# To 30 June 2018

# Buckland Dry Creek PEPR Compliance Report



For Holding Pattern and Residual Operations

#### **Buckland Dry Creek Pty Ltd**

GPO Box 234 Port Adelaide South Australia 5015

(ACN 114 007 153; ABN 82 114 007 153) 1 November 2018

#### **Document Control**

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#### **Executive Summary**

This document has been prepared to fulfil the requirement under Regulation 86 for the tenements listed herein

This report provides and references information concerning the compliance of PEPR / MoP operations at the Dry Creek Salt Field in the period from 1 July 2017 to 30 June 2018.

The information in and referenced by this report demonstrates the extent to which the Holding Pattern and Residual Operations at the Dry Creek Salt Field have complied with the environmental outcomes and measurement criteria in the DEM approved PEPR / MoP.

The information presented in the text of this report, in the Appendices to this report and that is accessible via the links referenced in this report is designed to be read as a whole for the purposes of assessing this compliance.

## **Acronyms and Abbreviations**

AMLR	Adelaide and Mount Lofty Ranges
ACM	Asbestos Containing Material
AHD	Australian Height Datum
Anaerobic	Relating to or requiring an absence of free oxygen
ASS	Acid Sulfate Soils
Biodiversity	The variety of plant and animal life in the world or in a particular habitat.
Bitterns	A solution of bromides, magnesium and calcium salts remaining after sodium chloride is crystallised out of seawater
BOD	Biological Oxygen Demand
Brine	Water saturated with or containing large amounts of salt, especially sodium chloride
Calsilt	Calsilt was a byproduct from the Penrice manufacturing plant, and is mostly calcium
Camelles	Salt stacks formed from a series of overlapping cones of salt
CE Steering	Chief Executives Steering Group
СоР	Change of process
CoS	City of Salisbury
Cst	Coastal Zone under the current Development Plan
DEWNR	Department of Environment, Water and Natural Resources
DO	Dissolved oxygen
DoE	Department of the Environment (Cth)
DPTI	Department of Planning, Transport and Infrastructure
DEM	Department of State Development (including the former Department for Manufacturing, Innovation, Trade, Resources and Energy prior to 1 July 2014)
DSTO	Defence Science and Technology Organisation
Eln	Extractive Industry zone under the current Development Plan
Entrainment	The upward movement of eroded particles into the water column by net turbulent
Eol	Expressions of Interest
ЕРА	Environment Protection Authority
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
Freehold	Permanent and absolute tenure of land or property with freedom to dispose of it at

Maiden brine Saturated brine ready for the crystallisation of salt  MBO Mono-sulphidic black ooze  MFP Multifunction Polis zone  ML Mining Lease  MOP Mine Operations Plan  MOSS Metropolitan Open Space System  NABCWMB Northern Adelaide and Barossa Catchment Water Management Board  NaCl Chemical grade solar salt  NEPM National Environment Protection Measure  NGO Non Government Organisation  NRM Natural Resource Management  OTH Over-the-horizon radar  PASS Potential acid sulfate soils  PEPR Program for Environment Protection and Rehabilitation  ppt Parts per thousand  PIRSA Department of Primary Industries and Regions SA  Ramsar The Convention on Wetlands (Ramsar, Iran, 1971)  SA South Australian (Government)  Salinas a set of interconnected lagoons  Samphire Sparse to medium density dwarf shrubland of semi-woody plants  SAR sodium absorption ratio (
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SAR sodium absorption ratio (
SEB significant environmental benefit
SME Special Mining Enterprise Agreement
SOP Standard Operating Procedure
STAG Strategy and Technical Advisory Group
TDS Total dissolved solids
TJpa Terajoule per annum
tpa tonne per annum

#### 1. Introduction

Table 1: PEPR Number & Approval; Mining Leases

Mine Name	Name Dry Creek Salt Fields PEPR #			PEPR470606	
			Date App	roved	12 April 2017
Lease Holder	Buckland Dry Creek Pty Ltd (from 1 Ju			ne 2016)	
Operator	Buckland Dry	Creek Pty Ltd	reek Pty Ltd (from 1 June 2016)		
Mining Lease	Mining Lease	Registration (	Grant Date	Next renewal d	ate
Approval Date	234	1/4/19	928	31/3/2019	
Date	235	1/4/19	928	31/3/2019	
	237	1/4/19	928	31/3/2019	
	357	1/7/19	976	30/6/2019	
	358	1/7/19	976	30/6/2019	
	359	1/7/19	976	30/6/2019	
	360	1/7/19	976	30/6/2019	
	361	1/7/19	976	30/6/2019	
	389	1/7/19	978	31/3/2019	
	390	1/7/19	978	31/3/2019	
	391	1/7/19	978	31/3/2019	
	392	1/7/19	978	31/3/2019	
	404	1/10/1	956	31/3/2019	
	405	1/10/1	956	31/3/2019	
	406	1/10/1	956	31/3/2019	
	416	1/1/19	978	30/6/2019	
	417	1/1/19	978	31/3/2019	
	418	1/1/19	978	31/3/2019	
	421	1/1/19	979	31/3/2019	
	429	1/4/19	980	30/6/2019	
	439	1/4/19	980	31/3/2019	
	440	1/4/19	980	31/3/2019	
	441	1/4/19	980	31/3/2019	
	442	1/4/19	980	31/3/2019	
	443	1/4/19	980	31/3/2019	
	444	1/4/19	980	31/3/2019	
	445	1/4/19	980	31/3/2019	
	446	1/4/19	980	31/3/2019	
	447	1/4/19	980	31/3/2019	
	448	1/4/19	980	31/3/2019	

	587	1/	7/1975	31/3/2019		
	600	1/	4/1977	31/3/2019		
	605	605 1/4/1956				
	606	606 1/4/1956				
	607	1/	4/1956	31/3/2019		
	608	1/	4/1956	31/3/2019		
	617	1/	4/1978	31/3/2019		
	618	1/	4/1978	31/3/2019		
	702	1	./4/73	31/3/2019		
	5205	16/	03/1984	30/6/2019		
	5206	16/	03/1984	30/6/2019		
	5207	16/	03/1984	30/6/2019		
	5208	16/	03/1984	30/6/2019		
	5209	16/	03/1984	30/6/2019		
	5210	16/	03/1984	30/6/2019		
	5908	25/	10/1994	25/10/2015		
	Private Mine #	Registrat	tion Grant Date			
	248	Private Mine # Registration Grant Date				
	248 22/8/1974 199 25/10/1973					
	25/10/15/3					
Associated Tenements	MLs 234, 235, 237, 357, 358, 359, 360, 361, 389, 390, 391, 392, 404, 405, 406, 416, 417, 418, 421, 429, 439, 440, 441, 442, 443, 444, 445, 446, 447, 448, 587, 600, 605, 606, 607, 608, 617, 618, 702, 5205, 5206, 5207, 5208, 5209, 5210, 5908 and PMs 248 and 199			587, 600, 605,		
Approval Document	MO6628.055, da	ated 12 Ap	oril 2017			
Ministerial Determination	MD09					
Site Contact	Allan Mathieson					
	Email Buckland@epicbuilding.com.au					
	Phone Number		0407 792 134			
Registered Mine Manager	Allan Mathieson	n				
<u> </u>	1					

# **Buckland Dry Creek Pty Ltd** (ACN 114 007 153; ABN 82 114 007 153)

Site Location Details	The site office can be accessed from the Salisbury Highway, entering via Magazine Road, Dry Creek. The site extends from Dry Creek to Middle Beach – an approximate distance of 28 km				
Reporting Period	From	1 July 2017	То	30 June 2018	
Date of Compliance Report Preparation	30 October	2018	1	1	

#### 2. Executive Declaration

#### **Table 2: Executive Declaration**

Person responsible	for preparation of the comp	oliance report		
This document has been prepared to fulfil the requirement under Regulation 86 for the tenements listed herein. The information contained in this report is to the best of my knowledge a true and accurate record of the mining activities and compliance status for the reporting period.				
Name:	Position or Agent:	Signature	Date:	
Petar Jurkovic	Managing Director, Buckland Dry Creek Pty Ltd		31   11   1	
Agency Agreement	*	, ,	· ·	

### 3. Tenements

A table and map showing the Mine leases and Private Mines

**Table 3: Tenements** 

Tenement	Tenement number	Next Renewal Date	Forward work plan
ML	234	31/03/2019	
ML	235	31/03/2019	
ML	237	31/03/2019	
ML	357	30/06/2019	
ML	358	30/06/2019	
ML	359	30/06/2019	
ML	360	30/06/2019	
ML	361	30/06/2019	
ML	389	31/03/2019	
ML	390	31/03/2019	
ML	391	31/03/2019	
ML	392	31/03/2019	
ML	404	31/03/2019	
ML	405	31/03/2019	
ML	406	31/03/2019	
ML	416	30/06/2019	
ML	417	31/03/2019	
ML	418	31/03/2019	
ML	421	31/12/2019	
ML	429	30/06/2019	
ML	439	31/03/2019	
ML	440	31/03/2019	
ML	441	31/03/2019	
ML	442	31/03/2019	
ML	443	31/03/2019	
ML	444	31/03/2019	
ML	445	31/03/2019	
ML	446	31/03/2019	
ML	447	31/03/2019	
ML	448	31/03/2019	
ML	587	31/12/2019	
ML	600	31/03/2019	
ML	605	31/03/2019	
ML	606	31/03/2019	
ML	607	31/03/2019	
ML	608	31/03/2019	
ML	617	31/03/2019	
ML	618	31/03/2019	
ML	702	31/03/2019	
ML	5205	30/06/2019	
ML	5206	30/06/2019	
ML	5207	30/06/2019	
ML	5208	30/06/2019	
ML	5209	30/06/2019	
ML	5210	30/06/2019	
ML	5908	25/10/2015	
PM	199	Granted 25/10/1973	
PM	248	Granted 22/08/1974	

#### **Buckland Dry Creek Pty Ltd**

(ACN 114 007 153; ABN 82 114 007 153)

Figure 1: SARIG Map of Tenements in Salt Field – 1

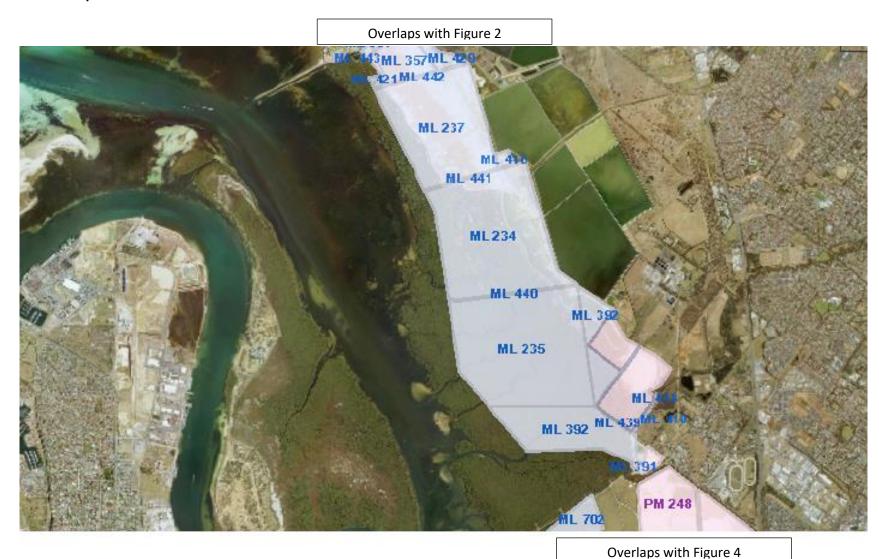
https://map.sarig.sa.gov.au



Figure 2: SARIG Map of Tenements in Salt Field - 2



Figure 3: SARIG Map of Tenements in Salt Field - 3



**UNCONTROLLED COPY.** Printed document may not be current issue.

Figure 4: SARIG Map of Tenements in Salt Field – 4



Figure 5: Historic Aerial Photo with Overlaid Cadastral Boundaries - 1

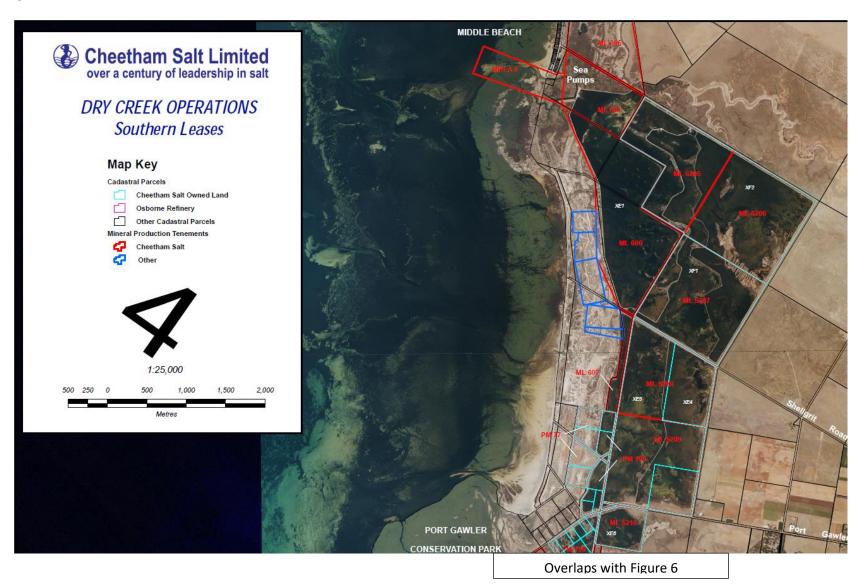


Figure 6: Historic Aerial Photo with Overlaid Cadastral Boundaries - 2

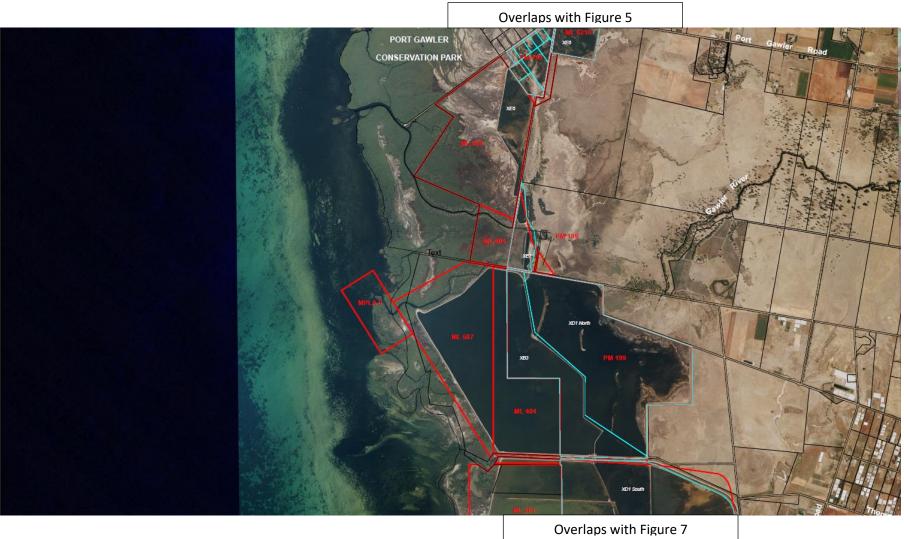
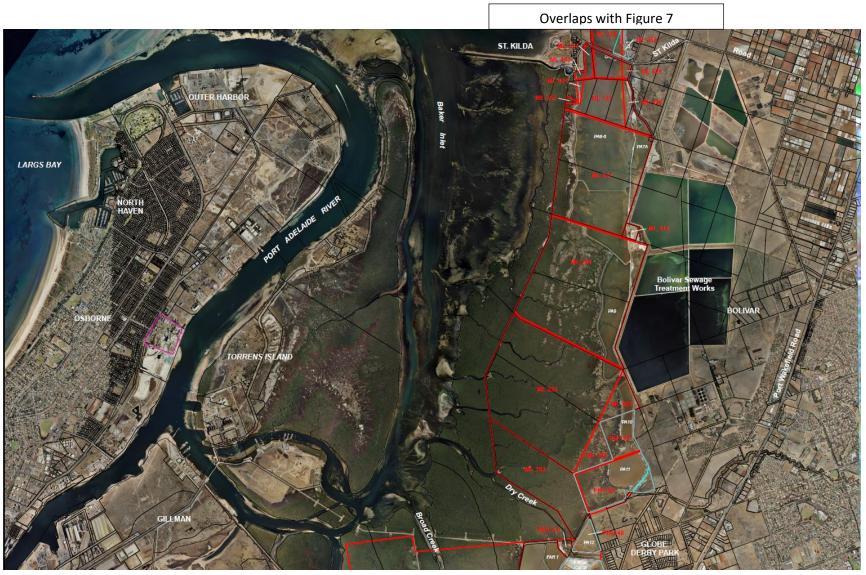


Figure 7: Historic Aerial Photo with Overlaid Cadastral Boundaries - 3

Overlaps with Figure 6



Figure 8: Historic Aerial Photo with Overlaid Cadastral Boundaries - 4



Overlaps with Figure 9

#### **Buckland Dry Creek Pty Ltd**

(ACN 114 007 153; ABN 82 114 007 153)

Figure 9: Historic Aerial Photo with Overlaid Cadastral Boundaries - 5

Overlaps with Figure 8



#### 4. Other Licences and Permits

**Table 4: Other Licences and Permits** 

Licence, Permit or Agreement	Regulatory Authority or Other	Supporting Document	Associated ML, MPL, EML lease condition or Outcome Measurement Criteria
EPA Licence	40942 Commencement Date: 01 Apr 2016 Expiry Date: 31 Mar 2021		
Fisheries Management Act Permit	Exemption No. ME9902699	MPEPR2014/100	
AMLNRM Permit and Agreement with City of Playford	AMLNRM Permit A14010  Agreement dated 12 December 2014 between Ridley Dry Creek Pty Ltd (Ridley) and the City of Playford - Stormwater Harvesting		
Water Extraction Licences	211790, 211788		

## 5. Mining Operations and Closure

**Table 5: Mine Operations & Closure** 

Mining Operations	Information
Ore Reserves and Mine Life	The Mine is in a Holding Pattern, Pending closure. No new
	salt is being produced
Overburden Ore and Concentrate	NIA.
	NA
	As 30 June 2018, approximately 240,000 tonnes of salt remains in the floors of crystallisers and the final areas in
	Section 1
	NA
	NA
Holding Pattern and Residual Operations	
	The residual operations in Section 1:
	<ul> <li>The residual operations in Section 1:</li> <li>pumping bore water from the T1 aquifer and sea water to dissolve or wash salt in stockpiles or in crystallisers</li> <li>excavation of salt from crystallisers and loading this into trucks for transport to stockpile or to an on-site salt washing plant</li> <li>washing salt to stockpile</li> <li>loading salt from stockpile into trucks for transport offsite</li> <li>pumping "MagBrine" into a tanker for use on site or for transport offsite</li> <li>workshop operations for the maintenance and repair of equipment</li> <li>when permitted, the pumping of diluted waste brine from salt washing into sea water</li> <li>storage of waste brine from salt washing or brine from dissolved salt</li> <li>recrystallisation of brine in crystallisers</li> <li>pumping and storage of stormwater</li> <li>maintenance of existing roads and bunds</li> <li>environmental management as per the existing management plans and procedures</li> <li>the operations of the site office.</li> <li>Holding Pattern Activities</li> <li>Continuation of the historic operational seawater entrainment at Middle Beach into Section 4</li> <li>Entrainment at Chapman Creek into Section 3. This used to be the operational entrainment location until superseded by Middle Beach.</li> <li>Entraining and discharging sufficient volumes of water, and managing flows of water between ponds to manage water levels and quality within the inundated ponds. Information is provided below about target ranges for water levels. The water quality parameters include Dissolved Oxygen, Temperature, Specific Gravity, and pH. The aim with these is to stay broadly consistent with values that pertained during normal operations, except to the extent this objective</li> </ul>

Classing	is unavoidably constrained by the point of discharge being moved from PA12 to PA5.  A trial of discharges to the Gawler River from Pond XE6  Investigations and Studies  Topography and Bathymetry (None in this reporting period)  Land Management Investigations / Trials (None in this reporting period)  Acid Sulfate Soils / Mono-sulfidic Black Ooze (None in this reporting period)  Odours / dust prevention / mitigation trials (None in this reporting period)  Migratory birds monitoring and investigations  Surface water management  Infrastructure management  Vegetation surveys (None in this reporting period)  DEWNR Trials for controlled tidal inundation of Pond XB8A  Trials for discharges of brine to the Port River or to North Arm Creek or to Dry Creek (None in this reporting period)  SA Water Trials of Nitrogen removal from treated sewage effluent using selected Ponds in Section 2  Trial of placement of salt residues in F and G Row Pits (None in this reporting period)  The trial of construction of layered fill profile intended for use in closure works for land in Section 1 (Preparatory works including some importation of fill in this reporting period – See Appendix J)
Closure	<ul> <li>NA for this reporting period:</li> <li>Certain Closure Works in PM248 of Section 1 are permitted by the PEPR. None have yet been implemented.</li> <li>Other Closure Works to be regulated by future approved revisions to the PEPR</li> </ul>

# 6. Voluntary Information

#### **Table 6: Voluntary Information**

Activity	Description					
Voluntary Reporting	This takes the following forms:					
	Reporting to DPC and EPA by providing graphs and tabulated					
	monitoring data for pond water quality, and levels, for pumping					
	volumes and for discharge water quality on a DataStream web site,					
	from where it can be downloaded. The DataStream web site has been					
	made accessible to DEM and EPA staff.					
Charter for Coordinated	Ridley sought and facilitated the creation of an agreed Charter for the					
DoE and DEWNR / DEM	coordinated DoE and DEWNR / DEM assessment of Impacts on Matters of					
assessment of Impacts on	National Environmental Significance. A draft Charter was created and is filed					
Matters of National	with Buckland Dry Creek Pty Ltd.					
Environmental						
Significance	This is needed as the Mining Act and the EPBC Act both apply (in different					
	ways to the) management and protection of birds and vegetation at the site,					
	and it is important therefore that there is a coordinated approach (as between					
	State and Commonwealth Agencies) to impact assessment and compliance,					
	particularly in respect of migratory shorebirds and certain vegetation					

## 7. Summary of Project Variations

**Table 7: Project Variations** 

Description of Project Variation	Date Project Variation submitted to DEM	Document Control Number	Date regulatory authority endorsement received	Forward Work Plan i.e. Included in annual PEPR update?
Initial PEPR	17 December 2014	Dry Creek Salt Field PEPR December 2014.pdf	18 December 2014	
SA Water Trial in PA9	5 December 2014	Minor Change Application 141205.docx	8 December 2014	
Drain XF1	16 January 2015	Change of Process Application 140930	22 January 2015	
Extension of SA water trial to more of PA9 and to PA10	24 July 2015	Minor Change Application 150724.docx	28 August 2015	
Revision 2 – for changed compliance point for discharges via SA Water outfall and for extension of trial discharges to Gawler River	9 October 2015	Dry Creek Salt Field PEPR October 2015.pdf	23 October 2015	
Initial trial of Brine Discharges to Port River	23 November 2015 – submitted to DEM and EPA	Email of 23  November 2015, with attached documents:  Brine Main Pressure Test Procedure 151112 Results of lab tests on brine Main Water Sample AWQC report 140411_P-7	EPA email of 25 November 2015	Not included in the Forward Work Plan.  Due to leaks from the Brine Main uncovered by preliminary testing, this trial has been deferred pending outcomes from salt removal from Section 1  If the trial is conducted and if it proved successful, then apply for a) EPA Licence Variation to allow

Description of Project Variation	Date Project Variation submitted to DEM	Document Control Number	Date regulatory authority endorsement received	Forward Work Plan  i.e. Included in annual PEPR update?
				discharge into the Port River; and b) a Minor Change under the PEPR to allow resumption of pumping brine into the Brine Main (once a normal part of site operations)
Revision 3 – for inclusion of a) soil filling works in PM248 (in Section1) and b) additional trials and investigations to inform selection of closure strategies	March 2017	Dry Creek Salt Field Integrated Program f or Environment Protection and Rehabilitation and Mine Operations Plan  Revision 3 v.3  March 2017	13 April 2017	Change under the PEPR to fill PM248, and to conduct other approved trials and investigations  The DEWNR Trial in XB8A  The continuation / extension of the SA Water Trial in Section 2
Resumption of salt production in A, B, C Row crystallisers in Section 1, Using Brine from condensers in Sections 2, 3 and 4 of the saltfield	Plan for this variation is in preparation			Planning is underway (from 2Q of 2018) and will be documented  Some restoration of previously used salt production systems and infrastructure will be required  The types of salt production operations would be the same as when the salt field was in use up to 2013, and so consistent with existing approvals for the salt field

## 8. Complaints

**Table 8: Complaints** 

Complaint Reference Notes: Date, type (resident, general public etc.)	Complaint Type Notes: e.g. noise, dust or traffic complaint.	Was the complaint as a result of a PEPR non-compliance?	Resolution Date	Forward Work Plan Notes: e.g. additiona I screening installed, or "NIL" if no evidence found to support complaint
From 1 June 2016, Bu	ıckland Dry Creek Pty I	Ltd became the operat	or of the Salt Field.	
8th March 2017	Dust from XC2	No	No dust from XC2 was visible on structures at the complainants property. BDC has communicated this with DEM and EPA.	Work thus far has involved:  1. Constructing wind barrier to induce turbulence and reduce dust carried offsite  2. Trial Use of
2nd August 2017	Dust from XC2	No	No dust from XC2 was visible on structures at the complainants property. BDC has communicated this with DEM and EPA.	Mag Brine to form a dust emission resistant crust 3. Exploration of feasibility of pumping shallow groundwater to moisten soil surface
12 th and 14th March 2018	Dust from XC2 and XC2E	No	No dust from the saltfield was visible around or at the complainants property. The saltfield operator in their daily report have indicated no issues with dust in and around the Brooks road area.  BDC has communicated	ahead of adverse weather conditions for dust 4. Exploration of possibility to import mulch to place as soil cover over dust prone areas

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Complaint Reference Notes: Date, type (resident, general public etc.)	Complaint Type Notes: e.g. noise, dust or traffic complaint.	Was the complaint as a result of a PEPR non-compliance?	Resolution Date	Forward Work Plan Notes: e.g. additiona I screening installed, or "NIL" if no evidence found to support complaint
			this with DEM and EPA.	

# **9. Compliance Summary Table**

**Table 9: Compliance Summary** 

Outcome	Outcome Measurement Criteria (OMC)	OMC Compliance	Leading Indicator*	Leading Indicator	Leading Indicator	Evidence* Notes: For each criterion, state what measurements have been taken to monitor compliance and provide an interpretation of the results (i.e. compliant or	Forward Work Plan*  Notes: If non-compliant summarise actions being undertaker rectify. If unable to demonstrate compliance state reasons
		Status Compliant (C)	Notes: Is there an associated Leading indicator?	Status*	Actions Summary*	noncompliant Provide a summary of the key measurements (use a graph to summarise data where possible) and refer to a summary of the detailed/raw data (if necessary) in an appendix but only to the extent necessary to verify the compliance	rectify. If unable to demonstrate computance state reasons relevance of the outcome measurement criteria to the current risk profile of the project or current stage of the project. Are outcome measurement criteria or lease condition amendments
		/ Non-		Triggered/Not	Notes: If triggered describe what	conclusion reached. Where graphs are used to illustrate compliance, the relevant compliance limits must be clearly included on the graph. Evidence where applicable	required? Quantify the risks associated with the non- compliance if applicable? Was the Leading indicator adequ
		Compliant (NC) *		Triggered	actions were taken as a result of	should include document control number of report or technical memo	to pick up the non-compliance or does it need to be amended
		Notes: Compliant,			triggering the leading indicator. Have the actions		
		Non-Compliant, Unable to Determine			been implemented or remain		
		or No longer relevant to risk profile of project			outstanding?		
No adverse public	Dust:	Dust	Dust	Dust	Dust	Dust	Continue implementation of PEPR, and in
nealth and or significant	Register demonstrates that in respect of						particular in respect of dusts:
nuisance impacts due to air emissions, dust, pest	complaints relating to impacts from dust outside site boundary:	С	None	Not Applicable	Not Applicable	There have been no complaints of dust from Sections 1, 3, 4 of the salt field	<ol> <li>Explore feasibility to cover cals         on XC2E mulch or other suitable</li> </ol>
nsect species, odour, or	o complaint initially responded to				Applicable	1, 5, 4 of the sait field	materials
noise	within 48 hours;					Complaints received in respect of dusts from Section	2. Monitor and report on trial
						3were responded to within the time frames. Investigations	coating of parts of Xc2 with
A significant nuisance mpact is considered to be	<ul> <li>issues underlying complaint investigated and causes identified</li> </ul>					of complaints and operational records indicate no dust	magnesium brine
one that generates a	within 2 weeks or					from the saltfield. DPC and EPA kept informed. (See	3. Continue trial of dust forecasting
complaint that is	other time frame agreed by DEM;					Appendix B)	to see if a reliable tool for forewarning neighbours can be
confirmed as attributable	o complaint closed out within 4 weeks						developed.
o the salt field	or other time frame agreed by DEM  Pest Insects:					Pest Insects	developed.
nd cannot be addressed vithin the timeframes	Register demonstrates that in respect of	Pest Insects	B. at lancets	Pest Insects			
specified in the	complaints relating to impacts outside		Pest Insects		Pest Insects		
measurement criteria.)	site boundary from pests:					No Complaints Received	
	<ul> <li>complaint initially responded to within 48 hours;</li> </ul>	С		Not Applicable	Not	No complaints received	
	o issues underlying complaint		None		Applicable		
	investigated and causes identified						
	within 2 weeks or other time frame						
	agreed by DEM;  complaint closed out within 4 weeks						
	or other time frame agreed by DEM					Odour	
	Odour:	Odour	Odour	Odour			
	Register demonstrates that in respect of	С	None	Net Andicalds	Odour	No complaints received	
	any complaints relating to impacts outside site boundary from pests:		None	Not Applicable	Not		
	<ul> <li>Complaint initially responded to</li> </ul>				Applicable		
	within 48 hours;				присавіс		
	Issues underlying complaint						
	investigated and causes identified within 2 weeks or other time frame						
	agreed by DEM;						
	o Complaint closed out within 4						
	weeks or such other time frame						
	agreed by DEM  Noise		Noise			Noise	
	Register demonstrates that in respect of	Noise		Noise	Noise		
	any complaints relating to impacts from						
	noise outside the site boundary:		None			No Complaints Received	
	<ul> <li>complaint initially responded to within 48 hours;</li> </ul>	С		Not Applicable	Not	- Somplanta Hoosiva	
	o issues underlying complaint				Applicable		
	investigated and causes identified						
	within 2 weeks or other time frame						

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No adverse impacts to adjacent land use	Inundated ponds¹ Records from weekly monitoring of pond water levels demonstrate pumped entrainment and discharge have maintained water levels in ponds within target range set out in Table 31, or other levels agreed with EPA in writing.	OMC Compliance Status Compliant (C) / Non- Compliant (NC) * Notes: Compliant, Non-Compliant, Unable to Determine or No longer relevant to risk profile of project Inundated Ponds C	Leading Indicator* Notes: Is there an associated Leading indicator?  Inundated Ponds  None	Leading Indicator Status* Notes: Triggered/Not Triggered Inundated Ponds Not Applicable	Leading Indicator Actions Summary* Notes: If triggered describe what actions were taken as a result of triggering the leading indicator. Have the actions been implemented or remain outstanding?  Inundated Ponds Not Applicable	Evidence* Notes: For each criterion, state what measurements have been taken to monitor compliance and provide an interpretation of the results (i.e. compliant or noncompliant Provide a summary of the key measurements (use a graph to summarise data where possible) and refer to a summary of the detailed/raw data (if necessary) in an appendix but only to the extent necessary to verify the compliance conclusion reached. Where graphs are used to illustrate compliance, the relevant compliance limits must be clearly included on the graph. Evidence where applicable should include document control number of report or technical memo  Inundated Ponds See Appendix D	Forward Work Plan*  Notes: If non-compliant summarise actions being undertaken to rectify. If unable to demonstrate compliance state reasons relevance of the outcome measurement criteria to the current risk profile of the project or current stage of the project. Are outcome measurement criteria or lease condition amendments required? Quantify the risks associated with the non-compliance if applicable? Was the Leading indicator adequate to pick up the non-compliance or does it need to be amended?  Inundated Ponds  Continued Implementation of Water Management Strategy with monthly reporting
	Other ponds <sup>2</sup> Records demonstrate:  ASS / MBO investigations undertaken and results provided to EPA/DEM  risk monitoring and management plan prepared as agreed with DEM/EPA  actions in risk monitoring and management plan implemented in accordance with timeframes specified in plan  outcome measurement criteria specified in plan met	Other Ponds	Other Ponds  The results of investigations in previous reporting periods for ponds in Sections 2 and 4.	Other Ponds  Not triggered by the results of these investigations	Other Ponds  Not Applicable	Other Ponds  All reports of investigations in previous reporting periods were provided to EPA / DEM. These cover:  Section 2 Section 4 XF1, XF2, XE4	Other Ponds  Continue with management of drainage to keep drained ponds as free draining as possible, noting that where there is seepage from an adjacent inundated pond, pooling of water in low areas will be inevitable
	Bund banks  Records demonstrate that:  Inspections every six months of bunds banks for inundated ponds demonstrate are stable and maintained at a height that will ensure no unplanned overflow from ponds; or  If any maintenance / repairs issues are identified from six monthly inspections, they are closed off within 1 calendar month unless otherwise agreed with DEM and EPA  Seepage Drains  Records demonstrate that:  quarterly inspections of seepage drains demonstrate they are stable; or if any maintenance / repairs issues identified from quarterly inspections of seepage drains are closed off within 1 calendar month unless otherwise agreed with DEM and EPA	Bund banks  C  Seepage Drains  C	Bund banks  None  Seepage Drains  None	Bund banks  Not applicable  Seepage Drains  Not Applicable	Not applicable  Seepage Drains Not Applicable	Bund banks  See Appendix E  Bunds for these ponds are inspected routinely as part of the regular (daily, weekly) movement of staff through the site to monitor and control flows and water quality in these ponds. As maintenance issues are identified they are addressed.  Seepage Drains  The key seepage drains outside those ponds that are still inundated are inspected routinely as part of the regular (daily, weekly) movement of staff through the site to monitor and control flows and water quality in these ponds. If maintenance issues are identified they are addressed. No maintenance issues have yet been identified.	Bund banks Continue with this inspection and maintenance regime  Seepage Drains Continue with this inspection and maintenance regime

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Outcome	Outcome Measurement Criteria (OMC)	OMC Compliance Status Compliant (C) / Non- Compliant (NC) * Notes: Compliant, Non-Compliant, Unable to Determine or No longer relevant to risk profile of project	Leading Indicator* Notes: Is there an associated Leading indicator?	Leading Indicator Status*  Notes: Triggered/Not Triggered	Leading Indicator Actions Summary* Notes: If triggered describe what actions were taken as a result of triggering the leading indicator. Have the actions been implemented or remain outstanding?	Evidence*  Notes: For each criterion, state what measurements have been taken to monitor compliance and provide an interpretation of the results (i.e. compliant or noncompliant Provide a summary of the key measurements (use a graph to summarise data where possible) and refer to a summary of the detailed/raw data (if necessary) in an appendix but only to the extent necessary to verify the compliance conclusion reached. Where graphs are used to illustrate compliance, the relevant compliance limits must be clearly included on the graph. Evidence where applicable should include document control number of report or technical memo	Forward Work Plan*  Notes: If non-compliant summarise actions being undertaken to rectify. If unable to demonstrate compliance state reasons relevance of the outcome measurement criteria to the current risk profile of the project or current stage of the project. Are outcome measurement criteria or lease condition amendments required? Quantify the risks associated with the non-compliance if applicable? Was the Leading indicator adequate to pick up the non-compliance or does it need to be amended?
No adverse impacts on other groundwater users	Water bores           Records of meter readings           demonstrate the volume of water extracted per annum does not exceed the following allocations:           Bore Number         Aquifer         Allocation           6628_19184         T1         1,177,255 kL           6628_10427         T1         6628_04356         T1           6628_13020         T1         850,255 kL           6628_13170         T1         850,255 kL           6628_18042         T1         1,200,000 kL	Water Bores C Drained Ponds C	Water Bores  No leading Indicator for Water Bores.  Drained Ponds  Leading Indicator is visual indication of soil acidification from water discharging via pond drains into external seepage drains	Water Bores  Not Applicable  Drained Ponds  Not Triggered	Not Applicable  Drained Ponds  Not Applicable	See Appendix H  The aggregate licence allocation for the six T1 bores has not been exceeded by the metered usage  Drained Ponds Configuration and condition of drained ponds and their drainage channels connecting to external seepage drains has not changed since the previous compliance report.  Inspections with EPA have not yielded reports of visual signs of soil acidification in external drains specifically resulting from discharge water	Water Bores  Continue to Track Meter Readings and to report consumption as per PEPR  Drained Ponds  Visual inspections of drainage at quarterly intervals

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Outcome	Outcome Measurement Criteria (OMC)	OMC Compliance Status Compliant (C) / Non- Compliant (NC) * Notes: Compliant, Non-Compliant, Unable to Determine or No longer relevant to risk profile of project	Leading Indicator* Notes: Is there an associated Leading indicator?	Leading Indicator Status*  Notes: Triggered/Not Triggered	Leading Indicator Actions Summary* Notes: If triggered describe what actions were taken as a result of triggering the leading indicator. Have the actions been implemented or remain outstanding?	Evidence*  Notes: For each criterion, state what measurements have been taken to monitor compliance and provide an interpretation of the results (i.e. compliant or noncompliant Provide a summary of the key measurements (use a graph to summarise data where possible) and refer to a summary of the detailed/raw data (if necessary) in an appendix but only to the extent necessary to verify the compliance conclusion reached. Where graphs are used to illustrate compliance, the relevant compliance limits must be clearly included on the graph. Evidence where applicable should include document control number of report or technical memo	Forward Work Plan*  Notes: If non-compliant summarise actions being undertaken to rectify. If unable to demonstrate compliance state reasons relevance of the outcome measurement criteria to the current risk profile of the project or current stage of the project. Are outcome measurement criteria or lease condition amendments required? Quantify the risks associated with the non-compliance if applicable? Was the Leading indicator adequate to pick up the non-compliance or does it need to be amended?
No loss of abundance or diversity of native vegetation on or off Sections 2 to 4 of salt field through clearance arising from Holding Pattern, unless prior approval under relevant legislation is obtained	Records demonstrate that all clearance of native vegetation has been undertaken with appropriate permissions.  It is noted that clearance can also include loss from  • physical works, • dust/contaminant deposition, • fire, or • other damage.	C Clearance C	None.  Clearance None	Approvals  Not applicable.  Clearance  Not applicable.	Not applicable.  Clearance  Not applicable.	Approvals  No approvals have been sought or granted for loss of abundance or diversity of native vegetation arising from Holding Pattern or other activities in Sections 2 to 4, and due to clearance.  Clearance  Baseline vegetation surveys are included in Appendix F. There has been no clearance of native vegetation arising from Holding Pattern or other activities in Sections 2 to 4. The evidence for this is:  1. Since the start of the Holding Pattern in 2013 there have been no changes to the land outside the ponds in Sections 2 to 4 or to operations on the land outside the bunds to the ponds in Sections 2 to 4. There is no reason to expect any loss of native vegetation outside these ponds from the Holding Pattern  2. A report from EcoAerial's aerial survey of vegetation in mid 2015 in 3Q 2016 and – See Appendix F – indicates that regeneration of native vegetation is occurring in parts of the drained ponds in Sections 2 to 4  3. Inspection of aerial photos on Google Earth do reveal any significant loss of native vegetation outside the ponds in Sections 2 to 4 since the start of the Holding Pattern in 2013  4. There have been no physical works outside the ponds in Sections 2 to 4 except for a) for the EPA licensed discharges of Brine from PA5 into the SA water outfall and from XE6 into the Gawler River; and b) associated with the DEWNR Trial in XB8A and the SA Water Trial in Section 2 (see Appendix C)  5. There has been no fire in Sections 2 to 4 under the Holding Pattern	Approvals Should clearance need to occur, prior approval under the relevant legislation will be obtained.  Clearance Nil

