moving through the *ruwe* of the Witjarlun clan which began near Karikalinga, a name still on the map as Carrickalinga. He arrived at Wituwatangk (now known as Brighton). He and his family were welcome visitors in the clan lands of the Jatabiling at Wituwatangk whose *pangkarra* (hunting territory) extended northward along the coast beyond the place now known as Outer Harbor. Tjirbruki spent much of his time at Wituwatangk fishing for *kurari*, also called *darawe* (beaked salmon, *Gonorhynchus greyi*). He used a special *nere* or net, termed a *darawenjeri nere*, with which several persons helped in the haul.

Meanwhile Kulultuwi and his companions, travelling ahead, had sought out, and quietly were driving several emus ahead of them without revealing their presence masking their moves by holding up shields of branches of eucalyptus leaves. They moved across the middle of the Mikawoma, the Adelaide plain, because they needed to keep the birds close to the coast so as to corner them at Muldang on the northern tip of the Outer Harbor Peninsula. Ancestors had made the Port River for them so that this could be

done. Four male *kari* and four females, known as *tartja*, were caught up in their drive. By keeping on the coastward side of the plain, the hunters were avoiding trespass on Tandanja hunting grounds because they had not received permission to take emus there. The hunt was going well.

However there was a disturbance. Near Patawiljank, now called Glenelg, some Jatabiling women were cooking herbs in their stone ovens. This caused the emus to turn away inland. Kulultuwi had to race around, going far into the Tandanja *ruwe* by way of Medaindi, now known as Medindie, to prevent the birds escaping from the trap. During this trespass Kulultuwi had killed a female bird. Some *kari* had escaped but others were successfully held over several days at Muldang while the men and their families fed on the body of the *tartja*.

While this was going on Tjirbruksi and other people with him had shifted camp to Tulukudangk, now called Kingston Park. From here he made short excursions inland. He saw the old tracks of emus and their hunters going north but also the fresh tracks of one male bird, he decided that this would be his bird to hunt, since according to custom the first to sight the presence of game had the right to take it. For a while he continued to fish, taking several further hauls of *kurari* for his journey.

Then Tjirbruksi left, following the track of his *kari* along the coast to Kareildug (Hallett Cove) and on to Tainbarang now Port Noarlunga, to Ruwarun (Port Wilunga) and to Witawali where the tracks turned inland. There, near Sellicks Hill, the old name of which has been forgotten, the tracks were lost.

Meanwhile the hunters decided to go back to the rest of their people. They arrived in Wituwatangk during a very heavy morning fog, found the camp empty and that Tjirbruksi had left.

Tjirbruksi, having lost all traces of tracks, and judging that the male bird would continue its movements southward along the coast, turned inland on a path which took him through the valley at Maitpanga (which still bears the name as Myponga), travelling to Mutaparinga, a place where there are many blackwood trees, continuing down the Hindmarsh Valley (Jaladula), and passing Jerltoworti, to Victor Harbor at Latarng. He still thought the emu might come around by the coast so he hid in ambush and watched for several days. No tracks appeared so he went back on his own trail and found a place where the old tracks had been covered by newer ones. There was good food for the bird here in the forest, far inland from his Witawatang camp at Rapid Head. In the distance he saw the smoke of a small fire and, heading in that direction, he heard the voice of Kulultuwi singing while one of the younger men was preparing a cooking Fire for an emu Kulultuwi had killed.

This was the bird which Tjirbruksi had been following and expecting to spear. He confronted Kululuwi claiming that his *nangari* had been wrong in killing his male bird. His own footprints should have indicated this to the younger man.

Kululuwi said, "Sorry, I did not know it was your *kari*. You saw the bird first. Cook it and take it home to your children".

Tjirbruksi replied, 'No! You killed it. You cook it and give us some of the meat'. He had some kangaroo meat and did not need the emu. Tjirbruksi then departed.

Kululuwi made ready the *wintjimi* oven, making the bed of hot stones, placing the green herbs over them, putting the bird on and covering it with further herbs and earth, and pouring on water to make much steam. After waiting for it to cook Kululuwi, as was customary, dug in and took out the head of the bird to see if it was ready when a sudden burst of steam blinded him. Thereupon his part brothers, Tetjawi arid Jurawi taking advantage rushed in, speared, and killed him.

The boys reasoned they had killed their *junalja*, or elder brother, because he had transgressed, having really known from reading the tracks that the bird belonged to their *wannu*. The youths cut off the meat'. from the bones of the bird and carried it to their own people of the Jatabiling clan. They left the body of Kululuwi. They told their folk that Kululuwi had done wrong. They used a northern word for emu implying that the bird meat was evidence that Kululuwi transgressed. Their people carried the body of Kululuwi to Warrpari (Sturt Creek) on the Adelaide plains near Marion where they continued the drying of the flexed body on a rack over a fire.

The youths made up a story that Kululuwi, in fear of the anger of Tjirbruksi, had gone away elsewhere to hunt further for emus. When this false story reached him at Rapid Bay, Tjirbruksi asked several members of the Witjarlung clan living north of his country give a message of forgiveness to Kululuwi. Although they knew of the death of Kululuwi they with malice, did not tell him the truth.

