### Vegetation Monitoring Report Salty Lagoon – May 2013



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Prepared for: Richmond Valley Council © GeoLINK, 2013



PO Box 119 Lennox Head NSW 2478 T 02 6687 7666

PO Box 1446 Coffs Harbour NSW 2450 T 02 6651 7666

info@geolink.net.au

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### Introduction

#### 1.1 Background

GeoLINK has been engaged by Richmond Valley Council (RVC) to implement the Salty Lagoon Ecosystem Recovery Monitoring Program: Pre-Post Closure of the artificial channel (MPPC). This engagement is part of a detailed rehabilitation strategy for Salty Lagoon that has been implemented by RVC.

The rehabilitation strategy comprises three parts:

Part 1: Issues evaluation and information gap analysis;

- Part 2: Rehabilitation and management options assessment; and
- Part 3: Implementation strategy.

A comprehensive description of the rehabilitation strategy is provided in the Salty Lagoon Rehabilitation Plan (Hydrosphere 2011).

Prior to this current engagement, RVC implemented the Salty Lagoon Ecosystem Recovery Monitoring Program (ERMP). In brief, the ERMP aimed to monitor the ecological health of the system for a two year period, and to collect data across a range of disciplines to allow for further planning to be undertaken in accordance with the broader aims of the rehabilitation strategy. This work included a flora and vegetation mapping component and was completed in March 2010 (Hydrosphere 2010a).

The current engagement is part of the final phase of work (Part 3) which documents the implementation strategy and deals specifically with the closure of the Artificial Channel and associated actions. As part of this strategy, RVC are implementing the MPPC (Hydrosphere 2010b).

The key objectives of the MPPC are to:

- 1. confirm positive predicted changes in Salty Lagoon ecological and cultural values, particularly in response to the closure of the artificial channel;
- 2. provide adaptive management response mechanisms before and after closure to inform future stages of the rehabilitation strategy; and
- 3. inform long term strategies with respect to the management of effluent from the Evans Head Sewage Treatment Plan (STP).

#### 1.1.1 ERMP Vegetation Monitoring

The aim of the flora and vegetation mapping components of the ERMP is to "document the status of key ecosystem components as baseline data to inform planning for recovery" (Hydrosphere 2010a). Field sampling was undertaken to allow the production of a base map and a transect and quadrat-based sampling program designed to facilitate future detection of changes to vegetation boundaries, structure and floristics was implemented. The program was particularly designed to monitor the following potential changes:



- condition of the Broad-leaved Paperbark (*Melaleuca quinquenervia*) dieback zone (referred to herein as the Melaleuca dieback zone);
- changes to the extent of Broad-leaved Cumbungi (*Typha orientalis*) and Duckweed (*Lemma* sp.) in the STP channel (drainage channel); and
- changes to the vegetation on banks of the lower reaches of Salty Creek.

A comprehensive description of methods and results from the ERMP monitoring is provided in Hydrosphere (2010a).

#### 1.1.2 MPPC Vegetation Monitoring

The MPPC was initiated in March 2011 and is due to be completed in June 2017. Vegetation monitoring is part of the Ecosystem Health and Trend Assessment of the MPPC.

The focus for the vegetation component of the MPPC monitoring is identifying and documenting the occurrence of the predicted changes in the vegetation habitat zone boundaries below 2 m AHD. The other major component is to document any re-colonisation or reduction within the Melaleuca dieback zone on the western side of the lagoon.

#### 1.1.2.1 Predicted Changes to Vegetation Habitat Zones

Vegetation communities are anticipated to change in response to the closure of the artificial channel (this closure occurred in June 2012). A description of the potential changes is described in Hydrosphere (2010b) and in further detail in Hydrosphere (2011). The area of open water is predicted to increase. Giant Waterlilies (*Nymphaea gigantea*) were predicted to colonise the central portions of the lagoon and are also expected to occur on the fringes. Mixed sedges and rushes such as *Juncus* spp. and *Baumea* spp. are expected to dominate the western area currently occupied by Fringing Marsh. Broad-leaved Paperbark may also expand to the east.

Other predicted changes include:

- establishment of Gahnia spp. and Broad-leaved Cumbungi in the deeper depressions that occur on the western shore;
- drier extremities of the lagoon, where water levels will be less than 0.1 m deep are likely to remain unchanged; and
- other vegetation habitat zones that occur below 2 m AHD will also be potentially affected along the drainage channel (Sedge Swamp/ open water) and along the eastern edge of the lagoon (Fringing Marsh and Banksia Woodland).

A detailed vegetation map showing the predicted water level and vegetation habitat zones is provided in Hydrosphere (2011).

Methods that will be used to monitor changes to the location of vegetation habitat zone boundaries include recording floristic composition within each of the three main vegetation habitat zones below the 2 m AHD level, and recording and mapping the location of the current vegetation habitat zone boundaries. The three main vegetation habitat zones that potentially will be affected by the closure of the channel are located predominantly on the western side of Salty Lagoon and comprise the following:

- Fringing Marsh;
- Swamp Forest; and
- Sedge Swamp.



#### 1.1.2.2 Re-colonisation of Broad-leaved Paperbark and a Reduction in the Area of Dieback

Historical information and evidence on site (i.e. several large tree stumps in the lagoon) indicates that Broadleaved Paperbark once occurred further east, closer to the lagoon.

Potential re-colonisation of Broad-leaved Paperbark will be monitored using three of the four transects that were established for the ERMP to allow for comparison with ERMP data and assessment for longer term changes at these locations.

#### 1.1.2.3 Pre-closure Baseline Vegetation Monitoring

Baseline vegetation monitoring for the MPPC at Salty Lagoon pre-closure of the artificial channel was undertaken in March-April 2011 by GeoLINK. This is referred to in this report as 'baseline vegetation monitoring'. For specific details of the methodology and findings of the baseline vegetation monitoring refer to GeoLINK (2012).

#### 1.1.3 Purpose of this report

The purpose of this report is to document the state of vegetation at the Salty Lagoon site in 2013 post-closure of the artificial channel, and compare these findings with the findings from the baseline vegetation monitoring undertaken in 2011.



### Methodology

The following section details the methodology used for the 2013 vegetation monitoring. This methodology follows the methods used for the baseline vegetation monitoring and is summarised where appropriate to reduce repetition with the baseline vegetation report. More detail on methodology can be found in that report (GeoLINK 2012).

#### 2.1 Vegetation Transects

#### 2.1.1 Timing

Vegetation sampling was undertaken over three days on 6 March, 12 March and 27 March 2013.

Water levels at the time of sampling were relatively high, as a result of the combined effects of closure of the artificial channel linking Salty Lagoon with Salty Creek in June 2012 and a wet summer/ early autumn period experienced just prior to sampling in 2012-2013. Some of the monitoring quadrats closest to the pre-closure edge of the lagoon were covered by up to 60 cm of water at the time of sampling, and were in the process of converting from fringing marsh to open water as vegetation died from inundation. Water levels in Swamp Forest and Sedge Swamp were lower, but nonetheless were higher than previously recorded during the 2011 monitoring event, as influenced from rainfall runoff and accumulation after the wet weather, compared with previous monitoring events.

#### 2.1.2 Vegetation Habitat Zones

The boundaries of the vegetation were evidenced in the field by the following criteria:

- Sedge Swamp/Swamp Forest: Sedge Swamp has a clearly defined edge and generally comprises a
  dense thicket dominated by Gahnia sieberiana, which occurs in all strata including the upper stratum
  (generally <3 m in height). Emergent Broad-leaved Paperbark and Tea Tree can be present.</li>
- Swamp Forest/ Fringing Marsh: the edge of the Swamp Forest is poorly defined due to the zone dominated by dead/ dying Broad-leaved Paperbark. The point at which the boundary was defined was where percentage foliage cover (PFC) of the Broad-leaved Paperbark greater than 3 m in height was >10%. The recorded way points should be used to accurately relocate this boundary (refer to Appendix A [Table A1]).

Transects in which data was collected for this monitoring are the same as those used for baseline vegetation monitoring, as outlined below.

Transects 1-3 are 400-600 m in length and each extends across the three distinct vegetation habitat zones of Fringing Marsh, Swamp Forest and Sedge Swamp. Two quadrats (10 m x 10 m) are located in each vegetation habitat zone along each transect (i.e. total of six quadrats per transect). Quadrats are orientated generally in an east-west direction and run from the open water at the eastern end through the Sedge Swamp to the heathland boundary to the west. The location of the boundary of each of the vegetation habitat zones was recorded via global positioning system (GPS) (refer to **Appendix A** [Table A1]).

Transects 4-6 are between 20-60 m in length and each comprise two distinct vegetation habitat zones. One quadrat (10 m x 10 m) is located in each vegetation habitat zone along each of these transects (i.e. total of two quadrats per transect).



Transect 4 traverses the drainage channel (i.e. channel from the STP) and is orientated generally in a northsouth direction. The two vegetation habitat zones sampled include Sedge Swamp/ open water and Swamp Forest. Transect 5 and Transect 6 are located on the eastern side of Salty Lagoon. These transects are less than 20 m in length and are orientated generally in an east-west direction. The vegetation habitat zones sampled at both transects include Fringing Marsh and Banksia Woodland.

GPS waypoints identifying the location of vegetation quadrats along transects 1-3 are provided in **Appendix A** (Table A2).