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Outcome	Outcome Measurement Criteria (OMC)	OMC Compliance Status Compliant (C) / Non- Compliant (NC) * Notes: Compliant, Non-Compliant, Unable to Determine or No longer relevant to risk profile of project	Leading Indicator* Notes: Is there an associated Leading indicator?	Leading Indicator Status* Notes: Triggered/Not Triggered	Leading Indicator Actions Summary* Notes: If triggered describe what actions were taken as a result of triggering the leading indicator. Have the actions been implemented or remain outstanding?	Evidence* Notes: For each criterion, state what measurements have been taken to monitor compliance and provide an interpretation of the results (i.e. compliant or noncompliant Provide a summary of the key measurements (use a graph to summarise data where possible) and refer to a summary of the detailed/raw data (if necessary) in an appendix but only to the extent necessary to verify the compliance conclusion reached. Where graphs are used to illustrate compliance, the relevant compliance limits must be clearly included on the graph. Evidence where applicable should include document control number of report or technical memo	Forward Work Plan*  Notes: If non-compliant summarise actions being undertaken to rectify. If unable to demonstrate compliance state reasons relevance of the outcome measurement criteria to the current risk profile of the project or current stage of the project. Are outcome measurement criteria or lease condition amendments required? Quantify the risks associated with the non-compliance if applicable? Was the Leading indicator adequate to pick up the non-compliance or does it need to be amended?
No adverse impacts on the environmental values of marine waters due to water discharge	PAS discharges, measured at the "SA Water Outfall compliance point" taken no less frequently than each 10 minutes is within the 45ppt TDS threshold for the 6 hour rolling average.  • XE6 discharges, measured at the "Gawler River Discharge compliance point" taken no less frequently than each 5 minutes is within criterion for this compliance point being the greater of:  • The maximum diurnal TDS measured in the past 30 days at the compliance point in the absence of discharge from XE6; or  • The measured contemporaneous maximum diurnal TDS in Chapman Creek (at the pumping station).  In the event of an exceedance at a discharge compliance point, records will demonstrate that:  • there has been notification to DEM, PIRSA and EPA within 24 hrs exceedance was followed by a period of nil discharge from PA5 or XE6, as appropriate, unless and until further discharge is approved by EPA Exceedance reports were provided within 3 days with root cause assessment and proposed or taken corrective action.	C Trial of Discharges to Gawler River C	PA5 Discharges  Salinity in Outfall at the Bridge over the Outfall  Estimates of salinity at Weir 2 from salinity in PA5, Outfall flow rate and salinity.  Trial of Discharges to Gawler River  Salinity in XE6	The leading indicators provide a reliable predictor of the potential for exceedance of the compliance criterion.  Trial of Discharges to Gawler River  The leading indicator provides a reasonable estimate of the salinity in the Gawler River at the compliance point when there is continuous discharge	PA5 Discharges  The leading indicators continue to be tracked and used to manage the discharge  Trial of Discharges to Gawler River  The leading indicator continues to be tracked and used to manage the discharge	<ol> <li>The records available to DEM and EPA via the Ridley DataStream web site. This provides continuous data</li> <li>Trial of Discharges to Gawler River (see Appendix G)</li> <li>The records available to DEM and EPA via the Ridley DataStream web site. This provides continuous data</li> <li>DEWNR Trial of Tidal Inflows and Outflows at XB8A</li> <li>See the information in Appendix C</li> </ol>	Continue with the documented water management regime as discussed with STAG, DEM and EPA  Trial of Discharges to Gawler River Continue with the trial of the documented water management regime as discussed with STAG, DEM and EPA  DEWNR Trial of Tidal Inflows and Outflows at XB8A  DEWNR Continue with the trial as per its agreement with Buckland Dry Creek. That agreement has DEWNR taking responsibility for this trial complying with all relevant environmental outcomes and measurement criteria in the PEPR.  As part of that trial. DEWNR to implement its documented monitoring and management plans and to produce reports to Buckland Dry Creek that demonstrate PEPR compliance, and that can be attached to the annual compliance reports

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Outcome	Outcome Measurement Criteria (OMC)	OMC Compliance Status Compliant (C) / Non- Compliant (NC) * Notes: Compliant, Non-Compliant, Unable to Determine or No longer relevant to risk profile of project	Leading Indicator* Notes: Is there an associated Leading indicator?	Leading Indicator Status* Notes: Triggered/Not Triggered	Leading Indicator Actions Summary* Notes: If triggered describe what actions were taken as a result of triggering the leading indicator. Have the actions been implemented or remain outstanding?	Evidence*  Notes: For each criterion, state what measurements have been taken to monitor compliance and provide an interpretation of the results (i.e. compliant or noncompliant Provide a summary of the key measurements (use a graph to summarise data where possible) and refer to a summary of the detailed/raw data (if necessary) in an appendix but only to the extent necessary to verify the compliance conclusion reached. Where graphs are used to illustrate compliance, the relevant compliance limits must be clearly included on the graph. Evidence where applicable should include document control number of report or technical memo	Forward Work Plan*  Notes: If non-compliant summarise actions being undertaken to rectify. If unable to demonstrate compliance state reasons relevance of the outcome measurement criteria to the current risk profile of the project or current stage of the project. Are outcome measurement criteria or lease condition amendments required? Quantify the risks associated with the non-compliance if applicable? Was the Leading indicator adequate to pick up the non-compliance or does it need to be amended?
No adverse impacts to avifauna using the site beyond internationally recognised impact thresholds, or outside historic ranges of variability in species and bird numbers	Records demonstrate that impacts on listed migratory birds from activities in this PEPR / MOP are below significant impact threshold as determined by EPBC Act significant impact guidelines for Matters of National Environmental Significance.  Inundated ponds  Records from weekly monitoring of pond water levels demonstrate pumped entrainment and discharge have maintained water levels in ponds within target range set out in Table 31, or other levels agreed with EPA in writing	C	Salinities and water depths of Inundated ponds remaining within the limits specified in the PEPR	Water levels in ponds stayed within limits.  In a few ponds salinity in summer exceeded the limits.	The issues with salinity have led to adaptation and refinement of the water management regime by agreement with DEM and EPA. This has proved effective, with control over salinity in summer improving each year of the holding pattern	Bird Monitoring and Self Assessment Report – See Appendix I  Bird Monitoring has been conducted in 2013 / 2014 and 2014 / 2015, 2015 / 2016, 2016 / 2017 and 2017 / 2018 migratory bird seasons.  The Self assessment report indicates compliance with the required outcome for 2013 / 2014, 2014 / 2015, 2015 / 2016, 2016 / 2017 and 2017 / 2018 seasons  See Appendix D for water level data	Continue implementing the water management and monitoring regime as agreed with DPC and EPA
No compromise to potential future land use	Compliance with measurement criteria (as above) for the following outcomes:	С	See above	See above	See above	See above	See above

 No adverse impacts to adjacent land use
 No adverse impacts to avifauna using the site beyond internationally recognised impact thresholds, or outside historic ranges of variability in

species and bird numbers

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<sup>&</sup>lt;sup>1</sup> Inundated ponds are defined as: Ponds XE1-3, XE5, XE6, XE7, XD1, XC3, XB3, XB4-5, XB6, XB8, XB8A, XA1, XA2, XA3, XA4, XA7, PA3, PA4, PA5

<sup>&</sup>lt;sup>2</sup> Other ponds are defined as XF1, XF2, XE4, XC1, XC2, XC2S, PA6, PA7, PA7A, PA8, PA9, PA10, PA11, PA12

# 10. Rectification of Non-Compliance (not subjects of complaint)

The following table lists the non-compliance matters (not subjects of complaints – See Section 8) and that have been rectified. There was no non-compliance matter in the period 1 July 2017 to 30 June 2018.

**Table 10: Rectification of Non-Compliance** 

Date of Incident	Detected by Operator or DEM	Date DEM Advised	Non- Compliance Notes: Refer to outcome or lease condition breached	Status*	Further Work Plan	
					Actions	Implemented
8 June 2014	Operator	Email from Ridley (NJW) 9 and 10 June 2014	Exceed 45 ppt at Weir 2	Resolved / Closed out	Adjusted pumping regime and its monitoring and controls	Yes
10 June 2014	Operator	Email from Ridley (NJW) 10 and 11 June 2014	Exceed 45 ppt at Weir 2	Resolved / Closed out	Further adjusted pumping regime and its monitoring and controls	Yes
22 June 2014	Operator	Email from Ridley (NJW) 23 June 2014	Exceed 45 ppt at Weir 2	Resolved / Closed out	Further adjusted pumping regime and its monitoring and controls	Yes
28 September 2014	Operator	Email from Ridley (NJW) 29 and 30 September 2014	Exceed 45 ppt at Weir 2	Resolved / Closed out	Further adjusted pumping regime and its monitoring and controls	Yes
6 October 2014	Operator	Email from Ridley (NJW) 7 October 2014	Exceed 45 ppt at Weir 2	Resolved / Closed out	Further adjusted pumping regime and its monitoring and controls	Yes
13 November 2014	Operator	Email from Ridley (NJW) 14 November 2014	Exceed 45 ppt at Weir 2	Resolved / Closed out	Further adjusted pumping regime and its monitoring and controls	Yes

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4 December 2015	Operator	Email from Ridley (NJW) 4 and 5 December 2015	Exceed 45 ppt at Site 1a / site 3	Resolved / Closed out	Further adjusted pumping regime and its monitoring and controls	Yes
July to Oct 2016 and May 2017 (See Figure 10)	Operator	DEM not advised	Water Level in XA 3 temporarily below minimum required	Resolved / Closed out	Cause was reduced inflow from XB6 – Solved by reducing outflow to XA4, & increasing inflow from XB6	Yes. Water level restored above minimum required by Nov 2016 and June 2017 respectively. No adverse impacts to migratory birds because of redundancy in bird carrying capacity in the salt field and b) the low water levels occurred outside on during "shoulders" of the bird season. Through the majority of the bird season, when bird numbers are high, water levels were within the compliance range

### 11. Disturbance and Rehabilitation Activities

**Table 11: Disturbance and Rehabilitation** 

Activity	Tenement	Tenement size (Ha)	Maximum amount approved in PEPR to be cleared (Ha)	Previously reported cleared area (Ha)	Estimated clearance for next reporting period (Ha)	SEB offset	Forward work plan
NA	NA	NA	NA	NA	NA	NA	NA

*NA* = Not applicable because there has been no new land disturbance and the Salt Field has been in a Holding Pattern under this PEPR

# 12. Environmental Protection and Biodiversity Conservation Act Reporting

Table 12: Reports provided under the EPBC Act (EPBC Ref 2015/418)

Date	Report	Reference
19 May 2014	Self Assessment	Brett Lane & Associates: 13061 (2.0) Self Assessment 140516.pdf
8 January 2015	EPBC Act Referral – Dry Creek Salt Field	EPBC Act Referral (Dry Ck Closure) 150108 - Referral Form.pdf
	Closure, South Australia	Plus Attachments 1 to 7
15 February 2015	Referral Decision	DOE 2015/7418
6 October 2015	Technical Report from Monitoring in 2013/2014 and 2014/2015 Migratory Bird Seasons	Brett Lane & Associates: 13061 (1.10) Dry Creek Technical Report 150917.pdf
6 October 2015	Update to Self Assessment	Brett Lane & Associates: 13061 (2 5) EPBC Act 2015 Self Assessment for Dry Creek Salt Field.pdf
8 June 2017	Update to Technical Report and Self Assessment (adding the 2015/2016 bird monitoring data)	Report 13061 (1.13) Final 170302.pdf  Report 13061 (2 7) EPBC Act 2016 Self Assessment for Dry Creek Salt Field 170203.pdf
24 October 2018	Update to Technical Report and Self Assessment (adding the 2016/ 2017 and 2017/2018 bird monitoring data)	Report 13061 (2.9) EPBC Act 2018 Self Assessment for Dry Creek Salt Field 181024

### 13. Audits and Reviews

A tabular summary of Audits or Reviews (if any) conducted for the purposes of Ridley's Management Systems or for PEPR compliance

#### Note:

- 1. No Audits have been conducted for the purposes of PEPR Compliance because:
  - a. DEM and EPA have made regular inspections of the site and checks of compliance with the PEPR conducted
  - b. Reports on the Bird Monitoring have been submitted to both DEWNR and to DoE for review and comment
  - c. Investigations and Monitoring of ASS conditions have been conducted by ASSC, jointly funded by the Government and Ridley. The reports from this work are available to both parties
  - d. Ground level surveys have been conducted by CSIRO and ARA jointly funded by the Government and Ridley. The reports from this work are available to both parties
  - e. EPA has conducted its own independent monitoring (chemical and biological) of the waters of the Gawler River, Chapman Creek and in the Gulf in the vicinity of the discharges from the SA Water Outfall

### 14. Uncertainties

A tabular summary of any key uncertainties affecting or potentially affecting compliance, and what actions (if any) are being taken or planned to reduce these

**Table 13: Uncertainties** 

Description of Uncertainty	Estimated Date to Resolve	Progress in Reporting Period	Confirmed?	Forward Work Plan
NA	NA	NA	NA	NA

NA= Not Applicable because the uncertainties that exist are as described and accounted for in the risk assessment and management plan in the current approved PEPR / MoP.

### 15. Technical Reports

Buckland Dry Creek has provided DEM and EPA with access to

 Technical Data in the "Ridley" Data Stream Website. The key data concerns water discharges from Sections 3 and 4 of the Salt Field and also Pond Water Quality in Sections 2, 3 and 4 of the Salt Field. This data is accessed at <a href="https://data.hydroterra.com.au/">https://data.hydroterra.com.au/</a> by logging in, using the password available to the relevant DEM and EPA staff.

The data is available in graphical formats on screen and raw data can also be downloaded.

- Technical Data and Reports in the following OneHub Folders. These are accessible to those Government Agency staff who have been invited:
  - PEPR Documents / Approved: <a href="https://ws.onehub.com/folders/tznhcbn7">https://ws.onehub.com/folders/tznhcbn7</a>
  - Documents provided to STAG relating to progress and issues arising during the conduct of the Holding Pattern: https://ws.onehub.com/folders/xcjx6e4f
  - Ground Level Survey Information: <a href="https://ws.onehub.com/folders/xx6wob19">https://ws.onehub.com/folders/xx6wob19</a>
  - o Acid Sulphate Soil Investigations: <a href="https://ws.onehub.com/folders/ykf4b3q7">https://ws.onehub.com/folders/ykf4b3q7</a>
- Appendices to this Compliance Report contain the following information

**Table 14: Technical Reports** 

Appendix	Document Name	Document Date	Author	Subject
В	Complaints Register 180630. pdf	August 2018	Buckland Dry Creek	The Register of Complaints and actions arising
С	SA Letter – 2018     Update. pdf      XB8A Trial PEPR	• Aug 2018	SA Water	SA Water's     Treated Sewage     Effluent     Denitrification     Trial in Section     2     The trial of tidal
	compliance report 17_18. pdf	• July 2018	• DEWNR	inflows and outflows at XB8A
D	Holding Pattern     Pond Water Levels     April 2013 to this     year 180829     2017.pdf     Summer Water	August 2018	WithERS     Environmental     Risk     Strategies (for     Buckland Dry     Creek)	Comparision of Pond Water Levels with Measurement Criteria
	Levels Sept 2017 to March 2018 vs Compliance Critera In PEPR.pdf	August 2018		

Appendix	Document Name	Document Date	Author	Subject
Е	2017 - 2018 Work on Bunds and Drains. pdf	• August 2018	Buckland Dry Creek	Site Works on Bunds and Drainage
F	2017 Dry Creek     Aerial Vegetation     Assessment FINAL     V1.2.pdf	• June 2017	EcoAerial (for Buckland Dry Creek)	Aerial mapping of vegetation in drained ponds
G	Salinity of     Discharges at Weir     2, Bridge and PA5     2017 - 2018.pdf	August 2018	WithERS     Environmental     Risk     Strategies (for     Buckland Dry     Creek)	The graphs of salinity for Weir 2 and Bridge demonstrate compliance with the compliance criterion.
	Salinity of Gawler River 2017 - 2018.pdf	• August 2018	WithERS     Environmental     Risk     Strategies (for     Buckland Dry     Creek)	The graphs of salinity in the Gawler River from the trial of discharges. The graphs cover the period from the start of the 1 July 2015 to 30 June 2018. They show the reasonable consistency of summer 2015/2016, 2016/2017 and 2017/2018 salinity in the Gawler River. This reflects control of the impacts on the salinity in the River from the discharges from XE6
H	Bore Water     Consumption 201 7 -     2018.pdf	• Aug 2018	WithERS     Environmental     Risk     Strategies     using data     provided by     Buckland Dry     Creek	Reconciliation of Bore water uses with Licence Allocation
I	Report 13061 (2.9)     EPBC Act 2018 Self     Assessment for Dry     Creek Salt Field	• Oct 2018	Brett Lane & Associates	Monitoring of Birds in 2013/2014, 2014/2015,

Appendix	Document Name	Document	Author	Subject
		Date		
	181024		Brett Lane & Associates	2015/2016, 2016/2017, and 2017/2018 Bird Seasons Self- Assessment (based on the above monitoring) of Holding Pattern Impacts on Matters of National Environmental Significance
J	• Filling Trial in H Row 2017-2018	• August 2018	WithERS     Environmental     Risk     Strategies (for     Buckland Dry     Creek)	Report on preliminary works for the trial filling in H Row

#### 16. Forward Works Plan

The following table summarises the actions raised throughout this compliance report. These actions will form the basis of some of the forward works plan for the 2018 / 2019 year.

It is also noted that during 2018 / 2019 Buckland Dry Creek Pty Ltd will be initiating certain investigations and trials to help design closure and completion works for the different parts of the site, or to assist the planning, design and implementation of work to resume salt production.. If these require a Minor Change Notification or Revision to the PEPR, they will be discussed with DEM and other relevant agencies and stakeholders as need arises. For now, they lie outside the scope of this present compliance report (reporting on compliance to 30 June 2018).

**Table 15: Forward Works Plan** 

Action No.	Action Description	Responsibility of:	Proposed Completion Date	Compliance Report Reference
1	Continue Implementation of the current Approved PEPR	Buckland Dry Creek Pty Ltd	Ongoing	Section 9 Compliance Summary
2	Exploration potentially feasible new land uses for XC2 and XC2E that would provide ways to limit risks of dust emissions from and to resolve complaints re this	Buckland Dry Creek Pty Ltd	Ongoing	Section 8 Complaints
3	Conduct filling trial in PM248 and progress to design and approval for bulk filling in PM248	Buckland Dry Creek Pty Ltd	End 2018	Section 7 Project Variations
4	Continue with DEWNR Trial in XB8A	DEWNR (under agreement with Buckland Dry Creek Pty Ltd)	Ongoing	Section 7 Project Variations
5	Continuation / Extension of SA Water Trial in Section 2	SA Water (under agreement with Buckland Dry Creek Pty Ltd)	Ongoing,	Section 7 Project Variations
6	Develop Plans to resume salt production in A, B, C Row Crystallisers, using brine from the condensers in Sections 2, 3 and 4 of the salt field	Buckland Dry Creek Pty Ltd	End 2018	

### 17. Ministerial Determination Checklist

#### Table 16: Checklist

Section	Included? Or N/A
Executive summary	YES
1. Introduction	YES
Tenement number(s)	YES
Name of the mine operation	YES
General location details	YES
Name(s) of the mine owner and mine operator(s)	YES
Site Contact	YES
Registered Mine Manager, Mines Works Inspection Act, 1920	YES
Reference and approved date of relevant PEPR being reported against	YES
Person accepting responsibility for the report	YES
Dates of the reporting period for the report	YES
Date of preparation of the report.	YES
2. Executive Declaration	YES
3. Tenements	
Summary table of all tenements including ML, MPL, EML etc.	YES
4. Other Licences, Permits, Waivers, Native Title and Agreements	
Summary table of all licences, permits, waivers, native title and other agreements relevant to the PEPR.	YES
Where applicable, provide a statement that all waivers for exempt land required for the current operation are in place in accordance with the Mining Act	
5. Mining operations and Closure	
Ore reserves and mine life	
new delineation or exploration drilling activities on or off the lease (if required)	NA
review of reserves (if required)	NA
Other potential sources of ore (e.g. from nearby mines) (if required)	NA
Overburden, Ore and Concentrate	
Overburden	NA
Ore	NA
Concentrate	NA
Holding Pattern and Residual Operations	YES
Closure	NA
6. Voluntary Information (not mandatory, but strongly recommended)	YES

7. Project Variation Summary	YES
Summary table of any changes/project variations submitted to DEM	YES
8. Complaints	
Summary table of complaints made by members of the public during the reporting period	YES
Indicate how concerns or complaints by third parties were addressed.	YES
9. Compliance Summary Table	
For <b>each</b> outcome in PEPR state if "complied", "not complied", or "unable to demonstrate compliance"	YES
For <b>each</b> outcome in the PEPR provide summary criteria data that supports the conclusion above	YES
For <b>each</b> lease or licence condition (other than environmental outcomes) state if "complied", "not complied", or "unable to demonstrate compliance"	YES
For each leading indicator criterion state if any were triggered in the reporting period	YES
If triggered, (if required)	YES
What actions were taken	YES
An assessment of the effectiveness of the current control strategies or criteria	YES
10. Rectification of Non-Compliances	
If a "not complied" is recorded, the following must be included: (if required)	YES
date of the incident	YES
<ul> <li>state if the incident was a Reportable Incident under Regulation 87. If so the report must also state the date the incident was initially reported to the Minister and the date the written report was provided to the Minister.</li> </ul>	YES
what environmental outcome or lease condition was breached	YES
if and how the noncompliance was, or is planned to be, rectified	YES
what measures, if any, will be taken to prevent recurrence.	YES
Progress update on previous non-compliances not fully rectified at time of last report	YES
11. Disturbance and Rehabilitation Activities	
Information on areas disturbed and current rehabilitation status	YES
The amount of land disturbed	YES
Vegetation cleared	YES
New measures implemented to avoid or control environmental impact	YES
Revegetation or rehabilitation earthworks conducted.	YES
Evidence (by using closure and rehabilitation criteria in the current approved PEPR) of the effectiveness of rehabilitation being progressively undertaken.	YES
	YES
Any problems or potential improvements learned from previous rehabilitation	

New strategies to be undertaken to achieve rehabilitation outcomes (if required)	YES
12. Environment Protection and Biodiversity Conservation Act reporting	
Demonstration of compliance with EPBC conditions (if required)	YES
13. Audits and Reviews	
If an audit or review of any part of the operation management system was conducted during the reporting period, the following information on the audit or review must be included: (if required)	YES
when the audit or review was undertaken	YES
who undertook the audit or review	YES
what aspect(s) of the management system was/were audited/reviewed	YES
what issues, or recommendations for improvement, were noted	YES
an assessment of the potential for any issues identified in the audit/ review to lead to a noncompliance with approved environmental outcomes	YES
what corrective action that has or will be taken to address any issues.	YES
14. Verification of Uncertainties	
Changes or failures of mining operations	YES
Increases to areas disturbed	YES
New baseline environmental data	YES
Reported to DEM?	YES
Uncertainties table	YES
15. Technical Reports	
Summary of technical data studies and reports generated in reporting period	YES
16. Forward Work Plan	
Action description	YES
Responsibility	YES
Proposed Completion Date	YES
17. Ministerial Determination Checklist	
This checklist	YES

### **Appendices of Supporting Information**

#### See also:

- Technical Data in the "Ridley" Data Stream Website concerning:
  - Salinity monitored at compliance locations for the licensed discharges from PA5 and XE6, as well as in these ponds
  - PA5 Discharge flow rates; and SA Water Outfall flow rates
  - Salinity in Chapman Creek
  - Pumped water volumes into and from Sections 3 and 4 of the Salt Field
  - Pond Water Levels and Quality in Sections 2, 3 and 4 of the Salt Field.

This data is accessed by logging in, using the password available to the relevant DEM staff at http://data.hydroterra.com.au/vdv/index.html.

Selected data is available in graphical formats on screen and all data can also be downloaded.

- Technical Data and Reports in the following OneHub Folders. These are accessible to those Government Agency staff who have been invited:
  - PEPR Documents / Approved: https://ws.onehub.com/workspaces/1007791/folders/2322773809
  - Documents provided to STAG relating to progress and issues arising during the conduct of the Holding Pattern: https://ws.onehub.com/workspaces/1007791/folders/2036078181
  - Ground Level Survey Information: https://ws.onehub.com/workspaces/1007791/folders/2036078511
  - Acid Sulphate Soil Investigations: https://ws.onehub.com/workspaces/538475/folders/2047375325

Appendix A – Progress and Incident Reporting to Agencies

Appendix B - Dust, Pest Insect, Odour, Noise

Appendix C – Investigations (ASS/MBO, other)

Appendix D – Risk monitoring and management plans

**Appendix E - Bunds and Seepage Drains** 

Appendix F - Vegetation

Appendix G – Licensed Water Discharges

Appendix H - Water Bores

**Appendix I - Birds** 

Appendix J - Trial Filling in H Row

### Appendix A - Progress and Incident Reporting to Agencies

Incident Reports	Progress Reports
<ol> <li>Initial Report within 48 hrs of incident or complaint; subsequent reports per incident or complaint as agreed with DEM / EPA</li> <li>Reports to be referenced in the relevant register</li> </ol>	The updates to the DataStream website called "Ridley"
Dust, Pest Insect, Odour, Noise	Updates to "Ridley" DataStream web site
• Complaints	For Inundated Ponds:
• Results of investigations and actions to close out	<ul> <li>Water levels</li> </ul>

Results of investigations and actions to close out complaints

#### **Pond Water Levels**

- Any non-compliances with pond levels specified in the outcome measurement criteria reported to DEM
- Progress reporting on remedial action taken as directed by DEM.

#### **Vegetation**

- Any unauthorized vegetation clearance reported to DEM
- Progress reporting on remedial action taken as directed by DEM.

#### <u>Licensed Water Discharges</u>

- Any -exceedances of the outcome measurement criteria notified to DEM, EPA and PIRSA within 24 hours
- Progress reporting on remedial action taken as directed by DEM, EPA or PIRSA.

- Pumped entrainment rates
- Pumped discharge rates
- Water specific gravity
- Salinity for:
  - O PAS
  - o The Bridge
  - o The compliance location for PA5 discharges
    - 1. Now Weir 2; and formerly
    - 2. Buoy 3a which replaced
    - 3. Site 1A / Site 3)
  - o Site 4 (Chapman Creek)
  - Site 5 The Gawler River the compliance location for XE6 discharges

## Appendix B - Dust, Pest Insect, Odour, Noise

Subject of Complaint (Dust, Odour, Noise, Pest Insects, Other)	Complaint No	Date complaint received	Complainant & Complaint	Date of Initial Response	Initial Response	Further Response / Communications (with dates)	Reporting to DMITRE / EPA (with dates)  • Investigation of Causes  • Communications with complainant	Complaint closure date	Mode of Complaint Closure
Odour from XC2S following high rainfall on 13 and February		20 Feb 2014	1. Bill Drew via EPA Tim Gubbin on 20 Feb 2014 2. 2 members of the community via a community meeting conducted by Jefferies, advised to Ridley by Tim Gubbin on 25 February 2014	21 Feb 2014	Nick Withers left phone messages with Bill	<ol> <li>Email on 21 Feb to Bill Drew</li> <li>Email on 22 Feb to Bill Drew</li> <li>Meeting on 6 March with Bill Drew (1st available time)</li> <li>7 May 2014 - Meeting held with Bill Drew to:         <ul> <li>a) Brief him on actions to address the odours from pond XC2S and more generally;</li> <li>b) Also to get further feedback on what the odour situation has been like since the March meeting</li> </ul> </li> </ol>	<ol> <li>Email to Tim Gubbin on 21 Feb re initial contact with Bill Drew</li> <li>Investigation of causes initiated in week of 24 Feb, and comprises         <ul> <li>a) Sampling for chemical and biological testing to help assess opportunities to suppress odours</li> <li>b) Trial lowering of water level in the natural creek line and western trench to investigate ability to drain depressions in the ground surface outside these water filled bodies</li> <li>c) Qualitative observation and monitoring of odours and water levels / appearance</li> <li>d) Trial introduction of water from XC3 when this is possible to improve water quality in the natural creek line and western trench</li> </ul> </li> <li>Email on 24 Feb to EPA and DMITRE re date of planned meeting with Bill Drew</li> <li>Report on status of investigations to STAG meeting on 6 March</li> <li>Email on 13 March to EPA and DMITRE re notes of meeting with Bill Drew on 6 March</li> <li>Report on status of investigations and communications with Complainant to STAG meeting on 20 March</li> <li>Further updates provided to subsequent STAG Meetings</li> <li>Email to EPA and DSD on 10 June, with attachments, reported the investigations and the cause of the odours. It also reported the works to prevent recurrence, and also the engagement with the complainant, Bill Drew</li> </ol>	10 June 2014	Email to EPA and DSD on 10 June, with attachments, reported the investigations and the cause of the odours. It also reported the works to prevent recurrence, and also the engagement with the complainant, Bill Drew. It is noted:  Bill expressed himself satisfied with our efforts.  No further odour complaints have been received in relation to the XC2 S incident.  STAG was advised of the above at its next meeting subsequent to 10 June
Odour	2	10 October 2014	Bill Drew complained of a "acid" odour coming from XC2 on 04/10/14	10 October 2014	Telecon between Allan Mathieson and Bill Drew	Review wind directions for 4 October 2014     Review odour observations with site personnel who were in the area of XC2 on 4 October 2014.     AirQP commissioned to investigate:	1. Email to EPA on 14 October 2014. 2. Email to EPA / DSD on 25 November 2014 with Air QP report  Output  Description:	25 November 2014	No further complaints since this date  STAG was advised of the actions to deal with the complaint above  EPA acknowledged receipt of email of 25 November

Subject of Complaint (Dust, Odour, Noise, Pest Insects, Other)	Complaint No	Date complaint received	Complainant & Complaint	Date of Initial Response	Initial Response	Further Response / Communications (with dates)	Reporting to DMITRE / EPA (with dates)  Investigation of Causes Communications with complainant	Complaint closure date	Mode of Complaint Closure
Odour	3	20 October 2014	Mark McCauley reports strong smell of (dynamic lifter  Bill Drew and Lindsay Virgo, both odour dust registered residents have complained of a strong odour. Both describe is as the same odour as last night. Lindsay's email to Alan states "  Hi Allen, tonight at 6.00pm I experienced a bad smell similar to sewage/sulphur. The strength of the smell was strong, there was no wind evident. I have logged this on my report for Tracy, and also at Tracy's suggestion from her visit today, advised EPA.  Had a phone call from Robyn Cook, who operates the Kiosk approx. 8.00pm to say that there was a terrible "sulphur like" smell reaching the kiosk. Can you tell me whether water is supposed to be in the lagoon area to the left of St.  Kilda road, as the sight of the dry beds is certainly not appealing, could this also be the origin of the smell in this warmer weather?	20 October 2014	Mark investigated this odour. The odour was strong in the St Kilda area between 5-10 pm. There was a light wind at the time. On further investigation the odour was found to emanate from SA Water Bio Solids area.  3. Tracy Freeman, of AirQP met with the Odour / dust diarists during the day on 21 Oct to review the diary process. All St Kilda diarists – Lindsay, Kevin, Marylin reported the odour. Tracy suggested Lindsay report the odour to EPA.  4. Allan Mathieson contacted Bill and Lindsay. in the evening of 21 October. At this stage it appears to be SA water bio solids. The smell is the bio solids mass heating up	Wind conditions could be suitable for odour transmission in th early hours of Thursday and Sunday morning. The following investigations are planned to provided evidence as to the source:  1. Ridley will review the diarists records 2. Ridley will monitor and log the air quality at locations around the north end of PAG, between the suspected odour source in SA Water Bolivar and St Kilda. The monitoring will be early and late in the working day, 3. Ridley will obtain a record of the hourly wind direction and strengths at BoM Edinburgh 4. Ridley will set up the Odalog on east side of PAG, in a line between the suspected odour source in SA Water Bolivar and St Kilda. 5. Ridley will collect and evaluate all the data from the above, and report on what it means	1. Email to EPA on 22 October 2. Email to EPA / DSD on 25 November 2014 with Air QP report  2. Email to EPA / DSD on 25 November 2014 with Air QP report	25 November 2014	Odour likely from SA Water Bolivar not from XC2  Odour likely from SA Water Bolivar not from XC2
			Can you please contact me regarding this issue, either by return email, or mobile 0408829586. At the time of writing this email, the smell is still quite evident."						

Subject of Complaint (Dust, Odour, Noise, Pest Insects, Other)	Complaint No	Date complaint received	Complainant & Complaint	Date of Initial Response	Initial Response	Further Response / Communications (with dates)	Reporting to DMITRE / EPA (with dates)  Investigation of Causes Communications with complainant	Complaint closure date	Mode of Complaint Closure
Dust	4	23 Feb 2015	Mr Robinson, Lot 2 Brookes Road. He complained to Council on about 3 February 2015. This complaint made its way through to EPA who alerted Ridley on 23 February	23 Feb 2015	Tracy Freeman (Air QP) contacted Mr Robinson to clarify complaint  1. Tracy Freeman (Air QP) contacted Mr Robinson to clarify complaint  2. Tracy Freeman (Air QP) contacted Mr Robinson to clarify complaint  3. Tracy Freeman (Air QP) contacted Mr Robinson to clarify complaint  4. Tracy Freeman (Air QP) contacted Mr Robinson to clarify complaint  4. Tracy Freeman (Air QP) contacted Mr Robinson to clarify complaint  5. Tracy Freeman (Air QP) contacted Mr Robinson to clarify complaint  6. Tracy Freeman (Air QP) contacted Mr Robinson to clarify complaint  7. Tracy Freeman (Air QP) contacted Mr Robinson to clarify complaint  8. Tracy Freeman (Air QP) contacted Mr Robinson to clarify complaint  9. Tracy Freeman (Air QP) contacted Mr Robinson to clarify complaint  9. Tracy Freeman (Air QP) contacted Mr Robinson to clarify complaint  9. Tracy Freeman (Air QP) contacted Mr Robinson to clarify complaint  9. Tracy Freeman (Air QP) contacted Mr Robinson to clarify complaint  9. Tracy Freeman (Air QP) contacted Mr Robinson to clarify contacted Mr Ro	Allan Mathieson contacted Mr Robinson on 26 February 2015: Actions so far are thus  1. Tracy has spoken with Mr Robinson to clarify his complaint 2. Allan has spoken with Mr Robinson 3. Tracy is investigating weather for the day(s) complained about and will be reporting to me on this 4. I have added this complaint to the register 5. I have sent Mr Robinson the link to the Ridley web page and document library Planned actions are:  1. When we have the report from Tracy, Allan and / or I will meet with Mr Robinson to explain the implications 2. Allan will in any case arrange to meet with Mr Robinson to show him the work we are doing to reduce quantities of wind blown dust exiting our site in his direction 3. We will by these means attempt to close out the complaint and record this 4 March 2015: Allan Mathieson has spoken to Steve Robinson and informed him we intend to use dust suppression on the access road on Ridley site that are adjacent to his property. He also enquired about the local council (Playford) using the same dust suppressant on Brooks road which runs alongside his property. Steve told him he will send him the contact details for the council. Allan will suggest to council that they use the suppressant on Brooks road to alleviated the dust for nearby residents.  Obtaining quotation for construction of windblown dust / soil trap (5m wide, 0.5m deep trench with spoil mounded on west side) along eastern bund of XC2. Works to be done over next 2 weeks approx.  17 March 2015  Draft report received from Tracy Freeman (Air QP). This being reviewed and will be transmitted to DSD / EPA  Dust / Soil collection traps are being constructed along the eastern boundary of XC2, in particular opposite Steve Robinson's house.  Further meeting will be held with Steve to show him these	1 Emails NJW and Allan Mathieson to EPA on 27 February 2015		

Subject of Complaint	Complaint No	Date complaint	Complainant & Complaint	Date of Initial	Initial Response	Further Response / Communications (with dates)	Reporting to DMITRE / EPA (with dates)	Complaint closure date	Mode of Complaint Closure
(Dust , Odour, Noise, Pest		received		Respons e			<ul><li>Investigation of Causes</li><li>Communications with complainant</li></ul>		
Insects,									
Dust	5	16 and 17 March 2015	Complaint received via media (Northern Messenger, ABC, Channel 7, Channel 9) news stories.  Complain is about dust impacts on properties and horticultural crops on land east of XC2 and XC2E	16 and 17 March 2015	Investigation and Risk assessment started:   Meeting separately with a number of the complainants (regarded as being those living to east of XC2 and Xc2E) scheduled for 25 March to discsover thei actual issues   Data on calsilt (from previous work by Penrice and others) sought from EPA   Golder instructed to provide initial letter of advice on potential risks from dusts by 28 March   Further Investigation and Risk assessment to be designed (in consultation with DSD and EPA) when we have assembled and reviewed the above and determine clear objectives.   Observational Monitoring along E boundary of XC2E devised. Implementation commenced 20/3/15). Initial frequency is daily   Communications	There has been periodic reporting to STAG, and provision of copies of reports of monitoring of XC2E (photos and observations of soil conditions)  Ridley has investigated the technical feasibility of dust prevention measures. The outcomes are:  1. A plan is in preparation for a trial (under the PEPR) of turning XC2E into a depot for the production of a Calsilt /Recycled Timber Product Blend for reuse elsewhere in non-sensitive areas of the Salt Field.  2. Implementation of that planwould see XC2E occupied and with active dust prevention via water carts ect  3. A successful trail would see the slow removal of all calsilt from XC2E — thereby removing this dust source  4. In respect of XC2, the ultimate solution is to find and implement a new use for this land. In the mean time it would appear that targeted watering is the most technically feasible method. A proposition is before the Ridley Board for approval.	Email from NJW to DSD / EPA on 18 March 2015, advising the initial programme of work to implement the protocol set out in the PEPR to  a. Contact and engage with the complainants  b. Investigate the issues  c. Identify an evidence based way to address the complaint  d. Consult and engage with DSD and EPA, as well as the complainants to obtain support for the proposed way to address the complaint  e. Address the complaint  f. Report on outcomes to the complainants and to DSD & EPA  g. Close the complaint		
					Initial further actions involves triggered deployment of a water cart to dampen soil in dust prone areas of XC2E				

Subject of Complaint N Complaint		Date complaint	Complainant	Date of	Initial Response	Further Response / Communications (with dates)	Reporting to DMITRE / EPA (with dates)	Complaint	Mode of Complaint Closure
(Dust , Odour, Noise, Pest Insects,		received		Initial Response			<ul> <li>Investigation of Causes</li> <li>Communications with complainant</li> </ul>	closure date	
Dust	6	6 October 2015	Jayne Plummer / Bryant via EPA	5 and 6 October 2015	<ol> <li>Telephone discussions and email / sms communications between Air QP (Ridley's Air Quality Advisor) and Jayne Plummer / Bryant; andf Steve Robinson on 5 and 6 October.</li> <li>Ridley Inspections and photos of XC2 and XC2E on 5 and 6 October. Those on 6 October in presence of Tim Gubbin of EPA</li> </ol>	On 7 October 2015, Allan Mathieson met both Steve Robinson and Jayne Plummer / Bryant.     A water cart with water cannon has been hired to water soils in XC2 from its eastern and western perimeter road	Telephone discussion between Ridley and DSD and Ridley and EPA on 7 October 2015 to discuss Ridley's response  Email to DSD / EPA on 7 October 2015 with copy of this Register  Based on investigations and also on discussions with EPA:  1. The source of the dust is dry fine grained sand and silt surface soils in XC2 and possibly also in XC1  2. The cause of the dust is high temperatures which caused further drying and strong N, NW, SW winds that entrained the soils in the air.  3. Dust that was entrained from Xc2E appears not to be calsilt but resuspension of dusts deposited from XC2 or XC1  4. Under the strong wind conditions the dust gets transported offsite and deposited on / in neighboring downwind properties .		
Dust	7	25 November 2015	Bill Drew / Jayne Bryant	25 November 2015	Tracy Freeman of Air QP organized to be on site this day to make own observations     Bill Drew called NJW – to advise that he had contacted EPA and was filming the dust, which he described as bad. NJW committed to meeting with Bill in December.	Investigations / Monitoring on 25 November 2015 to be included in a future report:  Photos taken by Ridley Air QP observations	NJW rang DSD (Ben Zammit) and EPA (Tim Gubbin). Tim was on his way to site to check conditions		
					From 4 have 2016 Burdland Day Cook Phys	Lad become the angulation of the Call Field			
Dust	8	8 <sup>th</sup> March 2017	Jayne Bryant	8 <sup>th</sup> March	From 1 June 2016, Buckland Dry Creek Pty Allan Mathieson rang Jane and discussed the issues with her.	1. On the 8th march the property was inspected from the	There was no evidence of dust around or	1	1
Dust	0	8 Watch 2017	Jayne bryant	2017	Allan offered to go and inspect the complainant's property. This offer was rejected by Jane Plummer/Bryant.	boundary of the property.  2. Photos were taken of the outer fencing. No dust was visible	near the property. The complainant does not wish to communicate with BDC. And will not allow any BDC employees access to inspect the property. At this time there are no dust issues in or around the property. BDC has communicated this with DSD and EPA. Jayne now refuses to speak to any personnel from BDC.		
Dust	9	2 <sup>nd</sup> August 2017	Jayne Bryant/Plummer	3 <sup>rd</sup> August 2017	1 Inspect the property and surrounding area for any evidence of dust or previous dust excursions from BDC property. 2 disseminate email chain surrounding Jayne's complaints. That were received on the 2 <sup>nd</sup> August 2017 from Ross Stevens of DSD. The operator that was working in that area on Saturday the 29 <sup>th</sup> August has a signed report that no dust was evidenced in or around the Brooks road area. There is an operator in the field 7 days a week that reports any issues with a very high priority placed on reporting conditions in and around the Brooks road area of the Salt filed	3rd August 2017. Visit the property and inspect the surrounding area. Take photos of conditions in and around XCC2E Brooks road Ryan's road.  Correspond via email to the complainant and offer to communicate on any level regarding any issues they may have.	Due to the very wet nature of the past week the likely hood of dust from any part of BDC property is extremely remote.  Wind conditions at the time of the complaint 10.00 am 29 <sup>th</sup> august 2017 were high however there was .2 mm of rain on 27 <sup>th</sup> July and 2.4 mm of rain on the 28 <sup>th</sup> July 2017. The very damp conditions would prevent dust from any of the condenser areas as evidenced by the photos taken.		
Dust	10	14 <sup>th</sup> March 2018	Jayne Bryant /Ross Stevens	14 <sup>th</sup> March 2018	BDC received a n email from ross Stevens of a dust complaint. There was no date to the complaint BDC found it difficult to determine the cause of the dust due to the lack of a date.	On the 14th march the property was inspected from the boundary of the property.     Photos were taken of the outer fencing. No dust was visible	There was no evidence of dust around or near the property. The complainant does not wish to communicate with BDC. And will not allow any BDC employees access to inspect the property. At this time there are no dust issues in or around the property. The weather site is inspected daily and		