Searching for Kululuwi Tjirbruksi went first to Longkowar (Rosetta Head), the great bluff on Encounter Hay, then up Mulpapari the Inman River to Towarangk near Moon Hill and on to Maikabanangk near the coast at Normanville. His family had gone with him. Then he began to wander about by himself going as far as Nutarang (Lands End), at that little still in Kaurna country (according to informant Karlowan).

Heading north again, he came to the place near where he had seen Kulultuwi last and chanced to see some sugar ants on the track. He picked up some ants carrying human hair and others with blood and red ochre. Further on, he found more and knew in his thoughts that *nangari* was dead. He saw where the body had been, and where people had made a smoke fire. They had made a *tirukati*, or drying rack of poles tied together like a raft such as a man uses when fishing. On the third day they had, as was customary, covered the body with red ochre *tauwe* from Potartang. They had carried the bier towards Adelaide.

Having made these discoveries Tjirbruки said, 'I have only one spear properly fixed. I am off!' He left the place in the *wita* (peppermint tree forest) and went towards Rawarangal (Port Elliot). At Rawarangal he had opportunities, through his *nianiampe* (trading partners), to obtain good spears which had come from the Tanganekald people on the Coorong. On the way, while walking along the Mulapari (Inman River), he met Jorlu the red-backed kingfisher (*Halcyon pyrrhopygus*) man. On hearing his story Jorlu gave him a spear as did another man, Joldi, of the black cormorant (*Phalacrocorax carbo*) totem at the Finniss. Tjirbruки, with his new weapons, chose to follow tracks along the eastern side of the Mount Lofty Ranges through Peramangk tribal country, keeping to their eastern boundary to avoid serious trespass. On the way he camped at Wiljauar near Strathalbyn then at Peiera (Woodchester Waterfall), then at Motonengal (Mount Barker), and at Barukungga, now the mining township of Brukunga. Travelling on through places not now remembered, he came to Kalia (Gawler) which was the beginning of Tandanja clan country. Keeping near the coast he travelled south. He had learned where a big camp (*taldamari*) was gathering al Marion on Sturt Creek. he arrived. very weary, at Witawatangk.

Children saw him and cried out, 'Here is old *mutarii*'. Old father's mother's brother soon was the centre of a gathering and he told them he would stay to rest only the one night. He saw that the two men, Jurawi and Tetjawi were present. Acknowledging that Kulultuwi was dead, they deceived Tjirbruки about the real killers. blaming his death on strange people who might have been Peramangk tribes-folk who had come along the Mount Lofty Range.

Tjirbruки ignored their implications, knowing that they were lying. He practised deception also, saying, 'Yes! I know! Strange men came from the *wirra* (forest) country in the north'. He thus made out that he thought the young men were innocent. On the following day Jurawi and Tetjawi with their families made a part day's journey to Warrpari (the Sturt Creek at Marion) where they settled in at the big *taldamarii* hut. The body of Kulultuwi was still being smoke-dried there on a rack. In the evening they

began *kuti* (dancing) for the old man and he initiated others. Then he sang the whole camp to sleep. He tested them by calling out, 'Come! Give help with a haul of *kurari* fish'. There was no response and the old man said, 'Ah! I've got you!'

Tjirbruksi was a master at fire-making. He took powdered stringybark tree bark *morthi* (tinder) and set it round the *taldamari* with much grass, leaving only a small gap at the entrance. Then, using a *baruke* (iron pyrites) stone and a piece of flintstone (*paldari*), he started fires at each pile of *morthi* or tinder, telling the fire to blaze up quickly. He cried out loudly, 'You are getting burned! Camp on fire'.

The top of the *taldamari* began to fall in as it burned and all the people attempted to rush out. As children came out he kicked them with his foot and hit them with his club. Out came Jurawi whom he speared with a *wundi* or dread-spear, one set with quartz chips in resin on its head. The spear entered Jurawi right up to the *tungi* or swelling of resin set on the spear to prevent its too ready removal from the wound.

Out came Tetjawi whom he speared also and held in the fire. Only when he felt no further kicking did he accept that 'they were done'. He pulled out the spears and waited until morning as the *taldamari* burned to the ground.

Tjirbruke took the dried body of his *nangari* to Tulukandangk, a spring of good water on the beach of Kingston Park Reserve at Marino. There he completed the smoking of the body of Kululuwi and an inquest was held. Many people gathered for the ceremony. The names of the two killers were confirmed. Tjirbruksi learned that his *nangari* had indeed been struck down while raking the head of the emu from the fire, looking for tire steam coming from its bill, indicating the bird was cooked.

Carrying his burden, now a dry compact parcel. Tjirbruksi said, 'I go back now!' He departed walking along the coast to Kareildun, now called Hallett Cove, where he rested. As he reclined he began to think about his nephew and burst into crying (*kareildun*). Tears ran down his face and here they fell to [he ground a spring of water welled up (thus the spot became a camping place). Tjirbruksi then journeyed to Tainbaran (Port Noarlunga) where he burst into fresh tears. He went on to Potartang (Red Ochre Cove, Section 362, Hundred of Willunga) where he cried again; yet another spring of water came up. He then walked to Ruwarun (several hundred metres south of Port Willunga jetty). The tide was out. He sat down on the beach and cried once more. The *luki* (tears) dropped on the sand, causing a spring to appear. At high tide the sea covered it, but when the tide fell again the fresh water could be obtained by scraping in the sand. It remains so today.