Data recorded for vegetation quadrats included:

- description of vegetation by stratum (height and total percentage cover) (modified Braun-Blanquet scale; refer to Table 2.1);
- floristic composition with cover abundance for each species;
- diameter at breast height (DBH recorded at 1.25 m above the ground) for each stem greater than 10 cm DBH;
- description of vegetation health; and
- photos taken from the north-east corner of each quadrat.

	•
Class	Percentage Cover
1	<5% sparse
2	<5% common
3	5-25%
4	26-50%
5	51-75%
6	76-100%

Table 2.1 Modified Braun-Blanquet Cover Classes

Trees with DBH >10 cm along Transects 1-3 are not permanently marked in the field, however to facilitate relocation of individual trees, quadrats are divided into four quarters (quadrants) and tree counts start in the north-west corner of the quadrat, moving in a clockwise direction.

#### 2.1.3 Selection of Indicator Species

Indicator flora species were identified in the baseline vegetation monitoring on the basis that will be useful for identifying changes that may occur in vegetation habitat zones once closure of the artificial channel has occurred. These indicator species were selected based on the following methodology:

- identified in the predicted changes to the Salty Lagoon flora in Hydrosphere (2010b) (refer to Section 1.1.2.1 of this report); and/ or
- dominant in a vegetation habitat zone, as identified in the cover abundance data collected; and
- primarily associated with a single habitat vegetation zone.

The distribution of these indicator species is expected to change over time and therefore these changes should be reflected in the cover abundance scores of the quadrat data. However, if it is apparent after a number of monitoring events that additional species should be included as indicator species it is recommended that these are included also.



#### 2.1.4 Melaleuca Dieback/ Recolonisation Transects

Melaleuca dieback transects and quadrats (10 m x 10 m) were established for the baseline vegetation monitoring according to the proposed methodology outlined in Hydrosphere (2010b). Three transects correspond with those previously established for the ERMP sampling (refer to Figure 2 in Hydrosphere 2010a). These transects are located along Transects 1-3 established to measure vegetation habitat zone changes (refer to **Illustration 2.1**) and quadrat locations correspond with the Fringing Marsh/ Swamp Forest boundary.

The waypoints identifying the location of each quadrat are provided in Appendix A (Table A3).

Data recorded at Melaleuca dieback quadrats included:

- vegetation description by stratum (height and total percentage cover);
- floristic composition with cover abundance for each species (modified Braun-Blanquet scale; refer to Table 2.1);
- description of vegetation health (presence of necrotic spots on leaves, galls on small branches);
- photos taken from the north-east corner of each quadrat;
- number of trees with >10 cm DBH (and the DBH of each stem >10cm);
- number of small trees (i.e. height <1.5 m and DBH >5 cm);
- number of seedlings (i.e. height <0.5 m);</li>
- condition of trees within the quadrat using the following categories:
  - unaffected/ full recovery;
  - resprouting; and
  - dead.





#### Indicative Vegetation Sampling Sites selected for the Monitoring Program and Broad Vegetation Habitat Zones (based on Figure 2 in Hydrosphere 2010a)



### **Findings and Observations**

#### 3.1 Vegetation Habitat Zonation

#### 3.1.1 Transects 1-3

#### 3.1.1.1 Boundaries of Vegetation Habitat Zones

Transects 1-3 extend across the three distinct vegetation habitat zones of Fringing Marsh, Swamp Forest and Sedge Swamp. The location of the vegetation habitat zone boundaries along these transects is shown in **Illustration 3.1** The relative distance occupied by the vegetation habitat zones along each transect is detailed in **Table 3.1**.

Note that due to the presence of an ecotone between the Swamp Forest and Fringing Marsh vegetation habitat zones along Transect 2, the extent of these vegetation habitat zones is provided as a range. The edges of this ecotone area are defined by:

- Western edge Broad-leaved Paperbark total cover ≈10%.
- Eastern edge re-shooting Broad-leaved Paperbark and the majority of dead/ alive trees end. Individuals east of here are isolated and total cover ≤10%.

Transect	Extent of Fringing Marsh (m)	Extent of Swamp Forest (m)	Extent of Sedge Swamp (m)	Total Length (m)
Transect 1	102	121	152	375
Transect 2	151-195	185-265	84	544
Transect 3	225	198	133	556

#### Table 3.1 Extent of Vegetation Habitat Zones along Transects 1-3

Also note that since the baseline vegetation monitoring the total length occupied by the vegetation habitat zones along the transects has decreased due to some of the fringing marsh being converted to open water as water levels in the lagoon have been raised since closure of the artificial channel.

#### 3.1.1.2 Species Composition of Vegetation Habitat Zones

In total, 55 flora species (both native and exotic) were recorded from the three vegetation habitat zones. The breakdown of species by vegetation habitat zones was as follows:

- Fringing Swamp 7 species;
- Swamp Forest 30 species;
- Sedge Swamp 32 species.

The dominant flora species by average cover abundance (three and above) within quadrats along Transects 1-3 is represented in **Table 3.2**.



Drawn by: TJP Checked by: MVE Reviewed by: GJM Date: April 2013 Source of base data: Richmond Valley Council







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#### Location of Vegetation Habitat Zone Boundaries

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	Common Name	Botanical Name	Fringing Marsh	Swamp Forest	Sedge Swamp						
Transect 1	Quadrat A1 easting 5415	64 northing 6783237									
	Grass Tree	Xanthorrhoea sp.			4						
	Weeping Baeckea	Baeckea frutescens			3						
	Plume Rush	Baloskion tetraphyllum			4						
	Red-fruited Saw-sedge	Gahnia sieberiana			3						
	Prickly Tea Tree	Leptospermum juniperinum			3						
	Broad-leaved Paperbark	Melaleuca quinquenervia			3						
	Quadrat A2 easting 5415	79 northing 6783231									
	Plume Rush	Baloskion tetraphyllum			6						
	Prickly Tea Tree	Leptospermum juniperinum			3						
	Broad-leaved Paperbark	Melaleuca quinquenervia			3						
	Quadrat B1 easting 541699 northing 6783134										
	Bare Twig-rush	Baumea juncea		4							
	Broad-leaved Paperbark	Melaleuca quinquenervia		3							
	Quadrat B2 easting 541743 northing 6783114										
	Sea Rush	Juncus krausii subsp. australiensis		5							
	Broad-leaved Paperbark	Melaleuca quinquenervia		3							
	Quadrat C1 easting 5418	32 northing 6783076									
	Sea Rush	Juncus krausii subsp. australiensis	3								
	Saltwater Couch	Paspalum vaginatum	3								
	Quadrat C2 easting 5418	85 northing 6783044	·	·	·						
	Sea Rush	Juncus krausii subsp. australiensis	3								
	Saltwater Couch	Paspalum vaginatum	3								

Table 3.2Dominant Flora by Cover Abundance (modified Braun-Blanquet Cover Classes) in<br/>Quadrats along Transects 1-3



	Common Name	Botanical Name	Fringing Marsh	Swamp Forest	Sedge Swamp					
Transect 2	Quadrat A1 easting 541411 northing 6782754									
	Weeping Baeckea	Baeckea frutescens			3					
	Plume Rush	Baloskion tetraphyllum			3					
	Didgery Sticks	Baloskion pallens			3					
	Swamp Selaginella	Selaginella uliginosa			3					
	Zig-zag Bog-rush	Schoenus brevifolius			3					
	Quadrat A2 easting 5414	53 northing 6782756								
	Bare Twig-rush	Baumea juncea			5					
	Broad-leaved Paperbark	Melaleuca quinquenervia			3					
	Sand Couch	Sporobolus virginicus			3					
	Quadrat B1 easting 541523 northing 6782775									
	Broad-leaved Paperbark	Melaleuca quinquenervia		4						
	Bare Twig-rush	Baumea juncea		3						
	Quadrat B2 easting 541646 northing 6782802									
	Broad-leaved Paperbark	Melaleuca quinquenervia		3						
	Sea Rush	Juncus krausii subsp. australiensis		3						
	Quadrat C1 easting 5418	333 northing 6782839								
	Saltwater Couch	Paspalum vaginatum	3							
	Shore Club-rush	Schoenoplectus subulatus	3							
	Quadrat C2 easting 5419	27 northing 6782849								
	No dominants (cover abundance >3)									



	Common Name	Botanical Name	Fringing Marsh	Swamp Forest	Sedge Swamp
Transect 3	Quadrat A1 easting 5415	59 northing 6782425			
	Swamp Twig-rush	Baumea arthrophylla			6
	Broad-leaved Paperbark	Melaleuca quinquenervia			3
	Bryophyte (a moss) sp.	unknown			4
	Pouched Coral Fern	Gleichenia dicarpa			3
	Quadrat A2 easting 5415	88 northing 6782425			
	Swamp Twig-rush	Baumea arthrophylla			5
	Broad-leaved Paperbark	Melaleuca quinquenervia			3
	Bryophyte (a moss) sp.	unknown			4
	Red-fruited Saw-sedge	Gahnia sieberiana			3
	Quadrat B1 easting 5416	97 northing 6782464			-
	*Groundsel Bush	Bachharis halamifolia		3	
	Broad-leaved	Melaleuca		4	
	Paperbark	quinquenervia			
	Tall Sedge	Carex apressa		4	
	Quadrat B2 easting 5417	84 northing 6782504			
	Broad-leaved Paperbark	Melaleuca quinquenervia		3	
	Blady Grass	Imperata cylindrica var. major		3	
	Bare Twig-rush	Baumea juncea		4	
	*Groundsel Bush	Baccharis halimifolia		3	
	Spiny-headed Mat-rush	Lomandra longifolia		3	
	Native Violet	Viola sp.		3	
	Quadrat C1 easting 5418	95 northing 6782543			
	No dominants (cover abu	indance >3)			
	Quadrat C2 easting 5420	02 northing 6782591			
	Sea Rush	Juncus krausii subsp. australiensis	3		
	Saltwater Couch	Paspalum vaginatum	3		

Note: indicator species shown in **bold** and exotic species are marked with \*

The cover abundance score for all flora species recorded within quadrats along Transects 1-3 is provided in **Appendix B** (Table B1). Ranges are given for cover abundance scores of species that occur in two quadrats of a particular vegetation habitat zone within a given transect.