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							there was no reports of dust from the salt	
1							fields at or around the time of this email.	
							BDC has communicated this with DSD and	
							EPA. Jayne now refuses to speak to any	
							personnel from BDC.	
Dust	11	12 <sup>nd</sup> March 18	Bill Drew	12 <sup>th</sup>	Allan Mathieson Inspected the property and surrounding area	Allan Mathieson Inspected the area around Bill Drews	From Allan Mathieson communication with	
Dust	1-1	12 March 10	Biii Biew	March	for any evidence of dust or previous dust excursions from BDC	property and found no evidence to suggest dust had	DSD:	
				2018		congregated in and around his property the property was	The weather conditions during that time	
				2010	property.			
					This can be be to be to the constitution of th	not entered by any BDC employee	were investigated as a possible cause of dust	
					This complaint relates to the email chain surrounding Jayne's		plumes. No conclusive evidence of dust from	
					complaints. That were received on the 14 <sup>th</sup> March 2018 from		emanating form the salt field was noted.	
					Ross Stevens of DSD .			
							Not knowing what time of day or other	
					There is an operator that was working in that area on the day		factors surrounding this complaint, I have on	
					and stated there was no dust was evidenced in or around the		receipt of the dust complaint investigated	
					Brooks road area. There is an operator in the field 7 days a		the area surrounding Brooks road. The only	
					week that reports any issues with a very high priority placed on		dust that was visible was created by passing	
					reporting conditions in and around the Brooks road area of the		motor vehicles.	
					Salt field			
							The reporting system for dust has not been	
							triggered this year.	
							The mean averages for weather conditions	
							1st January 2018 to 14th March 2018	
							demonstrate typical weather conditions.	
							The mean averages for wind in January	
							February and March to date show, no	
							abnormal wind conditions.	
							abnormal wind conditions.	
							The Operator in their daily report have	
							indicated no issues with dust in and around	
							the Brooks road area. That report on	
							weather conditions in and around Brooks	
							road is conducted every day of the year.	
							There are 8 pictures taken at 10 am	
							14/03/18	
1							Picture 1 demonstrates there is no dust	
							Picture 2 shows a white type of soil	
							used on the road surface	
							Picture 3 Shows the dust created by a	
							passing truck	
							Picture 4 shows the dust created by a	
1							passing truck	
1							Picture 5 . 6 .7 and 8 shows tyre marks	
							from vehicles doing burnouts and	
1							skidding around that section of road in	
							picture 2 (white type sop soil) this is	
							directly opposite Janes home.	
							Photos available on request	

Buckland Dry Creek Holding Pattern and Residual Operations Compliance Report to 30 June 2017 Buckland Dry Creek PEPR Compliance Report181101

**Buckland Dry Creek Pty Ltd** (ACN 114 007 153; ABN 82 114 007 153)

# **Appendix C - Investigations**



1/8/2018

George Kontogeorgos

**Buckland Dry Creek** 

412 Hanson Rd North

Dry Creek

SA, 5094

Dear George

#### Compliance update from SA Water salt fields trial for 2017/18 financial year

SA Water has continued to operate the Salt Pans Effluent Polishing Trial through the 2017/18 financial year as part of the ongoing investigation into the effective polishing and evaporation trial using treated effluent from the Bolivar High Salinity Wastewater Treatment Plant (HSP). To date a total volume of 3200 ML has been discharged to the trial area, with 1400 ML of this occurring during the 2017/18 financial year. The footprint of the trial increased during 2017/18 to include an additional 53 hectares through the expansion into PA8. This brought the total area of the trial to around 110ha. Although water was able to flow into PA8 there was very little movement of water into that pan due to the physical restriction on the volume of water that can be diverted to the trial site from the three discharge pipes that transfer the water from the HSP to the trial site. This restriction would need to be addressed if there is a desire to transfer additional water to the trial site to increase the cover of water over PA8.

The trial was approved on the basis that it did not have a negative impact on the following aspects:

- Odour generation
- Dust generation
- Midge and pest insect emergence
- Vegetation health of the surrounding areas
- Any notable offsite impacts on water quality, groundwater etc.

The following commentary addresses these aspects in relation to observations and monitoring conducted during the past financial year.

Odour was not an issue as a stable water level was maintained in the trial area throughout the period, negating any potential acid sulphate-related odour generation. Although some mats of algae were decomposing in the trial area over the summer period, no odour was detected from this or any other water related source of odour.

As with the odour observations, there was no issue with dust generation as the areas that had previously been inundated remained inundated through the financial year. The areas of the trial site that have not been inundated continue to have an intact gypsum cap, further mitigating the risk of dust generation from the dry parts of PA8, PA9 and PA10.



Continuous monitoring of midge fly emergence across a number of sites demonstrated that there was no change in midge fly emergence over the past financial year when compared to results from previous years. The numbers remain around 20 adult midges per square meter per day at the peak of the emergence season, which is an order of magnitude below the rate that would cause concern. Interestingly, the monitoring sites closer to the mangroves had higher rates of emergence than those within the trial site, suggesting that the mangroves provide a greater source of midge fly emergence, and other pest insect species, than the trial ponds.

Observations of the surrounding vegetation health did not show any changes around the trial site. There are areas of mangrove, on the seaward side of the sea wall, that remain impacted by the high salinity within the groundwater, possibly as a function of the increased hydraulic head from the trial ponds, however it is unclear if this is related to the current or historic activities in the salt ponds, or other factors such as sea level rise.

Monitoring of the groundwater, and observation of water within the seepage areas on the outer side of the salt pond bunds showed that there was no notable change compared to previous observations and monitoring data. There appears to be dilution of nitrogen from the east to the western side of the ponds, suggesting that the influence of seawater on the western side reduces the nitrogen concentration of the groundwater. This is also evident from both the salinity and pH concentrations on the western side of the ponds. From the initial sampling that was conducted during the development of the observation bores it was determined that the natural nitrogen concentration of the groundwater was significantly higher than that of the HSP water.

From the information above, and the continued success of the trial, SA Water is satisfied that the trial is progressing as planned and that no detrimental impacts have been recorded both within and outside of the trial ponds. Depending on the current negotiations about the future operation of the entire salt fields, SA Water would like to continue with the trial to determine if a permanent installation is possible in the near future.

Yours sincerely,

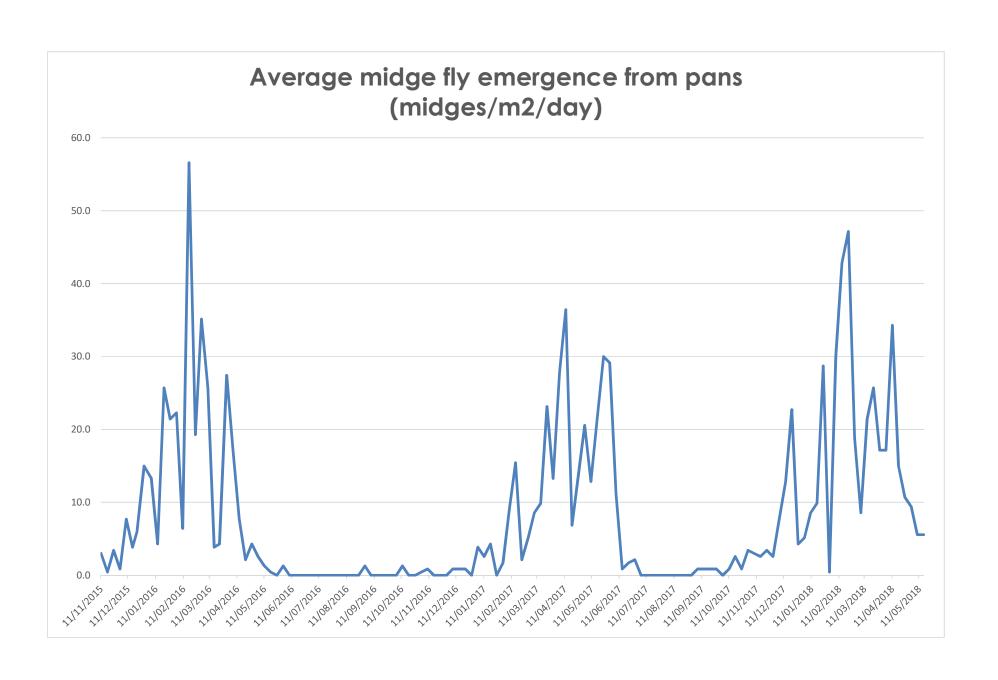
**Greg Ingleton** 

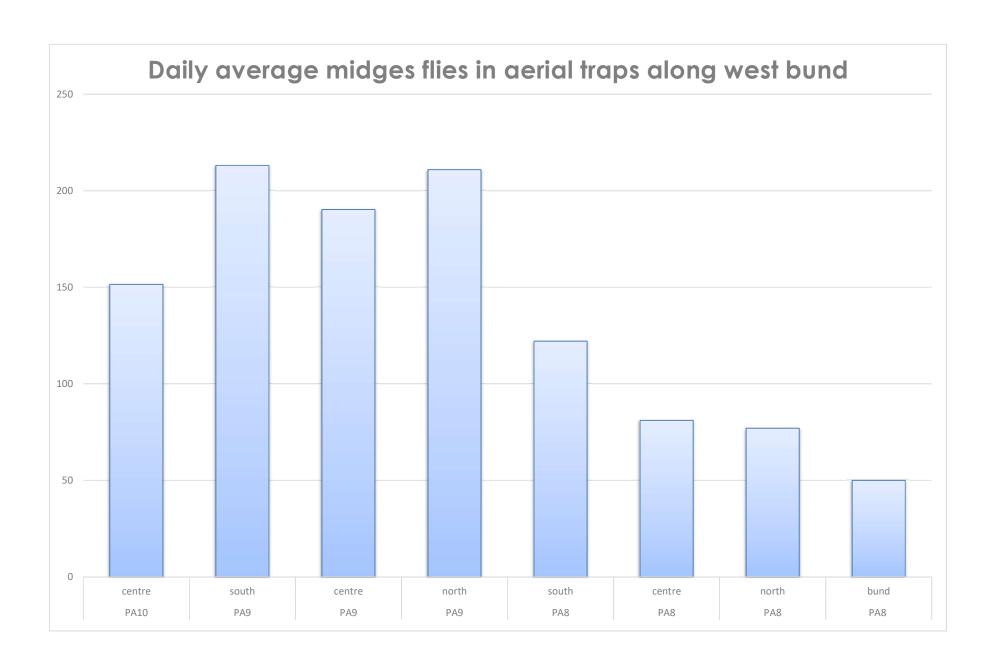
log Ingleton

Business Development Manager - Environmental Opportunities

Phone: 0438 457 543

Email: greg.ingleton@sawater.com.au





adult stickies	along	west	hund

PA10	PA9	PA9	PA9	PA8	PA8	PA8	PA8
centre	south	centre	north	south	centre	north	bund

	mid	lge Tyre	e traps		midegs/m2 overall
11/11/2015	A10 PA9	1	6	date 11/11/2015	3.0
18/11/2015 25/11/2015 2/12/2015		0 2 2	1 6 0	18/11/2015 25/11/2015 2/12/2015	0.4 3.4 0.9
9/12/2015 9/12/2015 16/12/2015		18 6	0	9/12/2015 16/12/2015	7.7 3.9
21/12/2015 29/12/2015		9 15	5 20	21/12/2015 29/12/2015	6.0 15.0
6/01/2016 13/01/2016		14 3	17 7	6/01/2016 13/01/2016	13.3 4.3
20/01/2016 27/01/2016		20 20	40 30	20/01/2016 27/01/2016	25.7 21.4
3/02/2016 10/02/2016		12 0	40 15	3/02/2016 10/02/2016	22.3 6.4
17/02/2016 24/02/2016		2 0	130 45	17/02/2016 24/02/2016	56.6 19.3
2/03/2016 9/03/2016	6	70 40	12 20	2/03/2016 9/03/2016	35.1 25.7
16/03/2016 22/03/2016	8 30	4 5	5 5	16/03/2016 22/03/2016	3.9 4.3
30/03/2016 6/04/2016	150 40	60 20	20	30/03/2016 6/04/2016	27.4 17.1
13/04/2016 20/04/2016	15 0	10 4	8	13/04/2016 20/04/2016	7.7 2.1
27/04/2016 4/05/2016 11/05/2016	4 0 0	6	4 0 3	27/04/2016 4/05/2016	4.3 2.6
18/05/2016 18/05/2016 25/05/2016	0	0	1	11/05/2016 18/05/2016 25/05/2016	1.3 0.4 0.0
1/06/2016 8/06/2016		0	3 0	1/06/2016 8/06/2016	1.3 0.0
15/06/2016 22/06/2016	12 60	0	0	15/06/2016 22/06/2016	0.0
29/06/2016 6/07/2016	0	0 0	0	29/06/2016 6/07/2016	0.0
13/07/2016 20/07/2016	12 0	0	0	13/07/2016 20/07/2016	0.0
27/07/2016 3/08/2016	0	0 0	0 0	27/07/2016 3/08/2016	0.0
10/08/2016 17/08/2016	0	0	0	10/08/2016 17/08/2016	0.0
24/08/2016 31/08/2016	13	0	3	24/08/2016 31/08/2016	1.3
7/09/2016 14/09/2016	25 0	0	0	7/09/2016 14/09/2016	0.0
21/09/2016 28/09/2016	0 0 0	0 0 0	0 0 0	21/09/2016 28/09/2016	0.0
5/10/2016 12/10/2016 19/10/2016	0	3	0	5/10/2016 12/10/2016 19/10/2016	0.0 1.3 0.0
26/10/2016 2/11/2016	0	0	0	26/10/2016 2/11/2016	0.0
9/11/2016 16/11/2016	0	0	2	9/11/2016 16/11/2016	0.9
23/11/2016 30/11/2016	0	0	0	23/11/2016 30/11/2016	0.0
7/12/2016 14/12/2016	0	2 1	0 1	7/12/2016 14/12/2016	0.9 0.9
21/12/2016 28/12/2016	0 3	0 0	2 0	21/12/2016 28/12/2016	0.9
4/01/2017 11/01/2017	11 7	2 2	7 4	4/01/2017 11/01/2017	3.9 2.6
18/01/2017 25/01/2017	8	0	6	18/01/2017 25/01/2017	0.0
1/02/2017 8/02/2017	0	3 13	8	1/02/2017 8/02/2017	9.0
15/02/2017 22/02/2017	2 6 3	30 5 12	6 0 0	15/02/2017 22/02/2017	15.4 2.1
1/03/2017 8/03/2017 15/03/2017	0	20 20	0	1/03/2017 8/03/2017 15/03/2017	5.1 8.6 9.9
22/03/2017 29/03/2017	10 30	50 30	4	22/03/2017 29/03/2017	23.1 13.3
5/04/2017 12/04/2017	20 15	60 80	5	5/04/2017 12/04/2017	27.9 36.4
19/04/2017 26/04/2017	20 15	15 30	1 2	19/04/2017 26/04/2017	6.9 13.7
3/05/2017 10/05/2017	12 8	40 30	8 0	3/05/2017 10/05/2017	20.6 12.9
17/05/2017 24/05/2017	6 2	50 70	0	17/05/2017 24/05/2017	21.4 30.0
31/05/2017 7/06/2017	1	60 25	8	31/05/2017 7/06/2017	29.1 11.1
14/06/2017 21/06/2017	3	4	0	14/06/2017 21/06/2017	0.9 1.7
28/06/2017 5/07/2017	6 0 0	4 0 0	1 0 0	28/06/2017 5/07/2017	0.0
12/07/2017 19/07/2017 26/07/2017	0	0	0	12/07/2017 19/07/2017 26/07/2017	0.0 0.0 0.0
2/08/2017 9/08/2017	0	0	0	2/08/2017 9/08/2017	0.0
16/08/2017 23/08/2017	0	0	0	16/08/2017 23/08/2017	0.0
30/08/2017 6/09/2017	0	0	0	30/08/2017 6/09/2017	0.0 0.9
13/09/2017 20/09/2017	0	0 0	2	13/09/2017 20/09/2017	0.9 0.9
27/09/2017 4/10/2017	0 5	1 0	1 0	27/09/2017 4/10/2017	0.9
11/10/2017 18/10/2017	6	2 1	0 5	11/10/2017 18/10/2017	0.9 2.6
25/10/2017 1/11/2017	0 3 12	0 8 1	2 0 6	25/10/2017 1/11/2017 8/11/2017	0.9 3.4 3.0
8/11/2017 15/11/2017 22/11/2017	7 11	2	4	15/11/2017 22/11/2017	2.6 3.4
29/11/2017 29/11/2017 6/12/2017	0	0	6 15	29/11/2017 6/12/2017	2.6 7.7
13/12/2017 20/12/2017	4 20	13 35	17 18	13/12/2017 20/12/2017	12.9 22.7
27/12/2017 3/01/2018	15 3	10 12	0 0	27/12/2017 3/01/2018	4.3 5.1
10/01/2018 17/01/2018	25 0	20 20	0 3	10/01/2018 17/01/2018	8.6 9.9
24/01/2018 31/01/2018	10 80	50 1	17 0	24/01/2018 31/01/2018	28.7 0.4
7/02/2018 14/02/2018	200 30	20 60	50 40	7/02/2018 14/02/2018	30.0 42.9
21/02/2018 28/02/2018	40 200	50 4	60 40	21/02/2018 28/02/2018	47.1 18.9
7/03/2018 14/03/2018 21/03/2018	150 80 50	10 40 40	10 10 20	7/03/2018 14/03/2018 21/03/2018	8.6 21.4 25.7
28/03/2018 28/03/2018 4/04/2018	30 50	25 15	15 25	28/03/2018 28/03/2018 4/04/2018	17.1 17.1
11/04/2018 11/04/2018 18/04/2018	30 45	70 25	10 10	11/04/2018 18/04/2018	34.3 15.0
25/04/2018 2/05/2018	20 10	10 20	15 2	25/04/2018 2/05/2018	10.7 9.4
9/05/2018 16/05/2018	3 5	6 8	7 5	9/05/2018 16/05/2018	5.6 5.6
23/05/2018 30/05/2018					
6/06/2018 13/06/2018					
20/06/2018 27/06/2018 4/07/2018					
11/07/2018 11/07/2018 18/07/2018					
25/07/2018					

13.9	40	10	35	4	2	2	4	
14.3	20	15	5	0	30	10	20	
65.0	50	50	150	100	35	10	60	
12.1	10	20	15	12	10	10	8	
46.3	20	60	100	90	30	4	20	
20.7	15	5	20	50	25	5	25	
35.0	30	80			35	10	20	
7.4	10	12	10	6	5	5	4	
6.3	10	2	3	4	20	3	2	
12.6	11	10	10	15	7	10	25	
13.3	20	23	18	14	5	8	5	
10.4	5	12	9	11	18	8	10	
8.4	15	8	4	4	15	3	10	
5.3	10	1	4	6	7	3	6	
12.9	15	5	5	10	20	15	20	
8.3	12	4	3	6	6	20	7	

2.3	2	2	2	1	5	2	8	
15.0	6	5	6	50	20	3		
163.0	10	100	50	800	10	8		
270.0	150	500	300	350	200	120		
191.7	250	200	250	200	100	150		
191.7	200	150	200	250	300	50		
493.3	200	1000	800	500	400	60		
141.7	150	100	200	50	100	250		
162.5	250	200	200	75	150	100		
104.2	100	150	100	125	100	50	150	
141.7	350	100	150	100	50	100	100	
60.8	150	50	25	30	30	80	50	50
	152	213	190	211	122	81	77	50

			average adult traps										
PA10	PA9		PA9	PA9		PA8		PA8		PA8		PA8	
centre	south		centre	north		south		centre		north		bund	
152		213	190		211		122		81		77		50

#### Adult emergence chart

The number of midge flies emerging from the pans over the 2017/18 season (Figure xx) was similar to the numbers observed in previous years. This suggests that, while the development of a benthic sediment layer would be expected to provide a more suitable habitat for midge larvae, the pond ecosystem is also developing and providing a sufficient level of biological control that has prevented midge fly number from increasing.

#### Adult traps chart

As can be seen from the chart of midges fly numbers in the aerial traps along west bund (Figure yy), numbers were elevated immediately adjacent the ponds but then declined quickly with distance away from the area where they are breeding. This suggests that after emerging from the ponds the midges are migrating into the mangrove vegetation to the east with relatively little migration of midges toward the residential areas to the north.

Overall, the midge fly monitoring data indicate that the number of midge flies breeding in the ponds are not in sufficient numbers to cause a nuisance to residents in the St Kilda and Waterloo Corner areas.

562994	SAW Environmental Management Dry Creek PA9 WU	1/06/2017	1.3430 mg/L	Ammonia as N
	SAW Environmental Management Dry Creek PA9 WU	1/06/2017	73100.0000 µS/cm	Conductivity
	SAW Environmental Management Dry Creek PA9 WU	1/06/2017	0.0060 mg/L	Copper - Total
	SAW Environmental Management Dry Creek PA9 WU	1/06/2017	0.0030 mg/L	Lead - Total
	SAW Environmental Management Dry Creek PA9 WU	1/06/2017	0.3060 mg/L	Nitrate + Nitrite as N
	SAW Environmental Management Dry Creek PA9 WU	1/06/2017	2.9800 mg/L	Nitrogen - Total
	SAW Environmental Management Dry Creek PA9 WU	1/06/2017	7.3000 pH units	
	SAW Environmental Management Dry Creek PA9 WU	1/06/2017	0.0470 mg/L	Phosphorus - Filterable Reactive as P
	SAW Environmental Management Dry Creek PA9 WU	1/06/2017	0.3140 mg/L	Phosphorus - Total
	SAW Environmental Management Dry Creek PA9 WU	1/06/2017	2.6700 mg/L	TKN as Nitrogen
	SAW Environmental Management Dry Creek PA9 WU	1/06/2017	51000.0000 mg/L	Total Dissolved Solids (by EC)
	SAW Environmental Management Dry Creek PA9 WU	1/06/2017	0.0840 mg/L	Zinc - Total
	SAW Environmental Management Dry Creek PA9 WL	1/06/2017	4.4190 mg/L	Ammonia as N
	SAW Environmental Management Dry Creek PA9 WL	1/06/2017	85400.0000 µS/cm	Conductivity
	SAW Environmental Management Dry Creek PA9 WL	1/06/2017	0.0190 mg/L	Copper - Total
	SAW Environmental Management Dry Creek PA9 WL	1/06/2017	0.0010 mg/L	Lead - Total
	SAW Environmental Management Dry Creek PA9 WL	1/06/2017	0.6320 mg/L	Nitrate + Nitrite as N
	SAW Environmental Management Dry Creek PA9 WL	1/06/2017	6.8000 mg/L	Nitrogen - Total
	SAW Environmental Management Dry Creek PA9 WL	1/06/2017	7.2000 pH units	=
	SAW Environmental Management Dry Creek PA9 WL	1/06/2017	0.1300 mg/L	Phosphorus - Filterable Reactive as P
	SAW Environmental Management Dry Creek PA9 WL	1/06/2017	1.1400 mg/L	Phosphorus - Total
	SAW Environmental Management Dry Creek PA9 WL	1/06/2017	6.1700 mg/L	TKN as Nitrogen
	SAW Environmental Management Dry Creek PA9 WL	1/06/2017	62000.0000 mg/L	Total Dissolved Solids (by EC)
	SAW Environmental Management Dry Creek PA9 WL	1/06/2017	0.1210 mg/L	Zinc - Total
	SAW Environmental Management Dry Creek PA9 EU	1/06/2017	1.8350 mg/L	Ammonia as N
	SAW Environmental Management Dry Creek PA9 EU		146000.0000 µS/cm	Conductivity
	SAW Environmental Management Dry Creek PA9 EU	1/06/2017	0.0190 mg/L	Copper - Total
	SAW Environmental Management Dry Creek PA9 EU	1/06/2017	0.0010 mg/L	Lead - Total
	SAW Environmental Management Dry Creek PA9 EU	1/06/2017	1.7000 mg/L	Nitrate + Nitrite as N
	SAW Environmental Management Dry Creek PA9 EU	1/06/2017	5.3500 mg/L	Nitrogen - Total
	SAW Environmental Management Dry Creek PA9 EU	1/06/2017	7.0000 pH units	<u> </u>
	SAW Environmental Management Dry Creek PA9 EU	1/06/2017	0.0030 mg/L	Phosphorus - Filterable Reactive as P
	SAW Environmental Management Dry Creek PA9 EU	1/06/2017	0.0880 mg/L	Phosphorus - Total
	SAW Environmental Management Dry Creek PA9 EU	1/06/2017	3.6500 mg/L	TKN as Nitrogen
	SAW Environmental Management Dry Creek PA9 EU		120000.0000 mg/L	Total Dissolved Solids (by EC)
	SAW Environmental Management Dry Creek PA9 EU	1/06/2017	0.0120 mg/L	Zinc - Total
	SAW Environmental Management Dry Creek PA9 EL	1/06/2017	3.7190 mg/L	Ammonia as N
	SAW Environmental Management Dry Creek PA9 EL		195000.0000 μS/cm	Conductivity
	SAW Environmental Management Dry Creek PA9 EL	1/06/2017	0.0030 mg/L	Copper - Total
	SAW Environmental Management Dry Creek PA9 EL	1/06/2017	0.0070 mg/L	Lead - Total
	SAW Environmental Management Dry Creek PA9 EL	1/06/2017	0.0500 mg/L	Nitrate + Nitrite as N
	SAW Environmental Management Dry Creek PA9 EL	1/06/2017	9.7000 mg/L	Nitrogen - Total
	SAW Environmental Management Dry Creek PA9 EL	1/06/2017	6.5000 pH units	=
	SAW Environmental Management Dry Creek PA9 EL	1/06/2017	0.0030 mg/L	Phosphorus - Filterable Reactive as P
	SAW Environmental Management Dry Creek PA9 EL	1/06/2017	0.1300 mg/L	Phosphorus - Total
	SAW Environmental Management Dry Creek PA9 EL	1/06/2017	9.6500 mg/L	TKN as Nitrogen
	SAW Environmental Management Dry Creek PA9 EL		180000.0000 mg/L	Total Dissolved Solids (by EC)
	SAW Environmental Management Dry Creek PA9 EL	1/06/2017	0.0160 mg/L	Zinc - Total
55200.		.,	5.5.55 mg/L	

563000	Dry Creek PA9 TOP	1/06/2017	117.0000 mg/L	Alkalinity as Calcium Carbonate
563000	Dry Creek PA9 TOP	1/06/2017	0.0050 mg/L	Ammonia as N
563000	Dry Creek PA9 TOP	1/06/2017	80.0000 mg/L	Bicarbonate
563000	Dry Creek PA9 TOP	1/06/2017	1550.0000 mg/L	Calcium
	Dry Creek PA9 TOP	1/06/2017	31.0000 mg/L	Carbonate
	Dry Creek PA9 TOP	1/06/2017	29600.0000 mg/L	Chloride
	Dry Creek PA9 TOP	1/06/2017	80300.0000 µS/cm	Conductivity
	Dry Creek PA9 TOP	1/06/2017	0.0010 mg/L	Copper - Total
	Dry Creek PA9 TOP	1/06/2017	1.9000 mg/L	Fluoride
	Dry Creek PA9 TOP	1/06/2017	0.0000 mg/L	Hydroxide
	Dry Creek PA9 TOP	1/06/2017	1810.0000 mg/L	Magnesium
	Dry Creek PA9 TOP	1/06/2017	0.1360 mg/L	Nitrate + Nitrite as N
	Dry Creek PA9 TOP	1/06/2017	5.8400 mg/L	Nitrogen - Total
	Dry Creek PA9 TOP	1/06/2017	8.7000 pH units	_
	Dry Creek PA9 TOP	1/06/2017	0.0030 mg/L	Phosphorus - Filterable Reactive as P
	Dry Creek PA9 TOP	1/06/2017	0.2090 mg/L	Phosphorus - Total
	Dry Creek PA9 TOP	1/06/2017	765.0000 mg/L	Potassium
	Dry Creek PA9 TOP	1/06/2017	17700.0000 mg/L	Sodium
	Dry Creek PA9 TOP	1/06/2017	1920.0000 mg/L	Sulphur as S - Total
	Dry Creek PA9 TOP	1/06/2017	2.0000 mg/L	Suspended Solids
	Dry Creek PA9 TOP	1/06/2017	5.7000 mg/L	TKN as Nitrogen
	Dry Creek PA9 TOP	1/06/2017	57000.0000 mg/L	Total Dissolved Solids (by EC)
	Dry Creek PA10 CENTRE	1/06/2017	108.0000 mg/L	Alkalinity as Calcium Carbonate
	Dry Creek PA10 CENTRE	1/06/2017	0.0050 mg/L	Ammonia as N
	Dry Creek PA10 CENTRE	1/06/2017	109.0000 mg/L	Bicarbonate
	Dry Creek PA10 CENTRE	1/06/2017	760.0000 mg/L	Calcium
	Dry Creek PA10 CENTRE	1/06/2017	11.0000 mg/L	Carbonate
	Dry Creek PA10 CENTRE	1/06/2017	6420.0000 mg/L	Chloride
	Dry Creek PA10 CENTRE	1/06/2017	26200.0000 µS/cm	Conductivity
	Dry Creek PA10 CENTRE	1/06/2017	0.0010 mg/L	Copper - Total
	Dry Creek PA10 CENTRE	1/06/2017	1.2000 mg/L	Fluoride
	Dry Creek PA10 CENTRE	1/06/2017	0.0000 mg/L	Hydroxide
	Dry Creek PA10 CENTRE	1/06/2017	503.0000 mg/L	Magnesium
	Dry Creek PA10 CENTRE	1/06/2017	0.0030 mg/L	Nitrate + Nitrite as N
	Dry Creek PA10 CENTRE	1/06/2017	6.1100 mg/L	Nitrogen - Total
	Dry Creek PA10 CENTRE	1/06/2017	8.6000 pH units	
	Dry Creek PA10 CENTRE	1/06/2017	0.2570 mg/L	Phosphorus - Filterable Reactive as P
	Dry Creek PA10 CENTRE	1/06/2017	0.7220 mg/L	Phosphorus - Total
	Dry Creek PA10 CENTRE	1/06/2017	210.0000 mg/L	Potassium
	Dry Creek PA10 CENTRE	1/06/2017	4800.0000 mg/L	Sodium
	Dry Creek PA10 CENTRE	1/06/2017	910.0000 mg/L	Sulphur as S - Total
	Dry Creek PA10 CENTRE	1/06/2017	61.0000 mg/L	Suspended Solids
	Dry Creek PA10 CENTRE	1/06/2017	6.1100 mg/L	TKN as Nitrogen
	Dry Creek PA10 CENTRE	1/06/2017	16000.0000 mg/L	Total Dissolved Solids (by EC)
	Dry Creek PA9 TOP	20/07/2017	168.0000 mg/L	Alkalinity as Calcium Carbonate
	Dry Creek PA9 TOP	20/07/2017	0.0050 mg/L	Ammonia as N
	Dry Creek PA9 TOP	20/07/2017	124.0000 mg/L	Bicarbonate
	Dry Creek PA9 TOP	20/07/2017	910.0000 mg/L	Calcium
22000		20,01,2011	3.3.3333 Hig/L	

563000	Dry Creek PA9 TOP	20/07/2017	40.0000 mg/L	Carbonate
563000	Dry Creek PA9 TOP	20/07/2017	16400.0000 mg/L	Chloride
563000	Dry Creek PA9 TOP	20/07/2017	49100.0000 µS/cm	Conductivity
563000	Dry Creek PA9 TOP	20/07/2017	0.0140 mg/L	Copper - Total
	Dry Creek PA9 TOP	20/07/2017	1.5000 mg/L	Fluoride
	Dry Creek PA9 TOP	20/07/2017	0.0000 mg/L	Hydroxide
	Dry Creek PA9 TOP	20/07/2017	896.0000 mg/L	Magnesium
	Dry Creek PA9 TOP	20/07/2017	0.0030 mg/L	Nitrate + Nitrite as N
	Dry Creek PA9 TOP	20/07/2017	3.9700 mg/L	Nitrogen - Total
	Dry Creek PA9 TOP	20/07/2017	8.8000 pH units	<del>-</del>
	Dry Creek PA9 TOP	20/07/2017	0.3410 mg/L	Phosphorus - Filterable Reactive as P
	Dry Creek PA9 TOP	20/07/2017	0.5680 mg/L	Phosphorus - Total
	Dry Creek PA9 TOP	20/07/2017	328.0000 mg/L	Potassium
	Dry Creek PA9 TOP	20/07/2017	9110.0000 mg/L	Sodium
	Dry Creek PA9 TOP	20/07/2017	1130.0000 mg/L	Sulphur as S - Total
	Dry Creek PA9 TOP	20/07/2017	3.0000 mg/L	Suspended Solids
	Dry Creek PA9 TOP	20/07/2017	3.9700 mg/L	TKN as Nitrogen
	Dry Creek PA9 TOP	20/07/2017	32000.0000 mg/L	Total Dissolved Solids (by EC)
	Dry Creek PA10 CENTRE	20/07/2017	123.0000 mg/L	Alkalinity as Calcium Carbonate
	Dry Creek PA10 CENTRE	20/07/2017	0.0050 mg/L	Ammonia as N
	Dry Creek PA10 CENTRE	20/07/2017	102.0000 mg/L	Bicarbonate
	Dry Creek PA10 CENTRE	20/07/2017	665.0000 mg/L	Calcium
	Dry Creek PA10 CENTRE	20/07/2017	24.0000 mg/L	Carbonate
	Dry Creek PA10 CENTRE	20/07/2017	6230.0000 mg/L	Chloride
	Dry Creek PA10 CENTRE	20/07/2017	22000.0000 µS/cm	Conductivity
	Dry Creek PA10 CENTRE	20/07/2017	0.0010 mg/L	Copper - Total
	Dry Creek PA10 CENTRE	20/07/2017	1.2000 mg/L	Fluoride
	Dry Creek PA10 CENTRE	20/07/2017	0.0000 mg/L	Hydroxide
	Dry Creek PA10 CENTRE	20/07/2017	418.0000 mg/L	Magnesium
	Dry Creek PA10 CENTRE	20/07/2017	0.0030 mg/L	Nitrate + Nitrite as N
	Dry Creek PA10 CENTRE	20/07/2017	4.9300 mg/L	Nitrogen - Total
	Dry Creek PA10 CENTRE	20/07/2017	8.8000 pH units	=
	Dry Creek PA10 CENTRE	20/07/2017	0.3050 mg/L	Phosphorus - Filterable Reactive as P
563001	Dry Creek PA10 CENTRE	20/07/2017	0.5990 mg/L	Phosphorus - Total
	Dry Creek PA10 CENTRE	20/07/2017	173.0000 mg/L	Potassium
	Dry Creek PA10 CENTRE	20/07/2017	3670.0000 mg/L	Sodium
	Dry Creek PA10 CENTRE	20/07/2017	770.0000 mg/L	Sulphur as S - Total
	Dry Creek PA10 CENTRE	20/07/2017	10.0000 mg/L	Suspended Solids
	·	20/07/2017	•	•
	Dry Creek PA10 CENTRE Dry Creek PA10 CENTRE	20/07/2017	4.9300 mg/L 13000.0000 mg/L	TKN as Nitrogen
	SAW Environmental Management Dry Creek PA9 WU	24/08/2017	_	Total Dissolved Solids (by EC) Ammonia as N
	, ,		0.0050 mg/L 69900.0000 µS/cm	
	SAW Environmental Management Dry Creek PA9 WU	24/08/2017 24/08/2017		Conductivity
	SAW Environmental Management Dry Creek PA9 WU		0.0010 mg/L	Copper - Total
	SAW Environmental Management Dry Creek PA9 WU	24/08/2017	0.0010 mg/L	Lead - Total
	SAW Environmental Management Dry Creek PA9 WU	24/08/2017	0.4210 mg/L	Nitrate + Nitrite as N
	SAW Environmental Management Dry Creek PA9 WU	24/08/2017	2.3800 mg/L	Nitrogen - Total
	SAW Environmental Management Dry Creek PA9 WU	24/08/2017	7.4000 pH units	· ·
ენ <u>∠</u> 994	SAW Environmental Management Dry Creek PA9 WU	24/08/2017	0.1050 mg/L	Phosphorus - Filterable Reactive as P