The old man then carried the body to Witawali (on the beach north of Sellicks Hill). He noticed that there was a fine bay which would serve at night as a good netting place for sea salmon. His tears were still flowing and brought a spring into being there (vicinity of Section 639 Hundred of Willunga).

While there, Tjirbruksi began to think of further grudges and as he was passing through the *pangkara* of the Wiljarlung families it disturbed him that they had failed to pass on his message of forgiveness to Kulultuwi and his other nephews. Instead of continuing along the beach he turned inland and climbed over Sellicks Hill. He kept Maitpanga on his left and climbed another high hill (it may have been Mount Jeffcott or Black Hill). There he made a smoke signal. White smoke went straight up. People who were camped at a place called Warabati (saw the smoke and began to interpret its meaning:

Turtıl garwand werati. (Smoke plenty-going upwards.)

Korn loro kutu malbur undul. (Men/straight up/good news of killing.) (Loosely translated as 'guilty of murder' in Jaralde.)

Itji nel lund. (He is coming home.)

Tjirbruke made other fires as he picked up the answering smoke, and continued to do so until he was close enough to hear the people shouting. It was the camp of the men Limi and Ngarakkani.

Naitj purtulunul. (He is coming.)

Those who were still in their huts asking:

Janaleitj? (How far away?)

Nitj teipuland. (He is close.)

Tjirbruksi heard their questioning. He untied his bundle of spears taking as many as he could hold, and walked directly into the camp. A first spear he drove into Ngarakkani, another into Nenaratawi, a third into Limi, and the last one into Tulaki. (Even in those days it was proper to spear people in the legs unless murder was the direct intention). The men saw that Tjirbruksi meant mischief and all took headers into the water and turned into fish. Thus, in the sea off Naldenga today you will find Ngarakkani the gummy shark (*Mustelus antarcticus*), Limi the cobbler carpet shark (*Surorectus tentaculatus*), also Nenaratawi the southern fiddler (*Trygonorrhina guanerius*), and Tulaki, the long thin shark with the flag on it (which we have not identified although it perhaps is the cocktail shark, *Carcharhinus brachyurus*). These fish became the *ngaitji* or totems of members of the Witjarlung clan of the Kaurna tribe. Any other people who were present when Tjirbruksi took his revenge fled and

turned into birds, leaving only the old man there, alone. Satisfied, Tjirbruки stayed there a while and when his nephew's body was again dry enough to carry, he rolled it in a kangaroo skin and continued on his journey.

Tjirbruки came to Karikalinga (Section 1018, Hundred of Yankalilla), just south of the place known to Europeans as Carrickalinga Head. Here there was (and is, for informant Karlowan had seen it himself) a little swamp flat where *nuri* grows, very green like a reed. Rafts, called *kundi* were made of the dried stems of this plant (probably a *Typha*). Tied up in bundles, they were used along the Murray River.

Continuing his journey along the coast Tjirbruки went to Konarartinga where there is a *perki*, or cave. Just before he arrived at the *perki* he again sat down and cried: a small spring flowed there. He did not go into the cave but walked further on, a few hundred metres to the mouth of a small creek that is a camping place. He continued walking, sometimes on the shore and at other times above the cliffs, all the way to Parewarangk (now Cape Jervis). From Parewarangk he returned northwards along the foreshore below the cliffs and came to another *perki* (called Janarwing by another informant). It is close to the place from which you *janarwing* (turn back) because the water is too deep for one to pass along the shore.

Tjirbruки left his nephew's body outside and, walking into the darkness, found a place where there was a suitable ledge of rock. He put sticks up, just was done when the body was being smoked, carried the body in, placed it on the platform, and left it. He did not emerge from the cave but went on into the depths of the hill for a long way. He made the way wide enough for him to continue inside right up on top of the range at Wateira nengal (now Mount Hayfield). Emerging there he shut the 'airhole' where he came out. He 'fixed it up with gravel' to appear he had 'never come out there'. Going down to the foot of the hill he shook his body and dust came off him. This became the *mul kali* (yellow paint or ochre) which is used for decorating or 'making spears flash'. (A further comment from the informant: 'Gold has been found there. It may be from off him').

Tjirbruки arrived at Tjutjugawi (west of Mount Robinson), the camp of the Ramindjeri tribesmen Kengori of the *wanmarai* totem (ring-tail possum, *Pseudochirus peregrinus*). Kengori was a member of the Polumpindjeri clan and Tjirbruки received permission from him to take *wanmarai* so that he could make a skin rug for the coming winter. He was feeling old. He looked out and saw a swampy lagoon and said to himself, 'There is no use in my living like a man anymore'. However, he left the camp of Kengori (whose adventures, which became a separate story, took place after Tjirbruки departed). The old man walked along the southern shore of the Fleurieu Peninsula on land well above the sea until he came to the *koinkanja* or 'high hill' called Longkowar (Rosetta Head).

'This place will do for me', Tjirbruки thought. How will I do it?' The answer came. On a tree nearby there was a bird, a *kelendi* (the grey curawong, *Strepera versicolor*). He stalked the bird, killed it, plucked the feathers, and then rubbed the bird's fat over his own body. He recalled that Kelendi, when he was still a man, was a great messenger who travelled around the country singing songs and telling people of the coming meetings for initiation of their young men. Tjirbruки tied the bird's tail feathers on his arms with hairstring. Then he split the flesh between his big toes, and the third and fourth ones, made a run, and 'straight away started to fly'. As a Tjirbruke, which white people today call the glossy ibis (*Plegadis falcinellus*), his spirit still appears in bird form where there are swampy areas. His body became a *martowatan* (a memorial), a rocky outcrop at Barukungga (on Section 1887, Hundred of Kanmantoo) the place of 'hidden fire'.