#### 3.1.1.3 Vegetation Habitat Zone Descriptions

#### Fringing Marsh

At the time of the survey, the Fringing Marsh community was dominated by Saltwater Couch (*Paspalum vaginatum*) and Sea Rush (*Juncus kraussii* subsp. *australiensis*), with these species occurring in moderate density in all six quadrats. Shore Club-rush (*Schoenoplectus subulatus*) also occurs commonly, being recorded in low-moderate density in three out of six quadrats.

#### Swamp Forest

The Swamp Forest community was dominated by Broad-leaved Paperbark and Bare Twig-rush (*Baumea juncea*). Saltwater Couch and Sea Rush were also present in low-moderate abundance in four quadrats each. Groundsel Bush (an exotic weed), Tall Sedge (*Carex apressa*), Blady Grass (*Imperata cylindrica* var. *major*), Spiny-headed Mat-rush (*Lomandra longifolia*) and Native Violet (*Viola* sp.) were all present in moderate density in one or more of the quadrats in this community.

#### Sedge Swamp

Sedge Swamp was dominated by Plume Rush (*Baloskion tetraphyllum*), which occurred at moderate to high density in five out of six of the quadrats. Swamp Twig-rush (*Baumea arthrophylla*) also occurred at a high density in two quadrats. Red-fruit Saw-sedge (*Gahnia sieberiana*), Weeping Baeckea (*Baeckea frutescens*), Grass Tree (*Xanthorrhoea* sp.) and Broad-leaved Paperbark were also present in moderate abundance, each being present in three to four quadrats.

Vegetation characteristics recorded within quadrats along Transects 1-3 are detailed in **Table 3.3**. Characteristics recorded include vegetation habitat zone, vegetation structure and the species and dimensions of all trees >10 cm DBH. Broad-leaved Paperbark was by far the most common tree species recorded.

#### Indicator Species

Based on the expected changes from Hydrosphere (2010b and 2011) and the quadrat data collected along Transects 1-3 the following species were identified as indicator species:

- Sea Rush (*Juncus krausii* subsp. *australiensis*): expected to decrease in the area currently occupied by Fringing Marsh and Swamp Forest.
- Saltwater Couch (*Paspalum vaginatum*): expected to decrease in the area currently occupied by Fringing Marsh and Swamp Forest.
- Bare Twig-rush (*Baumea juncea*): expected to increase in the area currently occupied by Fringing Marsh.
- Broad-leaved Paperbark (*Melaleuca quinquenervia*): expected to increase in the area currently occupied by Fringing Marsh.

The average cover abundance value for each of these indicator species in the vegetation habitat zones is graphically represented in **Figure 3.1**. It is apparent that Plume Rush is a prominent feature of the Sedge Swamp community and Bare Twig Rush is a prominent species of the Swamp Forest. Broad-leaved Paperbark occurs broadly across both the Sedge Swamp and Swamp Forest communities and Sea Rush and Saltwater Couch occur across both Fringing Marsh and Swamp Forest. However, Saltwater Couch occurs most frequently in the Fringing Marsh.

The occurrence of, and changes to, indicator species in relation to the baseline vegetation monitoring results and the channel closure are discussed in more detail in **Section 4** 





Figure abbreviations – SS = Sedge Swamp, SF = Swamp Forest, FM = Fringing Marsh. T = Transect number, A, B etc. =Quadrat ID)

Transect	Quadrat	t Vegetation	Vegeta	Vegetation Structure						Tree Characteristics			Comments on												
		Habitat Zone	Upper .	Stratum	Uppe Stra	er-mid atum	Mid Stra	atum	Lower	Stratum	Quadrant of Quadrat	Tree Species	DBH of trees (mm) (/ indicates	Vegetation Health											
			Height	Cover Class	Height	Cover Class	Height	Cover Class	Height	Cover Class	(Q1 = NW, Q2 = NE, Q3 = SE, Q4 = SW)		multiple trunks)												
Transect 1	A1	Sedge Swamp	6	3	-	-	3	2	<2	6	Q3	Eucalyptus robusta	130/ 110	Melaleuca quinquenervia											
													Eucalyptus robusta	170	bok healthy. Banksia ericifolia has died since previous monitoring										
												Q4	Melaleuca quinquenervia	200											
																							Melaleuca quinquenervia	120	event.
																					Melaleuca quinquenervia	200			
															Melaleuca quinquenervia	100	-								
	A2	Sedge Swamp	6	3	-	-	3	2	<1	6	Not recorded	Melaleuca quinquenervia	480												
												Melaleuca quinquenervia	100												
	B1	Swamp Forest	8-10	3	-	-	-	-	<1.2	4	Q2	Melaleuca quinquenervia	110/ 130	~30 cm water level.											
																		Melaleuca quinquenervia	130/ 180						
											Q4	Melaleuca	190/ 150												

#### Table 3.3Vegetation Structure and Characteristics - Quadrat Data for Transects 1-3



Transect	Quadrat	Vegetation	Vegeta	tion Stru	cture						Tree Chara	cteristics		Comments on
		Habitat Zone	Upper S	Stratum	Uppe Stra	er-mid atum	Mid Stra	atum	Lower	Stratum	Quadrant of Quadrat	Tree Species	DBH of trees (mm) (/ indicates	Vegetation Health
			Height	Cover Class	Height	Cover Class	Height	Cover Class	Height	Cover Class	(Q1 = NW, Q2 = NE, Q3 = SE, Q4 = SW)		multiple trunks)	
												quinquenervia		
												Melaleuca quinquenervia	180	
												Melaleuca quinquenervia	120	
												Melaleuca quinquenervia	130	
												Melaleuca quinquenervia	180	
												Melaleuca quinquenervia	110/ 140	
	B2	Swamp Forest	-	-	-	-	4	3	<1.2	4	Q2	Melaleuca quinquenervia	130	
												Melaleuca quinquenervia	150	
	C1	Fringing Marsh	-	-	-	-	-	-	<1.2	4	-	-	-	~ 70 cm inundation
	C2	Fringing Marsh	-	-	-	-	-	-	<1.2	4	-	-	-	~ 60 cm inundation
Transect	A1	Sedge	10	2	5	3	-	-	<1.2	6	Not	Banksia ericifolia	130	Melaleuca
2		Swamp									recorded	Banksia ericifolia	130	<i>quinquenervia</i> recorded in previous monitoring event is no longer



Transect	Quadrat	Vegetation	Vegeta	tion Stru	cture						Tree Chara	cteristics		Comments on
		Habitat Zone	Upper S	Stratum	Uppe Stra	er-mid atum	Mid Stra	atum	Lower S	Stratum	Quadrant of Quadrat	Tree Species	DBH of trees (mm) (/ indicates	Vegetation Health
			Height	Cover Class	Height	Cover Class	Height	Cover Class	Height	Cover Class	(Q1 = NW, Q2 = NE, Q3 = SE, Q4 = SW)		multiple trunks)	
														present.
	A2	Sedge Swamp	10-12	3	8-10	2	4-6	2	<1.2	5	Q1	Melaleuca quinquenervia	150/ 120	A number of the Melelauca
												Melaleuca quinquenervia	130	quinquenervia recorded as
											Q2	Melaleuca quinquenervia	300	quadrat in the
												Melaleuca quinquenervia	120/ 120	monitoring event were not
												Melaleuca quinquenervia	140	recorded subsequently.
											Q3	Melaleuca quinquenervia	430	This may be due to discrepancies in the sampling procedure.
	B1	Swamp Forest	10-12	4	6-8	2	-	-	<1.2	4	Q1	Melaleuca quinquenervia	340	Melaleuca quinquenervia
												Melaleuca quinquenervia	360	foliage relatively healthy. Dead
												Melaleuca quinquenervia	140/ 110	trees are not conspicuous.
											Q2	Melaleuca quinquenervia	180	
												Melaleuca quinquenervia	350	



Transect	Quadrat	Vegetation	Vegeta	tion Stru	cture						Tree Chara	cteristics		Comments on
		Habitat Zone	Upper S	Stratum	Uppe Stra	er-mid atum	Mid Str.	atum	Lower S	Stratum	Quadrant of Quadrat	Tree Species	DBH of trees (mm) (/ indicates	Vegetation Health
			Height	Cover Class	Height	Cover Class	Height	Cover Class	Height	Cover Class	(Q1 = NW, Q2 = NE, Q3 = SE, Q4 = SW)		multiple trunks)	
												Melaleuca quinquenervia	100	
												Melaleuca quinquenervia	130	_
												Melaleuca quinquenervia	320	
											Q3	Melaleuca quinquenervia	280	_
												Melaleuca quinquenervia	340	_
												Melaleuca quinquenervia	100	_
											Q4	Melaleuca quinquenervia	250	
	B2	Swamp Forest	8-10	4	6	2	-	-	<1.2	3	Q1	Melaleuca quinquenervia	100	_
												Melaleuca quinquenervia	100	_
												Melaleuca quinquenervia	200	_
												Melaleuca quinquenervia	160/ 100	
											Q2	Melaleuca quinquenervia	120	
												Melaleuca	100	