562994	SAW Environmental Management Dry Creek PA9 WU	24/08/2017	0.5380 mg/L	Phosphorus - Total
	SAW Environmental Management Dry Creek PA9 WU	24/08/2017	1.9600 mg/L	TKN as Nitrogen
	SAW Environmental Management Dry Creek PA9 WU	24/08/2017	48000.0000 mg/L	Total Dissolved Solids (by EC)
562994	SAW Environmental Management Dry Creek PA9 WU	24/08/2017	0.0030 mg/L	Zinc - Total
	SAW Environmental Management Dry Creek PA9 WL	24/08/2017	4.0610 mg/L	Ammonia as N
	SAW Environmental Management Dry Creek PA9 WL	24/08/2017	69600.0000 µS/cm	Conductivity
	SAW Environmental Management Dry Creek PA9 WL	24/08/2017	0.0010 mg/L	Copper - Total
	SAW Environmental Management Dry Creek PA9 WL	24/08/2017	0.0010 mg/L	Lead - Total
	SAW Environmental Management Dry Creek PA9 WL	24/08/2017	3.2900 mg/L	Nitrate + Nitrite as N
	SAW Environmental Management Dry Creek PA9 WL	24/08/2017	9.7600 mg/L	Nitrogen - Total
	SAW Environmental Management Dry Creek PA9 WL	24/08/2017	7.2000 pH units	
	SAW Environmental Management Dry Creek PA9 WL	24/08/2017	0.9690 mg/L	Phosphorus - Filterable Reactive as P
	SAW Environmental Management Dry Creek PA9 WL	24/08/2017	1.6800 mg/L	Phosphorus - Total
	SAW Environmental Management Dry Creek PA9 WL	24/08/2017	6.4700 mg/L	TKN as Nitrogen
	SAW Environmental Management Dry Creek PA9 WL	24/08/2017	•	Total Dissolved Solids (by EC)
	SAW Environmental Management Dry Creek PA9 WL	24/08/2017	0.0680 mg/L	Zinc - Total
	SAW Environmental Management Dry Creek PA9 EU	24/08/2017	1.7740 mg/L	Ammonia as N
	SAW Environmental Management Dry Creek PA9 EU	24/08/2017	0.0010 mg/L	Copper - Total
	SAW Environmental Management Dry Creek PA9 EU	24/08/2017	0.0010 mg/L	Lead - Total
	SAW Environmental Management Dry Creek PA9 EU	24/08/2017	1.4500 mg/L	Nitrate + Nitrite as N
	SAW Environmental Management Dry Creek PA9 EU	24/08/2017	5.3000 mg/L	Nitrogen - Total
	SAW Environmental Management Dry Creek PA9 EU	24/08/2017	7.1000 pH units	•
	SAW Environmental Management Dry Creek PA9 EU	24/08/2017	0.0480 mg/L	Phosphorus - Filterable Reactive as P
	SAW Environmental Management Dry Creek PA9 EU	24/08/2017	0.2350 mg/L	Phosphorus - Total
	SAW Environmental Management Dry Creek PA9 EU	24/08/2017	3.8500 mg/L	TKN as Nitrogen
	SAW Environmental Management Dry Creek PA9 EU		105000.0000 mg/L	Total Dissolved Solids (by evaporation)
	SAW Environmental Management Dry Creek PA9 EU	24/08/2017	0.0030 mg/L	Zinc - Total
	SAW Environmental Management Dry Creek PA9 EL	24/08/2017	4.4810 mg/L	Ammonia as N
	SAW Environmental Management Dry Creek PA9 EL	24/08/2017	0.0160 mg/L	Copper - Total
	SAW Environmental Management Dry Creek PA9 EL	24/08/2017	0.0050 mg/L	Lead - Total
	SAW Environmental Management Dry Creek PA9 EL	24/08/2017	4.1300 mg/L	Nitrate + Nitrite as N
	SAW Environmental Management Dry Creek PA9 EL	24/08/2017	14.8000 mg/L	Nitrogen - Total
	SAW Environmental Management Dry Creek PA9 EL	24/08/2017	6.8000 pH units	=
	SAW Environmental Management Dry Creek PA9 EL	24/08/2017	0.1230 mg/L	Phosphorus - Filterable Reactive as P
	SAW Environmental Management Dry Creek PA9 EL	24/08/2017	0.9460 mg/L	Phosphorus - Total
	SAW Environmental Management Dry Creek PA9 EL	24/08/2017	10.7000 mg/L	TKN as Nitrogen
	SAW Environmental Management Dry Creek PA9 EL		191000.0000 mg/L	Total Dissolved Solids (by evaporation)
	SAW Environmental Management Dry Creek PA9 EL	24/08/2017	0.0100 mg/L	Zinc - Total
	Dry Creek PA9 TOP	24/08/2017	•	Alkalinity as Calcium Carbonate
	Dry Creek PA9 TOP	24/08/2017	0.0050 mg/L	Ammonia as N
	Dry Creek PA9 TOP	24/08/2017	•	Bicarbonate
	Dry Creek PA9 TOP	24/08/2017	843.0000 mg/L	Calcium
	Dry Creek PA9 TOP	24/08/2017	0.0000 mg/L	Carbonate
	Dry Creek PA9 TOP	24/08/2017	14000.0000 mg/L	Chloride
	Dry Creek PA9 TOP	24/08/2017	•	Conductivity
	Dry Creek PA9 TOP	24/08/2017	0.0010 mg/L	Copper - Total
	Dry Creek PA9 TOP	24/08/2017	•	Fluoride
	Dry Creek PA9 TOP	24/08/2017	0.0000 mg/L	Hydroxide
30000		_ 1,00,2011	0.0000 mg/L	

563000	Dry Creek PA9 TOP	24/08/2017	763.0000 mg/L	Magnesium
563000	Dry Creek PA9 TOP	24/08/2017	0.0030 mg/L	Nitrate + Nitrite as N
	Dry Creek PA9 TOP	24/08/2017	3.5400 mg/L	Nitrogen - Total
	Dry Creek PA9 TOP	24/08/2017	8.2000 pH units	=
	Dry Creek PA9 TOP	24/08/2017	0.4670 mg/L	Phosphorus - Filterable Reactive as P
	Dry Creek PA9 TOP	24/08/2017	0.6730 mg/L	Phosphorus - Total
	Dry Creek PA9 TOP	24/08/2017	274.0000 mg/L	Potassium
	Dry Creek PA9 TOP	24/08/2017	3590.0000 mg/L	Sodium
	Dry Creek PA9 TOP	24/08/2017	1140.0000 mg/L	Sulphur as S - Total
	Dry Creek PA9 TOP	24/08/2017	26.0000 mg/L	Suspended Solids
	Dry Creek PA9 TOP	24/08/2017	3.5400 mg/L	TKN as Nitrogen
	Dry Creek PA9 TOP	24/08/2017	28000.0000 mg/L	Total Dissolved Solids (by EC)
	Dry Creek PA10 CENTRE	24/08/2017	105.0000 mg/L	Alkalinity as Calcium Carbonate
	Dry Creek PA10 CENTRE	24/08/2017	0.0080 mg/L	Ammonia as N
	Dry Creek PA10 CENTRE	24/08/2017	120.0000 mg/L	Bicarbonate
	Dry Creek PA10 CENTRE	24/08/2017	618.0000 mg/L	Calcium
	Dry Creek PA10 CENTRE	24/08/2017	4.0000 mg/L	Carbonate
	Dry Creek PA10 CENTRE  Dry Creek PA10 CENTRE	24/08/2017	_	Chloride
			5890.0000 mg/L	
	Dry Creek PA10 CENTRE	24/08/2017	21300.0000 µS/cm	Conductivity
	Dry Creek PA10 CENTRE	24/08/2017	0.0010 mg/L	Copper - Total
	Dry Creek PA10 CENTRE	24/08/2017	1.1000 mg/L	Fluoride
	Dry Creek PA10 CENTRE	24/08/2017	0.0000 mg/L	Hydroxide
	Dry Creek PA10 CENTRE	24/08/2017	341.0000 mg/L	Magnesium
	Dry Creek PA10 CENTRE	24/08/2017	0.0030 mg/L	Nitrate + Nitrite as N
	Dry Creek PA10 CENTRE	24/08/2017	5.1700 mg/L	Nitrogen - Total
	Dry Creek PA10 CENTRE	24/08/2017	8.4000 pH units	•
	Dry Creek PA10 CENTRE	24/08/2017	0.1300 mg/L	Phosphorus - Filterable Reactive as P
	Dry Creek PA10 CENTRE	24/08/2017	0.5400 mg/L	Phosphorus - Total
	Dry Creek PA10 CENTRE	24/08/2017	134.0000 mg/L	Potassium
	Dry Creek PA10 CENTRE	24/08/2017	2990.0000 mg/L	Sodium
	Dry Creek PA10 CENTRE	24/08/2017	810.0000 mg/L	Sulphur as S - Total
	Dry Creek PA10 CENTRE	24/08/2017	64.0000 mg/L	Suspended Solids
	Dry Creek PA10 CENTRE	24/08/2017	5.1700 mg/L	TKN as Nitrogen
	Dry Creek PA10 CENTRE	24/08/2017	13000.0000 mg/L	Total Dissolved Solids (by EC)
	Dry Creek PA9 TOP	28/09/2017	141.0000 mg/L	Alkalinity as Calcium Carbonate
	Dry Creek PA9 TOP	28/09/2017	0.0050 mg/L	Ammonia as N
	Dry Creek PA9 TOP	28/09/2017	125.0000 mg/L	Bicarbonate
	Dry Creek PA9 TOP	28/09/2017	994.0000 mg/L	Calcium
	Dry Creek PA9 TOP	28/09/2017	23.0000 mg/L	Carbonate
	Dry Creek PA9 TOP	28/09/2017	15400.0000 mg/L	Chloride
563000	Dry Creek PA9 TOP	28/09/2017	47700.0000 μS/cm	Conductivity
563000	Dry Creek PA9 TOP	28/09/2017	0.0010 mg/L	Copper - Total
563000	Dry Creek PA9 TOP	28/09/2017	1.5000 mg/L	Fluoride
563000	Dry Creek PA9 TOP	28/09/2017	0.0000 mg/L	Hydroxide
563000	Dry Creek PA9 TOP	28/09/2017	809.0000 mg/L	Magnesium
563000	Dry Creek PA9 TOP	28/09/2017	0.0000 mg/L	Magnesium
563000	Dry Creek PA9 TOP	28/09/2017	0.0110 mg/L	Nitrate + Nitrite as N
	Dry Creek PA9 TOP	28/09/2017	3.7400 mg/L	Nitrogen - Total
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563000	Dry Creek PA9 TOP	28/09/2017	8.6000 pH units	рН
	Dry Creek PA9 TOP	28/09/2017	0.3610 mg/L	Phosphorus - Filterable Reactive as P
	Dry Creek PA9 TOP	28/09/2017	0.5510 mg/L	Phosphorus - Total
	Dry Creek PA9 TOP	28/09/2017	385.0000 mg/L	Potassium
	Dry Creek PA9 TOP	28/09/2017	8890.0000 mg/L	Sodium
	Dry Creek PA9 TOP	28/09/2017	1460.0000 mg/L	Sulphur as S - Total
	Dry Creek PA9 TOP	28/09/2017	36.0000 mg/L	Suspended Solids
	Dry Creek PA9 TOP	28/09/2017	3.7300 mg/L	TKN as Nitrogen
	Dry Creek PA9 TOP	28/09/2017	31000.0000 mg/L	Total Dissolved Solids (by EC)
	Dry Creek PA10 CENTRE	28/09/2017	82.0000 mg/L	Alkalinity as Calcium Carbonate
	Dry Creek PA10 CENTRE	28/09/2017	0.0110 mg/L	Ammonia as N
	Dry Creek PA10 CENTRE	28/09/2017	90.0000 mg/L	Bicarbonate
	Dry Creek PA10 CENTRE	28/09/2017	802.0000 mg/L	Calcium
	Dry Creek PA10 CENTRE	28/09/2017	5.0000 mg/L	Carbonate
	Dry Creek PA10 CENTRE	28/09/2017	6780.0000 mg/L	Chloride
	Dry Creek PA10 CENTRE	28/09/2017	23500.0000 µS/cm	Conductivity
	Dry Creek PA10 CENTRE	28/09/2017	0.0010 mg/L	Copper - Total
	Dry Creek PA10 CENTRE	28/09/2017	1.2000 mg/L	Fluoride
	Dry Creek PA10 CENTRE	28/09/2017	0.0000 mg/L	Hydroxide
	Dry Creek PA10 CENTRE	28/09/2017	406.0000 mg/L	Magnesium
	Dry Creek PA10 CENTRE	28/09/2017	0.0070 mg/L	Nitrate + Nitrite as N
	Dry Creek PA10 CENTRE	28/09/2017	6.9700 mg/L	Nitrogen - Total
	Dry Creek PA10 CENTRE	28/09/2017	8.4000 pH units	<del>-</del>
	Dry Creek PA10 CENTRE	28/09/2017	0.0030 mg/L	Phosphorus - Filterable Reactive as P
	Dry Creek PA10 CENTRE	28/09/2017	0.5070 mg/L	Phosphorus - Total
	Dry Creek PA10 CENTRE	28/09/2017	184.0000 mg/L	Potassium
	Dry Creek PA10 CENTRE	28/09/2017	3510.0000 mg/L	Sodium
	Dry Creek PA10 CENTRE	28/09/2017	1030.0000 mg/L	Sulphur as S - Total
	Dry Creek PA10 CENTRE	28/09/2017	72.0000 mg/L	Suspended Solids
	Dry Creek PA10 CENTRE	28/09/2017	6.9600 mg/L	TKN as Nitrogen
	Dry Creek PA10 CENTRE	28/09/2017	14000.0000 mg/L	Total Dissolved Solids (by EC)
	Dry Creek PA9 TOP	17/10/2017	115.0000 mg/L	Alkalinity as Calcium Carbonate
	Dry Creek PA9 TOP	17/10/2017	0.0050 mg/L	Ammonia as N
	Dry Creek PA9 TOP	17/10/2017	56.0000 mg/L	Bicarbonate
	Dry Creek PA9 TOP	17/10/2017	1320.0000 mg/L	Calcium
	Dry Creek PA9 TOP	17/10/2017	41.0000 mg/L	Carbonate
	Dry Creek PA9 TOP	17/10/2017	16800.0000 mg/L	Chloride
	Dry Creek PA9 TOP	17/10/2017	54100.0000 μS/cm	Conductivity
	Dry Creek PA9 TOP	17/10/2017	0.0010 mg/L	Copper - Total
	Dry Creek PA9 TOP	17/10/2017	1.5000 mg/L	Fluoride
	Dry Creek PA9 TOP	17/10/2017	0.0000 mg/L	Hydroxide
	Dry Creek PA9 TOP	17/10/2017	964.0000 mg/L	Magnesium
	Dry Creek PA9 TOP	17/10/2017	0.0030 mg/L	Nitrate + Nitrite as N
	Dry Creek PA9 TOP	17/10/2017	4.4600 mg/L	Nitrogen - Total
	Dry Creek PA9 TOP	17/10/2017	9.0000 pH units	<del>-</del>
	Dry Creek PA9 TOP	17/10/2017	0.0550 mg/L	Phosphorus - Filterable Reactive as P
	Dry Creek PA9 TOP	17/10/2017	0.3630 mg/L	Phosphorus - Total
	Dry Creek PA9 TOP	17/10/2017	344.0000 mg/L	Potassium
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563000	Dry Creek PA9 TOP	17/10/2017	11000.0000 mg/L	Sodium
	Dry Creek PA9 TOP	17/10/2017	1610.0000 mg/L	Sulphur as S - Total
	Dry Creek PA9 TOP	17/10/2017	4.0000 mg/L	Suspended Solids
	Dry Creek PA9 TOP	17/10/2017	4.4600 mg/L	TKN as Nitrogen
	Dry Creek PA9 TOP	17/10/2017	36000.0000 mg/L	Total Dissolved Solids (by EC)
	Dry Creek PA10 CENTRE	17/10/2017	69.0000 mg/L	Alkalinity as Calcium Carbonate
	Dry Creek PA10 CENTRE	17/10/2017	0.0090 mg/L	Ammonia as N
	Dry Creek PA10 CENTRE	17/10/2017	85.0000 mg/L	Bicarbonate
	Dry Creek PA10 CENTRE	17/10/2017	832.0000 mg/L	Calcium
	Dry Creek PA10 CENTRE	17/10/2017	0.0000 mg/L	Carbonate
	Dry Creek PA10 CENTRE	17/10/2017	8060.0000 mg/L	Chloride
	Dry Creek PA10 CENTRE	17/10/2017	28200.0000 μS/cm	Conductivity
	Dry Creek PA10 CENTRE	17/10/2017	0.0010 mg/L	Copper - Total
	Dry Creek PA10 CENTRE	17/10/2017	1.2000 mg/L	Fluoride
	Dry Creek PA10 CENTRE	17/10/2017	0.0000 mg/L	Hydroxide
	Dry Creek PA10 CENTRE	17/10/2017	429.0000 mg/L	Magnesium
	Dry Creek PA10 CENTRE	17/10/2017	0.0180 mg/L	Nitrate + Nitrite as N
	Dry Creek PA10 CENTRE	17/10/2017	15.8000 mg/L	Nitrogen - Total
	Dry Creek PA10 CENTRE	17/10/2017	8.3000 pH units	_
	Dry Creek PA10 CENTRE	17/10/2017	0.0030 mg/L	Phosphorus - Filterable Reactive as P
	Dry Creek PA10 CENTRE	17/10/2017	1.2200 mg/L	Phosphorus - Total
	Dry Creek PA10 CENTRE	17/10/2017	175.0000 mg/L	Potassium
	Dry Creek PA10 CENTRE	17/10/2017	3790.0000 mg/L	Sodium
	Dry Creek PA10 CENTRE	17/10/2017	1230.0000 mg/L	Sulphur as S - Total
	Dry Creek PA10 CENTRE	17/10/2017	80.0000 mg/L	Suspended Solids
	Dry Creek PA10 CENTRE	17/10/2017	15.8000 mg/L	TKN as Nitrogen
	Dry Creek PA10 CENTRE	17/10/2017	17000.0000 mg/L	Total Dissolved Solids (by EC)
	SAW Environmental Management Dry Creek PA9 WU	23/11/2017	1.2200 mg/L	Ammonia as N
	SAW Environmental Management Dry Creek PA9 WU	23/11/2017	66400.0000 µS/cm	Conductivity
	SAW Environmental Management Dry Creek PA9 WU	23/11/2017	0.0130 mg/L	Copper - Total
	SAW Environmental Management Dry Creek PA9 WU	23/11/2017	0.0130 mg/L	Lead - Total
	SAW Environmental Management Dry Creek PA9 WU	23/11/2017	0.3590 mg/L	Nitrate + Nitrite as N
	SAW Environmental Management Dry Creek PA9 WU	23/11/2017	3.2000 mg/L	Nitrogen - Total
562994	SAW Environmental Management Dry Creek PA9 WU	23/11/2017	7.5000 pH units	pH
562994	SAW Environmental Management Dry Creek PA9 WU	23/11/2017	0.0070 mg/L	Phosphorus - Filterable Reactive as P
562994	SAW Environmental Management Dry Creek PA9 WU	23/11/2017	0.3670 mg/L	Phosphorus - Total
562994	SAW Environmental Management Dry Creek PA9 WU	23/11/2017	2.8400 mg/L	TKN as Nitrogen
562994	SAW Environmental Management Dry Creek PA9 WU	23/11/2017	45000.0000 mg/L	Total Dissolved Solids (by EC)
562994	SAW Environmental Management Dry Creek PA9 WU	23/11/2017	0.0380 mg/L	Zinc - Total
562995	SAW Environmental Management Dry Creek PA9 WL	23/11/2017	2.3000 mg/L	Ammonia as N
562995	SAW Environmental Management Dry Creek PA9 WL	23/11/2017	79700.0000 μS/cm	Conductivity
562995	SAW Environmental Management Dry Creek PA9 WL	23/11/2017	0.0030 mg/L	Copper - Total
562995	SAW Environmental Management Dry Creek PA9 WL	23/11/2017	0.0010 mg/L	Lead - Total
562995	SAW Environmental Management Dry Creek PA9 WL	23/11/2017	0.8760 mg/L	Nitrate + Nitrite as N
562995	SAW Environmental Management Dry Creek PA9 WL	23/11/2017	4.3100 mg/L	Nitrogen - Total
562995	SAW Environmental Management Dry Creek PA9 WL	23/11/2017	7.2000 pH units	pH
562995	SAW Environmental Management Dry Creek PA9 WL	23/11/2017	0.0030 mg/L	Phosphorus - Filterable Reactive as P
	SAW Environmental Management Dry Creek PA9 WL	23/11/2017	0.1410 mg/L	Phosphorus - Total
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562995	SAW Environmental Management Dry Creek PA9 WL	23/11/2017	3.4300 mg/L	TKN as Nitrogen
	SAW Environmental Management Dry Creek PA9 WL	23/11/2017	57000.0000 mg/L	Total Dissolved Solids (by EC)
	SAW Environmental Management Dry Creek PA9 WL	23/11/2017	0.0430 mg/L	Zinc - Total
	SAW Environmental Management Dry Creek PA9 EU	23/11/2017	2.3270 mg/L	Ammonia as N
	SAW Environmental Management Dry Creek PA9 EU	23/11/2017	0.0110 mg/L	Copper - Total
	SAW Environmental Management Dry Creek PA9 EU	23/11/2017	0.0030 mg/L	Lead - Total
	SAW Environmental Management Dry Creek PA9 EU	23/11/2017	0.2400 mg/L	Nitrate + Nitrite as N
	SAW Environmental Management Dry Creek PA9 EU	23/11/2017	5.0700 mg/L	Nitrogen - Total
	SAW Environmental Management Dry Creek PA9 EU	23/11/2017	6.9000 pH units	
	SAW Environmental Management Dry Creek PA9 EU	23/11/2017	0.0070 mg/L	Phosphorus - Filterable Reactive as P
	SAW Environmental Management Dry Creek PA9 EU	23/11/2017	0.1230 mg/L	Phosphorus - Total
	SAW Environmental Management Dry Creek PA9 EU	23/11/2017	4.8300 mg/L	TKN as Nitrogen
	SAW Environmental Management Dry Creek PA9 EU		202000.0000 mg/L	Total Dissolved Solids (by evaporation)
	SAW Environmental Management Dry Creek PA9 EU	23/11/2017	0.0130 mg/L	Zinc - Total
	SAW Environmental Management Dry Creek PA9 EL	23/11/2017	4.0540 mg/L	Ammonia as N
	SAW Environmental Management Dry Creek PA9 EL	23/11/2017	0.0110 mg/L	Copper - Total
	SAW Environmental Management Dry Creek PA9 EL	23/11/2017	0.0110 mg/L	Lead - Total
	SAW Environmental Management Dry Creek PA9 EL	23/11/2017	4.4200 mg/L	Nitrate + Nitrite as N
	SAW Environmental Management Dry Creek PA9 EL	23/11/2017	15.8200 mg/L	Nitrogen - Total
	SAW Environmental Management Dry Creek PA9 EL	23/11/2017	6.7000 pH units	<del>-</del>
	SAW Environmental Management Dry Creek PA9 EL	23/11/2017	0.0050 mg/L	Phosphorus - Filterable Reactive as P
	SAW Environmental Management Dry Creek PA9 EL	23/11/2017	0.7650 mg/L	Phosphorus - Total
	SAW Environmental Management Dry Creek PA9 EL	23/11/2017	11.4000 mg/L	TKN as Nitrogen
	SAW Environmental Management Dry Creek PA9 EL		139000.0000 mg/L	Total Dissolved Solids (by evaporation)
	SAW Environmental Management Dry Creek PA9 EL	23/11/2017	0.0250 mg/L	Zinc - Total
	Dry Creek PA9 TOP	23/11/2017	110.0000 mg/L	Alkalinity as Calcium Carbonate
	Dry Creek PA9 TOP	23/11/2017	0.0050 mg/L	Ammonia as N
	Dry Creek PA9 TOP	23/11/2017	50.0000 mg/L	Bicarbonate
	Dry Creek PA9 TOP	23/11/2017	1550.0000 mg/L	Calcium
	Dry Creek PA9 TOP	23/11/2017	41.0000 mg/L	Carbonate
	Dry Creek PA9 TOP	23/11/2017	21600.0000 mg/L	Chloride
	Dry Creek PA9 TOP	23/11/2017	65100.0000 µS/cm	Conductivity
	Dry Creek PA9 TOP	23/11/2017	0.0040 mg/L	Copper - Total
	Dry Creek PA9 TOP	23/11/2017	1.8000 mg/L	Fluoride
	Dry Creek PA9 TOP	23/11/2017	0.0000 mg/L	Hydroxide
	Dry Creek PA9 TOP	23/11/2017	1040.0000 mg/L	Magnesium
	Dry Creek PA9 TOP	23/11/2017	0.0120 mg/L	Nitrate + Nitrite as N
	Dry Creek PA9 TOP	23/11/2017	5.3000 mg/L	Nitrogen - Total
	Dry Creek PA9 TOP	23/11/2017	9.0000 pH units	•
	Dry Creek PA9 TOP	23/11/2017	0.0030 mg/L	Phosphorus - Filterable Reactive as P
	Dry Creek PA9 TOP	23/11/2017	0.1680 mg/L	Phosphorus - Total
	Dry Creek PA9 TOP	23/11/2017	391.0000 mg/L	Potassium
	Dry Creek PA9 TOP	23/11/2017	13700.0000 mg/L	Sodium
	Dry Creek PA9 TOP	23/11/2017	1970.0000 mg/L	Sulphur as S - Total
	Dry Creek PA9 TOP	23/11/2017	30.0000 mg/L	Suspended Solids
	Dry Creek PA9 TOP	23/11/2017	5.2900 mg/L	TKN as Nitrogen
	Dry Creek PA9 TOP	23/11/2017	44000.0000 mg/L	Total Dissolved Solids (by EC)
	Dry Creek PA10 CENTRE	23/11/2017	74.0000 mg/L	Alkalinity as Calcium Carbonate
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563001	Dry Creek PA10 CENTRE	23/11/2017	0.0070 mg/L	Ammonia as N
563001	Dry Creek PA10 CENTRE	23/11/2017	82.0000 mg/L	Bicarbonate
	Dry Creek PA10 CENTRE	23/11/2017	992.0000 mg/L	Calcium
	Dry Creek PA10 CENTRE	23/11/2017	4.0000 mg/L	Carbonate
563001	Dry Creek PA10 CENTRE	23/11/2017	7960.0000 mg/L	Chloride
	Dry Creek PA10 CENTRE	23/11/2017	26900.0000 μS/cm	Conductivity
	Dry Creek PA10 CENTRE	23/11/2017	0.0020 mg/L	Copper - Total
	Dry Creek PA10 CENTRE	23/11/2017	1.3000 mg/L	Fluoride
	Dry Creek PA10 CENTRE	23/11/2017	0.0000 mg/L	Hydroxide
	Dry Creek PA10 CENTRE	23/11/2017	520.0000 mg/L	Magnesium
	Dry Creek PA10 CENTRE	23/11/2017	0.0100 mg/L	Nitrate + Nitrite as N
	Dry Creek PA10 CENTRE	23/11/2017	10.8100 mg/L	Nitrogen - Total
	Dry Creek PA10 CENTRE	23/11/2017	8.4000 pH units	<del>-</del>
	Dry Creek PA10 CENTRE	23/11/2017	0.0030 mg/L	Phosphorus - Filterable Reactive as P
	Dry Creek PA10 CENTRE	23/11/2017	0.7080 mg/L	Phosphorus - Total
	Dry Creek PA10 CENTRE	23/11/2017	213.0000 mg/L	Potassium
	Dry Creek PA10 CENTRE	23/11/2017	4190.0000 mg/L	Sodium
	Dry Creek PA10 CENTRE	23/11/2017	1080.0000 mg/L	Sulphur as S - Total
	Dry Creek PA10 CENTRE	23/11/2017	98.0000 mg/L	Suspended Solids
	Dry Creek PA10 CENTRE	23/11/2017	10.8000 mg/L	TKN as Nitrogen
	Dry Creek PA10 CENTRE	23/11/2017	16000.0000 mg/L	Total Dissolved Solids (by EC)
	Dry Creek PA9 TOP	25/01/2018	148.0000 mg/L	Alkalinity as Calcium Carbonate
	Dry Creek PA9 TOP	25/01/2018	0.0060 mg/L	Ammonia as N
	Dry Creek PA9 TOP	25/01/2018	161.0000 mg/L	Bicarbonate
	Dry Creek PA9 TOP	25/01/2018	1050.0000 mg/L	Calcium
	Dry Creek PA9 TOP	25/01/2018	10.0000 mg/L	Carbonate
	Dry Creek PA9 TOP	25/01/2018	16600.0000 mg/L	Chloride
	Dry Creek PA9 TOP	25/01/2018	51800.0000 μS/cm	Conductivity
	Dry Creek PA9 TOP	25/01/2018	0.1610 mg/L	Copper - Total
	Dry Creek PA9 TOP	25/01/2018	1.9000 mg/L	Fluoride
	Dry Creek PA9 TOP	25/01/2018	0.0000 mg/L	Hydroxide
	Dry Creek PA9 TOP	25/01/2018	1030.0000 mg/L	Magnesium
	Dry Creek PA9 TOP	25/01/2018	0.0030 mg/L	Nitrate + Nitrite as N
	Dry Creek PA9 TOP	25/01/2018	7.5200 mg/L	Nitrogen - Total
	Dry Creek PA9 TOP	25/01/2018	8.4000 pH units	<del>-</del>
	Dry Creek PA9 TOP	25/01/2018	0.0030 mg/L	Phosphorus - Filterable Reactive as P
	Dry Creek PA9 TOP	25/01/2018	0.7890 mg/L	Phosphorus - Total
	Dry Creek PA9 TOP	25/01/2018	394.0000 mg/L	Potassium
	Dry Creek PA9 TOP	25/01/2018	10800.0000 mg/L	Sodium
	Dry Creek PA9 TOP	25/01/2018	1600.0000 mg/L	Sulphur as S - Total
	Dry Creek PA9 TOP	25/01/2018	22.0000 mg/L	Suspended Solids
	Dry Creek PA9 TOP	25/01/2018	7.5200 mg/L	TKN as Nitrogen
	Dry Creek PA9 TOP	25/01/2018	34000.0000 mg/L	Total Dissolved Solids (by EC)
	Dry Creek PA10 CENTRE	25/01/2018	96.0000 mg/L	Alkalinity as Calcium Carbonate
	Dry Creek PA10 CENTRE	25/01/2018	0.3260 mg/L	Ammonia as N
	Dry Creek PA10 CENTRE	25/01/2018	117.0000 mg/L	Bicarbonate
	Dry Creek PA10 CENTRE	25/01/2018	880.0000 mg/L	Calcium
	Dry Creek PA10 CENTRE	25/01/2018	0.0000 mg/L	Carbonate
300001			5.5555 mg/L	

563001	Dry Creek PA10 CENTRE	25/01/2018	7720.0000 mg/L	Chloride
563001	Dry Creek PA10 CENTRE	25/01/2018	26500.0000 µS/cm	Conductivity
563001	Dry Creek PA10 CENTRE	25/01/2018	0.0280 mg/L	Copper - Total
563001	Dry Creek PA10 CENTRE	25/01/2018	1.4000 mg/L	Fluoride
563001	Dry Creek PA10 CENTRE	25/01/2018	0.0000 mg/L	Hydroxide
	Dry Creek PA10 CENTRE	25/01/2018	519.0000 mg/L	Magnesium
	Dry Creek PA10 CENTRE	25/01/2018	0.0030 mg/L	Nitrate + Nitrite as N
	Dry Creek PA10 CENTRE	25/01/2018	7.4100 mg/L	Nitrogen - Total
	Dry Creek PA10 CENTRE	25/01/2018	7.4000 pH units	
	Dry Creek PA10 CENTRE	25/01/2018	0.0120 mg/L	Phosphorus - Filterable Reactive as P
	Dry Creek PA10 CENTRE	25/01/2018	0.4770 mg/L	Phosphorus - Total
	Dry Creek PA10 CENTRE	25/01/2018	206.0000 mg/L	Potassium
	Dry Creek PA10 CENTRE	25/01/2018	4570.0000 mg/L	Sodium
	Dry Creek PA10 CENTRE	25/01/2018	1140.0000 mg/L	Sulphur as S - Total
	Dry Creek PA10 CENTRE	25/01/2018	14.0000 mg/L	Suspended Solids
	Dry Creek PA10 CENTRE	25/01/2018	7.4100 mg/L	TKN as Nitrogen
	Dry Creek PA10 CENTRE	25/01/2018	16000.0000 mg/L	Total Dissolved Solids (by EC)
	SAW Environmental Management Dry Creek PA9 WU	12/02/2018	1.6930 mg/L	Ammonia as N
	SAW Environmental Management Dry Creek PA9 WU	12/02/2018	68100.0000 µS/cm	Conductivity
	SAW Environmental Management Dry Creek PA9 WU	12/02/2018	0.0160 mg/L	Copper - Total
	SAW Environmental Management Dry Creek PA9 WU	12/02/2018	0.0040 mg/L	Lead - Total
	SAW Environmental Management Dry Creek PA9 WU	12/02/2018	0.2940 mg/L	Nitrate + Nitrite as N
	SAW Environmental Management Dry Creek PA9 WU	12/02/2018	3.9100 mg/L	Nitrogen - Total
	SAW Environmental Management Dry Creek PA9 WU	12/02/2018	7.3000 pH units	
	SAW Environmental Management Dry Creek PA9 WU	12/02/2018	0.0130 mg/L	Phosphorus - Filterable Reactive as P
	SAW Environmental Management Dry Creek PA9 WU	12/02/2018	0.6940 mg/L	Phosphorus - Total
	SAW Environmental Management Dry Creek PA9 WU	12/02/2018	3.6200 mg/L	TKN as Nitrogen
	SAW Environmental Management Dry Creek PA9 WU	12/02/2018	47000.0000 mg/L	Total Dissolved Solids (by EC)
	SAW Environmental Management Dry Creek PA9 WU	12/02/2018	0.0830 mg/L	Zinc - Total
	SAW Environmental Management Dry Creek PA9 WL	12/02/2018	3.1970 mg/L	Ammonia as N
	SAW Environmental Management Dry Creek PA9 WL	12/02/2018	78300.0000 µS/cm	Conductivity
	SAW Environmental Management Dry Creek PA9 WL	12/02/2018	0.0070 mg/L	Copper - Total
562995	SAW Environmental Management Dry Creek PA9 WL	12/02/2018	0.0010 mg/L	Lead - Total
562995	SAW Environmental Management Dry Creek PA9 WL	12/02/2018	0.1100 mg/L	Nitrate + Nitrite as N
562995	SAW Environmental Management Dry Creek PA9 WL	12/02/2018	4.8100 mg/L	Nitrogen - Total
562995	SAW Environmental Management Dry Creek PA9 WL	12/02/2018	7.2000 pH units	pH
	SAW Environmental Management Dry Creek PA9 WL	12/02/2018	0.0100 mg/L	Phosphorus - Filterable Reactive as P
562995	SAW Environmental Management Dry Creek PA9 WL	12/02/2018	0.8620 mg/L	Phosphorus - Total
562995	SAW Environmental Management Dry Creek PA9 WL	12/02/2018	4.7000 mg/L	TKN as Nitrogen
562995	SAW Environmental Management Dry Creek PA9 WL	12/02/2018	55000.0000 mg/L	Total Dissolved Solids (by EC)
562995	SAW Environmental Management Dry Creek PA9 WL	12/02/2018	0.0830 mg/L	Zinc - Total
562996	SAW Environmental Management Dry Creek PA9 EU	12/02/2018	3.6000 mg/L	Ammonia as N
	SAW Environmental Management Dry Creek PA9 EU	12/02/2018	0.0390 mg/L	Copper - Total
562996	SAW Environmental Management Dry Creek PA9 EU	12/02/2018	0.0090 mg/L	Lead - Total
	SAW Environmental Management Dry Creek PA9 EU	12/02/2018	0.2120 mg/L	Nitrate + Nitrite as N
	SAW Environmental Management Dry Creek PA9 EU	12/02/2018	3.4000 mg/L	Nitrogen - Total
	SAW Environmental Management Dry Creek PA9 EU	12/02/2018	7.0000 pH units	<del>-</del>
	SAW Environmental Management Dry Creek PA9 EU	12/02/2018	0.0080 mg/L	Phosphorus - Filterable Reactive as P
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562996	SAW Environmental Management Dry Creek PA9 EU	12/02/2018	0.6680 mg/L	Phosphorus - Total
	SAW Environmental Management Dry Creek PA9 EU	12/02/2018	3.1900 mg/L	TKN as Nitrogen
	SAW Environmental Management Dry Creek PA9 EU	12/02/2018	156000.0000 mg/L	Total Dissolved Solids (by evaporation)
	SAW Environmental Management Dry Creek PA9 EU	12/02/2018	0.0300 mg/L	Zinc - Total
	SAW Environmental Management Dry Creek PA9 EL	12/02/2018	4.4290 mg/L	Ammonia as N
	SAW Environmental Management Dry Creek PA9 EL	12/02/2018	0.0590 mg/L	Copper - Total
	SAW Environmental Management Dry Creek PA9 EL	12/02/2018	0.0150 mg/L	Lead - Total
	SAW Environmental Management Dry Creek PA9 EL	12/02/2018	2.6800 mg/L	Nitrate + Nitrite as N
	SAW Environmental Management Dry Creek PA9 EL	12/02/2018	13.5800 mg/L	Nitrogen - Total
	SAW Environmental Management Dry Creek PA9 EL	12/02/2018	6.7000 pH units	<u> </u>
	SAW Environmental Management Dry Creek PA9 EL	12/02/2018	0.0030 mg/L	Phosphorus - Filterable Reactive as P
	SAW Environmental Management Dry Creek PA9 EL	12/02/2018	0.8630 mg/L	Phosphorus - Total
	SAW Environmental Management Dry Creek PA9 EL	12/02/2018	10.9000 mg/L	TKN as Nitrogen
	SAW Environmental Management Dry Creek PA9 EL		202000.0000 mg/L	Total Dissolved Solids (by evaporation)
	SAW Environmental Management Dry Creek PA9 EL	12/02/2018	0.0330 mg/L	Zinc - Total
	Dry Creek PA9 TOP	12/02/2018	136.0000 mg/L	Alkalinity as Calcium Carbonate
	Dry Creek PA9 TOP	12/02/2018	0.0050 mg/L	Ammonia as N
	Dry Creek PA9 TOP	12/02/2018	100.0000 mg/L	Bicarbonate
	Dry Creek PA9 TOP	12/02/2018	1130.0000 mg/L	Calcium
	Dry Creek PA9 TOP	12/02/2018	32.0000 mg/L	Carbonate
	Dry Creek PA9 TOP	12/02/2018	_	Chloride
	Dry Creek PA9 TOP	12/02/2018	59900.0000 μS/cm	Conductivity
	Dry Creek PA9 TOP	12/02/2018	0.0010 mg/L	Copper - Total
	Dry Creek PA9 TOP	12/02/2018	2.0000 mg/L	Fluoride
	Dry Creek PA9 TOP	12/02/2018	0.0000 mg/L	Hydroxide
	Dry Creek PA9 TOP	12/02/2018	1100.0000 mg/L	Magnesium
	Dry Creek PA9 TOP	12/02/2018	0.0030 mg/L	Nitrate + Nitrite as N
	Dry Creek PA9 TOP	12/02/2018	8.0200 mg/L	Nitrogen - Total
	Dry Creek PA9 TOP	12/02/2018	8.7000 pH units	=
	Dry Creek PA9 TOP	12/02/2018	0.0040 mg/L	Phosphorus - Filterable Reactive as P
	Dry Creek PA9 TOP	12/02/2018	0.6370 mg/L	Phosphorus - Total
	Dry Creek PA9 TOP	12/02/2018	483.0000 mg/L	Potassium
	Dry Creek PA9 TOP	12/02/2018	10800.0000 mg/L	Sodium
	Dry Creek PA9 TOP	12/02/2018	1690.0000 mg/L	Sulphur as S - Total
	Dry Creek PA9 TOP	12/02/2018	6.0000 mg/L	Suspended Solids
	Dry Creek PA9 TOP	12/02/2018	8.0200 mg/L	TKN as Nitrogen
	Dry Creek PA9 TOP	12/02/2018	_	Total Dissolved Solids (by EC)
	Dry Creek PA10 CENTRE	12/02/2018	105.0000 mg/L	Alkalinity as Calcium Carbonate
	Dry Creek PA10 CENTRE	12/02/2018	_	Ammonia as N
	Dry Creek PA10 CENTRE	12/02/2018	105.0000 mg/L	Bicarbonate
	Dry Creek PA10 CENTRE	12/02/2018	1010.0000 mg/L	Calcium
	Dry Creek PA10 CENTRE	12/02/2018	11.0000 mg/L	Carbonate
	Dry Creek PA10 CENTRE	12/02/2018	9170.0000 mg/L	Chloride
	Dry Creek PA10 CENTRE	12/02/2018	•	Conductivity
	Dry Creek PA10 CENTRE	12/02/2018		•
	Dry Creek PA10 CENTRE  Dry Creek PA10 CENTRE	12/02/2018	0.0010 mg/L 1.7000 mg/L	Copper - Total Fluoride
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	Dry Creek PA10 CENTRE	12/02/2018	•	Hydroxide
J03001	Dry Creek PA10 CENTRE	12/02/2018	667.0000 mg/L	Magnesium