Shipwrecks in the Cove

Text extracted from the Department for Environment and Heritage's Ships Graveyards website

http://www.environment.sa.gov.au/heritage/ships_graveyards/locating.html

JUPITER – Mutton Cove

The composite paddle steamer *Jupiter* was originally built as an iron barge, which was shipped in sections from Scotland and assembled by Henry Fletcher at Port Adelaide in 1866. It was imported specifically for trading on the River Murray, through the Mouth, but continued delays waiting for favorable conditions made the project unprofitable.

In 1868 an engine was installed at Goolwa, and the *Jupiter* converted to a side paddler measuring 110.0 feet (33.5m) in length, 19.5 feet (5.9m) breadth, 6.0 feet (1.8m) depth, 119 gross tons and rated at seven knots. For more than 30 years the *Jupiter* was employed on the Murray and Darling Rivers, regularly carrying bales of wool to ports including Morgan and Wentworth, from stations such as Lake Victoria, Tapalind and Cobdogla. The vessel also carried passengers, shearers and even sheep between river towns.

In 1903 the *Jupiter* became the mail steamer on Lakes Alexandrina and Albert, trading 40 miles across the lakes between Milang, Narrung and Meningie. During 1923 the owners, Messrs Dunk, tried to establish an excursion trade and had the vessel altered. When completed the *Jupiter* was 127 gross tons and was licensed to carry 164 passengers – 134 on deck and 30 in cabins. In 1930, when it was laid up at Milang, the *Jupiter* was the last regular trader on the lakes. After two years tied up at the Milang wharf, the *Jupiter* was eventually sold to F T Frinsdorf. On 27 February 1933 it negotiated the Murray Mouth on its way to Port Adelaide, reportedly arriving there under tow of the fishing cutter *Rapid* on 8 March.

During the next few months, the vessel was converted into a crayfish depot at Birkenhead. The funnels, engines and paddles were removed, with a landing platform built in place of the paddles. A 40 foot by 18 foot well was built into the steamer's old engine room and 5000 slots cut into the walls. As this area was largely below water level, these slots enabled sea water to wash through the four compartments of the well. The depot's capacity was estimated at 10 000 'fish'.

On 17 June 1933, with the conversions completed, the *Jupiter* was towed down the Port River to new moorings opposite the north end of the Outer Harbor Wharf. Fishing cutters operating in the Gulf were able to discharge catches of crayfish into the barge's wells, where they remained alive until required, thus regulating the market supply. The *Jupiter* is believed to have been the first floating fish depot in Australia.

In addition to the crayfish, any unusual marine specimens caught by the fishermen were also placed in the wells until they could be transferred to the Glenelg Aquarium.

The vessel's history from this time to the mid-1940s is not definite. What is known is that, after only a short time off Outer Harbor, the vessel was towed back upstream to Corporation Wharf, Port Adelaide, where it continued to store and trade in fresh crayfish, before being abandoned at Mutton Cove c1945. Today the hull is basically intact to deck level, but is predominantly covered by silt and the tides. Detached iron superstructure is lying off the stern.

EXCELSIOR – Mutton Cove

The screw steamer *Excelsior* was built in 1897 by Gourlay Brothers of Dundee, Scotland. The steel hulled vessel measured 131.0 feet (39.9 m) in length, 24.0 feet (7.3 m) breadth, 10.8 feet (3.3 m) depth and was 310 gross tons.

The *Excelsior* was originally registered in Sydney (1897) and employed on the north coast of New South Wales before its purchase by the Tahiti firm, L Ballands, with its register transferred to Papeete.

In 1904 the vessel was again registered in Sydney, and in 1908 was owned by South Australian flour millers, John Darling and Sons. By 1912 the *Excelsior* was owned by the South Australian Farmers Union Cooperative (registered in Adelaide) and remained under their ownership until 1933 when it was sold to the South Australian Harbors Board. The steamer was converted to a coal hulk, lightering coal to the steam powered dredges working in Port Adelaide.

As diesel-powered dredges took over from the coal-fuelled ones, the *Excelsior* was laid up, eventually being abandoned at Mutton Cove, on the northern end of the Lefevre Peninsula, in 1945. Today the remains lie embedded in mud, east of Outer Harbor. The rusting hull shows little sign of salvage. The bow is intact but sections of the stern have collapsed.

Signage at Mangrove Cove, Bunbury WA.



Mangrove Cove is a low-lying saltmarsh and mangrove area near Bunbury in Western Australia. The high ground in the fore of the picture is composed of mineral sands tailings dump, that has been revegetated. The site has been developed as an ecological visitation site, with signage, boardwalks and picnic facilities.

Sign 1 - Welcome to Mangrove Cove

Mangrove Cove has been developed to provide visitors with a unique insight into the maritime history of Bunbury and the magnificent ecosystem of the famous white mangrove colony.