Transect	Quadrat	Vegetation	Vegeta	tion Stru	cture						Tree Chara	cteristics		Comments on
		Habitat Zone	Upper S	Stratum	Uppe Stra	er-mid atum	Mid Stra	atum	Lower S	Stratum	Quadrant of Quadrat	Tree Species	DBH of trees (mm) (/ indicates	Vegetation Health
			Height	Cover Class	Height	Cover Class	Height	Cover Class	Height	Cover Class	(Q1 = NW, Q2 = NE, Q3 = SE, Q4 = SW)		multiple trunks)	
												quinquenervia		
												Melaleuca quinquenervia	100	
												Melaleuca quinquenervia	110	
												Melaleuca quinquenervia	130	
												Melaleuca quinquenervia	130	
												Melaleuca quinquenervia	100/ 110	
												Melaleuca quinquenervia	100	
												Melaleuca quinquenervia	120	
												Melaleuca quinquenervia	140	
												Melaleuca quinquenervia	130	
											Q3	Melaleuca quinquenervia	180	
												Melaleuca quinquenervia	180/ 100	
											Q4	Melaleuca quinquenervia	140/ 120/ 130	



Transect	Quadrat	Vegetation	Vegeta	tion Stru	cture						Tree Chara	cteristics		Comments on
		Habitat Zone	Upper :	Stratum	Uppe Stra	er-mid atum	Mid Stra	atum	Lower S	Stratum	Quadrant of Quadrat	Tree Species	DBH of trees (mm) (/ indicates	Vegetation Health
			Height	Cover Class	Height	Cover Class	Height	Cover Class	Height	Cover Class	(Q1 = NW, Q2 = NE, Q3 = SE, Q4 = SW)		multiple trunks)	
												Melaleuca quinquenervia	100	
												Melaleuca quinquenervia	110	_
												Melaleuca quinquenervia	140	-
	C1	Fringing Marsh	-	-	-	-	-	-	<1.2	3	-	-	-	
	C2	Fringing Marsh	-	-	-	-	-	-	<1.2	3	-	-	-	
Transect 3	A1	Sedge Swamp	10-12	4	6-8	2	>1.2-5	2	<1.2	6	Q1	Melaleuca quinquenervia	150	Sedge Swamp according to methodology despite a high cover of <i>Melaleuca</i> <i>quinquenervia</i> .
												Melaleuca quinquenervia	110/ 110	
												Melaleuca quinquenervia	200	
												Melaleuca quinquenervia	140	
												Melaleuca quinquenervia	160	



Transect	Quadrat	Vegetation	Vegeta	tion Stru	cture						Tree Chara	cteristics		Comments on
		Habitat Zone	Upper S	Stratum	Uppe Stra	er-mid atum	Mid Stra	atum	Lower S	Stratum	Quadrant of Quadrat	Tree Species	DBH of trees (mm) (/ indicates	Vegetation Health
			Height	Cover Class	Height	Cover Class	Height	Cover Class	Height	Cover Class	(Q1 = NW, Q2 = NE, Q3 = SE, Q4 = SW)		multiple trunks)	
											Q2	Melaleuca quinquenervia	130	
												Melaleuca quinquenervia	140	
												Melaleuca quinquenervia	100/ 150	
												Melaleuca quinquenervia	140	
												Melaleuca quinquenervia	100/ 100	
												Melaleuca quinquenervia	130	
											Q3	Melaleuca quinquenervia	150	
												Melaleuca quinquenervia	100/ 110/ 130	
												Melaleuca quinquenervia	110	
												Melaleuca quinquenervia	120	
												Melaleuca quinquenervia	120	
												Melaleuca quinquenervia	120	
												Melaleuca	110/ 110	



Transect	Quadrat	Vegetation	Vegeta	tion Stru	cture						Tree Chara	cteristics		Comments on
		Habitat Zone	Upper S	Stratum	Uppe Stra	er-mid atum	Mid Stra	atum	Lower S	Stratum	Quadrant of Quadrat	Tree Species	DBH of trees (mm) (/ indicates	Vegetation Health
			Height	Cover Class	Height	Cover Class	Height	Cover Class	Height	Cover Class	(Q1 = NW, Q2 = NE, Q3 = SE, Q4 = SW)		multiple trunks)	
												quinquenervia		
												Melaleuca quinquenervia	150	
												Melaleuca quinquenervia	120	
												Melaleuca quinquenervia	110	
												Melaleuca quinquenervia	140/ 120	
											Q4	Melaleuca quinquenervia	130	
												Melaleuca quinquenervia	140	
												Melaleuca quinquenervia	120	
												Melaleuca quinquenervia	170	
	A2	Sedge Swamp	12-15	3	8	1	>1.2-5	2	<1.2	6	Q1	Melaleuca quinquenervia	150	Some trees flowering
												Melaleuca quinquenervia	140	
												Melaleuca quinquenervia	110/ 130	
												Melaleuca quinquenervia	110/ 130	



Transect	Quadrat	Vegetation	Vegeta	tion Stru	cture						Tree Chara	cteristics		Comments on
		Habitat Zone	Upper S	Stratum	Uppe Stra	er-mid atum	Mid Stra	atum	Lower S	Stratum	Quadrant of Quadrat	Tree Species	DBH of trees (mm) (/ indicates	Vegetation Health
			Height	Cover Class	Height	Cover Class	Height	Cover Class	Height	Cover Class	(Q1 = NW, Q2 = NE, Q3 = SE, Q4 = SW)		multiple trunks)	
												Melaleuca quinquenervia	100	
												Melaleuca quinquenervia	160	
												Melaleuca quinquenervia	160	
												Melaleuca quinquenervia	170	
											Q2	Melaleuca quinquenervia	170	
												Melaleuca quinquenervia	130	
												Melaleuca quinquenervia	120	
												Melaleuca quinquenervia	180	
												Melaleuca quinquenervia	140	
												Melaleuca quinquenervia	140	
												Melaleuca quinquenervia	130	
											Q3	Melaleuca quinquenervia	200	
												Melaleuca	150	



Transect	Quadrat	Vegetation	Vegeta	tion Stru	cture						Tree Chara	cteristics		Comments on
		Habitat Zone	Upper S	Stratum	Uppe Stra	er-mid atum	Mid Stra	atum	Lower S	Stratum	Quadrant of Quadrat	Tree Species	DBH of trees (mm) (/ indicates	Vegetation Health
			Height	Cover Class	Height	Cover Class	Height	Cover Class	Height	Cover Class	(Q1 = NW, Q2 = NE, Q3 = SE, Q4 = SW)		multiple trunks)	
												quinquenervia		
												Melaleuca quinquenervia	200	
												Melaleuca quinquenervia	150	
												Melaleuca quinquenervia	110	_
											Q4	Melaleuca quinquenervia	130	
												Melaleuca quinquenervia	140	_
												Melaleuca quinquenervia	150	_
												Melaleuca quinquenervia	120	_
												Melaleuca quinquenervia	150	_
												Melaleuca quinquenervia	150	-
												Melaleuca quinquenervia	170	
												Melaleuca quinquenervia	150	
												Melaleuca quinquenervia	150	



Transect	Quadrat	Vegetation	Vegeta	tion Stru	cture						Tree Chara	cteristics		Comments on
		Habitat Zone	Upper S	Stratum	Uppe Stra	er-mid atum	Mid Stra	atum	Lower S	Stratum	Quadrant of Quadrat	Tree Species	DBH of trees (mm) (/ indicates	Vegetation Health
			Height	Cover Class	Height	Cover Class	Height	Cover Class	Height	Cover Class	(Q1 = NW, Q2 = NE, Q3 = SE, Q4 = SW)		multiple trunks)	
												Melaleuca quinquenervia	120	
	B1	Swamp Forest	15-18	4	8-12	2	>1.2-5	1	<1.2	4	Q1	Melaleuca quinquenervia	220	
												Melaleuca quinquenervia	300	
												Melaleuca quinquenervia	150	
												Melaleuca quinquenervia	120	
												Melaleuca quinquenervia	130	
												Melaleuca quinquenervia	140	
												Melaleuca quinquenervia	150	
												Melaleuca quinquenervia	250	
												Melaleuca quinquenervia	250	
												Melaleuca quinquenervia	200	
												Melaleuca quinquenervia	130	
												Melaleuca	140	



Transect	Quadrat	Vegetation	Vegeta	tion Stru	cture						Tree Chara	cteristics		Comments on
		Habitat Zone	Upper S	Stratum	Uppe Stra	er-mid atum	Mid Stra	atum	Lower S	Stratum	Quadrant of Quadrat	Tree Species	DBH of trees (mm) (/ indicates	Vegetation Health
			Height	Cover Class	Height	Cover Class	Height	Cover Class	Height	Cover Class	(Q1 = NW, Q2 = NE, Q3 = SE, Q4 = SW)		multiple trunks)	
												quinquenervia		
											Q2	Melaleuca quinquenervia	140	
												Melaleuca quinquenervia	120	
											Q3	Melaleuca quinquenervia	450	-
											Q4	Melaleuca quinquenervia	140	-
	B2	Swamp Forest	12	3	8	2	>1.2-5	2	<1.2	5	Q1	Melaleuca quinquenervia	840	Groundsel conspicuous, foliage on <i>Melaleuca</i> <i>quinquenervia</i> noticeably denser than A1 and A2.
												Melaleuca quinquenervia	130	
											Q2	Melaleuca quinquenervia	130	
												Melaleuca quinquenervia	140	
												Melaleuca	130	