563001	Dry Creek PA10 CENTRE	12/02/2018	0.0030 mg/L	Nitrate + Nitrite as N
563001	Dry Creek PA10 CENTRE	12/02/2018	7.0700 mg/L	Nitrogen - Total
	Dry Creek PA10 CENTRE	12/02/2018	8.5000 pH units	<del>-</del>
563001	Dry Creek PA10 CENTRE	12/02/2018	0.0040 mg/L	Phosphorus - Filterable Reactive as P
563001	Dry Creek PA10 CENTRE	12/02/2018	0.6380 mg/L	Phosphorus - Total
	Dry Creek PA10 CENTRE	12/02/2018	270.0000 mg/L	Potassium
	Dry Creek PA10 CENTRE	12/02/2018	4680.0000 mg/L	Sodium
	Dry Creek PA10 CENTRE	12/02/2018	1180.0000 mg/L	Sulphur as S - Total
	Dry Creek PA10 CENTRE	12/02/2018	18.0000 mg/L	Suspended Solids
	Dry Creek PA10 CENTRE	12/02/2018	7.0700 mg/L	TKN as Nitrogen
	Dry Creek PA10 CENTRE	12/02/2018	19000.0000 mg/L	Total Dissolved Solids (by EC)
	Dry Creek PA9 TOP	27/03/2018	121.0000 mg/L	Alkalinity as Calcium Carbonate
	Dry Creek PA9 TOP	27/03/2018	0.0520 mg/L	Ammonia as N
	Dry Creek PA9 TOP	27/03/2018	54.0000 mg/L	Bicarbonate
	Dry Creek PA9 TOP	27/03/2018	1050.0000 mg/L	Calcium
	Dry Creek PA9 TOP	27/03/2018	46.0000 mg/L	Carbonate
	Dry Creek PA9 TOP	27/03/2018	16900.0000 mg/L	Chloride
	Dry Creek PA9 TOP	27/03/2018	51600.0000 μS/cm	Conductivity
	Dry Creek PA9 TOP	27/03/2018	0.0380 mg/L	Copper - Total
	Dry Creek PA9 TOP	27/03/2018	1.8000 mg/L	Fluoride
	Dry Creek PA9 TOP	27/03/2018	0.0000 mg/L	Hydroxide
	Dry Creek PA9 TOP	27/03/2018	939.0000 mg/L	Magnesium
	Dry Creek PA9 TOP	27/03/2018	0.0170 mg/L	Nitrate + Nitrite as N
	Dry Creek PA9 TOP	27/03/2018	1.8900 mg/L	Nitrogen - Total
	Dry Creek PA9 TOP	27/03/2018	9.1000 pH units	<del>-</del>
	Dry Creek PA9 TOP	27/03/2018	0.0190 mg/L	Phosphorus - Filterable Reactive as P
	Dry Creek PA9 TOP	27/03/2018	0.0520 mg/L	Phosphorus - Total
	Dry Creek PA9 TOP	27/03/2018	362.0000 mg/L	Potassium
	Dry Creek PA9 TOP	27/03/2018	9680.0000 mg/L	Sodium
	Dry Creek PA9 TOP	27/03/2018	1770.0000 mg/L	Sulphur as S - Total
	Dry Creek PA9 TOP	27/03/2018	11.0000 mg/L	Suspended Solids
	Dry Creek PA9 TOP	27/03/2018	1.8700 mg/L	TKN as Nitrogen
	Dry Creek PA9 TOP	27/03/2018	34000.0000 mg/L	Total Dissolved Solids (by EC)
563001	Dry Creek PA10 CENTRE	27/03/2018	110.0000 mg/L	Alkalinity as Calcium Carbonate
	Dry Creek PA10 CENTRE	27/03/2018	0.0050 mg/L	Ammonia as N
	Dry Creek PA10 CENTRE	27/03/2018	57.0000 mg/L	Bicarbonate
	Dry Creek PA10 CENTRE	27/03/2018	819.0000 mg/L	Calcium
	Dry Creek PA10 CENTRE	27/03/2018	38.0000 mg/L	Carbonate
	Dry Creek PA10 CENTRE	27/03/2018	8610.0000 mg/L	Chloride
	Dry Creek PA10 CENTRE	27/03/2018	28600.0000 µS/cm	Conductivity
	Dry Creek PA10 CENTRE	27/03/2018	0.0390 mg/L	Copper - Total
	Dry Creek PA10 CENTRE	27/03/2018	1.6000 mg/L	Fluoride
	Dry Creek PA10 CENTRE	27/03/2018	0.0000 mg/L	Hydroxide
	Dry Creek PA10 CENTRE	27/03/2018	562.0000 mg/L	Magnesium
	Dry Creek PA10 CENTRE	27/03/2018	0.0080 mg/L	Nitrate + Nitrite as N
	Dry Creek PA10 CENTRE	27/03/2018	1.4800 mg/L	Nitrogen - Total
	Dry Creek PA10 CENTRE	27/03/2018	9.1000 pH units	<del>-</del>
	Dry Creek PA10 CENTRE	27/03/2018	0.0440 mg/L	Phosphorus - Filterable Reactive as P
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563001	Dry Creek PA10 CENTRE	27/03/2018	0.0560 mg/L	Phosphorus - Total
	Dry Creek PA10 CENTRE	27/03/2018	228.0000 mg/L	Potassium
	Dry Creek PA10 CENTRE	27/03/2018	5010.0000 mg/L	Sodium
	Dry Creek PA10 CENTRE	27/03/2018	1190.0000 mg/L	Sulphur as S - Total
	Dry Creek PA10 CENTRE	27/03/2018	1.0000 mg/L	Suspended Solids
	Dry Creek PA10 CENTRE	27/03/2018	1.4700 mg/L	TKN as Nitrogen
	Dry Creek PA10 CENTRE	27/03/2018	17000.0000 mg/L	Total Dissolved Solids (by EC)
	Dry Creek PA8	27/03/2018	219.0000 mg/L	Alkalinity as Calcium Carbonate
	Dry Creek PA8	27/03/2018	0.3550 mg/L	Ammonia as N
	Dry Creek PA8	27/03/2018	267.0000 mg/L	Bicarbonate
	Dry Creek PA8	27/03/2018	813.0000 mg/L	Calcium
	Dry Creek PA8	27/03/2018	0.0000 mg/L	Carbonate
	Dry Creek PA8	27/03/2018	15800.0000 mg/L	Chloride
	Dry Creek PA8	27/03/2018	47200.0000 μS/cm	Conductivity
	Dry Creek PA8	27/03/2018	0.0090 mg/L	Copper - Total
	Dry Creek PA8	27/03/2018	1.4000 mg/L	Fluoride
	Dry Creek PA8	27/03/2018	0.0000 mg/L	Hydroxide
	Dry Creek PA8	27/03/2018	731.0000 mg/L	Magnesium
	Dry Creek PA8	27/03/2018	0.7770 mg/L	Nitrate + Nitrite as N
	Dry Creek PA8	27/03/2018	3.6300 mg/L	Nitrogen - Total
	Dry Creek PA8	27/03/2018	7.9000 pH units	
	Dry Creek PA8	27/03/2018	0.8810 mg/L	Phosphorus - Filterable Reactive as P
	Dry Creek PA8	27/03/2018	1.1200 mg/L	Phosphorus - Total
	Dry Creek PA8	27/03/2018	450.0000 mg/L	Potassium
	Dry Creek PA8	27/03/2018	9220.0000 mg/L	Sodium
	Dry Creek PA8	27/03/2018	932.0000 mg/L	Sulphur as S - Total
	Dry Creek PA8	27/03/2018	10.0000 mg/L	Suspended Solids
	Dry Creek PA8	27/03/2018	0.0000 mg/L	TKN as Nitrogen
	Dry Creek PA8	27/03/2018	4.2500 mg/L	TKN as Nitrogen
	Dry Creek PA8	27/03/2018	31000.0000 mg/L	Total Dissolved Solids (by EC)
	Dry Creek PA9 TOP	1/05/2018	155.0000 mg/L	Alkalinity as Calcium Carbonate
	Dry Creek PA9 TOP	1/05/2018	0.1630 mg/L	Ammonia as N
	Dry Creek PA9 TOP	1/05/2018	99.0000 mg/L	Bicarbonate
	Dry Creek PA9 TOP	1/05/2018	979.0000 mg/L	Calcium
	Dry Creek PA9 TOP	1/05/2018	44.0000 mg/L	Carbonate
	Dry Creek PA9 TOP	1/05/2018	15600.0000 mg/L	Chloride
	Dry Creek PA9 TOP	1/05/2018	49000.0000 μS/cm	Conductivity
	Dry Creek PA9 TOP	1/05/2018	0.0090 mg/L	Copper - Total
	Dry Creek PA9 TOP	1/05/2018	1.9000 mg/L	Fluoride
	Dry Creek PA9 TOP	1/05/2018	0.0000 mg/L	Hydroxide
	Dry Creek PA9 TOP	1/05/2018	935.0000 mg/L	Magnesium
	Dry Creek PA9 TOP	1/05/2018	0.0090 mg/L	Nitrate + Nitrite as N
	Dry Creek PA9 TOP	1/05/2018	9.3100 mg/L	Nitrogen - Total
	Dry Creek PA9 TOP	1/05/2018	8.9000 pH units	•
	Dry Creek PA9 TOP	1/05/2018	0.1470 mg/L	Phosphorus - Filterable Reactive as P
	Dry Creek PA9 TOP	1/05/2018	0.9170 mg/L	Phosphorus - Total
	Dry Creek PA9 TOP	1/05/2018	341.0000 mg/L	Potassium
	Dry Creek PA9 TOP	1/05/2018	8840.0000 mg/L	Sodium
	,		,	•

563000	Dry Creek PA9 TOP	1/05/2018	1460.0000 mg/L	Sulphur as S - Total
563000	Dry Creek PA9 TOP	1/05/2018	63.0000 mg/L	Suspended Solids
563000	Dry Creek PA9 TOP	1/05/2018	9.3000 mg/L	TKN as Nitrogen
	Dry Creek PA9 TOP	1/05/2018	32000.0000 mg/L	Total Dissolved Solids (by EC)
	Dry Creek PA10 CENTRE	1/05/2018	101.0000 mg/L	Alkalinity as Calcium Carbonate
	Dry Creek PA10 CENTRE	1/05/2018	0.1160 mg/L	Ammonia as N
	Dry Creek PA10 CENTRE	1/05/2018	73.0000 mg/L	Bicarbonate
	Dry Creek PA10 CENTRE	1/05/2018	798.0000 mg/L	Calcium
	Dry Creek PA10 CENTRE	1/05/2018	25.0000 mg/L	Carbonate
	Dry Creek PA10 CENTRE	1/05/2018	7810.0000 mg/L	Chloride
	Dry Creek PA10 CENTRE	1/05/2018	•	Conductivity
	Dry Creek PA10 CENTRE	1/05/2018	0.0320 mg/L	Copper - Total
	Dry Creek PA10 CENTRE	1/05/2018	1.5000 mg/L	Fluoride
	Dry Creek PA10 CENTRE	1/05/2018	0.0000 mg/L	Hydroxide
	Dry Creek PA10 CENTRE	1/05/2018	545.0000 mg/L	Magnesium
	Dry Creek PA10 CENTRE	1/05/2018	0.0050 mg/L	Nitrate + Nitrite as N
	Dry Creek PA10 CENTRE	1/05/2018	4.8200 mg/L	Nitrogen - Total
	Dry Creek PA10 CENTRE	1/05/2018	8.9000 pH units	=
	Dry Creek PA10 CENTRE	1/05/2018	0.1150 mg/L	Phosphorus - Filterable Reactive as P
	Dry Creek PA10 CENTRE	1/05/2018	0.3630 mg/L	Phosphorus - Total
	Dry Creek PA10 CENTRE	1/05/2018	228.0000 mg/L	Potassium
	Dry Creek PA10 CENTRE	1/05/2018	4370.0000 mg/L	Sodium
	Dry Creek PA10 CENTRE	1/05/2018	989.0000 mg/L	Sulphur as S - Total
	Dry Creek PA10 CENTRE	1/05/2018	5.0000 mg/L	Suspended Solids
	Dry Creek PA10 CENTRE	1/05/2018	4.8100 mg/L	TKN as Nitrogen
	Dry Creek PA10 CENTRE	1/05/2018	_	Total Dissolved Solids (by EC)
	Dry Creek PA8	1/05/2018	349.0000 mg/L	Alkalinity as Calcium Carbonate
	Dry Creek PA8	1/05/2018	0.0050 mg/L	Ammonia as N
	Dry Creek PA8	1/05/2018	415.0000 mg/L	Bicarbonate
	Dry Creek PA8	1/05/2018	1080.0000 mg/L	Calcium
	Dry Creek PA8	1/05/2018	6.0000 mg/L	Carbonate
	Dry Creek PA8	1/05/2018	67000.0000 mg/L	Chloride
	Dry Creek PA8	1/05/2018	0.0120 mg/L	Copper - Total
	Dry Creek PA8	1/05/2018	1.9000 mg/L	Fluoride
	Dry Creek PA8	1/05/2018	0.0000 mg/L	Hydroxide
	Dry Creek PA8	1/05/2018	3670.0000 mg/L	Magnesium
	Dry Creek PA8	1/05/2018	0.0110 mg/L	Nitrate + Nitrite as N
	Dry Creek PA8	1/05/2018	15.9100 mg/L	Nitrogen - Total
	Dry Creek PA8	1/05/2018	8.3000 pH units	
	Dry Creek PA8	1/05/2018	1.0600 pr drills	Phosphorus - Filterable Reactive as P
	Dry Creek PA8	1/05/2018	1.2800 mg/L	Phosphorus - Total
	Dry Creek PA8	1/05/2018	1410.0000 mg/L	Potassium
	Dry Creek PA8	1/05/2018	_	Sodium
	Dry Creek PA8	1/05/2018	2870.0000 mg/L	Sulphur as S - Total
	Dry Creek PA8	1/05/2018	1.0000 mg/L	Suspended Solids
	Dry Creek PA8	1/05/2018	15.9000 mg/L	TKN as Nitrogen
	·			•
	Dry Creek PA8		148000.0000 mg/L	Total Dissolved Solids (by evaporation)
563001	Dry Creek PA10 CENTRE	6/06/2018	80.0000 mg/L	Alkalinity as Calcium Carbonate

563001	Dry Creek PA10 CENTRE	6/06/2018	0.0120 mg/L	Ammonia as N
563001	Dry Creek PA10 CENTRE	6/06/2018	45.0000 mg/L	Bicarbonate
563001	Dry Creek PA10 CENTRE	6/06/2018	816.0000 mg/L	Calcium
563001	Dry Creek PA10 CENTRE	6/06/2018	26.0000 mg/L	Carbonate
563001	Dry Creek PA10 CENTRE	6/06/2018	6770.0000 mg/L	Chloride
	Dry Creek PA10 CENTRE	6/06/2018	23200.0000 μS/cm	Conductivity
	Dry Creek PA10 CENTRE	6/06/2018	0.0030 mg/L	Copper - Total
	Dry Creek PA10 CENTRE	6/06/2018	1.3000 mg/L	Fluoride
	Dry Creek PA10 CENTRE	6/06/2018	0.0000 mg/L	Hydroxide
	Dry Creek PA10 CENTRE	6/06/2018	522.0000 mg/L	Magnesium
	Dry Creek PA10 CENTRE	6/06/2018	0.0040 mg/L	Nitrate + Nitrite as N
	Dry Creek PA10 CENTRE	6/06/2018	3.7700 mg/L	Nitrogen - Total
	Dry Creek PA10 CENTRE	6/06/2018	9.0000 pH units	=
	Dry Creek PA10 CENTRE	6/06/2018	0.0030 mg/L	Phosphorus - Filterable Reactive as P
	Dry Creek PA10 CENTRE	6/06/2018	0.1920 mg/L	Phosphorus - Total
	Dry Creek PA10 CENTRE	6/06/2018	182.0000 mg/L	Potassium
	Dry Creek PA10 CENTRE	6/06/2018	4440.0000 mg/L	Sodium
	Dry Creek PA10 CENTRE	6/06/2018	946.0000 mg/L	Sulphur as S - Total
	Dry Creek PA10 CENTRE	6/06/2018	1.0000 mg/L	Suspended Solids
	Dry Creek PA10 CENTRE	6/06/2018	21.2000 °C	Temperature at which pH is measured
	Dry Creek PA10 CENTRE	6/06/2018	3.7700 mg/L	TKN as Nitrogen
	Dry Creek PA10 CENTRE	6/06/2018	14000.0000 mg/L	Total Dissolved Solids (by EC)
	SAW Environmental Management Dry Creek PA9 WU	6/06/2018	0.2590 mg/L	Ammonia as N
	SAW Environmental Management Dry Creek PA9 WU	6/06/2018	65900.0000 µS/cm	Conductivity
	SAW Environmental Management Dry Creek PA9 WU	6/06/2018	0.0160 mg/L	Copper - Total
	SAW Environmental Management Dry Creek PA9 WU	6/06/2018	0.0040 mg/L	Lead - Total
	SAW Environmental Management Dry Creek PA9 WU	6/06/2018	0.1900 mg/L	Nitrate + Nitrite as N
	SAW Environmental Management Dry Creek PA9 WU	6/06/2018	2.2900 mg/L	Nitrogen - Total
	SAW Environmental Management Dry Creek PA9 WU	6/06/2018	7.3000 pH units	
562994	SAW Environmental Management Dry Creek PA9 WU	6/06/2018	0.1060 mg/L	Phosphorus - Filterable Reactive as P
562994	SAW Environmental Management Dry Creek PA9 WU	6/06/2018	0.3880 mg/L	Phosphorus - Total
562994	SAW Environmental Management Dry Creek PA9 WU	6/06/2018	20.4000 °C	Temperature at which pH is measured
562994	SAW Environmental Management Dry Creek PA9 WU	6/06/2018	2.1000 mg/L	TKN as Nitrogen
562994	SAW Environmental Management Dry Creek PA9 WU	6/06/2018	45000.0000 mg/L	Total Dissolved Solids (by EC)
562994	SAW Environmental Management Dry Creek PA9 WU	6/06/2018	0.0430 mg/L	Zinc - Total
562995	SAW Environmental Management Dry Creek PA9 WL	6/06/2018	3.3890 mg/L	Ammonia as N
562995	SAW Environmental Management Dry Creek PA9 WL	6/06/2018	66000.0000 µS/cm	Conductivity
562995	SAW Environmental Management Dry Creek PA9 WL	6/06/2018	0.0070 mg/L	Copper - Total
562995	SAW Environmental Management Dry Creek PA9 WL	6/06/2018	0.0010 mg/L	Lead - Total
562995	SAW Environmental Management Dry Creek PA9 WL	6/06/2018	0.6210 mg/L	Nitrate + Nitrite as N
562995	SAW Environmental Management Dry Creek PA9 WL	6/06/2018	7.7100 mg/L	Nitrogen - Total
562995	SAW Environmental Management Dry Creek PA9 WL	6/06/2018	7.1000 pH units	рН
562995	SAW Environmental Management Dry Creek PA9 WL	6/06/2018	0.1710 mg/L	Phosphorus - Filterable Reactive as P
562995	SAW Environmental Management Dry Creek PA9 WL	6/06/2018	0.5320 mg/L	Phosphorus - Total
562995	SAW Environmental Management Dry Creek PA9 WL	6/06/2018	19.9000 °C	Temperature at which pH is measured
562995	SAW Environmental Management Dry Creek PA9 WL	6/06/2018	7.0900 mg/L	TKN as Nitrogen
562995	SAW Environmental Management Dry Creek PA9 WL	6/06/2018	45000.0000 mg/L	Total Dissolved Solids (by EC)
562995	SAW Environmental Management Dry Creek PA9 WL	6/06/2018	0.0100 mg/L	Zinc - Total

562996	SAW Environmental Management Dry Creek PA9 EU	6/06/2018	2.6780 mg/L	Ammonia as N
	SAW Environmental Management Dry Creek PA9 EU	6/06/2018	0.0090 mg/L	Copper - Total
	SAW Environmental Management Dry Creek PA9 EU	6/06/2018	0.0010 mg/L	Lead - Total
	SAW Environmental Management Dry Creek PA9 EU	6/06/2018	0.1970 mg/L	Nitrate + Nitrite as N
	SAW Environmental Management Dry Creek PA9 EU	6/06/2018	4.5800 mg/L	Nitrogen - Total
	SAW Environmental Management Dry Creek PA9 EU	6/06/2018	•	
		6/06/2018	0.0240 mg/L	Phosphorus - Filterable Reactive as P
	SAW Environmental Management Dry Creek PA9 EU	6/06/2018	0.1140 mg/L	Phosphorus - Total
	SAW Environmental Management Dry Creek PA9 EU	6/06/2018	20.2000 °C	Temperature at which pH is measured
	SAW Environmental Management Dry Creek PA9 EU	6/06/2018	4.3800 mg/L	TKN as Nitrogen
	SAW Environmental Management Dry Creek PA9 EU		114000.0000 mg/L	Total Dissolved Solids (by evaporation)
		6/06/2018	0.0130 mg/L	Zinc - Total
	SAW Environmental Management Dry Creek PA9 EL	6/06/2018	4.9740 mg/L	Ammonia as N
	SAW Environmental Management Dry Creek PA9 EL	6/06/2018	0.0160 mg/L	Copper - Total
	SAW Environmental Management Dry Creek PA9 EL	6/06/2018	0.0240 mg/L	Lead - Total
	SAW Environmental Management Dry Creek PA9 EL	6/06/2018	1.1100 mg/L	Nitrate + Nitrite as N
	SAW Environmental Management Dry Creek PA9 EL	6/06/2018	13.2100 mg/L	Nitrogen - Total
	SAW Environmental Management Dry Creek PA9 EL	6/06/2018	6.6000 pH units	
	SAW Environmental Management Dry Creek PA9 EL	6/06/2018	0.0030 mg/L	Phosphorus - Filterable Reactive as P
	SAW Environmental Management Dry Creek PA9 EL	6/06/2018	0.6700 mg/L	Phosphorus - Total
	SAW Environmental Management Dry Creek PA9 EL	6/06/2018	20.6000 °C	Temperature at which pH is measured
	SAW Environmental Management Dry Creek PA9 EL	6/06/2018	12.1000 mg/L	TKN as Nitrogen
	SAW Environmental Management Dry Creek PA9 EL		202000.0000 mg/L	Total Dissolved Solids (by evaporation)
	SAW Environmental Management Dry Creek PA9 EL	6/06/2018	0.0420 mg/L	Zinc - Total
	Dry Creek PA9 TOP	6/06/2018	153.0000 mg/L	Alkalinity as Calcium Carbonate
	Dry Creek PA9 TOP	6/06/2018	0.0130 mg/L	Ammonia as N
	Dry Creek PA9 TOP	6/06/2018	91.0000 mg/L	Bicarbonate
	Dry Creek PA9 TOP	6/06/2018	848.0000 mg/L	Calcium
	Dry Creek PA9 TOP	6/06/2018	47.0000 mg/L	Carbonate
563000	Dry Creek PA9 TOP	6/06/2018	10600.0000 mg/L	Chloride
563000	Dry Creek PA9 TOP	6/06/2018	34000.0000 μS/cm	Conductivity
	Dry Creek PA9 TOP	6/06/2018	0.0020 mg/L	Copper - Total
563000	Dry Creek PA9 TOP	6/06/2018	1.6000 mg/L	Fluoride
563000	Dry Creek PA9 TOP	6/06/2018	0.0000 mg/L	Hydroxide
563000	Dry Creek PA9 TOP	6/06/2018	736.0000 mg/L	Magnesium
563000	Dry Creek PA9 TOP	6/06/2018	0.0310 mg/L	Nitrate + Nitrite as N
563000	Dry Creek PA9 TOP	6/06/2018	3.9000 mg/L	Nitrogen - Total
563000	Dry Creek PA9 TOP	6/06/2018	9.0000 pH units	
563000	Dry Creek PA9 TOP	6/06/2018	0.3770 mg/L	Phosphorus - Filterable Reactive as P
563000	Dry Creek PA9 TOP	6/06/2018	0.4660 mg/L	Phosphorus - Total
563000	Dry Creek PA9 TOP	6/06/2018	244.0000 mg/L	Potassium
563000	Dry Creek PA9 TOP	6/06/2018	6250.0000 mg/L	Sodium
563000	Dry Creek PA9 TOP	6/06/2018	1100.0000 mg/L	Sulphur as S - Total
563000	Dry Creek PA9 TOP	6/06/2018	1.0000 mg/L	Suspended Solids
	Dry Creek PA9 TOP	6/06/2018	21.2000 °C	Temperature at which pH is measured
	Dry Creek PA9 TOP	6/06/2018	3.8700 mg/L	TKN as Nitrogen
	Dry Creek PA9 TOP	6/06/2018	21000.0000 mg/L	Total Dissolved Solids (by EC)
	Dry Creek PA8 North	6/06/2018	205.0000 mg/L	Alkalinity as Calcium Carbonate
	•		<b>.</b>	•

563003	Dry Creek PA8 North
563003	Dry Creek PA8 North

6/06/2018	0.3030	mg/L	Ammonia as N
6/06/2018	250.0000	mg/L	Bicarbonate
6/06/2018	925.0000	mg/L	Calcium
6/06/2018	0.0000	mg/L	Carbonate
6/06/2018	25000.0000	mg/L	Chloride
6/06/2018	71400.0000	μS/cm	Conductivity
6/06/2018	0.0060	mg/L	Copper - Total
6/06/2018	1.6000	mg/L	Fluoride
6/06/2018	0.0000	mg/L	Hydroxide
6/06/2018	1080.0000	mg/L	Magnesium
6/06/2018	1.3700	mg/L	Nitrate + Nitrite as N
6/06/2018	11.4700	mg/L	Nitrogen - Total
6/06/2018	7.8000	pH units	рН
6/06/2018	0.9570	mg/L	Phosphorus - Filterable Reactive as P
6/06/2018	1.6700	mg/L	Phosphorus - Total
6/06/2018	452.0000	mg/L	Potassium
6/06/2018	13200.0000	mg/L	Sodium
6/06/2018	1480.0000	mg/L	Sulphur as S - Total
6/06/2018	6.0000	mg/L	Suspended Solids
6/06/2018	21.2000	°C	Temperature at which pH is measured
6/06/2018	10.1000	mg/L	TKN as Nitrogen
6/06/2018	50000.0000	mg/L	Total Dissolved Solids (by EC)



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11 July 2018

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To whom it may concern,

The following short report details the progress on the Dry Creek Salt Field XB8A Tidal Flooding Trial to 30 June 2018 and is written as a supplement to Buckland Dry Creek Pty Ltd's PEPR compliance report for the period 1 June 2017 to 30 June 2018.

### Introduction

The purpose of the XB8A trial is to re-establish a tidal connection between a tidal creek, Pumping Creek, to evaporation pond XB8A in the Dry Creek Salt Field. This is through the installation of four gated pipes and civil earthworks including the isolation of the pond and dredging to tidally reconnect the pond to the sea via the adjacent creek. The pond is located on Crown land and the results of the proposed tidal inundation trial will inform alternative uses for evaporation ponds in the salt field, including further ponds on Crown land.

The trial is a 'proof of concept' approach to treating the environmental hazards in the evaporation pond and restoring tidal wetlands within it. The Department for Environment and Water (DEW) has been working with the University of Adelaide (UoA), CSIRO, the EPA and PIRSA to develop a prototype concept that will be tested and on the basis of lessons learned, potentially up-scaled to more ponds over subsequent years.

The aim of the project is to trial a long-term future management option for a portion of the salt field should no commercial proposal(s) come to fruition. This will be achieved by:

- 1. Trialling reconnection of Pond XB8A at the salt field to tidal exchange.
- 2. Reducing the hyper-salinity and monosulfide hazard in Pond XB8A while minimising impacts on adjacent coastal ecosystems.
- 3. Improving sediment and water quality conditions to enable recolonisation by benthic invertebrates and native vegetation.
- 4. Restore intertidal mudflat habitat that is utilised my migratory shorebirds.

Mosley, L. 2017.

## Progress to 30 June 2018

### **Monitoring**

The UoA were engaged to operate the trial, once commissioned, and carry out all water quality monitoring, sediment sampling and reporting. Baseline sampling was conducted in April 2017 in the trial pond and at control sites in XB8, Pumping Creek and a nearby natural saltmarsh area. In 2018 monitoring continued of water quality, sediment quality, hydrology and benthic macroinvertebrates, described further below. Monitoring / sampling events were scheduled at 1, 3, 6, and 9 months after tidal restoration commenced (on 29 July 2017). Monitoring variables that formed the basis of reporting include:

- Water quality analysis of temperature, electrical conductivity, pH, dissolved oxygen, redox potential, turbidity, total suspended solids, alkalinity, metals (Al, Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb, S, V, Zn) and metalloid (As), chlorophyll a and nutrients.
- Sediment sampling via coring for electrical conductivity (to assess dilution of hypersalinity from pond sediment and water during trial), redox potential (to quantify development of more oxidising conditions following wetting and drying during tidal action), acid volatile sulfide (AVS, measure of monosulfide content that is hypothesised to decrease with wetting and drying cycles), pyrite (to assess if AVS:pyrite ratio decreases as hypothesised), pH (to assess effects of sulfide oxidation and metal availability), pore water and reactive metals and metalloids (e.g. As, Al, Fe, Mn, Cd, Co, Cu, Ni, Pb, V, Zn to assess if these metals are released from the sediment into the pore water during monosulfide oxidation), total inorganic and organic carbon, and available nitrogen (nitrate and ammonium).
- Benthic invertebrate sampling

In addition, waterbird surveys were again commissioned over summer 2017-18 for comparison to the 2016-17 survey. The survey included the adjacent ponds XB8, XA1, XA7 and PA3 for comparison with future surveys. Field survey and reporting was provided by Graham Carpenter eight times on monthly intervals and timed to coincide with high tide counts of the entire salt field by EBS Ecology for Buckland Dry Creek.

## Results

Three reports are attached detailing the methods and results of the monitoring conducted in 2017-18:

- Mosley LM, Dang T, Marschner P, Fitzpatrick R, and Quinn J (2018). Tidal restoration trial at the Dry Creek salt field; Monitoring Report June 2018. Report to the Department for Environment and Water and Adelaide-Mt Lofty Ranges Natural Resources Management Board. The University of Adelaide.
- 2. Cummings, C and Goonan P (2018). Trends in macroinvertebrate assemblages following tidal re-connection of a salt pond. Report to the Department for Environment and Water and Adelaide-Mt Lofty Ranges Natural Resources Management Board. The Environment Protection Authority.
- 3. Carpenter, G (2018). Waterbird surveys at St Kilda saltfields, XB8A and adjacent ponds –summer 2017-18. A report prepared DEW, Coastal Management Branch.

#### Summary of Results

Pond XB8A is now an intertidal system with saltmarsh vegetation and marine fauna recolonising the degraded area that previously existed under the salt production regime.

Significant progress towards achieving the aims of the tidal flooding trial was made in 2017-18, with the following key outcomes delivered:

- Tidal connection was successfully restored to pond XB8A with regular wetting and drying cycles occurring driven by the natural tidal variation with no measured impact to receiving waters or environmental receptors.
- Salinity in the pond was rapidly restored to near coastal seawater conditions; salinity
  in the sediment has showed less change but slow improvement.
- pH, dissolved oxygen, dissolved metals, chlorophyll a and nutrients are variable but are being maintained at satisfactory levels during tidal exchange.
- No significant acid sulfate soil risks have eventuated and wetting and drying cycles have maintained saturated conditions over most of the site.
- Improved sediment and water quality conditions have enabled recolonisation by benthic invertebrates and native vegetation, with the restored intertidal mudflat habitat being utilised by local and migratory shorebirds.

Three fixed photo monitoring posts were installed on 9 March 2018, on the edge of XB8A to encourage repeatable and comparable photo capture over time. The emergence of coastal vegetation is noticeable for example at Photo Point 1, located on the southern corner of XB8A. The photo monitoring point does not capture the initial emergence of saltmarsh and dune shrubs on the higher land in the foreground as it was installed 7 months after the lowering of water level. However in the short time of 4 months between photos below the growth and spread of vegetation is obvious.





Figure 1. Photo monitoring point 1, photos taken 9/3/2018 (L) and 6/7/2018 (R)

Similarly, within the pond saltmarsh plants are establishing and growing rapidly as shown in Figure 2 below.



Figure 2. Sarcocornia quinquiflora and Suaeda australis species of saltmarsh on the edge of the Pumping Creek channel in Pond XB8A.

## Supplementary notes

All works and operation of the tidal trial were completed in accord with the approved PEPR. There was no reported incidents of adverse public health and/or significant nuisance impacts due to dust, odour or noise.

Authority to dredge, in order to place the pipes and reconnect Pumping Creek, was provided by an EPA Dredging Licence (Licence No. 50299) and PIRSA Permit to Undertake Activities within an Aquatic Reserve (St Kilda-Chapman Creek).

There was no loss of native vegetation in the course of undertaking the excavation and laying of pipes. There was no impact to the receiving waters of Gulf St Vincent or to other environmental receptors.

### References

Carpenter G. (2017), *Waterbird surveys at St Kilda saltfields, XB8A and adjacent ponds – summer 2016-17.* Report to the Department of Environment, Water and Natural Resources and the Adelaide-Mt Lofty Ranges Natural Resources Management Board. Unpublished.

Carpenter G. (2018), Waterbird surveys at St Kilda saltfields, XB8A and adjacent ponds – summer 2017-18. Report to the Department for Environment and Water. Unpublished.

Cummings, C and Goonan P (2018). Trends in macroinvertebrate assemblages following tidal re-connection of a salt pond. Report to the Department for Environment and Water and Adelaide-Mt Lofty Ranges Natural Resources Management Board. The Environment Protection Authority.

Mosley L. M. (2017), Environmental Monitoring and Risk Management Plan for a Tidal Restoration Trial at the Dry Creek Saltfield. The University of Adelaide.

Mosley LM, Dang T, Marschner P, Fitzpatrick R, and Quinn J (2018). Tidal restoration trial at the Dry Creek salt field; Monitoring Report June 2018. Report to the Department for Environment and Water and Adelaide-Mt Lofty Ranges Natural Resources Management Board. The University of Adelaide.

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Yours Sincerely

Manne

Jason Quinn

Project Manager, Dry Creek Salt field Closure Coastal Management Branch, Department for Environment and Water

# **Environment Protection Authority**

# Trends in macroinvertebrate assemblages following tidal re-connection of a salt pond

**Draft Report 2018** 



## Trends in macroinvertebrate assemblages following tidal re-connection of a salt pond

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# **Summary**

The value of coastal habitats has increased significantly over recent decades and, as a result, focus has been directed to restoring impacted coastal areas to their original functional state. As one such restoration attempt, a tidal restoration has been trialled over the past 12 months in one of the decommissioned salt ponds in the northern suburbs of Adelaide. One trial pond (XB8a) was reconnected via a series of gates within a levee bank at the top of the existing tidal creek line in July 2017. The aims of the tidal restoration project are to reduce the hypersaline and monosulfide hazard in Pond XB8a while minimising impacts on adjacent coastal ecosystems, and to promote the restoration of healthy benthic invertebrate communities as a measure of environmental success by the project. This report focusses on the assessment of the benthic invertebrate communities during the first 12 months of the trial.

For the assessment, macroinvertebrates were sampled in four habitats; XB8a (the trial pond), XB8 (an adjacent control pond which remained hypersaline, a reference saltmarsh habitat and Pumping Creek, the tidal creek that originally connected XB8a to Barker Inlet. The abundance, richness and community dynamics of the benthic macroinvertebrates inhabiting the sediment were sampled on five occasions: Sampling Event 1 (S01; April 2017; pre-trial), Sampling Event 2 (S02; August 2017; 1 month post trial commencement), Sampling Event 3 (S03; November 2017; 4 months post trial commencement), Sampling Event 4 (S04; January 2018; 6 months post trial commencement) and Sampling Event 5 (S05; April 2018; 9 months post trial commencement). Aquatic macroinvertebrates, sampled using a dip net, were also sampled in all four habitats and five sampling events, however only the results from XB8a and XB8 are presented in this report.

Trends in benthic macroinvertebrates showed that the assemblage present within XB8 (control salt pond) of salinity ranging between 110 to 170 mS/cm consists of a simple, yet highly abundant, salt-tolerant assemblage. *Tanytarsus barbitarsus* was the dominant salt-tolerant species present within XB8, at times consisting 100% of the individuals recorded in samples. Other salt tolerant taxa included *Parartemia zietziana*, *Haloniscus* and Ephydridae. In contrast, the reference saltmarsh consisted of a diverse species including polychaetes, molluscs and additional species of crustacean and insects. Abundances were not necessarily higher in the reference saltmarsh habitat, however the more diverse species assemblage infers a more resilient ecosystem with increased ecosystem functionality. For example, the prevalence of detritivores within the reference saltmarsh habitat allows for the breakdown of large volumes of organic carbon, fuelling the saltmarsh food web and exporting nutrients to adjacent coastal habitats.

The benthic assemblage within the trial pond XB8a both prior to the tidal restoration trail began and one month post tidal reconnection, resembled the benthic assemblage of the hypersaline XB8 control pond. However, by as soon as four months post tidal reconnection, the assemblage within XB8a had significantly shifted to a more diverse assemblage of taxa which more closely resembled the reference saltmarsh habitat than the prior salt pond assemblage. This shift remained during subsequent sampling events, although some seasonal variation was evident among the assemblage present in the trial pond during the final three sampling events. The assemblage in Pumping Creek also increased in diversity following tidal reconnection, shifting to an assemblage more similar to that of the reference habitat.

The trends in the aquatic assemblage recorded aligned with trends in the benthic assemblage. The aquatic assemblage within XB8 on all sampling occasions, and XB8a during both S01 and S02, consisted of an abundance of only a few salt-tolerant species. Consistent with the trends observed in the benthic assemblage, a significant shift in the aquatic assemblage occurred in XB8a from four months following the tidal reconnection, with a much more diverse assemblage present in sampling events thereafter.

The considerably quick shift in assemblage within XB8a in both the water column and benthic zone following tidal reconnection, suggests the tidal restoration method for restoring benthic invertebrate assemblages was effective in XB8a. The timing of the tidal reconnection is likely to have integral for this success, with spring tides able to effectively reduce the salt loads significantly from the trial pond quickly, and also allowed the recolonisation of taxa within the pond by moving vast amounts of wrack and invertebrates into the trial pond. Deep burrowing polychaetes and larger bivalves are still absent from XB8a, suggesting that either the deeper sediments are not yet suitable for recolonisation, colonists are not locally available to move into the pond yet, or our sampling techniques were not suitable to collect and record larger

invertebrates. Further shifts in invertebrate assemblage are highly likely as the vegetation within the trial pond continues to establish, and further improvements to the benthic and aquatic habitat occur as time progresses.



## 1 Introduction

Saltmarshes are one of the most productive ecosystems in the world and have unfortunately experiences high rates of loss worldwide (Mitsch 2005) due to factors such as urban development, sea level rise and geological subsidence (Day et al. 2011). They serve as a nursery ground for many economically important fish and shellfish, such as crabs, mussels and clams, and they fuel food webs by cycling and exporting large amounts of nutrients. Substantial areas of saltmarsh have been infilled for development, and tidal flows have been altered by artificial structures such as sea walls. Man-made dams and levees have disrupted sediment supply to salt marsh areas, limiting the increase in salt marsh elevation that occurs due to sedimentation, and preventing reversal of the processes of costal wetland loss (Day et al. 2011).

Saltmarshes are important coastal habitats, serving four ecological roles: providing habitat, providing food, acting as a buffer and filter of nutrients (reducing erosion and maintaining water quality), and as a carbon sink (Connor et al. 2001). Saltmarsh protects estuary foreshores by absorbing the energy of wind and wave actions, and providing a natural buffer that helps minimise erosion. This buffer between the terrestrial and aquatic environments assists in trapping and stabilising sediment, dampening the effects of floodwaters, collecting and recycling nutrients and contaminants from runoff, thus also helping to maintain water quality. With predicted increases in storm surge intensity and rising sea levels associated with climate change, saltmarsh will become increasingly important in protecting estuary foreshores.

Given the increasing recognition of the value of coastal saltmarsh habitats, there is an increasing focus on restoring coastal marshes. Restoration of coastal salt ponds saltmarsh habitat specifically, entails a complex process that can include transforming the status from a salt pond to the ultimate goal for that site (i.e. mangroves, tidal saltmarsh or wetlands). The rate at which salt ponds can be restored to tidal marsh can be influenced by the proximity to colonising plants and animals, initial site elevations, sediment supply and dredged sediment availability, pond desalinisation, containment of invasive species, protecting existing biological resources and survival pressures on the many special status species that often utilise tidal marsh and salt ponds. Restoring sufficient tidal flows in saltmarsh habitats is important to maintain a diverse faunal assemblage in the newly created habitat.