“My name is Jack Jolly, a sailor off one of the ships that were wrecked on these shores 150 years ago. I’m still here in spirit to spin a few yarns about this important place in Bunbury’s history. Keep an eye out for me when you travel around. I’ll show you a **Mangrove Boardwalk, shipwreck** sites, a deserted island and lots of **wildlife**. There are plenty of seats and picnic shelters where you can put down anchor and take in the sights of Mangrove Cove.”

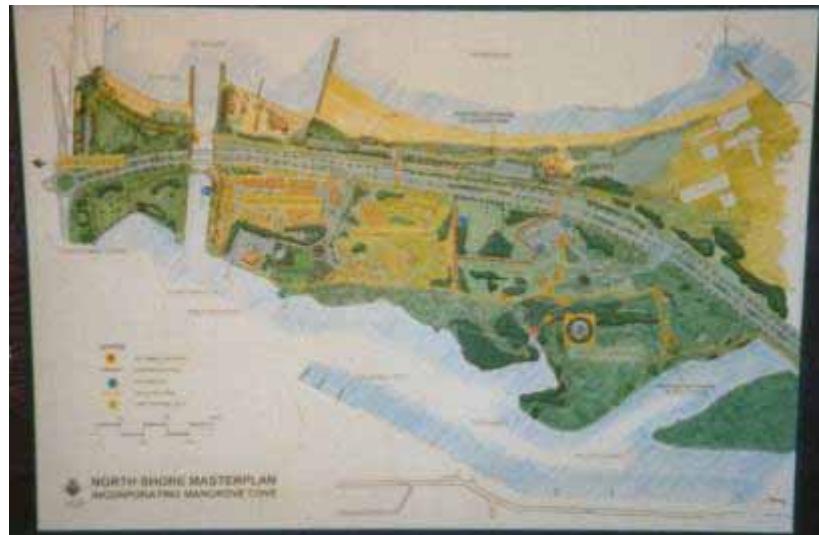
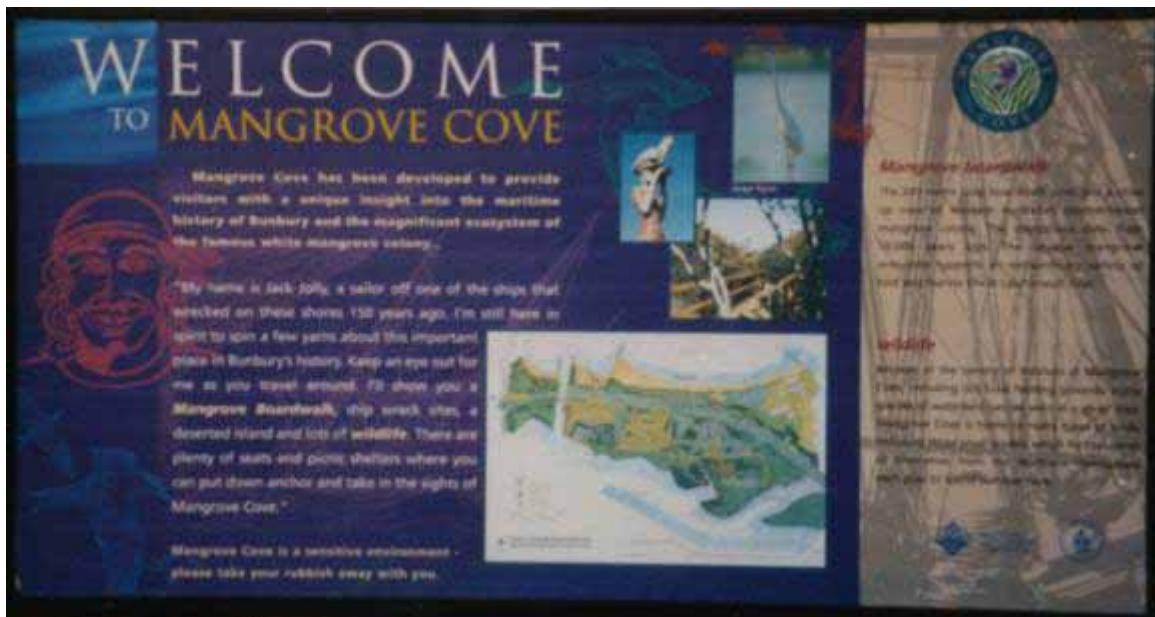
Mangrove Cove is a sensitive environment – please take your rubbish away with you.

Mangrove Boardwalk

The 200m long boardwalk gives you a close up view of Western Australia's southern-most mangrove colony. The mangroves date from 10,000 years ago. The unique mangrove ecosystem supports an extraordinary variety of bird and marine life in the Leschenault Inlet.

Wildlife

Because of the variety of habitats at Mangrove Cove, including rich tidal feeding grounds, many species of waterbird can be seen in a small area. Mangrove Cove is home to many types of birds, including three small waders that fly thousands of kilometres from the Northern Hemisphere each year to spend summer here.