Transect	Quadrat	Vegetation	Vegeta	tion Stru	cture						Tree Chara	cteristics		Comments on
		Habitat Zone	Upper S	Stratum	Uppe Stra	er-mid atum	Mid Stra	atum	LowerS	Stratum	Quadrant of Quadrat	Tree Species	DBH of trees (mm) (/ indicates	Vegetation Health
			Height	Cover Class	Height	Cover Class	Height	Cover Class	Height	Cover Class	(Q1 = NW, Q2 = NE, Q3 = SE, Q4 = SW)		multiple trunks)	
												quinquenervia		
												Melaleuca quinquenervia	140	
												Melaleuca quinquenervia	140	
											Q3	Melaleuca quinquenervia	100	
												Melaleuca quinquenervia	140	
												Melaleuca quinquenervia	150	
												Melaleuca quinquenervia	220	
												Melaleuca quinquenervia	150/ 180	
											Q4	Melaleuca quinquenervia	110	
												Melaleuca quinquenervia	100/ 100	
												Melaleuca quinquenervia	150	
	C1	Fringing Marsh	-	-	-	-	-	-	<1.2	2		-	-	
	C2	Fringing Marsh	-	-	-	-	-	-	<1.2	4		-	-	



#### 3.1.2 Transects 4-6

#### 3.1.2.1 Vegetation Habitat Zone Boundaries

Transects 4-6 each traverse the following two distinct vegetation habitat zones:

- Transect 4: Sedge Swamp/ open water and Swamp Forest; and
- Transect 5 and 6: Fringing Marsh and Banksia Woodland.

The location of the monitoring transects is shown in **Illustration 3.1**.

Transect 4 traverses the drainage channel (i.e. channel from the STP) and is orientated generally in a north-south direction while Transects 5 and 6 lie generally east-west and are located behind the dune system, immediately to the east of Salty Lagoon.

The vegetation habitat zone boundaries along Transects 5 and 6 were fairly well defined in the field at the time of survey. However, as the level of the lagoon has increased following the artificial channel closure, the extent of the Fringing Marsh community has decreased substantially.

#### 3.1.2.2 Species Composition of Vegetation Habitat Zones

In total, 38 flora species (both native and exotic) were recorded from the four vegetation habitat zones. The breakdown of species by vegetation habitat zones was as follows:

- Sedge Swamp/ Open Water 12 species
- Swamp Forest 6 species
- Fringing Marsh 20 species
- Banksia Woodland 17 species

Note that some species from Banksia woodland were also present in areas broadly identified as Fringing Marsh, particularly in quadrat A1 of Transect 5.

The dominant flora species by average cover abundance (three and above) within quadrats along Transects 4-6 is represented in **Table 3.4**.

### Table 3.4Dominant Flora by Cover Abundance (modified Braun-Blanquet cover classes) in Quadratsalong Transects 4-6

	Common Name	Botanical Name	Sedge Swamp/ Open Water	Swamp Forest	Fringing Marsh	Banksia Woodland
Transect 4	Quadrat A1 eas	ting 541785 northing 6782	669			
	Jointed Twig- rush	Baumea articulata	3			
	Sea Rush	Juncus krausii subsp. australiensis	3			
	Quadrat B1 eas	ting 541783 northing 6782	683			
	Bare Twig- rush	Baumea juncea		3		
	Saltwater Couch	Paspalum vaginatum		4		
	Broad-leaved Paperbark	Melaleuca quinquenervia		3		
	Sea Rush	Juncus krausii subsp. australiensis		3		



	Common Name	Botanical Name	Sedge Swamp/ Open Water	Swamp Forest	Fringing Marsh	Banksia Woodland
Transect 5	Quadrat A1 eas	ting 541783 northing 6782	683			
	Knotted Club- rush	Ficinia nodosa			3	
	Broad-leaved Paperbark	Melaleuca quinquenervia			3	
	Bare Twig- rush	Baumea juncea			3	
	Blady Grass	Imperata cylindrica			4	
	Quadrat B1 eas	ting 542072 northing 6782	821			
	Coast Banksia	Banksia integrifolia				4
	Bitou Bush	Crysanthemoides monilifera				3
	-	Cyperus polystachyos				3
	Blady Grass	Imperata cylindrica				5
Transect 6	Quadrat A1 eas	ting 542109 northing 6783	073			
	Broad-leaved Paperbark	Melaleuca quinquenervia			3	
	Bare Twig- rush	Baumea juncea			3	
	Quadrat B1 eas	ting 542118 northing 6783	068			
	Indian Pennywort	Centella asiatica				3
	Blady Grass	Imperata cylindrica				5
	Bitou Bush	Crysanthemoides monilifera				3
	Bare Twig- rush	Baumea juncea				3

Note: indicator species shown in **bold** 

The cover abundance score for all flora species recorded within quadrats along Transects 4-6 is provided in **Appendix B** (Table B2).

#### 3.1.2.3 Vegetation Habitat Zone Descriptions

#### Transect 4

#### Sedge Swamp/ Open Water

Sedge Swamp/ open water supports a mixture of rushes and sedges and has a moderate density of Sea Rush. Saw-sedge (*Gahnia clarkel*) and Cumbungi (*Typha orientalis*) are present in this community at a low density.

#### Swamp Forest

Swamp Forest in this location is dominated by Broad-leaved Paperbark in the upper stratum and Saltwater Couch and Sea Rush in the lower stratum.



#### Transects 5 and 6

#### Fringing Marsh

Fringing Marsh at this location consists of an understorey dominated by Blady Grass along with a variety of rushes. Bare Twig-rush was the most prominent rush species recorded. Broad-leaved Paperbark is scattered in the overstorey. No indicator species were recorded as dominant flora along these transects.

#### Banksia Woodland

This relatively low diversity vegetation habitat zone consists of an open canopy of Coast Banksia with an understorey dominated by Blady Grass along with Bare Twig-rush. The quadrats were significantly infested with the exotic weed Bitou Bush.

#### 3.1.2.4 Indicator Species

Based on the expected changes from Hydrosphere (2010b and 2011) and the results of the baseline vegetation monitoring, indicator species selected consisted of:

- Sea Rush (*Juncus krausii* subsp. *australiensis*) (prediction is that this species will decrease in the area currently occupied by the Gahnia sedge/ open water habitat zone along Transect 4)
- Saltwater Couch (*Paspalum vaginatum*) (prediction is that this species is expected to decrease in the area currently occupied by the Swamp Forest along Transect 4 and Fringing Marsh along Transect 5).
- Shore Club-rush (Schoenoplectus subulatus) (prediction is that this species is expected to decrease in the area currently occupied by Fringing Marsh vegetation habitat zone along Transects 5 and 6).
- Saw-sedge (*Gahnia* spp.) (prediction is that this species is expected to increase in the area currently
  occupied by Sedge Swamp/ open water in Transect 4).
- Coast Banksia (*Banksia integrifolia* subsp. *integrifolia*) (prediction is that this species is expected to retain current density within the Banksia Woodland with expected water level changes).

The average cover abundance value for each of these indicator species in the vegetation habitat zones is shown in **Figure 3.2**.

The occurrence of, and changes to, indicator species in relation to the baseline vegetation monitoring results and the channel closure are discussed in **Section 4**.





Figure 3.2 Cover Abundance Scores for Indicator Species in Vegetation Habitat Zones of Transects 4-6

Figure abbreviations – SS = Sedge Swamp, OW = Open Water, SF = Swamp Forest, FM = Fringing Marsh, BW = Banksia Woodland T = Transects number, A, B etc. = Quadrat ID



#### 3.2 Melaleuca Dieback/ Recolonisation Monitoring

Results from the Melaleuca dieback quadrats are shown in **Table 3.5**. Less than half of the quadrats contained dead Melaleuca individuals (7 out of 15), with the least dieback being recorded in the quadrats located along Transect 1. This reflects a very low general occurrence of Melaleuca (living or dead) in Melaleuca dieback quadrats along this transect. Most of the Melaleuca dieback recorded was in quadrats furthest from the edge of the lagoon, where Melaleuca dominance was also greatest.

Where applicable, observations of vegetation health (presence of necrotic spots on leaves, galls on small branches) for Broad-leaved Paperbark at the Salty Lagoon site was recorded as part of the vegetation zonation quadrats along Transects 1-3 (refer to comments in **Table 3.5**). Melaleuca dieback quadrats were located in close proximity to the vegetation zonation quadrats (and occasionally used the same quadrat). Therefore, assessment of Melaleuca dieback/ recolonisation monitoring should also take into account comments made for these quadrats (refer to **Table 3.3**). In general, the observations taken indicated that Broad-leaved Paperbark health was good, with no discernible substantial necrosis of leaves or galls.