Macroinvertebrates are critical components of aquatic habitats, including saltmarsh and mangroves, being the link between primary producers and higher trophic levels (e.g. Sheaves and Molony 2000). They are a food source for birds, fish and other taxa (Levin et al. 1996), and contribute to the decomposition of organic matter in the soil (Levin et al. 2001). Invertebrates convert tough saltmarsh plants into a more palatable form for other organisms, allowing other invertebrates, fish, and birds to benefit from the rich productivity. Thus, invertebrates are partly responsible for providing the food resources that help fuel saltmarsh and marine ecosystems. And the condition of the invertebrate community will ultimately influence the health of all saltmarsh dependent fauna.

Macroinvertebrates within coastal marsh and mangrove habitats can be generalists, feeding on different sources of carbon within different microhabitats, for example feeding on mangrove leaves within mangrove forests and microbenthic algae in gaps between mangrove forests, with the latter supporting the greatest biomass of macroinvertebrates (Kon et al. 2007). Saltmarsh invertebrates display a wide range of tolerances for both physical and chemical conditions such a salinity and tidal influence. Species will occupy different areas of tidal habitats depending on their tolerance for local conditions and can migrate between different habitats with tidal movements. The low marsh and permanently flooded areas support species that require almost constant inundation, including most mussels, clams, shrimps, crabs and polychaete worms. The high marsh and marsh border supports a variety of marine and terrestrial invertebrates.

Research on saltmarsh restoration has tended to not include detailed studies of changes to the macroinvertebrate assemblages, despite being good indicators of saltmarsh condition. Previous restoration efforts have shown that different members of the macroinvertebrate community recover at different rates (ranging between less than 5 years and greater than 20 years, Warren et al. 2002). Warren et al. (2002) showed that isopods and amphipods tended to recover quicker than snails and mussels. It is unclear whether the trajectory of macroinvertebrate populations in the restoration of salt marshes is correlated with the response of other biological groups, including vegetation. Restoring the tidal cycle within tidal marshes often has a strong vegetation response, which alters the physical habitat of the marsh and may influence food for consumers (Roman et al. 1984). Many arthropods are intimately associated with the native vegetation or the

microhabitat that it creates (Gratton and Denno 2005). However, macroinvertebrate recovery has also been shown to not necessarily correlate to vegetation change (Warren et al. 2002).

The Dry Creek salt fields north of Adelaide has produced salt since 1940, by evaporating seawater within a series of concentrating ponds. As the water evaporates, precipitates of both gypsum (CaSO<sub>4</sub>) and common salt (halite, NaCl) are formed. Beneath the gypsum and salt layers, monosulfidic sediments have built up over large areas of the 4,000 ha site, which poses an environmental hazard. Recently, the salt production at Ridley Salt has ceased and the aim is to close and rehabilitate the site. Tidal cycling is one option to remediate salt ponds to their former condition, by re-connecting the pond to the adjacent habitat. By carefully managing tidal flushing, the hypersalinity and monosulfidic hazards with salt ponds is mitigated, and the regeneration of tidal creeks and habitat provide shelter and food resources (i.e. invertebrates) for birds and fish.

The overall aims of the broader tidal restoration project, managed by the UoA for DEWNR, are to reduce the hypersaline and monosulfide hazard in Pond XB8a while minimising impacts on adjacent coastal ecosystems, and to promote the restoration of healthy benthic invertebrate communities as a measure of environmental success by the project. The aim of the benthic ecological assessment component is to determine whether tidal restoration has changed and/or improved benthic ecological resources within the trial pond XB8a. Invertebrates are a useful component to monitor in saltmarshes because they cover a wide range of organisms covering all trophic levels, they are ubiquitous so a large number of organisms can be recorded per sampling effort, and macroinvertebrates complete their life cycle within the marsh and thus reflect ambient and past habitat conditions. Invertebrates are good indicators of changes to habitat, including changes in tidal flow, vegetation cover, salinity regime, nutrients and dissolved oxygen. Benthic invertebrates are the primary food source for wading birds within tidal habitats, and changes in benthic invertebrate populations has demonstrated changes in both the types of wading bird species present, and their abundances. Monitoring changes in the benthic invertebrate community thus provides a valuable measure of the food resources available, and of general environmental condition.

## 2 Methods

## **Benthic Sampling**

Benthic macroinvertebrates were collected from 14 sites, including sites within XB8a (trial pond; four sites), within XB8 (an adjacent control pond; four sites), in Pumping Creek (two sites) and within a reference tidal marsh area (four sites; Table 1; Figure 1). Within XB8a, samples were selected to cover a range of elevations and to align with sites previously used by CSIRO. Benthic macroinvertebrates were collected on five sampling occasions: Sampling Event 1 (S01; April 2017; pre-trial), Sampling Event 2 (S02; August 2017; 1 month post trial commencement), Sampling Event 3 (S03; November 2017; 4 months post trial commencement), Sampling Event 4 (S04; January 2018; 6 months post trial commencement) and Sampling Event 5 (S05; April 2018; 9 months post trial commencement).

Benthic macroinvertebrates were collected using a Russian D sediment corer of diameter 75 mm to a depth of 10 cm. Aquatic fauna were collected by disturbing 2 m of edge with a triangular sweep net (width 30 cm). Five replicate sediment cores and sweep net samples were collected at each site per sampling event. Each sample was placed in labelled plastic containers, preserved with methylated spirits and then transported to the laboratory for processing. To count and enumerate macroinvertebrates, samples were washed through a 0.5 mm sieve and all invertebrates collected were identified and enumerated to a suitable level (i.e. mostly species, genus or family level) under a light microscope.

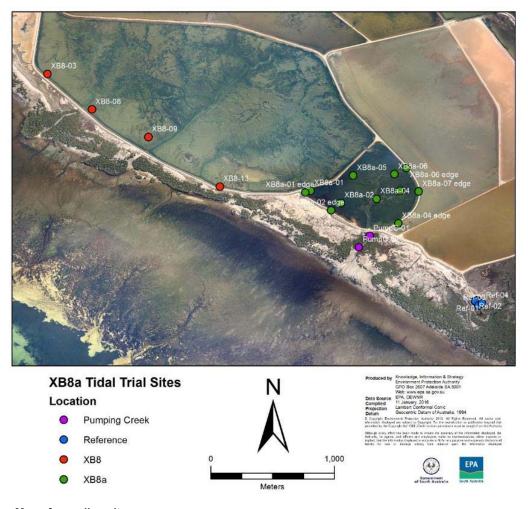


Figure 1 Map of sampling sites

Table 1 Locations of sampling sites for the trial restoration project

Table I Locations of s	ampining onco		oracion projec
Location	Site	Longitude	Latitude
Pumping Creek	PumpC-01	138.51679	-34.7286
	PumpC-02	138.51602	-34.7294
Reference Saltmarsh	Ref-01	138.52462	-34.7333
	Ref-02	138.52447	-34.7333
	Ref-03	138.52469	-34.7337
	Ref-04	138.52496	-34.7335
XB8 Control Pond	XB8-03	138.49336	-34.7168
Abo Control Pond			
	XB8-08	138.4966	-34.7194
	XB8-09	138.5007	-34.7214
	XB8-13	138.5059	-34.7250
XB8a Trial Pond	XB8a-01	138.5125	-34.7253
	XB8a-02	138.5147	-34.7262
	XB8a-04	138.5173	-34.7259
	XB8a-05	138.5156	-34.7242
	XB8a-06	138.5186	-34.7241
	XB8a-07	138.5190	-34.7253

## **Data Analysis**

To display trends in abundance, richness and proportion of *Tanytarsus barbitarsus*, bar plots were created using the ggplot package (Wickham 2009) in R (R Core Team 2016).

To test trends in abundance, richness and proportion of *Tanytarsus barbitarsus*, a permutation-based multivariate analysis of variance (PERMANOVA) was undertaken on each parameter individually using PRIMER v.6, with the PERMANOVA+ add-on (Clarke & Gorley 2006, Anderson et al. 2008). A three-way design was used to determine differences among Sampling Event (fixed factor, 5 levels: S01, S02, S03, S04, S05), Location (fixed factor, 4 levels: XB8a, XB8, Reference Saltmarsh, Pumping Creek), and Site (random factor nested within Location). To determine which pairs within a factor significantly differed, pair-wise PERMANOVA were used (Anderson et al. 2008).

Multivariate trends in both the benthic and aquatic macroinvertebrate assemblages were also analysed using PRIMER v.6 with the PERMANOVA+ add-on. Data were analysed separately for each sampling technique (i.e. benthic cores vs. aquatic net samples), with both datasets first log transformed to reduce the importance of taxa with high abundances. Aquatic assemblage data were also standardised to account for any variability in sampling effort. Benthic core data were not standardised due the standardised methodology used to collect the benthic core samples. To display the data in a two-dimensional format, an nMDS plot was created from Bray-Curtis based similarity matrices.

## 3 Results

## Trends in benthic fauna

A total of 37 benthic species were recorded from the benthic samples, including eleven Mollusca, eleven Diptera, five Polychaeta, five Crustacea and Oligochaeta, Nematoda, one Collembola, one Hemiptera and one Cnidaria taxa. *Tanytarsus barbitarsus* was the most abundant taxa recorded across all samples, present in 55% of benthic core samples including all four sampling locations, and comprising 32.4% of the total individuals recorded. *Salinator fragilis* was recorded in 12.6% of benthic samples and was present in 21.3% of benthic samples. *Culicoides* and *Capitella* were also present in greater than 10% of benthic samples, being recorded in 16.0% and 10.8% of benthic samples, respectively.

The taxon richness in benthic core samples varied between 0 and 8 taxa, with an average richness of 2 taxa per benthic core sample. Taxon richness was lowest among XB8 (control) samples, with only four taxa present across all samples; *T. barbitarsus* (comprising 94% of the individuals recorded and present in 78% of benthic samples), *Haloniscus* (comprising 3.6% of the individuals recorded and present in 3% of benthic samples), Ephydridae and dipteran pupae (both comprising 1.2% of individuals recorded and present in 1% of benthic samples), and with a mean richness of one taxa per XB8 sample. Taxon richness was greatest within Reference Saltmarsh samples, with a total of 23 taxa present across all samples, predominantly *Tanytarsus barbitarsus* (22.8% of individuals recorded), *Culicoides* (17.6% of individuals), Gastropod sp. B (11.6% of individuals) and *Capitella* (11.2% of individuals). The taxon richness within XB8a was not significantly different to the taxon richness within the control pond during S01 and S02, however was significantly greater in S03 – S05 (P = 0.0134; Figure 2). Taxon richness increased marginally in Pumping Creek from S01 and S02 to S03-S05. By S03, the taxon richness in both XB8a (trial) and Pumping Creek were both not significantly different from the taxon richness in the Reference Saltmarsh habitat (P = 0.0696 and P = 0.3031, respectively).

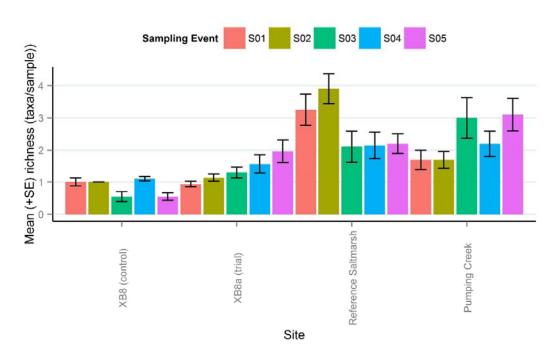


Figure 2 Mean taxon richness of benthic infauna per location, for each sampling event.

The benthic abundance per m² varied greatly among samples, ranging from 0 individuals m² to 14,033 individuals per m². No fauna were recorded in 60 of the 400 benthic samples processed, and the mean abundance across all samples was 1086 individuals m². The total abundance of benthic macroinvertebrates varied significantly among sampling events and

locations (P = 0.0036; Figure 3). The mean abundance for both the Reference Saltmarsh and Pumping Creek was not significantly different among sampling events. The abundance within XB8 (control pond) was significantly lower in S03 and S05, when compared to other sampling events (P = 0.0001). For XB8a, the abundance in S01 was significantly greater than S03 (P = 0.0406). All other trends in abundance among sampling events and locations were masked by high variability among the samples.

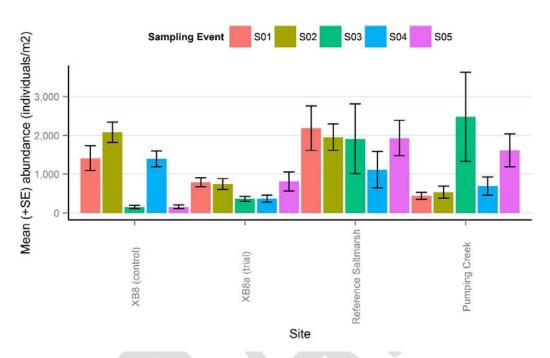


Figure 3 Mean abundance (individuals/m²) of benthic infauna per location, for each sampling event.

Trends in the proportion of *T. barbitarsus* for each sample varied greatly among locations (Figure 4). In XB8, the proportion of *T. barbitarsus* averaged 99% of all individuals recorded per sample, when taxa were present. Within the Reference Saltmarsh habitat, the proportion of *T. barbitarsus* averaged 24% of the total individuals but the proportion increased significantly in S05 to 79.0%. The proportion of *T. barbitarsus* within XB8a averaged 97.1% in S01 and 89.1% in S02 but reduced significantly by S03 to 5.3% of all individuals and remained below 5% of the individuals in S04 (1.7%) and S05 (3.3%). The proportion of *T. barbitarsus* in Pumping Creek was generally low, ranging from 1.4% to 5.4%, except for S02, where the proportion of *T. barbitarsus* increased to 76.8%.

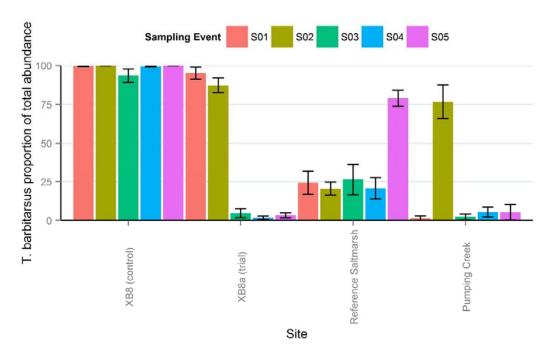


Figure 4 Mean proportion of *Tanytarsus barbitarsus* of the total abundance of benthic infauna per location, for each sampling event.

#### **Community Analysis**

Multi-variate trends within the benthic cores are displayed in Figure 5. On this plot, each benthic macroinvertebrate sample is displayed as a symbol, with the distance between each symbol indicative of the similarity in species composition between the samples (i.e. samples closer together are more similar; samples further apart are more dissimilar). The symbols are colour coded by the sampling event where S01 is January 2017, S02 is August 2017, S03 is November 2017, S04 is January 2018 and S05 is April 2018. The symbols for each sample depict the Location the samples were collected from, with closed triangles depicting Pumping Creek samples, closed diamonds depicting the Reference Saltmarsh samples, open squares depicting samples from the control pond XB8 and asterisks depicting samples from the trial pond. Given there are the similarities of 400 samples presented on this plot, further MDS plots on subsets of the data are also showed in Figures A1.1 – A1.9 (Appendix 1) to demonstrate further trends within the benthic dataset.

There are some groupings evident from the benthic core macroinvertebrate community composition (Figure 5). The benthic macroinvertebrates within the control pond show similarity with each other among the five sampling events, with all samples clustered towards the top right of the plot. Samples from XB8a from S01 to S03, show no significant difference from XB8 community composition, suggesting that pre- tidal reconnection the macroinvertebrates communities between the two salt ponds were not significantly different from one-another, and the composition within XB8a had not significantly shifted by November 2017. This community composition can be characterised by a high abundance of *Tanytarsus barbitarsus* and low abundances of *Haloniscus*, Ephydridae and Dipteran pupae. The macroinvertebrate community composition within the benthic cores of XB8a for both S04 and S05 were significantly different from that of XB8, and preceding sampling events within XB8a (P = 0.0001), suggesting that a shift in the benthic community occurred by January 2018 and was sustained to April 2018. The benthic macroinvertebrate community composition within XB8a for S04 and S05 had a higher diversity of taxa present, and included the presence of various species of polychaetes, crustaceans, molluscs and dipterans.

The benthic community composition in the Reference Saltmarsh had a large amount of variability among the samples, with some samples fairly similar to the benthic composition within the control pond XB8 on some occasions, particularly evident in S05 (April 2018). Trends in benthic community composition in Pumping Creek were not significantly different to trends in benthic community composition in the Reference Saltmarsh habitat.

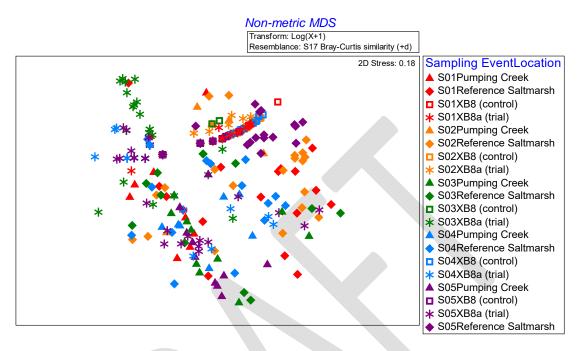


Figure 5 nMDS plot of species composition of benthic cores

## Trends in aquatic fauna

Across all XB8a and XB8 aquatic samples, a total of 73 taxa were recorded, all of which were present within the XB8a trial pond during at least one sampling event, but only 14 of the taxa present within the control pond. Majority of the individuals recorded from XB8 (control pond) were *Tanytarsus barbitarsus* (93% of total numbers recorded) and the isopod *Haloniscus* was also commonly observed (3.8% of total number of individuals recorded). *T. barbitarsus* was also prevalent in XB8a (trial pond) aquatic samples, comprising 63.5% of the total number of individuals recorded. Other prominent taxa within XB8a included Amphipoda, (14.9%) and *Salinator fragilis* (13.8%).

Taxonomic richness within the control pond varied between 2 and 5 taxa across all five sampling events. Taxonomic richness in the trial pond pre-tidal reconnection was comparable to that of the control pond (4 taxa), and increased significantly across the sampling events, reaching a maximum of 18 taxa per sample in April 2018 (Figure 6). Interestingly, in both trial and control ponds, the taxonomic richness in sampling event S03 (November 2017) had a higher taxonomic richness compared to both sampling event S02 and S04, suggesting a seasonal trend.

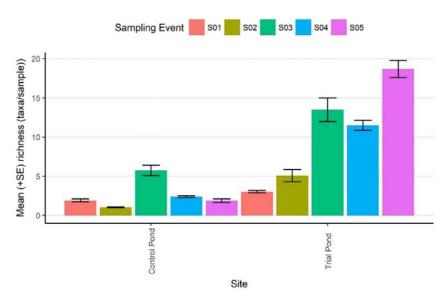


Figure 6 Mean richness (individuals/ 2m) of aquatic infauna per location, for each sampling event.

The mean proportion of *T. barbitarsus* within each sample is displayed in Figure 7 and highlights the high proportion of *T. barbitarsus* in both the control and trial ponds in both S01 and S02. In XB8, the proportion of *T. barbitarsus* in S01 and S02 was above 95% and in later sampling events, the proportion reduced sequentially from 77% of the total abundance in S03, down to 50% proportion of the total individuals recorded in S05. Within XB8a, the proportion of *T. barbitarsus* was above 95% of all recorded individuals for S01 and S02, but reduced significantly to below 25% for subsequent sampling events.

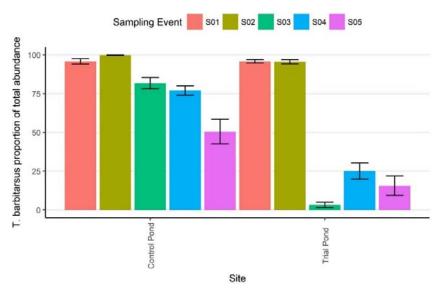


Figure 7 Proportion of *Tanytarsus barbitarsus* of total individuals of aquatic infauna per location, for each sampling event.

#### **Community Analysis**

Multi-dimensional analyses show the macroinvertebrate community composition of the control pond was consistent across the five sampling events, evident from the samples with closed symbols all present to the left-hand side of the MDS plot (Figure 8). Within the trial pond, the community composition on sampling events 1 and 2 (April 2017; pre-tidal reconnection and August 2017) were not significantly different from the community composition within the control pond. The invertebrate community composition in November 2017, January 2018 and April 2018 was significantly different from that in the control pond and in earlier sampling events (depicted in Figure 8 as the samples to the right of the plot). The invertebrate composition of the control pond, and the trial pond during April 2017 and August 2017, comprised of predominantly *Tanytarsus barbitarsus*, *Haloniscus* isopods, *Parartemia zietziana* brine shrimp, Ephydridae and the occasional Dolichopodidae and Hemipteran. The community composition of the trial pond from November onwards comprised a much more diverse assemblage, and included the salt tolerant species found within XB8 and XB8a before November 2017 with exception to the brine shrimps, as well as many species of polychaete worms, crustaceans, gastropods and molluscs, dipteran flies.

The differences in species composition between the two clusters of samples (cluster a to the b to the left of the plot and cluster a to the right of the plot) include the proportion of *T. barbitarsus* (60.05% in cluster b and 11.78% in cluster a), *Salinator fragilis* (0.22% in cluster b vs. 18.39% in cluster a), *Haloniscus* (12.69% in cluster b vs. 0.1% in cluster a).

The community assemblage within XB8a during November 2017, January 2018 and April 2018 did vary significantly among these three sampling events (P = 0.0019), suggesting seasonal variation. Difference in community composition include a higher proportion of *S. fragilis* in S03 and S04 compared to S05, a greater proportion of *T. barbitarsus* proportion in S04 then in both S03 and S05, an increase in Amphipoda and Chiltonidae Amphipoda proportion in S05.

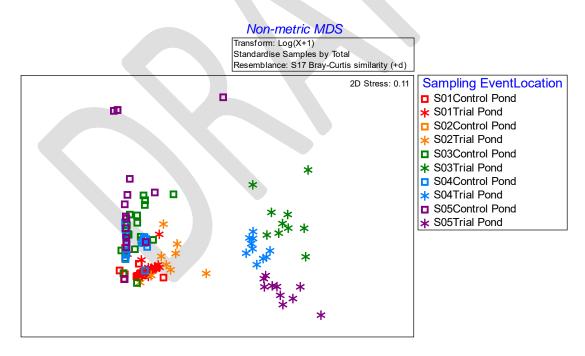


Figure 8 nMDS plot of species composition of sweep net samples from XB8 and XB8a ponds.

## 4 Discussion

The value of coastal habitats has increased significantly over recent decades and, as a result, focus has been directed to restoring impacted coastal areas to their original functional state. As one such restoration attempt, a tidal restoration has been trialled over the past 12 months in one of the decommissioned salt ponds in the northern suburbs of Adelaide. One trial pond (XB8a) was reconnected via a series of gates within a levee bank at the top of the existing tidal creek line in July 2017.

Trends in benthic macroinvertebrates showed that the assemblage present within XB8 (control salt pond; of salinity ranging between 110 to 170 mS/cm) consisted of a simple, yet highly abundant, salt tolerant assemblage. *Tanytarsus barbitarsus* was the dominant species present, at times consisting 100% of the individuals recorded in samples, and other taxa included *Parartemia zietziana*, *Haloniscus* and Ephydridae. This is common for hypersaline ecosystems, where dense populations of few hypersaline tolerant species are commonly observed (De Deckker P 1983). In contrast, the reference saltmarsh consisted of a much more diverse assemblage, consisting of a range of polychaetes, molluscs and additional crustacean and insect species. Abundances were not necessarily higher in the reference saltmarsh habitat, however there are a broader range of ecosystem functions provided by the increased diversity within the reference saltmarsh. For example, the prevalence of detritivores within the reference saltmarsh habitat allows for the breakdown of large volumes of organic carbon, fuelling the saltmarsh food web and exporting nutrients to adjacent coastal habitats.

The benthic assemblage within the trial pond XB8a both prior to the tidal restoration trail began and one month post tidal reconnection, resembled the benthic assemblage of the XB8 control pond. The assemblage within XB8a consisted of the same hypersaline species present within XB8. However, by as soon as four months post tidal reconnection, the assemblage within XB8a had significantly shifted to a more diverse assemblage of taxa more closely resembling the reference saltmarsh habitat than the prior salt pond assemblage. This shift remained during subsequent sampling events, although some seasonal variation was evident among the assemblage present in the trial pond at the final three sampling events.

The assemblage in Pumping Creek also increased in species diversity following the tidal reconnection, to something more closely related to the reference saltmarsh habitat in S04, as hypothesised. The tidal reconnection of XB8a was also hypothesised to improve the benthic habitat and assemblages within Pumping Creek given hypersaline seepage from XB8a was noted in pilot studies carried out prior to the commencement of the trial. The input of hypersaline water at the top of Pumping Creek prior to the trial was most evident at low tides, where saline inputs were increasing the salinity of Pumping Creek to salinities consistent with those within the salt pond (i.e. >110 mS/cm). At high tides, the salinity inputs from the salt pond was mixed with tidal waters, reducing salinities in Pumping Creek to salinities just above marine waters (ranging 50-60 mS/cm). The daily fluctuations of salinity within Pumping Creek created a hostile environment for invertebrates to permanently inhabit, although it was expected invertebrates and fish were utilising habitats within the tidal creek during higher tides.

The trends in the aquatic assemblage (sampled using a dip net) aligned with trends in the benthic core assemblage. The aquatic assemblage within XB8 on all sampling occasions, and XB8a during both S01 and S02, consisted of an abundance of only a few hypersaline taxa. Consistent with the trends observed in the benthic assemblage, a significant shift in the aquatic assemblage also occurred in XB8a from four months following the tidal reconnection, with a much more diverse assemblage present. The increase in diversity, including colonisation of a range of gastropods, crustaceans and polychaetes, occurred much quicker than previously documented in creations of new salt marsh habitat, with some previous restoration efforts taking years to see significant shifts in the macroinvertebrate assemblage. For example, Levin et al. (1996) showed that mud snails (*Nassarius obsoletus*) took 18 months to colonise both a planted and unplanted salt marsh, and mussels (*Littorines* sp.), and mud crabs (*Sesarma* sp.) were not recorded within 27 months of creating a saltmarsh habitat in North Carolina, USA. In this study, *Capitella* did colonise the salt marsh habitat within one month. They concluded that burrowing and grapsid crabs are characteristic early successional fauna in created *Spartina* marshes, that grazing snails appear later, but that many other epifaunal forms are slow to invade the developing marsh habitat.

Several created marshes appear to exhibit nearly complete re-establishment of low-elevation macrofauna within three years based on assessing total macrofaunal densities and some measure of diversity but did not achieve functional similarities in species composition. Sacco et al. (1994) found that of five created saltmarshes of ages between 10-17 years, not all species had returned to similar densities as adjacent natural marshes. Species with planktonic dispersal stages, like oligochaetes and tanaids, are dominant members of natural-marsh assemblages but can be among the slowest to recover in created marshes. Our findings are not consistent with these results; they show a much more rapid colonisation of a range of tidal macroinvertebrates.

The rapid shift in assemblage within XB8a in both the water column and benthic zone following tidal reconnection, suggests the tidal restoration method for restoring benthic invertebrate assemblages was effective in XB8a. The timing of the tidal reconnection is likely to be integral for this success, with spring tides able to effectively reduce the salt loads significantly from the trial pond quickly, and also allowed the recolonisation of taxa within the pond by moving vast amounts of wrack and invertebrates into the trial pond. Deep burrowing polychaetes and larger bivalves are still absent from XB8a, suggesting that the either the deeper sediments are not yet suitable for recolonisation, colonists are not locally available to move into the pond yet, or our sampling techniques were not suitable to collect and record larger invertebrates. Further shifts in invertebrate assemblage are highly likely as the vegetation within the trial pond continues to establish, and further improvements to the benthic and aquatic habitat occur as time progresses.

## 5 References

Anderson MJ, Gorley RN, Clarke KR (2008), *PERMANOVA+ for PRIMER: Guide to software and statistical methods*. PRIMER-E, Plymouth, UK.

Clarke KR, Gorley RN (2006), PRIMER v6: User manual/Tutorial. PRIMER-E, Plymouth, UK.

Connor RF, Chmura GL, Beecher B (2001), 'Carbon accumulation in Bay of Fundy salt marshes: Implications for restoration of reclaimed marshes,' *Global Biogeochemical Cycles*, **15**: 943-954.

Day JW, Kemp GP, Reed DJ, Cahoon DR, Boumans RM, Suhayda JM, Gambrell R (2011), 'Vegetation death and rapid loss of surface elevation in two contrasting Mississippi delta salt marshes: The role of sedimentation, autocompaction and sea-level rise,' *Ecological Engineering*, **37:** 229-240.

De Deckker P (1983), 'Australia salt lakes: their history, chemistry, and biology – a review', Hydrobiologia 105: 231-244.

Gratton C, Denno RF (2005), 'Restoration of arthropod assemblages in a *Spartina* salt marsh following removal of the invasive plant *Phragmites australis*,' *Restoration Ecology* **13:** 358-372.

Kon K, Kurokura H, Hayashizaki K (2007), 'Role of microhabitats in food webs of benthic communities in a mangrove forest,' *Marine Ecology Progress Series* **340**: 55-62.

Moy LD, Levin LA (1991), 'Are *Spartina* marshes a replaceable resource? A functional approach to evaluation of marsh creation efforts,' *Estuaries*, **14:** 1-16.

Levin LA, Talley D, Thayer G (1996), 'Succession of macrobenthos in a created salt marsh,' *Marine Ecology Progress Series*, **141**: 67-82.

Levin LA, Boesch DF, Covich A, Dahm C, Erséus C, Ewel KC, Kneib RT, Moldenke A, Palmer MA, Snelgrove P, Strayer D, Weslawski JM, (2001), 'The function of marine crticial transition zones and the importance of sediment biodiversity,' *Ecosystems*, **4:** 430-451.

Roman CT, Niering WA, Warren S, (1984), 'Salt marsh vegetation change in respnose to tidal restriction,' *Environmental Management*, **8:** 141-149.

Sheaves M, Molony B, (2000), 'Short-circuit in the mangrove food chain,' Marine Ecology Progress Series, 199: 97-109.

Warren RS, Fell PE, Rozsa R, Brawley AH, Orsted AC, Olson ET, Swamy V, Niering WA (2002), 'Salt marsh restoration in Connecticut: 20 Years of Science and Management,' *Restoration Ecology* **10**: 497-513.

# Appendix 1 Benthic macroinvertebrate community structure

To display the trends in the bethic macroinvertebrate community assemblage further, the dataset was split by firstly Location (Figures A1 - A4), then by Sampling Event (Figures A5 - A9) and nMDS plots produced for each of the subsetted datasets.

## Benthic macroinvertebrate community structure, analysed by habitat

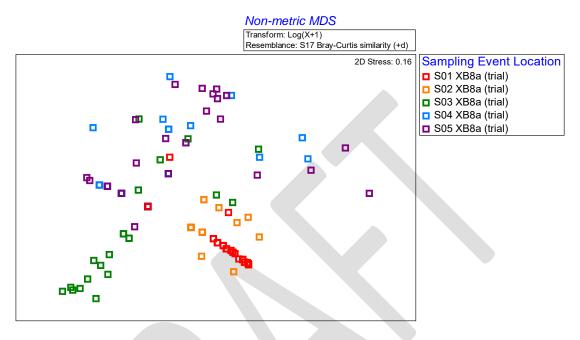


Figure A1. 1 nMDS plot of the benthic macroinvertebrate assemblage from XB8a (trial) pond.

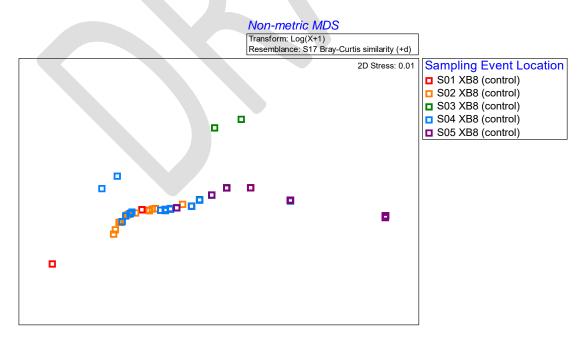


Figure A1. 2 nMDS plot of the benthic macroinvertebrate assemblage from XB8 (control) pond.

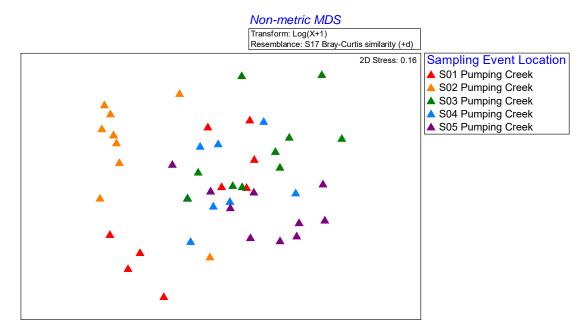


Figure A1. 3 nMDS plot of the benthic macroinvertebrate assemblage from XB8 Pumping Creek.

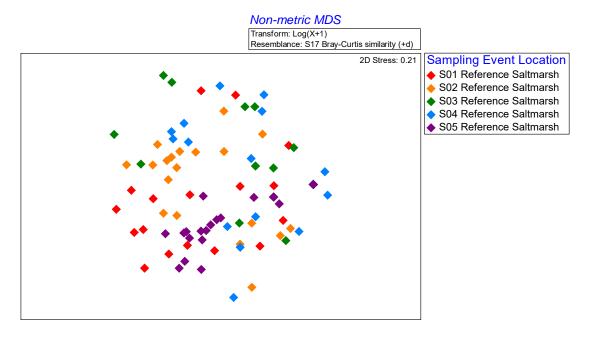


Figure A1. 4 nMDS plot of the benthic macroinvertebrate assemblage from XB8 Reference Saltmarsh.

### Benthic macroinvertebrate community structure, analysed by sampling event

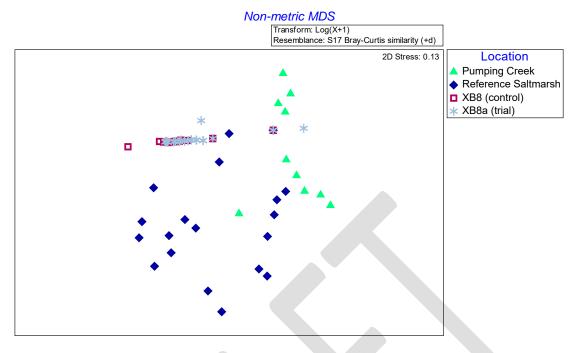


Figure A1. 5 nMDS plot of the benthic macroinvertebrate assemblage from Sampling Event 01, January 2017, pre tidal-restoration.

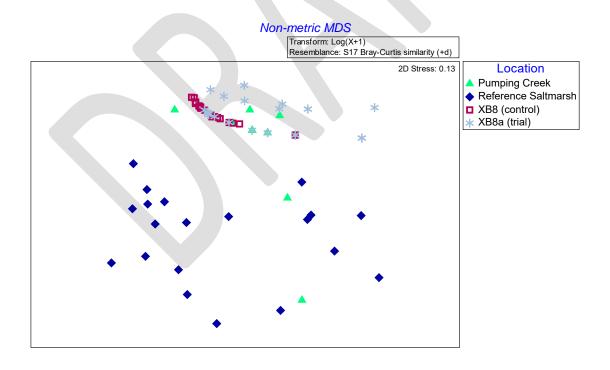


Figure A1. 6 nMDS plot of the benthic macroinvertebrate assemblage from Sampling Event 02, August 2017, one month post tidal-restoration.

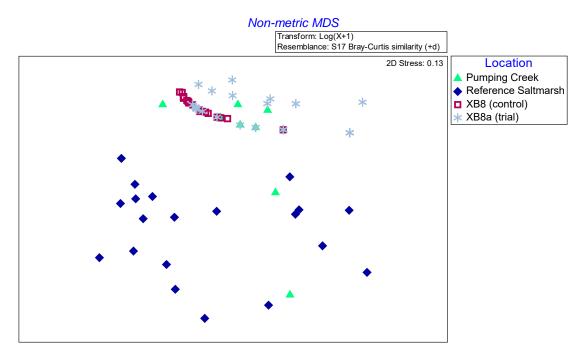


Figure A1. 7 nMDS plot of the benthic macroinvertebrate assemblage from Sampling Event 03, November 2017, four months post tidal-restoration.

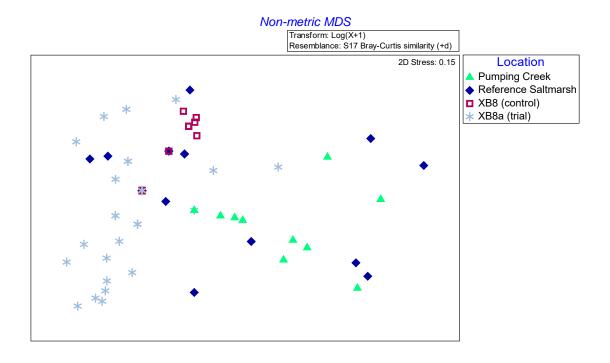


Figure A1. 8 nMDS plot of the benthic macroinvertebrate assemblage from Sampling Event 04, January 2018, six months post tidal-restoration.

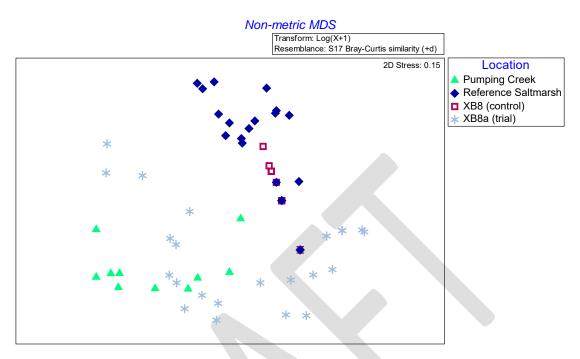


Figure A1. 9 nMDS plot of the benthic macroinvertebrate assemblage from Sampling Event 05, April 2018, nine months post tidal-restoration.

# Waterbird surveys at St Kilda saltfields, XB8A and adjacent ponds – summer 2017-18

A report prepared by G. Carpenter, June 2018, for Jason Quinn, DEW Coast Management.

### Introduction

With the closure of the St Kilda saltfields, former salt evaporation ponds have become available for other uses. A trial breach of pond XB8A occurred in mid 2017 to re-instate tidal flows and associated intertidal habitat. If successful, this trial may be expanded to include other ponds within the saltfields.

The current survey provides information on waterbirds using pond 'XB8A' and adjacent ponds during summer 2017-18. The survey compares birds using XB8A prior to and after its breach in mid 2017.

### Methods

Ponds surveyed were the breach pond XB8A plus adjacent ponds XB8, XA1, XA7 and PA3. XB8A was directly linked to XB8 prior to the breach. The area of XB8A is 29 ha compared to a combined total of 463 ha for the other four ponds. Ponds were surveyed during high tides on dates of >2.3m tides if possible as predicted from tide charts, plus during low tide on the same day. The aim was to determine the importance of the ponds as high tide roosts and as feeding habitat in their own right. In addition, intertidal areas between the ponds and mangroves were counted at high tide.

In 2017-8 waterbird surveys were conducted six times at monthly intervals from 23 November 2017 to 19 April 2018. The ponds were circumnavigated as far as possible by vehicle with regular stops to identify and count waterbirds, using 10x50 binoculars and a 30x tripod-mounted spotting scope. Much of the western embankment of XB8A was accessed on foot. Waterbirds were included within a pond if they were within the pond or on the embankment adjacent the pond. Where an embankment ran between ponds, the count was divided down the middle of the embankment.

Waterbird activities (feeding, roosting) and an estimate of water levels in the ponds were also noted.

Count dates were timed to coincide with high tide counts of the entire saltfield conducted by EBS Ecology (for the salt field owners), to avoid duplication of survey effort. High tide counts also included all ponds south of XB8A for this purpose, with the data being provided to EBS Ecology.

#### Results

A total of 33 waterbird species were recorded over the six surveys in 2017-18 (Table 1). Included were six northern-hemisphere migrants. The most abundant species were Banded Stilt, Silver Gull and Red-necked Stint. The most abundant northern-hemisphere migrant was the Red-necked Stint.

In 2017-18 pond XB8A supported a total of 22 waterbird species including 3 northern hemisphere migrants, and a maximum of 1895 individuals. This was less than in 2016-17 although monthly counts had a similar number of species and individuals (Figures 1 & 2). The most abundant species in 2017-8 were Red-capped Plovers and Red-necked Stints, compared with Pied Cormorant and Little Black Cormorant in 2016-17. Pond XB8A supported a lower diversity of species than adjacent ponds, but had a relatively large number of Red-capped Plovers and Red-necked Stints given its small size.