Sign 2 - Mangrove Boardwalk

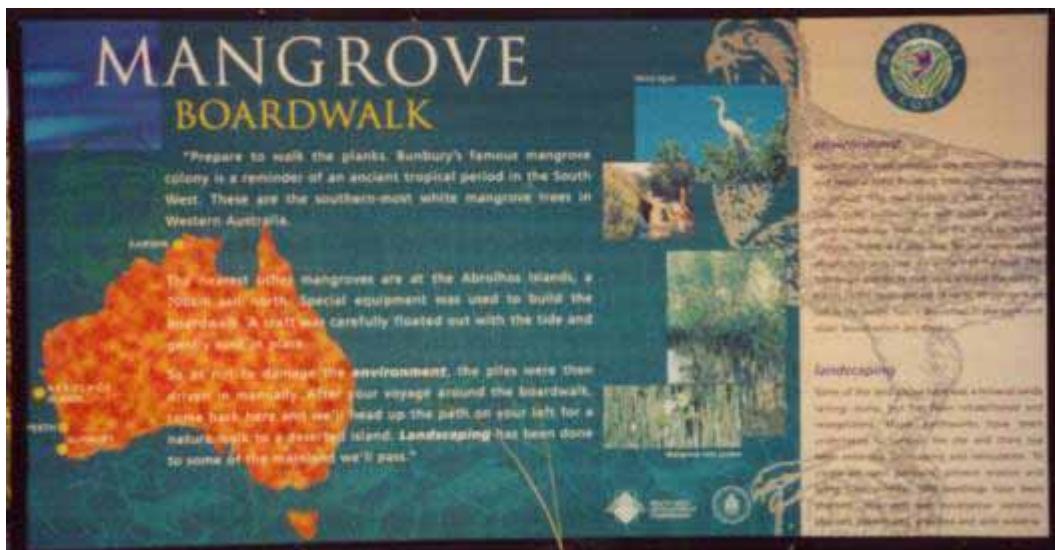
"Prepare to walk the planks. Bunbury's famous mangrove colony is a reminder of an ancient tropical period in the South West. These are the southern-most white mangrove trees in Western Australia.

The nearest other mangroves are at the Abrolhos Islands, a 700km sail north. Special equipment was used to build the boardwalk. A craft was carefully floated out with the tide and gently sunk into place.

So as not to damage the **environment**, the piles were then driven in manually. After your voyage around the boardwalk, come back here and we will head up the path to your left for a nature walk to a deserted island. **Landscaping** has been done to some of the mainland we'll pass."

Environment

Leschenault Inlet provides the protected shores and regular tidal inundation the mangroves need to survive. The root system is well adapted to salty tidal waters. You will notice pencil-like roots that rise high out of the mud to absorb oxygen. There are also line feeder roots, which absorb nutrients near the surface of the mud. The tide helps distribute nutrients around the colony. Filters in the roots get rid of up to 90% of the salt in the water. Salt is deposited in the bark and in older leaves, which are shed.



Landscaping

Some of the land above here was mineral sands tailings dump, but has been rehabilitated and revegetated. Major earthworks have been undertaken to contour the

site and there has been extensive landscaping and reticulation. To create and open parkland, prevent erosion and bring back wildlife, 1000 seedlings have been planted. You will see eucalyptus varieties, sheoak, paperbarks, grevillea and wild wisteria.

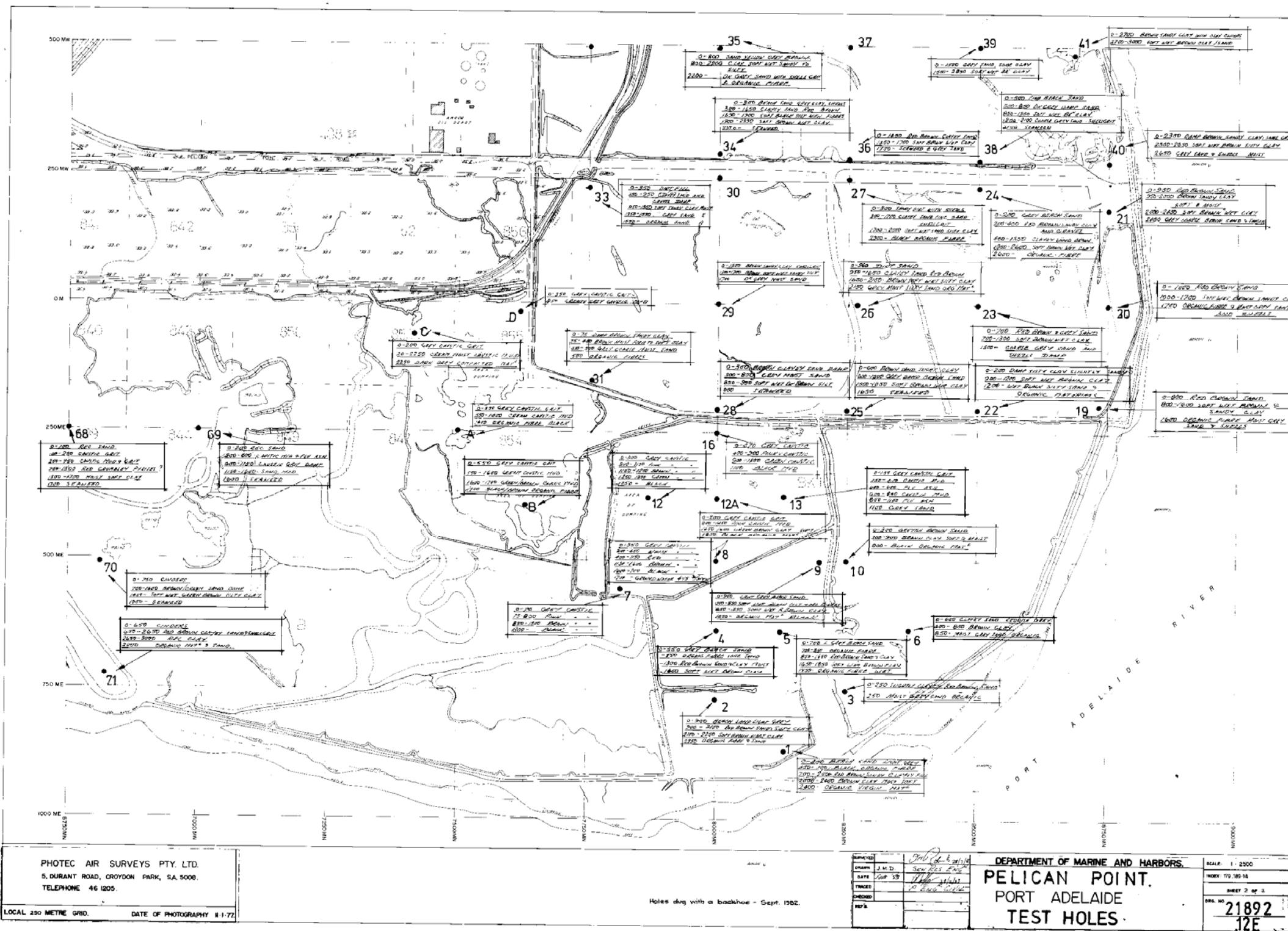
No further pictures were obtained although there was signage relating to features of the landscape and shipwrecks.