#### Table 3.5 Melaleuca Dieback Quadrat Data

Transect	Vegetation		Vegetation			Structure	•			Melaleuca Counts					Condition
	Habitat Zone	Upper Str	ratum	Mid-u Stra	upper ntum	Mid-s	tratum	Lower	Stratum	Trees#	Small Trees^	Seedlings*	Dead individuals	Tree diameter (including dead trees >100 mm DBH)	
		Height (m)	Cover Class	Height (m)	Cover Class	Height (m)	Cover Class	Height (m)	Cover Class	Trees Count	Small Trees Count	Seedling Count	Dead Individual Count	DBH (mm) of trees >100 mm (/ indicates multiple trunks)	
Transect 1	Quadrat A (ea	asting 541828	northing 6	5783071)										-	
	Fringing Marsh	-	-	-	-	2	2	<1.2	6	0	6	1	0	-	Unaffected
	Quadrat B (ea	asting 541811	northing 6	5783082)		1	1	1	1	1		1		1	
	Fringing Marsh/ Swamp	-	-	-	-	-	-	1 - 1.2	5	0	3	5	0	-	Unaffected
	Forest	ooting 541705	northing (	(70000)											
		asiing 541795		578309Z)				1 0	4	0	10	6	1		Upoffoctod
	Marsh/ Swamp Forest	2.5 - 3	Z	-	-	-	-	1.2	4	0	10	0		-	(small trees and seedlings). Dead - 1 small tree
	Quadrat D (ea	asting 541796	northing 6	5783092)	1										
	Fringing Marsh/ Swamp Forest	3 - 4	4	_	-	-	-	<1.2	4	4	14	0	2	100 130 (dead) 190 (dead) 110	Unaffected (small trees and seedlings). Dead - 2 trees
	Quadrat E (ea	asting 541760	northing 6	5783108)											
	Fringing Marsh/ Swamp Forest	4-5	1	-	-	-	-	1 - 1.2	5	1	1	2	0	160/160/160 (dead)	Unaffected (Small trees and seedlings). Dead – 1 tree.



Transect	Vegetation	Vegetat			egetation	Structure	Structure			Melaleuca Counts					Condition
	Habitat Zone	Upper Sti	ratum	Mid-u Stra	ipper tum	Mid-si	tratum	Lower	Stratum	Trees#	Small Trees^	Seedlings*	Dead individuals	Tree diameter (including dead trees >100 mm DBH)	
		Height (m)	Cover Class	Height (m)	Cover Class	Height (m)	Cover Class	Height (m)	Cover Class	Trees Count	Small Trees Count	Seedling Count	Dead Individual Count	DBH (mm) of trees >100 mm (/ indicates multiple trunks)	
Transect 2	Quadrat A (ea	asting 541833	northing (	5782839)								1		1	
	Fringing Marsh	-	-	-	-	-	-	<1.2	3	0	0	0	0	-	No Broad- leaved Paperbark present
	Quadrat B (ea	asting 541817	northing (	5782833)										·	
	Fringing Marsh	-	-	-	-	>1.2	1	<1.2	4	0	3	0	2	-	Dead (2 small trees)
	Quadrat C (ea	asting 541790	northing (	6782829)											
	Fringing Marsh	-	-	-	-	-	-	<1.2	3	0	2	0	0	-	Unaffected
	Quadrat D (ea	asting 541767	northing	6782824)		1						1			
	Fringing Marsh	-	-	-	-	-	-	<1.2	4	1	5	0	2	110 (dead)	Dead (1 tree and 1 small tree)
	Quadrat E (ea	asting 541751	northing (	5782825)						1		1	1	I	
	Fringing Marsh	5	1	-	-	-	-	<1.2	4	8	0	0	6	120 (dead) 110/100 110 (dead) 100 (dead) 130 (dead) 120 (dead) 130	Dead (8 trees)
Iransect 3	Quadrat A (ea	asting 541909	northing 6	5/82556)	1		1	1.0	0	2	0	0	0		
	Fringing Marsh	-	-	-	-	-	-	<1.2	3	U	0	U	U	-	No Broad- leaved Paperbark present
	Quadrat B (ea	asting 541895	northing (	6782543)											



Transect	Vegetation		Vegetation Structure				ć	Melaleuca Counts						Condition	
	Habitat Zone	Upper Str	ratum	Mid-u Stra	ipper tum	Mid-st	ratum	Lower	Stratum	Trees#	Small Trees^	Seedlings*	Dead individuals	Tree diameter (including dead trees >100 mm DBH)	
		Height (m)	Cover Class	Height (m)	Cover Class	Height (m)	Cover Class	Height (m)	Cover Class	Trees Count	Small Trees Count	Seedling Count	Dead Individual Count	DBH (mm) of trees >100 mm (/ indicates multiple trunks)	
	Fringing Marsh	-	-	-	-	-	-	<1.2	2	0	0	0	0	-	No Broad- leaved Paperbark present
	Quadrat C (ea	asting 5418/1	northing 6	o/82545)				1.0	F	0	0	0	2	100	Deed (2
	Fringing	-	-	-	-	-	-	<1.2	5	0	0	0	3	100	Dead (3
	IVIAI SI I													120 110/120/140	liees)
	Quadrat D (ea	asting 5/1853	northina A	782532)										110/130/100	
	Fringing Marsh	-	-	-	-	-	-	<1.2	6	0	0	0		0	No Broad- leaved Paperbark present
	Quadrat E (ea	asting 541835	northing 6	782524)	1				1	1					•
	Swamp Forest	10	3	6	1	-	-	>1.2	4	24	0	0	9	110 (dead) 130 (dead) 120 (dead) 120 (dead) 100 (dead) 100 (dead) 100 (dead) 100 (dead) 110 (dead) 130/100/120/90/100 100 100 100 100 100 100 100	Unaffected small trees and seedlings. Dead (9 trees)



Transect	Vegetation		Vegetation Structure						Melaleuca Counts						Condition
	Habitat	Upper Sti	ratum	Mid-u	upper	Mid-st	tratum	Lower	Stratum	Trees#	Small	Seedlings*	Dead	Tree diameter	
	Zone			Stra	itum						Trees^		individuals	(including dead trees	
														>100 mm DBH)	
		Height (m)	Cover	Height	Cover	Height	Cover	Height	Cover	Trees Count	Small	Seedling	Dead	DBH (mm) of trees	
		-	Class	(m)	Class	(m)	Class	(m)	Class		Trees	Count	Individual	>100 mm (/ indicates	
											Count		Count	multiple trunks)	
														110/100	
														110	
														120	
														100/140	
														110	
														130	
														160/130	
														110	
														130	

Trees –DBH of each stem >100mm #

Small trees - DBH 50 mm - 100 mm Seedlings - height <0.5 m Λ

\*



#### 3.3 Photo-point Monitoring

Photos taken at photo monitoring points in March 2013 are shown in Appendix C



### Discussion and Comparison with Previous Monitoring

#### 4.1 Vegetation Habitat Zonation

#### 4.1.1 Transects 1-3

The main change to occur in the location of the vegetation communities occurring on the western edge of Salty Lagoon since the baseline vegetation monitoring is the reduction in the extent of the Fringing Marsh community. This can be directly attributed to the closure of the artificial channel leading to higher water levels and inundation of some area previously covered by Fringing Marsh and conversion to open water. Discerning the boundary between the Fringing Marsh and open water is practically challenging as some isolated clumps of rushes (primarily Sea Rush) have not yet fully died and decomposed and are therefore scattered across areas that will become open water sometime in the future.

The greatest reduction in Fringing Marsh occurred in the northern part of Salty Lagoon where the measured extent reduced by 80 m over the period since baseline vegetation monitoring.

#### 4.1.1.1 Species Composition of Vegetation Habitat Zones

The overall number of species recorded in the 3 vegetation communities is less in 2013 compared with the results of the baseline vegetation monitoring. The major factor contributing to this decrease in the number of species recorded was the closure of the artificial channel and the resulting expansion of open water covering previously exposed ground in the fringing marsh. Twenty-eight flora species were recorded in the Fringing Marsh in 2011 compared with a count of 7 species in 2013. A relatively large proportion of the flora species occurring in the Fringing Marsh community were low-growing herbaceous species that are intolerant of submersion for an extended period.

#### 4.1.1.2 Species Dominance

Species dominance was relatively stable between monitoring events, with the same species dominating each of the 3 vegetation communities.

#### 4.1.1.3 Predicted Changes and Indicator Species

The following predicted changes were listed in the baseline vegetation monitoring report. These are discussed in turn.

1. Sea Rush (*Juncus krausii* subsp. *australiensis*): expected to decrease in the area currently occupied by Fringing Marsh and Swamp Forest.

There has been a decrease in cover of Sea Rush in both of these communities. More of a reduction has occurred in the Fringing Marsh community when compared with the Swamp Forest. This may be attributable to the greater degree of inundation closer to the lagoon.

2. Saltwater Couch (*Paspalum vaginatum*): expected to decrease in the area currently occupied by Fringing Marsh and Swamp Forest.

A similar pattern to that seen for Sea Rush has also occurred with Saltwater Couch. There has been a decrease in cover of this species in both of these communities, with the most notable reduction occurring in the Fringing Marsh community. Once again, this is likely to be the result of inundation of the Fringing Marsh community after closure of the artificial channel.



3. Shore Club-rush (*Schoenoplectus subulatus*): expected to decrease in the area currently occupied by Fringing Marsh and Swamp Forest.

In the MPCC vegetation monitoring report, Shore Club-rush (*Schoenoplectus subulatus*) was identified as a potential indicator species that was expected to decrease in the area currently occupied by Fringing Marsh and Swamp Forest. This species was not recorded in the Swamp Forest community in either the MPCC vegetation monitoring or the 2013 monitoring. This species was not recorded at a high density in the MPCC vegetation monitoring. Nonetheless, this species has generally declined in cover in the Fringing Marsh since channel closure.