Ponds adjacent XB8A supported more birds in 2016-17, particularly ducks, grebes and Banded Stilts.

Table 1. Waterbirds recorded during surveys with maximum count on any one survey.

Adj sum = sum ponds XB8, XA1, XA7, PA3 and tidal areas between these ponds and the mangroves

	2016-17	2017-18	2016-17	2017-18
SPECIES	XB8A	XB8A	Adj sum	Adj sum
Chestnut Teal	2		2	
Grey Teal	400	30	587	410
Pacific Black Duck	0		2	
Musk Duck	25		10	28
Blue-billed Duck			50	10
Cape Barren Goose	0		9	
Black Swan	0		12	
Pink-eared Duck	0		100	
Australian Shelduck	55		131	72
Hoary-headed Grebe	0	1	420	113
Little Pied Cormorant	15	2	2	53
Little Black Cormorant	500	1	1	126
Pied Cormorant	1600	1	0	30
Great Cormorant				25
Australian Pelican	9	1	4	3
Eurasian Coot				1
Great Egret	1	3	4	16
Little Egret	0	1	5	10
White-faced Heron	0	8	16	32
Royal Spoonbill	1		0	
Australian White Ibis	20	20	101	15
Pied Oystercatcher	2		0	
Banded Stilt	1	2	10312	1085
Black-winged Stilt	0	10	195	92
Red-necked Avocet	0		15	66
Double-banded Plover	0	1	1	
Red-capped Plover	3	750	148	970

		_		
Red-kneed Dotterel	0	9	5	37
Grey Plover	0		1	
Masked Lapwing	2	3	35	16
Common Sandpiper	1		0	
Ruddy Turnstone	4		15	1
Sharp-tailed Sandpiper	3	40	120	104
Curlew Sandpiper	0		7	8
Red-necked Stint	155	810	906	1515
Eastern Curlew	0		19	10
Common Greenshank	1		60	24
Whiskered Tern	3	150	50	1025
Silver Gull	90	50	3202	1580
Gull-billed Tern	0		1	
Caspian Tern	1	1	2	8
Fairy Tern	0	1	4	4
Crested Tern	6		400	1000
TOTAL indiv	2900	1895	16954	8489
Total species	24	22	37	32

Tide had a major influence on about half the species (Table 2), although tidal influence was not as pronounced at XB8A as it was in 2016-7 (Figure 2). At high tide there were overall many more Grey Teal, White-faced Heron, Australian White Ibis, Red-capped Plover, Sharptailed Sandpiper, Red-necked Stint, Common Greenshank, Silver Gull and Crested Tern than at low tide. At XB8A there were similar numbers of Red-necked Stint at high and low tides. XB8A also had more Whiskered Tern at high tide than low tide.

Table 2. Influence of high vs low tide on mean maximum count in 2016-7 and 2017-8.

	2016-7		2017-8		2016-7		2017-8	
	XB8A	XB8A	XB8A	XB8A	Adj	Adj	Adj	Adj
Species	AvHigh	AvLow	Avhigh	Avlow	AvHigh	AvLow	AvHigh	AvLow
Chestnut Teal	0.3	0.0			0.0	0.3		
Grey Teal	50.0	7.5	6.5	8.8	143.0	117.4	210	129
Pacific Black Duck	0.0	0.0			0.3	0.0		
Musk Duck	3.8	0.1			4.5	1.6	7.2	7.5
Blue-billed Duck							1.7	0
Cape Barren Goose	0.0	0.0			0.1	1.1		
Black Swan	0.0	0.0			1.5	0.3		
Pink-eared Duck	0.0	0.0			12.5	12.5		
Blue-billed Duck	0.0	0.0			11.8	3.8		
Australian Shelduck	7.4	3.5			70.0	37.8	44.8	26.8
Hoary-headed Grebe	0.0	0.0	0.2	0	116.9	75.3	24	24
Little Pied Cormorant	3.8	0.1	0.3	0	0.1	0.3	2.5	11.8
Little Black Cormorant	173.1	89.3	0.2	0	0.0	0.1	22	12
Pied Cormorant	676.3	32.6	0.2	0	0.0	0.0	1.5	5.5
Australian Pelican	3.5	0.5	0.2	0	0.6	1.0	0.8	0.3
Great Egret	0.1	0.0	0.5	0	1.3	0.0	2.8	0
Little Egret	0.0	0.0	0.3	0	1.5	0.9	3.5	2.5
White-faced Heron	0.3	0.0	2.5	0.8	3.3	0.3	8.8	0
Royal Spoonbill	0.1	0.0			0.0	0.0		
Australian White Ibis	4.1	0.1	3.3	0	15.3	7.3	4.2	0
Pied Oystercatcher	0.0	0.3			0.0	0.0		
Banded Stilt	0.1	0.0	0.3	0.3	2623.6	2524.5	375.5	227
Black-winged Stilt	0.0	0.0	1.7	1.7	29.4	26.0	37.3	16.8
Red-necked Avocet	0.0	0.0			1.9	1.9	11.8	12.2
Double-banded				0.2				
Plover	0.0	0.0			0.0	0.1		
Red-capped Plover	1.0	0.3	240	140.5	55.8	37.5	362	111
Red-kneed Dotterel	0.0	0.0	1.5	0	0.1	0.6	11.7	0.3
Grey Plover	0.0	0.0			0.1	0.0		

Masked Lapwing	0.3	0.3	0.7	0	19.0	7.3	8.7	2.5
Common Sandpiper	0.1	0.0			0.0	0.0		
Ruddy Turnstone	1.5	0.5			1.9	1.9	0.2	0
Sharp-tailed			9.8	3.3			41	9
Sandpiper	0.4	0.0			21.9	5.6		
Curlew Sandpiper	0.0	0.0			1.9	0.1	1.5	0
Red-necked Stint	40.0	4.4	268	238	441.3	149.8	580	162.5
Eastern Curlew	0.0	0.0			8.3	0.0	2.3	0
Common Greenshank	0.4	0.1			14.3	6.4	9.3	1.2
Whiskered Tern	0.1	0.4	35	0.2	13.5	5.1	125	190
Silver Gull	38.8	13.5	20.2	2.7	1222.3	507.0	576	197
Gull-billed Tern	0.0	0.0			0.0	0.1		
Caspian Tern	0.1	0.1	0.3	0.2	0.9	0.6	2.2	0.3
Fairy Tern	0.0	0.0	0.2	0	1.0	0.0	1.2	0
Crested Tern	0.8	0.0			50.1	0.3	170	13

At XB8A, 12 of 22 species recorded were observed feeding. Birds fed at both high and low tides with a higher proportion feeding at low tide. Large differences occurred between the annual surveys, with a much higher proportion of Grey Teal, Red-necked Stint and Silver Gull feeding in 2017-8 compared with 2016-7.

Table 3. Proportion (%) of feeding birds at XB8A at high and low tides.

	2016-7		2017-8	
Species	high	low	high	low
Chestnut Teal				
Grey Teal	0	0	62	4
Pacific Black Duck				
Musk Duck	89			
Cape Barren Goose				
Black Swan				
Pink-eared Duck				
Blue-billed Duck				
Australian Shelduck	0	0		
Hoary-headed Grebe			100	
Little Pied Cormorant	0	0	0	
Little Black Cormorant	0	0	0	
Pied Cormorant	0	0		
Australian Pelican	0	0	0	
Great Egret			30	
Little Egret				
White-faced Heron				
Royal Spoonbill				
Australian White Ibis	0	0	0	

Pied Oystercatcher				
Banded Stilt			0	0
Black-winged Stilt			50	80
Red-necked Avocet				
Double-banded Plover			100	
Red-capped Plover	25		48	76
Red-kneed Dotterel			100	
Grey Plover				
Masked Lapwing			0	
Common Sandpiper				
Ruddy Turnstone	0			
Sharp-tailed Sandpiper			78	100
Curlew Sandpiper				
Red-necked Stint	4	0	55	89
Eastern Curlew				
Common Greenshank				
Whiskered Tern			100	100
Silver Gull	10	12	58	100
Gull-billed Tern				
Caspian Tern			0	0
Fairy Tern			100	
Crested Tern				

Table 3. Proportion (%) of feeding birds at adjacent ponds at high and low tides.

	2016-7		2017-8	
Species	High	low	high	low
Chestnut Teal	-			
Grey Teal	0	1	0	4
Pacific Black Duck				
Musk Duck	62	31	53	0
Cape Barren Goose				
Black Swan				
Pink-eared Duck	0	0		
Blue-billed Duck	53	0	0	
Australian Shelduck	20	18	8	0
Hoary-headed Grebe	52	13	2	15
Little Pied Cormorant			0	2
Little Black Cormorant			0	0
Pied Cormorant			0	0
Australian Pelican	0	0		
Great Egret				
Little Egret	77	100	50	87
White-faced Heron	0		0	
Royal Spoonbill				
Australian White Ibis	2	26		
Pied Oystercatcher				
Banded Stilt	72	53	92	90
Black-winged Stilt	18	70	40	26
Red-necked Avocet	12	73	88	7
Double-banded Plover				
Red-capped Plover	36	25	32	65
Red-kneed Dotterel			0	0
Grey Plover				
Masked Lapwing	1	6	0	0
Common Sandpiper				
Ruddy Turnstone	0	0	0	
Sharp-tailed Sandpiper	18	0	4	35
Curlew Sandpiper	91		100	
Red-necked Stint	44	39	23	48
Eastern Curlew	0			
Common Greenshank	38	34	11	40
Whiskered Tern	43	73	44	45
Silver Gull	68	52	51	88
Gull-billed Tern				

Caspian Tern		0	0
Fairy Tern		0	
Crested Tern	0	0	0

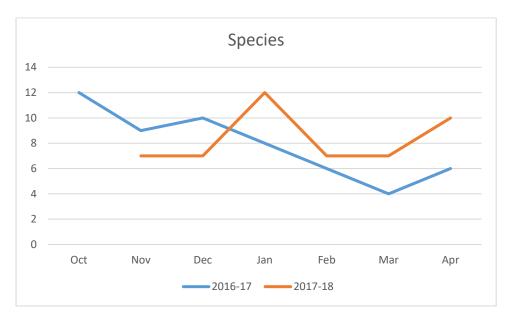


Figure 1. Comparison of the number of species on monthly counts at XB8A.

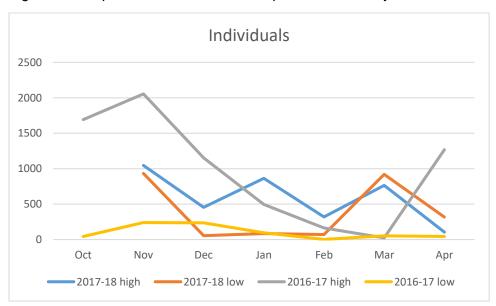


Figure 2. Comparison of the number of individuals on monthly counts at XB8A, showing differences in high and low tide counts.

#### Discussion

The hydrological change to pond XB8A has caused an obvious change in birdlife between 2016-7 and 2017-8. It has changed from a deep stable-level pond to an intertidal pond that fills only on larger tides. Rather than just open water, there is now shallow muddy areas and open mud. This has meant that most of the roosting ducks and cormorants have gone, but have been replaced by feeding waders, especially Red-capped Plovers and Red-necked Stints.

Significant numbers of Red-capped Plovers (750 birds) fed and roosted in XB8A in 2017-18, plus at least one pair bred. Also significant numbers of Red-necked Stints (almost 1000 birds) fed and roosted in the area.

Observations made during the surveys suggest that XB8A partly fills on larger tides, then mostly empties between tides leaving only limited areas of shallow water and mud. Thus it was not possible to determine the total period that suitable shallow water and mud for feeding exists, thus the overall value of the area for waterbirds. It was also noted that some water seeped into XB8A from adjacent filled ponds, which also provided a suitable feeding habitat for waders.

XB8A would likely provide a better habitat for waders if some water was retained after a high tide and allowed to dry out slowly, rather than being wholly released. However, it is understood that the intent of management is to replicate natural tidal flows.

It is likely that more waterbirds will use XB8A in future years, although it is likely that overall numbers could decline as open muddy areas are colonised and covered by samphires.

### Reference

Carpenter, G. (2017) Waterbird surveys at St Kilda saltfields, XB8A and adjacent ponds – summer 2016-17. Unpub report to Adelaide Mt Lofty Ranges NRM Board.

### **Acknowledgements**

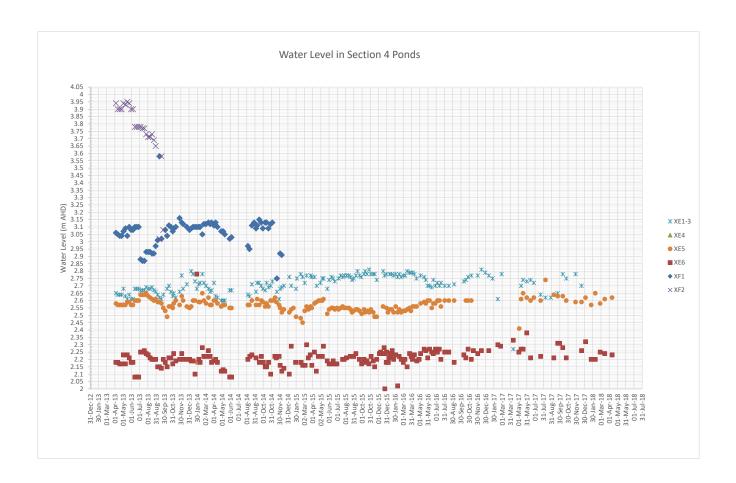
Jason Quinn, DEW Coast Management, and Tony Flaherty, Adelaide & Mount Lofty Ranges NRM organised the surveys. Ridley Corp (Alan Mathieson) kindly provided access to the saltfields.

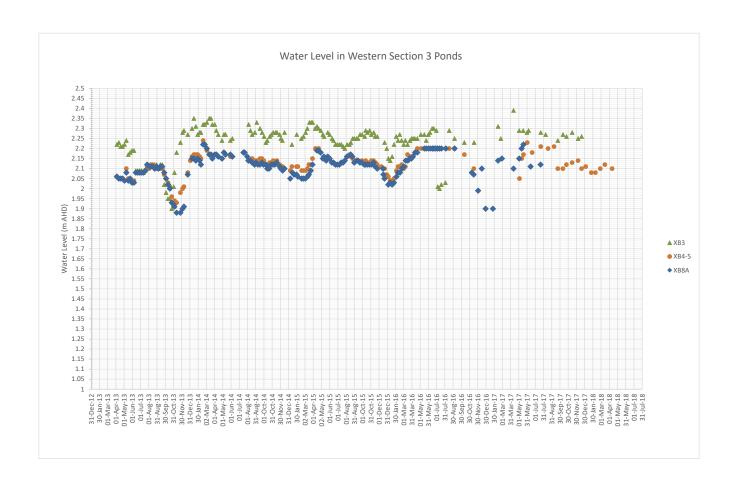


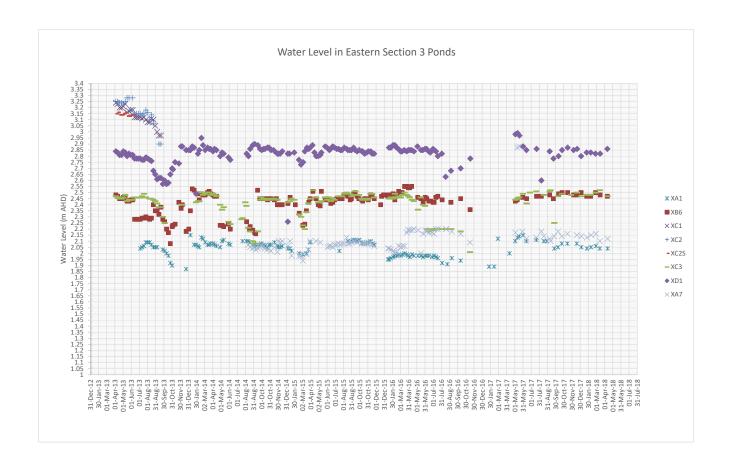
New conditions in XB8A showing main channel and extensive muddy flats flooded on high tides.

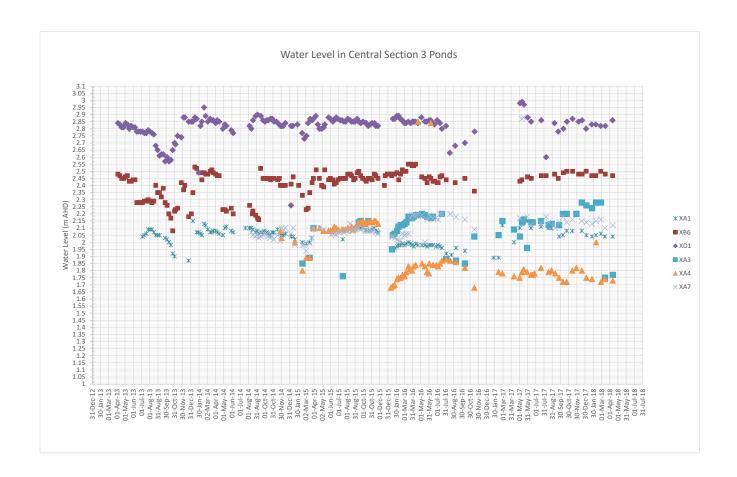
# **Buckland Dry Creek Pty Ltd** (ACN 114 007 153; ABN 82 114 007 153)

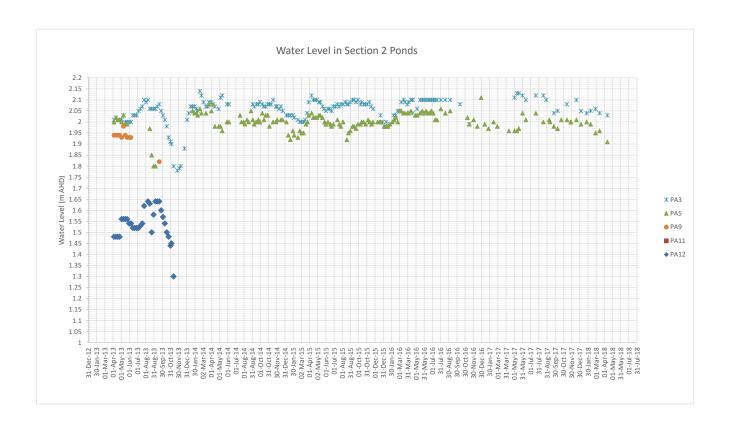
## **Appendix D - Water Level Monitoring**











			Enviror	ed from Table of nmental Outcomes asurement Criteria in PEPR			Statistics of M	easured Levels (Se 2018)	pt 2017 to March
Section	Pond	Maximum Water Level (m AHD) 2003 - 2013	Average water level (m AHD) 2003 - 2013	Minimum Water Level (m AHD) 2003 - 2013	Fluctuation in Water Level (Maximum – Minimum) (m)	Min to Max Levels = Compliance Range for Purposes of Table 30	Minimum	Median	Maximum
Section 4	XE1-3	3.10	2.65	2.52	0.58	Yes	2.65	2.75	2.78
	XF1	3.24	3.11	2.87	0.37	No – This is a drained / dry pond			
	XF2	4.08	3.96	3.77	0.31	No – This is a drained / dry pond			
	XE4	3.07	2.97	2.41	0.66	No – This is a drained / dry pond			
	XE5	2.68	2.59	2.06	0.62	Yes	2.60	2.60	2.60
	XE6	2.34	2.18	2.00	0.34	Yes. Minimum level of 1.99	1.99	2.25	2.30
Section 3	XE7	Water level o	ontrolled by XD1			No			
Section 5	XD1	2.90	2.82	2.59	0.31		2.78	2.83	2.87
	XB6	2.78	2.48	2.28	0.50	Yes.	2.45	2.48	2.50
	XC1	3.35	3.23	3.10	0.25	No – This is a drained / dry pond			
	XC2	3.34	3.24	3.14	0.20	No – This is a drained / dry pond			
	XC2S	3.30	3.16	3.06	0.24	No – This is a drained / dry pond			
	XC3	2.56	2.49	2.05	0.51	Yes.	2.25	2.43	2.52
	XB3	2.38	2.26	2.03	0.35	Yes	2.24	2.27	2.31
	XB4-5	2.21	2.10	1.97	0.24		2.08	2.11	2.21
	XA3	2.14	2.08	1.98	0.16	Yes. Minimum level of	1.75	2.22	2.28
	XA4	Water level of	ontrolled by XA2 or	VA1		1.75 m No	1.72	1.75	2.00
					0.46		Water level cont	rolled by XB4-5 a	nd XB8
	XA2	2.16	2.09	2.00	0.16	Yes			
	XB8 XB8A	2.16	2.07	1.97	0.19	No. This Pond taken over by DEWNR for Tidal flushing trial			
	XA7	Water level of	ontrolled by XA1 or	DVS			2.10	2.14	2.18
					0.47		2.04	2.05	2.08
	XA1	2.12	2.04	1.95	0.17		2.04	2.05	2.10
Section 2	PA3	2.11	2.03	1.90	0.21	Yes			
	PA4	Water level co	ontrolled by PA5			No	1.95	2.00	2.01
	PA5	Water level co	2.01 ontrolled by PA9	1.65	0.47	Yes  No – This is a drained / dry pond that may be used for contingency brine containment and evaporation			
	PA7	Water level co	ontrolled by PA9			No – This is a drained / dry pond that may be used for contingency brine containment and Evaporation. In 2016-2017 this pond used by SA Water for its trial of denitrification			
	РА7А	2.45	2.37	2.00	0.45	No – This is a drained / dry pond. In 2016-2017 this pond used by SA Water for its trial of denitrification			

PA8	Water level controlled by PA9	No – This is a drained / dry pond that may be		
		used for contingency		
		brine containment and		
		evaporation In 2016-2017		
		this pond used by SA		
		Water for its trial of		
		denitrification		

	Copy from Table 31 In PEPR							esured Levels (July 2016)	2014 to February
Section	Pond	Maximum Water Level (m AHD) 2003 - 2013	Average water level (m AHD) 2003 - 2013	Minimum Water Level (m AHD) 2003 - 2013	Fluctuation in Water Level (Maximum – Minimum) (m)	Min to Max Levels = Compliance Range for Purposes of Table 30	Minimum	Median	Maximum
	PA9	2.20	1.98	1.86	0.34	No – This is a drained / dry pond that may be used for contingency brine containment and evaporation			
	PA10	Water level co	ontrolled by PA12			No – This is a drained / dry pond			
	PA11 Water level controlled by PA12		No – This is a drained / dry pond						
	PA12	1.99	1.57	1.30	0.69	No – This is a drained / dry pond			

# **Buckland Dry Creek Pty Ltd** (ACN 114 007 153; ABN 82 114 007 153)

### **Appendix E - Bunds and Seepage Drains**

### **Bunds and Drains**

All Bunds and drains are inspected on a daily basis by the brine operators

#### St Kilda XB8A and XB8 Grade road way into the XB8A and XB8 from the road way until the intersection of XB8A and XB8 1 **XB8 XA1** 2 Increase flow through pipe work XB8 to XA1 Middle beach Grade and build up camber on the sea wall road to the middle beach pumps for a distance of 1.5 kilometres 3 **Gawler river** The cause way over Buckland lake repaired and remade to allow heavy vehicle access repaired the road remade to allow heavy vehic 4 **Chapmans Creek** Grade road to Chapmans Creek from the cause way over Buckland park lake to the pump set at Chapmans Creek 5 XB3 Sea wall to the Sewer bridge 6 Grade road way from Chapmans Creek to the intersection of XB3 and the sewer bridge 2.5 kilometres



Buckland Dry Creek Holding Pattern and Residual Operations Compliance Report to 30 June 2017 Buckland Dry Creek PEPR Compliance Report181101

**Buckland Dry Creek Pty Ltd** (ACN 114 007 153; ABN 82 114 007 153)

### **Appendix F - Vegetation**

# Buckland Dry Creek Pty Ltd

Dry Creek Aerial Vegetation Mapping Final Report





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### **Executive Summary**

EcoAerial was engaged by Buckland Dry Creek Pty Ltd to undertake aerial mapping of vegetation within a number of ponds in Section 2, 3 and 4 of the coastal lease boundaries of the Dry Creek Salt Fields in South Australia. The objective was to obtain a baseline measure of the existing vegetation to monitor the rate and extent of regeneration over time.

The Dry Creek Salt Field comprises a series of artificially constructed ponds formerly used for evaporating pumped sea-water to produce salt. They extend for approximately 25 km's along the east coast of the Gulf St Vincent, north from St Kilda on the northern outskirts of Adelaide. Extensive areas of tidal mudflats, saltmarsh and mangrove exist to the west of the site.

The sole customer for salt from the Dry Creek Salt Fields was the Penrice's factory at Osborne. When in operation, the salt field produced 500,000 to 700,000 tonnes of salt per annum. In 2013, Penrice announced the cessation of the manufacture of soda ash effective from 1st July 2013. The lack of demand by Penrice for purified salt brine from Ridley's Dry Creek Salt facility rendered the dry creek salt fields financially unviable and the site is now in a Holding Pattern, while future land uses and rehabilitation requirements are investigated.

The site and the operations on it are presently regulated under the *South Australian Mining Act* 1971. As such the *'Holding Pattern'*, and the investigations are conducted under the Programme for Environmental Protection and Rehabilitation (PEPR), approved by the Department of State Development.

In respect of vegetation, the PEPR requires:

- No loss of abundance or diversity of native vegetation on or off Sections 2 to 4 through clearance arising from *Holding Pattern* unless prior approval under relevant legislation is obtained. In this context clearance includes physical loss from physical works, dust / contaminant deposition, fire, or other damage
- A register of approvals sought and granted.
- Measures of loss of abundance or diversity of native vegetation due to clearance arising from the *Holding Pattern*
- Incident reporting for any unauthorised clearance
- 6 monthly reporting of approvals sought and granted; with a map showing any areas cleared.

The purposes of the work described in this report were to:

- Interpret the extent of vegetation within the drained / dry ponds and coastal lease boundary.
- Map the extent of vegetation as part of annual aerial mapping (using the same methods used in 2015) to:
  - o measure the progress of revegetation
  - o track and assess the impacts of dust deposition on existing vegetation.
- Provide maps of assessed areas of vegetation in the ponds that would form part of the compliance reports on impacts on native vegetation from the Holding Pattern.

 Assess if there have been any impact or reduction in abundance of the Environment Protection and Biodiversity Conservation Act 1999 listed; Bead Samphire Tecticornia flabelliformis.

The work undertaken involved aerial photography (in October 2016) from a manned fixed wing aircraft to record regeneration of saltmarsh vegetation communities in 14 ponds; PA6, PA7, PA8, PA9, PA10, PA11, PA12 (Section 2), XC1, XC2, XC2E XC2S (Section 3), XE4, XF1, XF2 (Section 4) and, adjacent to the Bolivar Channel in Section 3. The estimated area of vegetation on the bunds and within the ponds in 2016 compared to 2015 is as follows.

Pond	Total Ha 2015	Total Ha 2016	Variance Ha
XE 4	25.21	29.84	4.63
XF 1	6.88	7.97	1.10
XF 2	24.67	27.16	2.48
XC 1	2.66	4.08	1.42
XC 2E	17.46	20.84	3.38
XC2	3.66	6.21	2.54
XC 2S	10.12	14.67	4.54
PA 6	3.47	4.79	1.32
PA 7	1.25	2.08	0.83
PA 8	2.98	4.31	1.32
PA 9	1.38	0.94	-0.44
PA 10	0.63	0.08	-0.55
PA 11	1.23	1.39	0.16
PA 12	0.29	0.36	0.07
Adjacent to Bolivar Channel	24.69	24.84	0.15
	126.66Ha	149.65Ha	22.98

The 2016 aerial mapping indicates an increase in the area occupied by vegetation of approximately 23Ha. Ponds PA 9 and PA 10 were the only ponds to record a decrease. This was due to the ponds being used by SA water as part of denitrification trials of waste water.

An on-ground assessment was undertaken of the *Environment Protection and Biodiversity Conservation Act 1999* listed Bead Samphire. The assessment revealed that there has been no contraction of its distribution and there is recruitment occurring increasing its abundance with each patch.

In summarising, the *holding pattern* has **not** had any negative impact on the saltmarsh vegetation. The extent of the salt marsh continues to increase and, the Bead Samphire is increasing in abundance within the patches previously mapped.

### 1 Introduction

EcoAerial was engaged by WithERS Environmental Risk Strategies Pty Ltd on behalf of Buckland Dry Creek Pty Ltd to undertake mapping of vegetation communities within designated areas within the lease boundaries of the Dry Creek Salt Fields located in the north of Adelaide. This report is the 5<sup>th</sup> vegetation related report undertaken by EcoAerial.

### 1.1 Project Background

The salt fields comprise both Crown land and freehold land (Buckland Dry Creek Pty Ltd) is owned by ARR. The study site was previously owned by Ridley Corporation and was purchased by ARR in 2015 and took possession of the site in March 2016.

The salt fields are classified as a mine and regulated under the South Australian (SA) Mining Act by Department of State Development (DSD). Site operations occur under an Environment Protection Authority (EPA) license.

The southernmost portion of the field is located at Dry Creek about 14 km north of Adelaide on the Port Wakefield Road. Seventy five (75) Mineral Leases and three private mines provide the mining tenure for the existing operations and for an undeveloped area (the Northern Leases). The northern leases were never developed and were handed back to the South Australian Government in 2014. The surrendered northern leases are not part of this project.

The aerial vegetation mapping covered 14 drained or dry ponds, PA6, PA7, PA8, PA9\*, PA10\*, PA11, PA12, XC1, XC2, XC2E, XC2S, XE4, XF1 and XF2 in the southern leases. These ponds are located in sections 2 (St Kilda), 3 (Port Gawler) and 4 (Middle Beach) which extend approximately 25 km on the eastern boundary of the salt fields (refer to Figure 1). The term Dry Creek Salt Field refers to the southern leases only.

**Note:** PA9 & 10 were inundated with water in 2016 by SA Water to conduct trials of processes to denitrify treated effluent from Port Adelaide.

The salt field operations fall within the cadastral land tenure of the; Hundreds of Port Adelaide, Port Gawler, and Dublin. This area also encompasses several local government areas; City of Salisbury, City of Port Adelaide Enfield, City of Playford and the District Council of Mallala. The entire site occurs within the 2008 gazetted boundaries of the Adelaide and Mt Lofty Ranges Natural Resource Management Board. The majority of the Mining Leases are current until 2019 when they are then eligible to be renewed for a further period of 21 years.

During operation, the salt field produced 500,000 to 700,000 tonnes of salt per annum. The production involved:

- Pumping sea water into the salt field at Middle Beach. Pumping occurred
  predominantly in the warmer months of October to March to replenish the water lost
  from the salt field by evaporation and seepage, and pumped as concentrated brine into
  the crystalliser beds.
- Evaporation to concentrate the salinity of the water as it travelled through the condenser ponds in the salt field from Middle Beach to Dry Creek.

- The crystallisation of salt in crystallizer beds at Dry Creek this mostly occurred in the warmer months of October to March
- The harvesting and stockpiling of salt from the crystallisers.

The sole customer for salt from the Dry Creek Salt Fields was the Penrice's factory at Osborne. In 2013, Penrice announced the cessation of the manufacture of soda ash effective from 1st July 2013. The lack of demand by Penrice for purified salt brine from Ridley's Dry Creek Salt facility rendered the salt fields financially unviable and the site is now in a *Holding Pattern*, while future land uses and rehabilitation requirements are investigated.

The site and operations on it are presently regulated under the *South Australian Mining Act* 1971. As such the *Holding Pattern*, and the investigations are conducted under the Programme for Environmental Protection and Rehabilitation (PEPR), approved by the Department of State Development.

In respect of vegetation, this PEPR requires:

- No loss of abundance or diversity of native vegetation on or off Sections 2 to 4 through clearance arising from *Holding Pattern* unless prior approval under relevant legislation is obtained. In this context clearance includes physical loss from physical works, dust / contaminant deposition, fire, or other damage
- A register of approvals sought and granted.
- Measures of loss of abundance or diversity of native vegetation due to clearance arising from the *Holding Pattern*
- Incident reporting for any unauthorised clearance
- 6 monthly reporting of approvals sought and granted; with a map showing any areas cleared.

#### It is noted that:

- The Holding Pattern entails no work in, or change of use of, land outside the ponds and their external seepage drains. Therefore there is no reason for there to be any significant change in abundance or diversity of native vegetation - that is no reason for any change that would constitute clearance as described in the PEPR
- The areas and types of vegetation outside the ponds have been investigated (reference previous reports)
- There is native vegetation along and within the bunds of the ponds. The Holding Pattern entails changes in the conditions of some of the ponds, so that the only water they receive is from rainfall or from seepage from adjacent ponds that are still inundated:
  - o XC1, XC2, XC2S, PA6 to PA12 from spring 2013;
  - o XE4, XF2 from summer 2013/2014;
  - o XF1 from summer 2014/2015;

- SA Water's use of the southern part of PA9 from summer 2014, and also more of PA9 and all of PA10 from spring 2015 for a trial of processes to denitrify treated effluent from Port Adelaide. This involves pumping the treated effluent into these ponds at such a rate as to balance evaporative losses and maintain salinity in the pond similar to that of sea water. The effect is that these ponds have a lower water level than when the ponds were in use for salt production.
- As a result of an increase in water levels in Ponds PA 9 & 10 in 2016, there was less land available within these ponds for regeneration to occur.

The purposes of the work described in this report were to:

- Provide a measure of areas of vegetation within the ponds, using annual aerial repeats of this work, using the same methods as per 2015:
- The significance of impacts from dust deposition on existing vegetation could be tracked and assessed.
- Provide the maps of vegetation and assessed areas of vegetation in the ponds that would form part of the compliance reports on impacts on native vegetation from the Holding

For the purposes of the PEPR, the site has been divided into 4 sections – named Sections 1 to 4. Section 1, at the southern end of the salt field, comprises the crystallisers and salt production facilities. Sections 2 to 4 include both inundated and drained / dry condenser ponds and, coastal lease boundaries. The latter are the subject of this report.



Figure 1: Dry Creek Salt Fields – Southern Leases

# 1.2 Objectives

To date there has been a wide ranging number of environmental studies undertaken at the site, some of which have specifically assessed the ecological values (Appendix A). EcoAerial has been responsible for conducting a number of vegetation assessments including, trialling the use of Remotely Piloted Aircraft (RPA) to monitor changes in vegetation cover.

As a consequence of the staged closure, the key objective of the aerial vegetation assessments was to provide up to date distribution and cover abundance of vegetation within the following ponds that have recently been dried; PA6, PA7, PA8, PA9, PA10, PA11, PA12 (Section 2 – St Kilda), XC1, XC2, XC2E, XC2S (Section 3c- Port Gawler), XE4, XF1 and XF2 (Section 4 – Middle Beach) and, adjacent to the Bolivar Channel.

# 1.3 Study Site

The Dry Creek Salt Field comprises a series of artificially constructed ponds used for evaporating pumped sea-water to produce salt. They extend for approximately 25 km's along the east coast of the Gulf St Vincent, north from Dry Creek on the northern outskirts of Adelaide. Extensive areas of tidal mudflats, saltmarsh and mangrove exist to the west of the site (BL&A 2013 & EcoAerial 2014).

EcoAerial was previously engaged in 2014 by Ridley Corporation (Ridley) to undertake mapping of all vegetation communities within and immediately adjacent to the mine tenement (a mixture of mining leases and private mines) boundaries of Sections 1 to 4 of the Dry Creek Salt Fields. The scope of work also involved undertaking a targeted survey for Bead Samphire, *Tecticornia flabelliformis* within the mine tenement boundaries.

The land within the mine tenement boundaries includes:

- Land encompassing the bunded final areas, and crystallisers of Section 1
- Land encompassing the bunded condenser ponds and their seepage drains in Sections 2 to 4
- Land outside the above. This land has not been used actively for the salt production activities.

The focus of the 2014 mapping exercise was to: a) determine if the saltmarsh community meet the thresholds of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) listed Subtropical and Temperate Coastal Saltmarsh; b) determine the likelihood of whether the EPBC listed Bead Samphire occurs within the lease boundaries.

The total area of all vegetation communities combined within and adjacent to Sections 1~4 was approximately 3,100 ha. The vegetation communities were separated into 6 communities; Dryland Samphire, Intertidal Mangrove, Intertidal Samphire, Intertidal Samphire / Atriplex, Planted Sheoak, Samphire / Atriplex / Grassland.

The saltmarsh areas within the lease boundary consisted of approximately 558ha of saltmarsh (including Samphire/ Atriplex / Grassland) and 600ha of Intertidal Mangrove. The breakdown for each vegetation community within the leasehold is as follows:

- 1. Dryland Samphire 39ha
- 2. Intertidal Mangrove 600ha
- 3. Intertidal Saltmarsh (Samphire) 356ha
- 4. Intertidal Samphire / Atriplex 98 ha
- 5. Planted Sheoak 3.4ha
- 6. Samphire Atriplex / Grassland 65ha.

The 2014 assessment also identified areas that met the threshold criteria for the EPBC Act listed Subtropical and Temperate Coastal Saltmarsh both within the lease boundary and, adjacent to the Ridley's Dry Creek Salt Fields.

Two of the 6 vegetation communities, Dryland Samphire and Samphire Atriplex / Grassland, are present within the ponds. The majority of Samphire Atriplex / Grassland, is present within the ponds (approx. 90%). Dryland Samphire is equally present both in the ponds and on the pond bunds (EcoAerial 2014).

The vegetation assessment for the current (2016) assessment was confined to ponds PA6, PA7, PA8, PA9, PA10, PA11, PA12 in Section 2, ponds, XC1, XC2, XC2E, XC2S and areas adjacent to Bolivar Channel in section 3 and, ponds XE4, XF1 and XF2 in Section 4. Figures 2-4 details each of the sections and the ponds mapped.

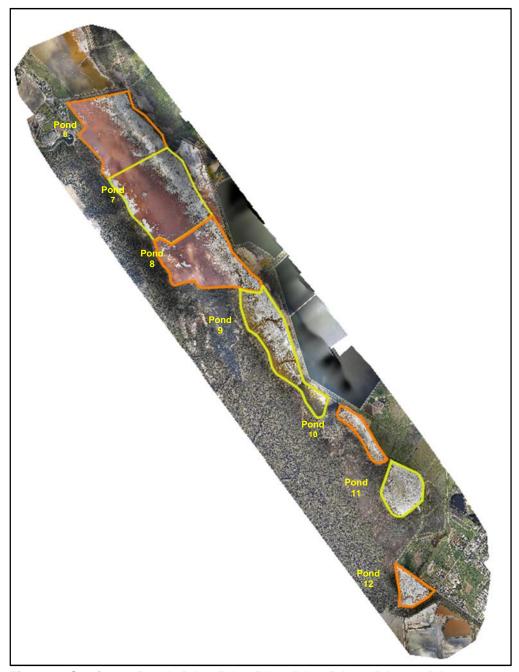


Figure 2: Section 2; Ponds PA 6, PA 7, PA 8, PA 9, PA 10, PA 11 & PA 12

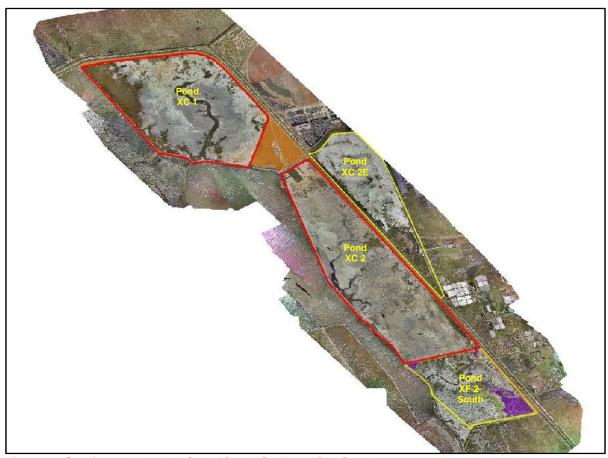


Figure 3: Section 3; Ponds XC 1, XC 2, XC 2E & XC 2-South

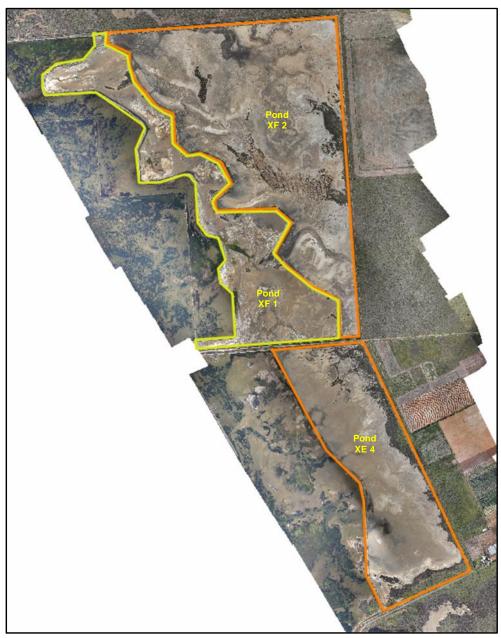


Figure 4: Section 4; Ponds XF 1, XF 2 & XE 4

## 2 Methods

The method deployed to map the regeneration of vegetation within ponds at Dry Creek is consistent with the methodology described in Coops and McVicar (2008); Horning et al (2010); Jones and Vaughan (2010) and Kelleway et al (2009).