Sign 3 – Thank you for visiting

“I hope you enjoyed your tour of Mangrove Cove. Have your self a look in the car park for a memorial about the shipwrecks. If you’re keen to do more exploring, there are trails to take you along the inlet foreshore, Koombana Beach and into town. Across Koombana Drive is the Dolphin Discovery Centre, where you can learn about the ocean and maybe see a dolphin in the bay. Where you are standing was the shoreline in my times. The road just ahead is where I pulled my boat onto the beach all those years ago. You can set sail now. I’ll be waiting for your next visit to Mangrove Cove.”



Soil cores in filled areas of Pelican Point



Neighbouring blocks – matrix

The parcel numbers in the following table are displayed on a map below the table

Parcel number	Current land use & zoning	Vegetation and biodiversity assessment	Last known date of filling	Possible contamination issues	General notes
2 & 17	Biodiversity Park (east) Zoning MOSS (B)	Northern portion: Introduced grassland with isolated native plants. Opposite & south of aquaculture farm: fewer weeds and more diversity of native herbage, but very poor soil cover over Penrice grits. Scald areas east of block 17 has introduced Juncus. Block 17 has one old <i>Melaleuca halmatuorum</i> . Small area south-east of block 17 has excellent native vegetation including grass, herb, shrub and tree canopies. At least 2 large <i>Melaleuca halmatuorum</i> . South to Veitch Rd, recent seagrass and rye cover with some isolated native herbage.	Northern portion 1990-1991 Central portion 1992 Southern portion: undated cinders	Ash, cinders, caustic wastes (high pH in groundwater and soil matrix). Pyritic waste in small patches near the end of Mersey Road. The following may be present in elevated concentrations in the soil some areas: cobalt, nickel, copper, zinc and cadmium, based on studies conducted for the MFP. Groundwater may contain elevated concentrations (to varying degrees) of chromium, manganese, nickel, copper, zinc, molybdenum, cadmium, antimony and barium. PAH possible near the aquaculture farm.	The southern part of this block contains a lot of ash and cinders. This generally does not support much vegetation. Surface materials in the northern section mainly consist of caustic material and marine hydraulic fill. The caustic materials support only limited vegetation. Some other materials in this parcel include waste materials from the Osborne power station and Osborne gasworks site. Data from the Ports Corporation suggested that kiln dust from Adelaide Brighton cement was disposed of on this parcel. ICI wastes were deposited on the site after excavation of soils to, or below, groundwater levels. Subsequent to the placement of caustic waste to a thickness of up to 3 m, excavated soils were placed as a surface layer. It is generally considered that this area was filled up to and after 1987. A groundwater sample taken at the boundary of 2 and 40 had a pH of 12.3 and above background concentrations of selected metals. There was also above background levels of phenolics. Large quantities of hard waste have been dumped on this site.
3	Biodiversity Park (west), Zoning Rec (B) and MOSS (B)	This area of Biodiversity Park is already being managed and revegetated, so was not assessed for vegetation.	Northern portion, 1961. Southern portion, 1970's	Caustic wastes, ash and cinders, metals, PAH, phenols, particularly in the north-western corner	The majority of fill on this block is hydraulic fill. The surface materials on this block consist of general fill in the southern areas, but the north-western area has some ash and cinders. Caustic grits and muds from Penrice/ICI operations were also found on site.
6	Unused, Zoning Industry (Port)	Excellent small area of native tussock grassland (<i>Stipa</i> and <i>Danthonia</i>) with <i>Vittadinia</i> .	1970's	Groundwater plume spreading from the block south of block 6 is contaminated with hydrocarbons.	Part of 'Title C' and being used in current expansion plans. The block is old hydraulic fill and has revegetated well.
7	Road access to Pelican Point Power Station	Roadway with some revegetation along the verges.	1970's	Groundwater plume spreading from the block south of block 6 is contaminated with hydrocarbons.	No specific comments made.
8	Unused, Zoning: Industry (Port)	North-east area has excellent cover of native high marsh and dune species. Northern area has areas of native tussock grassland (<i>Stipa</i> and <i>Danthonia</i>) with <i>Vittadinia</i> . Weed trees evident in the western end of the block, and more recent revegetation.	Northern and eastern hydraulic fill areas: 1977. South-west quarter: 1992	South-western portion of block contains caustic wastes, ash and cinders, metals, PAH, phenols, dumping and off-road vehicle damage.	This block includes the northern part of Mutton Cove and the wreck of the Jupiter, but extends east as far as Pelican Point Road. The western part of the block, contains stockpiles of seaweed and sand and has only recently been revegetated. While the majority of the block was filled with hydraulic fill, black surface material, possibly ash or cinders, was observed in the eastern part of the site immediately to the north of Mutton Cove and the entire western quarter of the block contain caustic grits and muds from the Penrice/ICI operations.
40	Unused, Conservation (Mutton Cove) & timber storage. Zoning in north west: Industry (Port) Zoning in south west: General Industry Zoning at Mutton Cove: MOSS (Conservation)	Northern recent fill area contains a small hollow near SEAGas line with good native high marsh species. Recent fill areas are depauperata. SWER line and south has thin soil cover over Penrice grits, with introduced grasses and isolated native shrubs and herbs.	Mutton Cove: not filled. North west portions of block, 1990's Central west, 1980's South west, cinders of unknown date	Ash, cinders, caustic wastes (high pH in groundwater and soil matrix). The following may be present in elevated concentrations in the soil some areas: cobalt, nickel, copper, zinc and cadmium, based on studies conducted for the MFP. Groundwater may contain elevated concentrations (to varying degrees) of chromium, manganese, nickel, copper, zinc, molybdenum, cadmium, antimony and barium.	The Cove is unfilled. Surface materials in the south-western part of block 40 consist of ash, cinders, and wood wastes. These areas generally do not support healthy vegetation. Other parts of the block contain cement cinders and iron pyrites from the sulfuric acid plant at Largs North, which may very well be acidic, contain metals or cyanides.