4. Bare Twig-rush (*Baumea juncea*): expected to increase in the area currently occupied by Fringing Marsh.

The monitoring results indicate that Bare Twig-rush has not increased in area in the area occupied by Fringing Marsh in the period of 2011-2013. As the closure of the artificial channel is a relatively recent event, it is too soon to form a judgement on whether this prediction has been proven to have not occurred at Salty Lagoon. Data from the next monitoring event in 2015 may show that this species has extended into the Fringing Marsh over a longer time frame.

5. Broad-leaved Paperbark (*Melaleuca quinquenervia*): expected to increase in the area currently occupied by Fringing Marsh.

Broad-leaved Paperbark has not extended into the Fringing Marsh as yet. The cover of this species has also remained relatively stable in and around the edge of the Swamp Forest community. As for Bare Twig-rush the timeframe since the closure of the artificial channel is likely to be insufficient to determine if this prediction will be borne out. The next monitoring event in 2015 (or later) may show that this species has extended into the Fringing Marsh over a longer time frame than was expected.

#### 4.1.2 Transects 4-6

The major influencing factor on the extent of the vegetation communities in transects 5 and 6 was also related to increased water levels caused by the closure of the artificial channel. This is most apparent when a comparison is made between the monitoring photos for the fringing marsh/ open water quadrats in the baseline vegetation monitoring report and the current monitoring event (refer to **Plate 4.1**).



Plate 4.1 Comparison between Transect 6, quadrat A1 in 2011 (left) and 2013 (right), showing a conversion from Fringing Marsh to open water.



#### 4.1.2.2 Species Composition of Vegetation Habitat Zones

The overall number of species recorded in the vegetation communities along these transects was relatively stable over the period of 2011 to 2013, with 32 species recorded in the baseline vegetation monitoring and 38 species recorded in 2013. One major change was a decrease from 13 species to 6 in the Swamp Forest at Transect 4 (drainage channel). This most likely reflects the proximity of this site to areas that are currently mostly open water, and the inundation of understorey herbaceous species in this part of the site since the closure of the artificial channel. This change can be seen in a comparison of the monitoring photos for the Swamp Forest along Transect 4 taken for the baseline vegetation monitoring and the current monitoring event (refer to **Plate 4.2**).



Plate 4.2 Comparison between Transect 4, quadrat B1 in 2011 (left) and 2013 (right), showing inundated ground since artificial channel closure.

#### 4.1.2.3 Species Dominance

Species dominance was relatively stable between monitoring events, with the exception of the Fringing Marsh community in which the dominant species have shifted from Saltwater Couch and Shore Club-rush in 2011 to Bare Twig-rush in fringing areas and Blady Grass where the transect crossed well-drained land just above the water level.

#### 4.1.2.4 Predicted Changes and Indicator Species

The following predicted changes were listed in the baseline vegetation monitoring report. These are discussed in turn.

1. Sea Rush (*Juncus krausii* subsp. *australiensis*) (expected to decrease in the area currently occupied by the Gahnia sedge/ open water habitat zone along Transect 4).

Sea Rush showed no significant difference in cover between the baseline vegetation monitoring and the current monitoring event in 2013. As the closure of the artificial channel is a relatively recent event, it is too soon to form a judgement on whether this prediction has been proven to have not occurred at Salty Lagoon. Data from the next monitoring event in 2015 may show that this species has decreased in extent in this community over a longer time frame.

2. Saltwater Couch (*Paspalum vaginatum*) (expected to decrease in the area currently occupied by the Swamp Forest along Transect 4 and Fringing Marsh along Transect 5).

This species has experienced a slight decrease in cover in these communities but not to a great degree. As mentioned previously this change may become more apparent in future monitoring events over a longer time frame.

3. Shore Club-rush (*Schoenoplectus subulatus*) (expected to decrease in the area currently occupied by Fringing Marsh vegetation habitat zone along Transects 5 and 6).

As predicted this species has decreased substantially in this vegetation community (no longer recorded in quadrat data in 2013).



4. Saw-sedge (*Gahnia* spp.) expected to increase in the area currently occupied by Sedge Swamp/ open water in Transect 4).

Saw-sedge was recorded at a slightly lower cover in 2013 that in the baseline vegetation monitoring. It is not clear whether this is due to small differences in sampling between individuals or whether this prediction will not occur. Data from future monitoring events will make this clearer.

5. Coast Banksia (*Banksia integrifolia* subsp. *integrifolia*) (expected to retain current density within the Banksia Woodland with expected water level changes).

As predicted, Coast Banksia has maintained a similar cover level in the Banksia Woodland between the baseline vegetation monitoring event and the current monitoring event.

#### 4.1.3 Melaleuca Dieback/ Recolonisation Monitoring

Data on Melaleuca dieback recorded in the baseline vegetation monitoring and the current monitoring is broadly consistent. There are some early indications of an increase in the number of seedlings, particularly at Transect 1. However, as the artificial channel closure occurred relatively recently, this trend will not be confirmed until more time has elapsed and the changes in the water levels have stabilised. The overall health of the existing Broad-leaved Paperbark was observed to be good, with no trees in an obvious state of decline. This would seem to indicate that the dieback event is no longer occurring and that this species should remain at its current extent or increase its extent over time.

#### 4.1.4 Future Monitoring

The results of the 2013 vegetation monitoring indicate early signs of vegetation change, particularly in relation to the Fringing Marsh community, which is decreasing in overall extent due to inundation. The changes that have been observed at Salty Lagoon since 2011are broadly consistent with the predictions made in Hydrosphere (2010b and 2011). Other changes may only become apparent as more time elapses since the closure of the artificial channel, and as such it will be necessary to wait until at least the next round of vegetation monitoring in 2015 to draw conclusions on whether these predicted vegetation changes have occurred or not.





Hydrosphere (2010a). *Salty Lagoon Ecosystem Recovery Monitoring Program (ERMP)*. A report by Hydrosphere Consulting to Richmond Valley Council. Hydrosphere Consulting, Ballina.

Hydrosphere (2010b). Salty Lagoon Ecosystem Recovery Monitoring Program Pre-Post Closure (MPPC). A report by Hydrosphere Consulting to Richmond Valley Council. Hydrosphere Consulting, Ballina.

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Hydrosphere (2011). *Salty Lagoon Rehabilitation Plan.* A report by Hydrosphere Consulting to Richmond Valley Council. Hydrosphere Consulting, Ballina.



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## Appendix A

GPS Locations of Vegetation Habitat Zone Boundaries and Monitoring Quadrats

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Transect	Vegetation Habitat Zone	Easting	Northing	Comment
1	Sedge Swamp (western boundary)	541565	6783210	
1	Sedge Swamp/ Swamp Forest	541701	6783141	
1	Swamp Forest/ Fringing Marsh	541807	6783085	
1	Fringing Marsh/ Open Water	541895	6783039	
2	Sedge Swamp (western boundary)	541402	6782749	
2	Sedge Swamp/ Swamp Forest	541485	6782762	
2	Ecotone between Swamp Forest and Fringing Marsh	541665- 541786	6782808- 6782821	Ecotone – location of edges is given as two figures
2	Fringing Marsh/ Open Water	541934	6782854	
3	Sedge Swamp (western boundary)	541786	6782821	
3	Sedge Swamp/ Swamp Forest	541646	6782463	
3	Swamp Forest/ Fringing Marsh	541834	6782526	Edge of forest supporting foliage
3	Fringing Marsh/ Open Water	542042	6782616	

Table A.1 Waypoints Defining the Boundaries of the Three Vegetation Habitat Zones along Transects 1-3



Transect Number	Quadrat Number	Vegetation Habitat Zone	Easting	Northing
1	A1	Sedge Swamp	541564	6783237
	A2		541579	6783231
	B1	Swamp Forest	541699	6783134
	B2		541743	6783114
	C1	Fringing Marsh	541832	6783076
	C2		541885	6783044
2	A1	Sedge Swamp	541411	6782754
	A2		541453	6782756
	B1	Swamp Forest	541523	6782775
	B2		541646	6782802
	C1	Fringing Marsh	541833	6782839
	C2		541927	6782849
3	A1	Sedge Swamp	541559	6782425
	A2		541588	6782425
	B1	Swamp Forest	541697	6782464
	B2		541784	6782504
	C1	Fringing Marsh	541895	6782543
	C2		542002	6782591
4	A1	Sedge Swamp Open Water	541785	6782669
	B1	Swamp Forest	541783	6782683
5	A1	Sedge Swamp Open Water	542090	6782821
	B1	Banksia Woodland	542072	6782821
6	A1	Sedge Swamp Open Water	542109	6783073
	B1	Banksia Woodland	542118	6783068

#### Table A2 Location of Vegetation Habitat Zone Quadrats



Transect Number	Quadrat Number	Vegetation Habitat Zone	Easting	Northing
1	А	Fringing Marsh	541828	6783071
	В		541811	6783082
	С	Fringing Marsh/ Swamp Forest	541795	6783092
	D		541796	6783092
	E		541760	6783108
2	А	Fringing Marsh	541833	6782839
	В		541817	6782833
	С		541790	6782829
	D		541767	6782824
	E		541751	6782825
3	А	Fringing Marsh	541909	6782556
	В		541895	6782543
	С		541871	6782545
	D		541853	6782532
	E	Swamp Forest	541835	6782524