41	Conservation (southern land fill area of Mutton Cove), road and transformer station Zoning currently General Industry, will be rezoned MOSS (Conservation), inside the Conservation Reserve and Road - Car Parking Reserve between MCCR and the Submarine Corporation.	This area is already included in the Conservation Reserve and has evidence of recent community revegetation efforts so was not assessed for vegetation. The soils are depauperate and need mulching.	Undated cinders	Metals, PAH, phenols, caustic wastes	This land is the filled area south of Mutton Cove proper, in the Conservation Reserve, as well as the roadway north of the Submarine Corporation and the Car Parking reserve next to the Port River. A considerable amount of illegal dumping of solid and liquid waste has also occurred in the area of parcel 41 within the Mutton Cove Reserve.
44	Overhead fuel tanks, and rail spur. Zoning: General Industry.	Virtually no plant cover.		Petroleum hydrocarbons	Currently used to storage and maintenance industrial equipment. It also contains to 2 overhead fuel tanks.
46	General industry, equipment storage adjacent to rail spur. Zoning: General Industry.	Virtually no plant cover		Petroleum hydrocarbons	Currently used for storage and maintenance of industrial equipment.
47	Battery manufacturing Zoning: General Industry.	Developed area		Acidic wastes, lead, other metals	This area contains a manufacturing plant for lead-acid batteries. Storage tanks for sulfuric acid are located along the southern boundary.
52	Car park at the end of Mersey Road,	Recently scalped, no vegetation.			No specific comments given.

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Figure 38 - Base map of the blocks itemised in the neighbouring land matrix

Details of the consultants

Peri Coleman (M AppSc - Environmental Management and Restoration) has extensive experience in identifying marine and terrestrial flora and fauna of the mainland states and Tasmania, conducting biological surveys, and producing reports and educational materials. Her main interests include biological survey work, revegetation and rehabilitation, scientific illustration and desktop publishing, preparation of herbarium and museum specimens, management plans, taxonomy and classification, solar saltfield biology, environmental education programs, computer application development, wetland studies and samphire and ecosystems.

Peri owns, and is senior consultant for, Delta Environmental Consulting. She is a member of the South Australian Coast Protection Board, Barker Inlet Port Estuary Committee and chair of the Northern Adelaide & Barossa Regional Steering Committee of Waterwatch. Peri has a strong commitment to research, with several recent papers accepted for international publication. She is a fellow of the Royal Society of South Australia and member of the International Society for Salt Lake Research.



Faith Cook (Grad Dip GIS & Remote Sensing, Dip Env Man) is employed by Delta Environmental Consulting to provide technical and consulting services. Faith has strengths in remote sensing, statistics and biometrics. She provides services in the GIS and mapping areas, development of computer database and spreadsheet applications, environmental risk assessments, archival searches, water testing and laboratory work, fieldwork, and desktop design and publishing.



Faith's wide range of interests includes radio telemetry and she has a Novice (limited) Amateur Radio Operator (WIA) licence and also holds a Marine band licence. Faith is a fellow of the Royal Society of South Australia and a member of the International Society for Salt Lake Research. Her current research interests include diatom ecological preferences and samphire ecology.

For further information on any Delta Environmental Consulting staff member, or information on the projects the company has been involved with, please visit our web site at <http://www.deltaenvironmental.com.au>