#### Table A3 Location of Melaleuca Dieback Quadrats





**Cover Abundance of All Flora Species** 



#### Table B1Cover Abundance of All Flora Species Occurring in Transects 1-3

			Transect 1			Transect 2			Transect 3	
Common Name	Species Name	Fringing Marsh	Swamp Forest	Sedge Swamp	Fringing Marsh	Swamp Forest	Sedge Swamp	Fringing Marsh	Swamp Forest	Sedge Swamp
Hickory Wattle	Acacia disparrima								1	
*Whiskey Grass	Andropogon virginicus					1				
Midgin Berry	Austromyrtus dulcis			1						
Azolla	Azolla filiculoides	1			1	2				
*Groundsel Bush	Baccharis halimifolia								3	
Васора	Bacopa monnieri					1				
Weeping Baeckea	Baeckea frutescens			1-3			3			
Didgery Sticks	Baloskion pallens						3			
Heath-leaved Banksia	Banksia ericifolia subsp. macrantha						1			1
Swamp Twig-rush	Baumea arthrophylla									5-6
Bare Twig-rush	Baumea juncea		2-4			2-3	5		4	
Swamp Water Fern	Blechnum indicum									
Tall Sedge	Carex apressa					1			4	
Dodder	Cassytha sp.			1						1
Indian Pennywort	Centella asiatica					1			1	
	Cyperus polystachyos								1	
a Rush	Cyperus sp.					1-2	1			
a Parrot-pea	Dillwynia sp.						1			



		Transect 1				Transect 2		Transect 3		
Common Name	Species Name	Fringing Marsh	Swamp Forest	Sedge Swamp	Fringing Marsh	Swamp Forest	Sedge Swamp	Fringing Marsh	Swamp Forest	Sedge Swamp
Swamp Mahogany	Eucalyptus robusta			1					1	
Common Finger-rush	Fimbristylis ferruginea				2			1		
Tall saw-sedge	Gahnia clarkei								2	
Red-fruit Saw-sedge	Gahnia sieberiana			3			2			2-3
	Gahnia sp.								1	
Pouched Coral Fern	Glichenia dicarpa									3
Purple Coral Pea	Hardenbergia violacea						1			
Climbing Guinea Flower	Hibbertia scandens		1	1						
A pennywort	Hydrocotyle bonariensis					1			2	
Pennywort	Hydrocotyle peduncularis					1-2			2	
Blady Grass	Imperata cylindrica								3	
Sea Rush	Juncus krausii subsp. australiensis	3	1-5		2	2-3	1	2-3		
	Lemnoidiae	1			1	1		1		
	Lepidosperma sp.			1						
Grey Rush	Lepironia articulata					1	1			
Slender Twine-rush	Leptocarpus tenax						2			
Prickly Tea Tree	Leptospermum juniperinum			3						
Olive Tea Tree	Leptospermum liversidgei									1-2
	Lepyrodia interupta			1						



	Transect 1				Transect 2		Transect 3			
Common Name	Species Name	Fringing Marsh	Swamp Forest	Sedge Swamp	Fringing Marsh	Swamp Forest	Sedge Swamp	Fringing Marsh	Swamp Forest	Sedge Swamp
	Leucopogon sp.								1	
Spiny-headed Mat- rush	Lomandra longifolia								3	
	Marsdenia rostrata								1	
Milk Vine	Marsdenia sp.					1			1	
Broad-leaved Paperbark	Melaleuca quinquenervia		3	3		3-4	2-3		3-4	3
	Melichrus sp.			1					1	
Duckweed	Myriophyllum sp.					1		1		
Creeping Beard Grass	Oplismenus imbecillis									
Monkey Rope	Parsonsia straminea						1		2	1
Saltwater Couch	Paspalum vaginatum	3	1-2		2-3	2		2-3	2	
Common Reed	Phragmites australis		2		1	2				
Bush-pea	Pultenaea sp.									1
a Buttercup	Ranunculus sp.									
Plume Rush	Baloskion tetraphyllum			4-6			2-3			1
	Schoenoplectus littoralis				3					
Shore Club-rush	Schoenoplectus subulatus	2								
Zig-zag Bog-rush	Schoenus brevifolius						1-3		1	
a Bog-rush	Schoenus sp.									
Swamp Selaginella	Selaginella uliginosa			1			3			1



		Transect 1		Transect 2			Transect 3			
Common Name	Species Name	Fringing Marsh	Swamp Forest	Sedge Swamp	Fringing Marsh	Swamp Forest	Sedge Swamp	Fringing Marsh	Swamp Forest	Sedge Swamp
*Fireweed	Senecia madagascariensis									
*Glossy Nightshade	Solanum americanum									
*Common Sowthistle	Sonchus oleraceus									
Knotted Scale-rush	Sporadanthus interruptus									
Sand Couch	Sporobolus virginicus						3			
Cumbungi	Typha orientalis									
Bryophyte (moss) sp.	unknown									4
a Speedwell	<i>Veronica</i> sp.					1			1-2	
Wild Violet	Viola banksii								2	
Ivy-leaved Violet	Viola hederacea					1				
Bryophyte (moss) sp.         a Speedwell         Wild Violet         Ivy-leaved Violet	unknown Veronica sp. Viola banksii Viola hederacea					1			1-2	

Denotes exotic species



#### Table B2Cover Abundance of all Flora Species Occurring in Transects 4-6

		Trai	nsect 4	Transect 5		Transect 6		
Common Name	Species Name	Sedge Swamp/ Open Water	Swamp Forest	Fringing Marsh	Banksia Woodland	Fringing Marsh	Banksia Woodland	
Lesser Joyweed	Alternanthera denticulata			1				
Azolla	Azolla filiculoides	2						
*Groundsel Bush	Baccharis halimifolia	1						
Coast Banksia	Banksia integrifolia subsp. integrifolia				4			
Jointed Twig-rush	Baumea articulata	3						
Bare Twig-rush	Baumea juncea	2	3	3	2	3	3	
	Callitriche muelleri			1		1		
Tall Sedge	Carex appressa			1				
Gotu Cola	Centella asiatica			1	1	1	3	
*Flaxleaf Fleabane	Conyza bonariensis			2	1		1	
*Bitou Bush	Crysanthemoides monilifera			2	3	1	3	
Barb-wire Grass	Cymbopogon refractus				1			
	Cyperus polystachyos	2	2	2	3	1	2	
	<i>Cyperus</i> sp.	2						
*Cockspur Coral Tree	Erythrina crista-galli			1				
Knobby Club-rush	Ficinia nodosa			3	1	2	1	
Common Finger-rush	Fimbristylis ferruginea			1		1		
Tall saw-sedge	Gahnia clarkei	1						
Climbing Guinea Flower	Hibbertia scandens						1	
Pennywort	Hydrocotyle peduncularis	2	2	2	1	1		
Shield Pennywort	Hydrocotyle verticillata			2		1		
Harsh Ground Fern	Hypolepis muelleri	1						



		Transect 4		Tran	sect 5	Transect 6		
Common Name	Species Name	Sedge Swamp/ Open Water	Swamp Forest	Fringing Marsh	Banksia Woodland	Fringing Marsh	Banksia Woodland	
Blady Grass	Imperata cylindrica			4	5	2	5	
*Coastal Morning Glory	Ipomoea cairica					1		
Sea Rush	Juncus krausii subsp. australiensis	3	3					
Cockspur Vine	Maclura cochinchinensis				1		2	
Milk Vine	Marsdenia sp.							
Broad-leaved Paperbark	Melaleuca quinquenervia		4	3		3		
	Oplismenus sp.			1	1			
	<i>Oxalis</i> sp.			1			1	
*Corky Passionflower	Passiflora suberosa				1			
Saltwater Couch	Paspalum vaginatum		4	2			2	
Shore Club-rush	Schoenoplectus subulatus	2		2		2		
Sweet Sarsaparilla	Smilax glyciphylla				1			
*Sow Thistle	Sonchus oleraceus						1	
Snake Vine	Stephania japonica var. discolor				2		1	
Broad-leaved Cumbungi	Typha orientalis	2						
* Donatas avatis spasis					·			

Denotes exotic species





### **Photo-point Monitoring Results**



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Transect 1 quadrat B1



Transect 1 quadrat A2



Transect 1 quadrat B2



Transect 1 quadrat C1



Transect 1 quadrat C2





*Not recorded* Transect 2 quadrat A1

Transect 2 quadrat A2



Transect 2 quadrat B1



Transect 2 quadrat B2



Transect 2 quadrat C1



Transect 2 quadrat C1





Transect 3 quadrat A1

Transect 3 quadrat A2



Transect 3 quadrat B1



Transect 3 quadrat B2



Transect 3 quadrat C1



Transect 3 quadrat C2





Transect 4 quadrat A1

Transect 4 quadrat B1



Transect 5 quadrat A1



Transect 5 quadrat B1



Transect 6 quadrat A1



Transect 6 quadrat B1







Melaleuca Dieback Transect 1 quadrat A

Melaleuca Dieback Transect 1 quadrat B



Melaleuca Dieback Transect 1 quadrat C



Melaleuca Dieback Transect 1 quadrat D



Melaleuca Dieback Transect 1 quadrat E





Not recorded Melaleuca Dieback Transect 2 quadrat A

Melaleuca Dieback Transect 2 quadrat B



Melaleuca Dieback Transect 2 quadrat C



Melaleuca Dieback Transect 2 quadrat D



Melaleuca Dieback Transect 2 quadrat E





Melaleuca Dieback Transect 3 quadrat A



Melaleuca Dieback Transect 3 quadrat C



Melaleuca Dieback Transect 3 quadrat E



Melaleuca Dieback Transect 3 quadrat B



Melaleuca Dieback Transect 3 quadrat D