#### Survey approach

#### Image capture

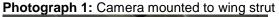
A Canon 5D MK3, 24MP SLR camera was mounted to the wing strut of a Cessna 172. The aircraft was piloted by Ross Anderson (Commercial Pilot) from AviAssist. The aircraft camera system and certification was undertaken by Richard Morrissey from Valley Panoramic. Richard was responsible for overseeing the technical function of the equipment and ensuring its correct operation.

## Flight system

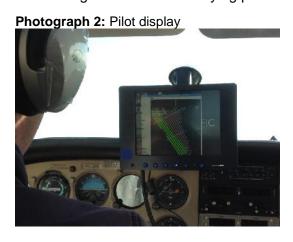
The flight paths were pre-programmed into the Aviatrix Aerial Mapping System. The flight paths and image trigger times were programed for an 80% / 60 % image overlap. This ensured that the mosaic of images (approx. 2,700 in total) could to be stitched together as a single image for each of the 3 sections.

The system consisted of a laptop computer with the flight planning software linked to the wing mounted camera (Photograph 1), GPS receiver and pilots display. The pilot display ensured the flight path was on the correct heading to trigger the camera at the correct location (Photograph 2).

The image capture of the 14 ponds was completed in 2 flights over a 6-hour flying period.







#### Image analysis

The flight plan coordinates and image capture points were linked to the relevant images to produce a series of georeferenced images. The images were then processed using Pix4D (Appendix B) mapping software. Pix4D automatically processed the georeferenced aerial imagery purely on image content and generated a tiff image file of the stitched images (Figures 2~4). The software generates highly precise, customizable images for GIS applications, including KML files for uploading into Google Earth. The ground sampling distance (GSD) was calculated at 7.5cm (average). A GSD of 7.5cm means that one pixel in the image represents 7.5cm on the ground.

### Aerial vegetation mapping

The georeferenced images produced by the Pix4D software were uploaded as raster files into QGIS open source GIS software. Analysing the vegetation was undertaken at a 1:500 scale (refer to figure 5). This scale was deemed the most suitable for mapping vegetation and, estimating cover abundance. Mapping of vegetation was separated into two parts; bund vegetation and patches within a pond. The basis of this approach was to simplify the mapping process.



Figure 5: Vegetation analysis at 1:500 scale

The method used to determine cover abundance was the modified Brauan-Blanquet classification system (Table 1) approach as described in; Guide to a Native Vegetation Survey, Using the Biological Survey of South Australia (DENR et al 1997), the GIS attribute table was assessed for each area of vegetation mapped and a cover abundance score assigned to each patch (refer to Table 3). Changes to the cover abundance scores were updated in the attribute tables where applicable.

Due to the scale of the areas assessed and the number of varying abundance scores for a given patch, only the totality of vegetation mapped for the bunds and within ponds is shown in the maps. There is a high degree of layer transparency with the mapped vegetation and areas of greater cover abundance are clearly discernible.

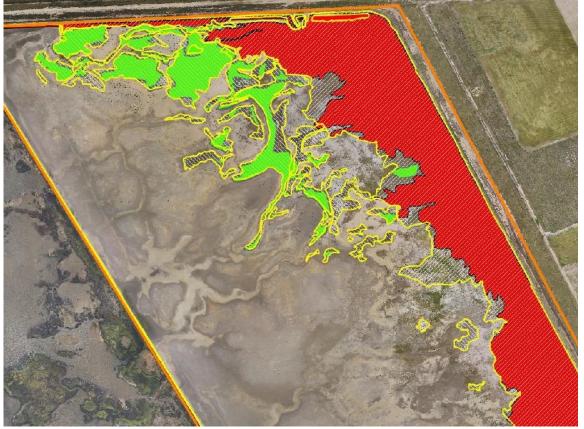
**Table 1:** Cover abundance ratings

Adapted from Bruan-Blanquet	(South Australian Department of Environment and Natural Resources 1997)
N	Not many, 1- 10 individuals
Т	sparsely or very sparsely present; cover very small (less than 5%)
1	plentiful, but of small cover (less than 5%)
2	any number of individuals covering 5-25% of patch
3	any number of individuals covering 25-50% of patch

4	any number of individuals covering 50-75% of patch
5	covering more than 75% of patch

#### Mapping was based on the following principles:

- Bund vegetation was analysed independently of isolated patches within a pond (refer to Figure 6).
- Where there was continuity of bund vegetation into the pond itself, this was deemed as bund vegetation
- Where there was no natural break in the vegetation occurring on a bund, a patch was based on a change in bund alignment
- A patch within the ponds was defined as where there was similar spatial continuity between plants (refer to Figure 6).
- Isolated plants were not recorded



**Figure 6:** *Bund vegetation:* 2015 Black outline with red in-fill; 2016 Yellow outline with top right to left diagonal lines. *In-pond patches:* 2015 Green in-fill; 2016 Yellow outline with top left to right lines.

#### Limitations

Identifying salt marsh communities from aerial images was not possible (e.g. Dryland Samphire & Samphire / Atriplex / Grassland). It must therefore be assumed that there is a likelihood that the vegetation is one of / or both of the two aforementioned communities. The cover abundance calculations on the bunds may have included non-indigenous species in some instances.

#### **Bead Samphire assessment**

An on-ground site assessment was undertaken of the EPBC listed Bead Samphire in February 2017. The assessment compared the extent and abundance of Bead Samphire with the studies undertaken in 2014 (EcoAerial) and, data provided by Peri Coleman (2014) after completion of the 2014 studies. The Coleman (2014) and EcoAerial (2014) mapping layers were uploaded onto a GPS enabled tablet (Getac V100). The on-ground surveys compared the current distribution of Bead Samphire against previously mapped areas.

The timing of the Bead Samphire surveys coincided with their active growing / flowering period (October to May).

## 2.1 Project team

The aerial assessments were undertaken by EcoAerial Principal Ecologist, Rob Gration; AviAssist's Chief pilot, Ross Anderson. Richard Morrissey (Valley Panoramic) provided technical assistance with the set up and operation of the camera and flight planning system.

#### **Rob Gration** - Principal Ecologist

Rob has in excess of 20-years of professional experience in the resource management sector. Rob has undertaken large scale projects throughout central and eastern Queensland, New South Wales, SA and Victoria as an environmental consultant. Rob's specific area of expertise is habitat assessment and management. Rob provides environmental advice on project impacts and, the preparation of referrals and advice under the EPBC Act & relevant state legislation. Rob has a Masters in Wildlife Management (Habitat).

#### Ross Anderson - Chief Pilot

Ross has 15 years commercial aviation and flight experience over a diverse background including aerobatics, aeromedical retrieval; fly in fly out, aerial survey (dugong) and Australian touring. Ross has a Bachelor of Science (Aviation).

# 3 Vegetation Mapping Results

As detailed in the methods section, the vegetation assessment was a 4 step process. This involved: 1) deploying a camera mounted to manned aircraft, 2) post flight image analysis, 3) interpretation of aerial images, 4) map vegetation and assign a score to the cover abundance for each patch.

# 3.1 Aerial interpretation

It was not possible to differentiate between the two vegetation communities likely to occur in the study area from the aerial imagery. However, based on ground truthing previously undertaken by the author, the dominant community is likely to be Dryland Samphire.

A total of 149.65 hectares was mapped across all ponds, bunds and sections of the Bolivar Channel, an increase of approximately 23Ha. A breakdown of the vegetation mapped in 2015 & 2016 is provided in Table 2 and, a visual representation in Chart 1.

Table 2: Areas of mapped vegetation

Pond	Total Ha 2015	Total Ha 2016	Variance Ha
XE 4	25.21	29.84	4.63
XF 1	6.88	7.97	1.10
XF 2	24.67	27.16	2.48
XC 1	2.66	4.08	1.42
XC 2E	17.46	20.84	3.38
XC2	3.66	6.21	2.54
XC 2S	10.12	14.67	4.54
PA 6	3.47	4.79	1.32
PA 7	1.25	2.08	0.83
PA 8	2.98	4.31	1.32
PA 9	1.38	0.94	-0.44
PA 10	0.63	0.08	-0.55
PA 11	1.23	1.39	0.16
PA 12	0.29	0.36	0.07
Adjacent to Bolivar Channel	24.69	24.84	0.15
	126.66Ha	149.65Ha	22.98

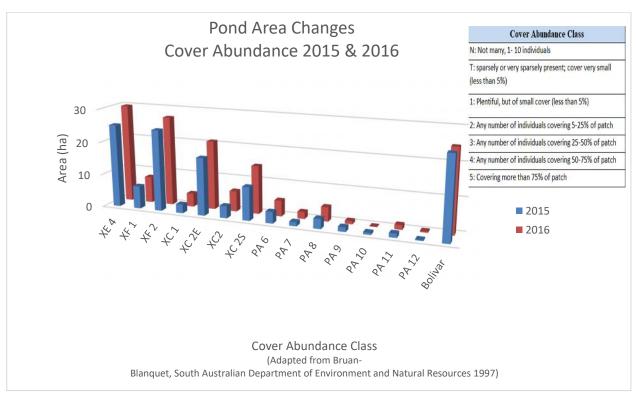


Chart 1: Cover Abundance changes

The tables presented in sections 3.2 to 3.4 provide an overview of the cover abundance ratings as a percentage of cover and of the total pond area.

A breakdown detailing the extent of each individual vegetated area and the associated cover abundance ratings assigned to each pond is provided in Appendix C. All references to a comparison of cover abundance ratings in the ponds and bunds are based on the analysis of these spreadsheets.

## 3.2 Middle Beach - Section 4

The vegetation was mapped for three ponds in the Middle Beach study area; XF 1, XF 2 and XE 4 (refer to Figure 4). A total of 65 hectares of vegetation was mapped within these ponds; 7.9ha (XF 1), 27.16 ha (XF 2) and 29.84ha (XE 4), an increase of 8.21ha when compared to the 2015 mapping.

As was the case in 2015, higher cover abundance ratings appear to be directly correlated to topography i.e. greater vegetation cover present on high ground / ridges and drainage lines.

## 3.2.1 Pond XF 1

A total of 7.97ha's of vegetation was mapped during the 2016 survey. The majority of vegetation (6.05ha) was mapped on or abutting the bunds (Figures 11~14).

There was more areas of vegetation with cover abundance scores of 4 (37.15%) & 5 (45.09%) across both the bunds and in pond. This is a slight reduction when compared to the 2015 results. This reduction is offset by increase in vegetation with a cover abundance score of 3 which increased in area of 3.95%.

The overall vegetation cover as a percentage the pond area is approximately 7% (Table 3), an increase of approximately 1% (1.1ha) compared to 2015. A visual representation of the changes between 2015 and 2016 is provided in Chart 2.

Table 3: Bund and pond cover abundance - Pond XF 1

20	016 Cover Abundance	Вι	Bund In Pond Total		tal		
Adapted from Bruan- Blanquet	(South Australian Department of Environment and Natural Resources 1997)	Area (m2)	%	Area (m2)	%	Area (m2)	%
N	Not many, 1- 10 individuals	12	0.02%	2782	14.43%	2794	3.50%
Т	sparsely or very sparsely present; cover very small (less than 5%)	0	0.00%	0	0.00%	0	0.00%
1	plentiful, but of small cover (less than 5%)	0	0.00%	0	0.00%	0	0.00%
2	any number of individuals covering 5-25% of patch	1103	1.82%	0	0.00%	1103	1.38%
3	any number of individuals covering 25-50% of patch	3411	5.64%	6857	35.57%	10268	12.87%
4	any number of individuals covering 50-75% of patch	23539	38.90%	6106	31.68%	29645	37.15%
5	covering more than 75% of patch	32451	53.62%	3531	18.32%	35982	45.09%
	Total	60,516	100.00%	19,276	100.00%	79,792	100.00%
			<u>,                                      </u>	Pond Area	1,160,000		
		Area w	ith vegetation	on as % of	Pond Area	6.88%	

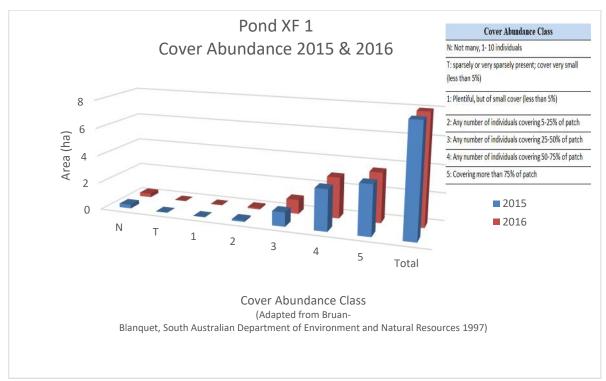


Chart 2: Cover Abundance changes

#### 3.2.2 Pond XF 2

A total of 27.16ha's of vegetation was mapped during the 2016 survey. As was the case with Pond XF 1, the majority of vegetation (20.5ha) was mapped on or abutting the bunds (Figures 8~10).

There was more areas of vegetation with cover abundance scores of 3 (65.70%) & 4 (16.02%) across both the bunds and in pond. This is a marked increase for cover abundance scores of 3 (41.29%) & 4 (11.59%) when compared to the 2015 results. This increase was offset by a reduction in vegetation with a cover abundance score of 5 which decreased in area by 31.87%.

The overall vegetation cover as a percentage of the total pond area is 11.91% (Table 4), an increase of 1.1% (2.48ha) compared to 2015. A visual representation of the changes between 2015 and 2016 is provided in Chart 3.

Table 4: Bund and pond cover abundance - Pond XF 2

2016 Cover Abundance		Bund		In F	Pond	Total	
Adapted from Bruan- Blanquet	(South Australian Department of Environment and Natural Resources 1997)	Area (m2)	%	Area (m2)	%	Area (m2)	%
N	Not many, 1- 10 individuals	185	0.09%	2027	3.06%	2212	0.81%
Т	sparsely or very sparsely present; cover very small (less than 5%)	1071	0.52%	592	0.89%	1663	0.61%
1	plentiful, but of small cover (less than 5%)	0	0.00%	9359	14.14%	9359	3.45%
2	any number of individuals covering 5-25% of patch	5990	2.92%	14783	22.33%	20773	7.65%
3	any number of individuals covering 25-50% of patch	157667	76.76%	20768	31.37%	178435	65.70%

4	any number of individuals covering 50-75% of patch	39338	19.15%	4182	6.32%	43520	16.02%
5	covering more than 75% of patch	1143	0.56%	14495	21.89%	15638	5.76%
	Total	205,394	100.00%	66,206	100.00%	271,600	100.00%
	Pond Area						
		Area wit	h vegetatio	n as % of	Pond Area	11.91%	

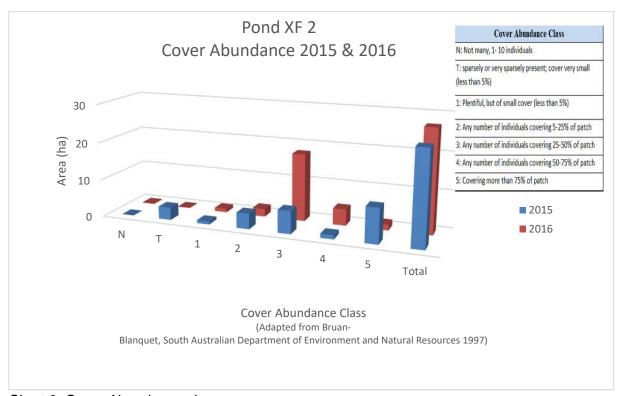


Chart 3: Cover Abundance changes

## 3.2.3 Pond XE 4

A total of 29.84ha's of vegetation was mapped during the 2016 survey. The majority of vegetation (22ha) was again most prevalent on, or abutting the bunds (Figures 15~17).

There was more areas of vegetation with cover abundance scores of 4 (9.39%) & 5 (73.04%) across both the bunds and in pond. There was decrease of cover abundance score of 3 (41.66%) when compared to the 2015 results. This decrease was partially offset by an increase in vegetation with a cover abundance score of 5 of 34.14%.

The overall vegetation cover as a percentage of the total pond area is 25.95% (Table 5), an increase of 4.92% (4.63ha) compared to 2015. A visual representation of the changes between 2015 and 2016 is provided in Chart 4.

Table 5: Bund and pond cover abundance – Pond XE 4

	2016 Cover Abundance	Bu	ınd	In F	Pond	Total	
Adapted from Bruan- Blanquet	(South Australian Department of Environment and Natural Resources 1997)	Area (m2)	%	Area (m2)	%	Area (m2)	%
N	Not many, 1- 10 individuals	27	0.01%	2108	3.05%	2135	0.72%
Т	sparsely or very sparsely present; cover very small (less than 5%)	20	0.01%	8167	11.81%	8187	2.74%
1	plentiful, but of small cover (less than 5%)	0	0.00%	18744	27.10%	18744	6.28%
2	any number of individuals covering 5-25% of patch	1005	0.44%	17948	25.95%	18953	6.35%
3	any number of individuals covering 25-50% of patch	1409	0.61%	3015	4.36%	4424	1.48%
4	any number of individuals covering 50-75% of patch	26264	11.45%	1765	2.55%	28029	9.39%
5	covering more than 75% of patch	200569	87.47%	17426	25.19%	217995	73.04%
	Total	229,294	100.00%	69,173	100.00%	298,467	100.00%
					Pond Area	1,150,000	
		Area wi	th vegetatio	n as % of	Pond Area	25.95%	

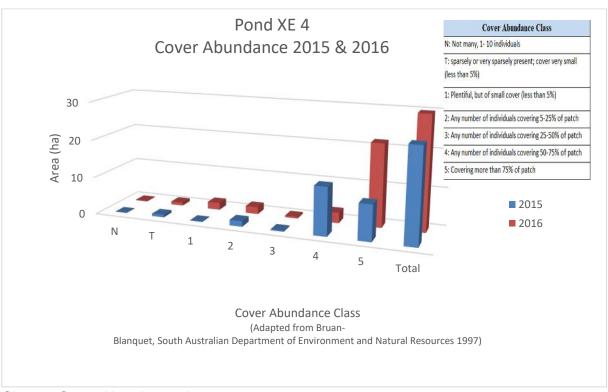


Chart 4: Cover Abundance changes

#### 3.3 Port Gawler - Section 3

The vegetation in four ponds was mapped in the Port Gawler study area; XC 1, XC 2 and XC 2E and XC 2 South (refer to Figure 3). A total of 45.83 hectares of vegetation was mapped within these ponds; 4.08 ha (XC 1), 6.21 ha (XC 2), 20.84 ha (XC 2E) and 14.67 (XC 2 South). An increase of 11.90 ha when compared to the 2015 mapping.

As was the case with Section 4, the higher ratings within the ponds are directly correlated to topography i.e. greater vegetation cover present on high ground / ridges and / or drainage lines.

## 3.3.1 Pond XC 1

A total of 4.08 ha of vegetation was mapped during the 2016 survey. The majority of vegetation (3.2ha) was again most prevalent on, or abutting the bunds (Figures 18~20).

There was more areas of vegetation with cover abundance scores of 4 (52.20.70%) & 5 (16.90%) across both the bunds and in pond. This is a substantial increase for cover abundance score 4 (38.00%) when compared to the 2015 results. This increase was offset by a reduction of vegetation with a cover abundance score of 5 (63.2%).

The overall vegetation cover as a percentage of the total pond area is 3.10% (Table 6), an increase of 1.08% (1.4ha) compared to 2015. A visual representation of the changes between 2015 and 2016 is provided in Chart 5.

Table 6: Bund and pond cover abundance - Pond XC 1

	2016 Cover Abundance	Вι	und	In Pond		Total	
Adapted from Bruan- Blanquet	(South Australian Department of Environment and Natural Resources 1997)	Area (m2)	%	Area (m2)	%	Area (m2)	%
N	Not many, 1- 10 individuals	4087	12.82%	591	6.57%	4678	11.44%
Т	sparsely or very sparsely present; cover very small (less than 5%)	0	0.00%	0	0.00%	0	0.00%
1	plentiful, but of small cover (less than 5%)	0	0.00%	0	0.00%	0	0.00%
2	any number of individuals covering 5-25% of patch	16	0.05%	5995	66.63%	6011	14.71%
3	any number of individuals covering 25-50% of patch	1238	3.88%	706	7.85%	1944	4.76%
4	any number of individuals covering 50-75% of patch	21336	66.93%	0	0.00%	21336	52.20%
5	covering more than 75% of patch	5203	16.32%	1705	18.95%	6908	16.90%
	Total	31,880	100.00%	8,997	100.00%	40,877	100.00%
	Pond Area					1,320,000	
		Area with	n vegetation	as % of	Pond Area	3.10%	

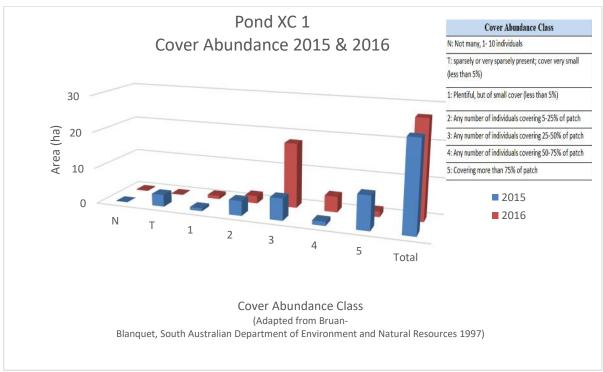


Chart 5: Cover Abundance changes

## 3.3.2 Pond XC 2

A total of 6.21 ha of vegetation was mapped during the 2016 survey. The majority of vegetation (4.2 ha) was again most prevalent on, or abutting the bunds (Figures 21~24).

There was more areas of vegetation with cover abundance scores of 3 (57.23%) & 4 (19.28%) across both the bunds and in pond. This is a substantial increase for cover abundance score 3 (53.8%) and minor increase for cover abundance score 4 (12.6%) when compared to the 2015 results. These increases were primarily offset by a reduction in vegetation with a cover abundance score of 5 which decreased in area by 75.25%.

The overall vegetation cover as a percentage of the total pond area is 5.02% (Table 7), an increase of 2.06% (2.54ha) compared to 2015. A visual representation of the changes between 2015 and 2016 is provided in Chart 6.

Table 7: Bund and pond cover abundance - Pond XC 2

	2016 Cover Abundance		Bund		In Pond		tal
Adapted from Bruan- Blanquet	(South Australian Department of Environment and Natural Resources 1997)	Area (m2)	%	Area (m2)	%	Area (m2)	%
N	Not many, 1- 10 individuals	386	0.90%	6380	33.02%	6766	10.88%
Т	sparsely or very sparsely present; cover very small (less than 5%)	0	0.00%	302	1.56%	302	0.49%
1	plentiful, but of small cover (less than 5%)	0	0.00%	2016	10.43%	2016	3.24%
2	any number of individuals covering 5-25% of patch	1403	3.27%	240	1.24%	1643	2.64%
3	any number of individuals covering 25-50% of patch	35524	82.86%	68	0.35%	35592	57.23%

4	any number of individuals covering 50-75% of patch	3048	7.11%	8941	46.27%	11989	19.28%
5	covering more than 75% of patch	2509	5.85%	1376	7.12%	3885	6.25%
	Total	42,870	100.00%	19,323	100.00%	62,193	100.00%
	Pond Area						
		Area wi	th vegetatio	n as % of	Pond Area	5.02%	

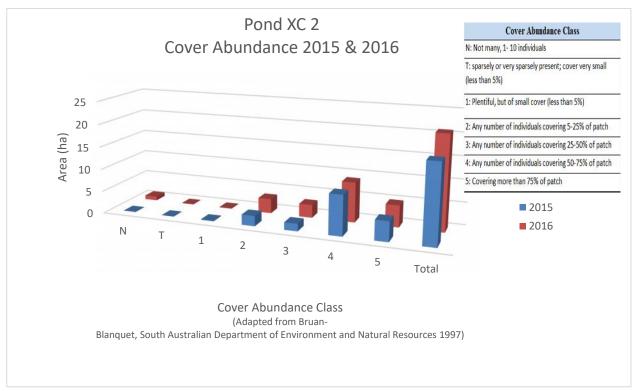


Chart 6: Cover Abundance changes

# 3.3.3 Pond XC 2 South

A total of 14.67 ha of vegetation was mapped during the 2016 survey. Vegetation was evenly distributed between the bunds (7.41ha) and in pond (7.14) Refer to Figures 25~26.

There was more areas of vegetation with cover abundance scores of 3 (16.38%) & 4 (60.32%) across both the bunds and in pond. This was a decrease for cover abundance score 3 (0.08%) and 4 (13.85%) when compared to the 2015 results. These decreases were primarily offset by a increase in vegetation with a cover abundance score of 5 which increased in area by 9.85%.

The overall vegetation cover as a percentage of the total pond area is 29.73% (Table 8), an increase of 9.06% (4.45ha) compared to 2015. A visual representation of the changes between 2015 and 2016 is provided in Chart 7.

Table 8: Bund and pond cover abundance - Pond XC 2 South

	2016 Cover Abundance	Bı	und	In F	ond	То	tal
Adapted from Bruan- Blanquet	(South Australian Department of Environment and Natural Resources 1997)	Area (m2)	%	Area (m2)	%	Area (m2)	%
N	Not many, 1- 10 individuals	0	0.00%	191	0.27%	191	0.13%
Т	sparsely or very sparsely present; cover very small (less than 5%)	0	0.00%	0	0.00%	0	0.00%
1	plentiful, but of small cover (less than 5%)	0	0.00%	0	0.00%	0	0.00%
2	any number of individuals covering 5-25% of patch	1603	2.16%	10333	14.44%	11936	8.19%
3	any number of individuals covering 25-50% of patch	6821	9.20%	17042	23.82%	23863	16.38%
4	any number of individuals covering 50-75% of patch	60867	82.13%	26996	37.73%	87863	60.32%
5	covering more than 75% of patch	4822	6.51%	16990	23.74%	21812	14.97%
	Total	74,113	100.00%	71,552	100.00%	145,665	100.00%
Pond Area					490,000		
	Area with vegetation as % of Pond Area					29.73%	

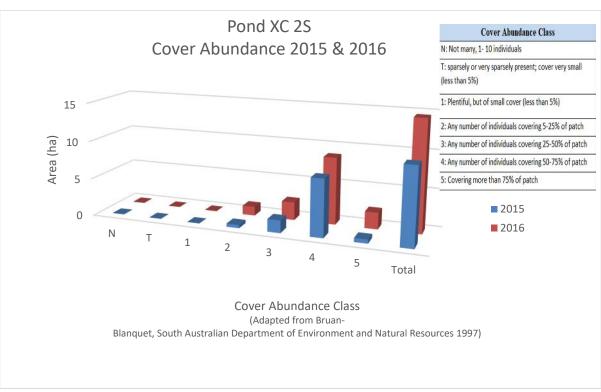


Chart 7: Cover Abundance changes

#### 3.3.4 Pond XC 2E

Vegetation (20.84ha) in Pond XC 2E was located abutting the Bolivar Channel and on the perimeter and southern sections of the pond. There was a high degree of crystallization occurring in those areas where vegetation was not present.

Although there was considerable in pond vegetation, based on the mapping rules described in the methods section (i.e. mapping contiguous vegetation on bunds into the pond areas), the vegetation was mapped as being present on the bunds only (Figures 27~29).

Cover abundance scores varied considerably with the higher scores assigned to the south and perimeter of the pond and adjacent to the Bolivar Channel where pumped saline water has not been present to the extent of the other ponds.

This pond had by far the greatest percentage of vegetation cover per area of pond of any of the ponds mapped for this study (excludes Bolivar Channel). The cover abundance ratings 4 (51.01%) & 5 (27.88%) constituted 78.89% of the total area of vegetation mapped (Table 9).

The overall vegetation cover as a percentage of the total pond area is 50.84% (Table 9), an increase of 8.43% (3.38ha) compared to 2015. This is due in part to the aerial images covering a larger area of the eastern section of the pond compared to 2015. A visual representation of the changes between 2015 and 2016 is provided in Chart 8.

Table 9: Bund and pond cover abundance - Pond XC 2E

	2016 Cover Abundance	Bu	ınd	To	tal
Adapted from Bruan- Blanquet	(South Australian Department of Environment and Natural Resources 1997)	Area % (m2)		Area (m2)	%
N	Not many, 1- 10 individuals	8981	5.16%	8981	5.16%
Т	sparsely or very sparsely present; cover very small (less than 5%)	37	0.02%	37	0.02%
1	plentiful, but of small cover (less than 5%)	940	0.54%	940	0.54%
2	any number of individuals covering 5-25% of patch	32385	18.62%	32385	18.62%
3	any number of individuals covering 25-50% of patch	28934	16.64%	28934	16.64%
4	any number of individuals covering 50-75% of patch	88722	51.01%	88722	51.01%
5	covering more than 75% of patch	48492	27.88%	48492	27.88%
	Total	208,491	100.00%	208,491	100.00%
		,	Pond Area	410,000	
	Area with vegetat	ion as % of	Pond Area	50.85%	

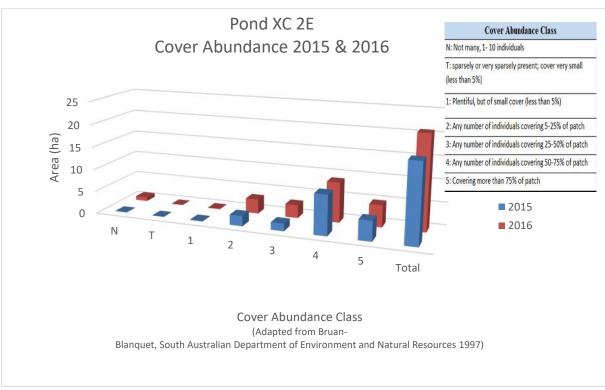


Chart 8: Cover Abundance changes

## 3.3.5 Bolivar Channel

The areas abutting the Bolivar Channel had extensive vegetation; 24.84ha (Figures 18~29) and the majority of vegetation recorded high cover abundance scores. It should be noted that the vegetation mapped within these areas was not located within any ponds or have been inundated with saline water. In some instances the vegetation is not located within the Ridley leases but in all instances abuts bunds or ponds of the lease area forming a contiguous patch of vegetation.

The vegetation adjacent and along the Bolivar Channel is extensive with total cover estimated at 86.03%, a small increase on 2015 (Table 10). Of the area mapped, 99.87% scored the top cover abundance rating of 5. A visual representation of the changes between 2015 and 2016 is provided in Chart 9.

Table 10: Cover abundance - Bolivar Channel

2016 Cover Abundance		Вι	ınd	То	otal
Adapted from Bruan-Blanquet	(South Australian Department of Environment and Natural Resources 1997)	Area %		Area (m2)	%
N	Not many, 1- 10 individuals	0	0.00%	0	0.00%
Т	sparsely or very sparsely present; cover very small (less than 5%)	0	0.00%	0	0.00%
1	plentiful, but of small cover (less than 5%)	0	0.00%	0	0.00%
2	any number of individuals covering 5-25% of patch	0	0.00%	0	0.00%
3	any number of individuals covering 25-50% of patch	252	0.10%	252	0.10%
4	any number of individuals covering 50-75% of patch	67	0.03%	67	0.03%
5	covering more than 75% of patch	246584	99.87%	246584	99.87%
	Total (m2)	246,903	100.00%	246,903	100.00%
	Area (m2)	287,000			
	Pond Area	86.03%			

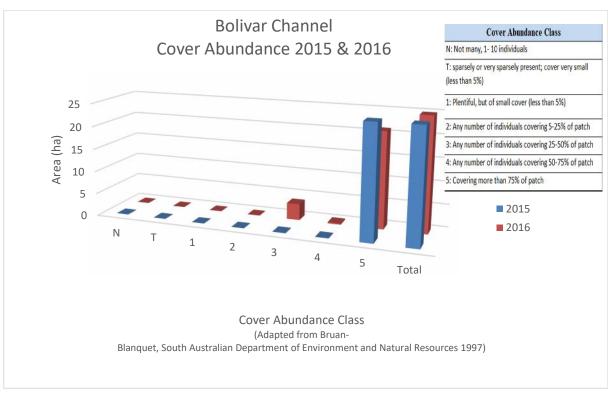


Chart 9: Cover Abundance changes

## 3.4 St Kilda - Section 2

The vegetation in seven ponds was mapped in the St Kilda study area; PA 6, PA 7, PA 8, PA 9, PA 10, PA 11 and PA 12 (refer to Figure 2). A total of 13.95 hectares of vegetation was mapped within these ponds; 4.79ha (PA 6); 2.08ha (PA 7); 4.31ha (PA 8); 0.94ha (PA 9); 0.083ha (PA 10); 1.39 ha (PA 11) and, 0.36 (PA 12). These ponds contained the least vegetation of any of the 3 study areas.

As was the case with Sections 3 & 4, the higher ratings within the ponds are directly correlated to topography i.e. greater vegetation cover present on high ground / ridges and drainage lines.

#### 3.4.1 Pond PA 6

A total of 4.79ha of vegetation was mapped during the 2016 survey. The majority of vegetation (2.7ha) was most prevalent on the pond (Figures 30~31).

There was more areas of vegetation with cover abundance scores of N (36.02%) and 3 (24.22%) across both the bunds and in pond. This is a substantial increase for cover abundance score N (35.84%) and a minor decrease for cover abundance score 3 (12.57%) when compared to the 2015 results.

The overall vegetation cover as a percentage of the total pond area is 9.05% (Table 11), a modest increase of 2.49% (1.32ha) compared to 2015. A visual representation of the changes between 2015 and 2016 is provided in Chart 10.

Table 11: Bund and pond cover abundance - Pond PA 6

	2016 Cover Abundance	Вι	und	In Pond		Total	
Adapted from Bruan- Blanquet	(South Australian Department of Environment and Natural Resources 1997)	Area (m2)	%	Area (m2)	%	Area (m2)	%
N	Not many, 1- 10 individuals	42	0.21%	17230	61.60%	17272	36.02%
т	sparsely or very sparsely present; cover very small (less than 5%)	0	0.00%	0	0.00%	0	0.00%
1	plentiful, but of small cover (less than 5%)	0	0.00%	0	0.00%	0	0.00%
2	any number of individuals covering 5-25% of patch	276	1.38%	6002	21.46%	6278	13.09%
3	any number of individuals covering 25-50% of patch	7594	38.00%	4022	14.38%	11616	24.22%
4	any number of individuals covering 50-75% of patch	7858	39.32%	718	2.57%	8576	17.88%
5	covering more than 75% of patch	4213	21.08%	0	0.00%	4213	8.79%
	Total	19,983	100.00%	27,972	100.00%	47,955	100.00%
Pond Area						530,000	
	Area with vegetation as % of Pond Area						

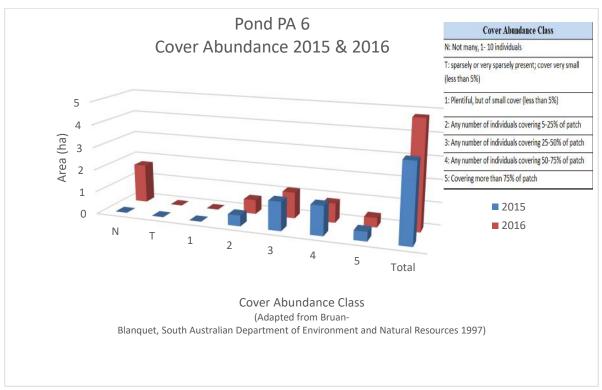


Chart 10: Cover Abundance changes

### 3.4.2 Pond PA 7

A total of 2.08ha of vegetation was mapped during the 2016 survey. The majority of vegetation was located on, or abutting the bunds (Figures 32~34).

There was more cover abundance scores of N (32.82%) and 2 (24.81%) across both the bunds and in pond. This is a substantial increase for cover abundance score N (31.31%) and a substantial decrease for cover abundance score 3 (31.59%) when compared to the 2015 results.

The overall vegetation cover as a percentage of the total pond area is 3.07% (Table 12), a modest increase of 1.23% (0.83ha) compared to 2015. A visual representation of the changes between 2015 and 2016 is provided in Chart 11.

Table 12: Bund and pond cover abundance - Pond PA 7

2016 Cover Abundance		Bund		In Pond		Total	
Adapted from Bruan- Blanquet	(South Australian Department of Environment and Natural Resources 1997)	Area (m2)	%	Area (m2)	%	Area (m2)	%
N	Not many, 1- 10 individuals	6594	44.87%	251	4.08%	6845	32.82%
Т	sparsely or very sparsely present; cover very small (less than 5%)	0	0.00%	0	0.00%	0	0.00%
1	plentiful, but of small cover (less than 5%)	0	0.00%	0	0.00%	0	0.00%
2	any number of individuals covering 5-25% of patch	1483	10.09%	3692	59.94%	5175	24.81%
3	any number of individuals covering 25-50% of patch	1605	10.92%	1598	25.95%	3203	15.36%
4	any number of individuals covering 50-75% of patch	3905	26.57%	618	10.03%	4523	21.69%
5	covering more than 75% of patch	1110	7.55%	0	0.00%	1110	5.32%

Total	14,697	100.00%	6,159	100.00%	20,856	100.00%
Pond Area						
Area with vegetation as % of Pond Area						

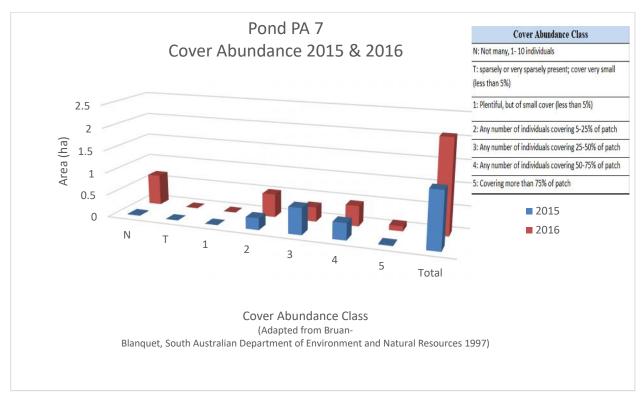


Chart 11: Cover Abundance changes

#### 3.4.3 Pond PA 8

A total of 4.31ha of vegetation was mapped during the 2016 survey. All vegetation was located on, or abutting the bunds (Figures 35~36).

There was more cover abundance scores of 4 (35.96%) and 5 (75.90%). This is a significant decrease for cover abundance score 4 (20.25%) and a substantial increase for cover abundance score 5 (75.49%) when compared to the 2015 results.

The overall vegetation cover as a percentage of the total pond area is 8.13% (Table 13), a modest increase of 2.5% (1.32ha) compared to 2015. A visual representation of the changes between 2015 and 2016 is provided in Chart 12.

Table 13: Bund and pond cover abundance - Pond PA 8

2016 Cover Abundance		Bund		То	tal
Adapted from Bruan- Blanquet	(South Australian Department of Environment and Natural Resources 1997)	Area (m2)	%	Area (m2)	%
N	Not many, 1- 10 individuals	5020	11.65%	5020	16.82%
Т	sparsely or very sparsely present; cover very small (less than 5%)	0	0.00%	0	0.00%
1	plentiful, but of small cover (less than 5%)	0	0.00%	0	0.00%
2	any number of individuals covering 5-25% of patch	3328	7.72%	3328	11.15%

3	any number of individuals covering 25-50% of patch	1380	3.20%	1380	4.62%	
4	any number of individuals covering 50-75% of patch	10731	24.89%	10731	35.96%	
5	covering more than 75% of patch	22647	52.54%	22647	75.90%	
	Total	43,106	100.00%	43,106	100.00%	
	Pond Area					
	Area with vegetation	Pond Area	8.13%			

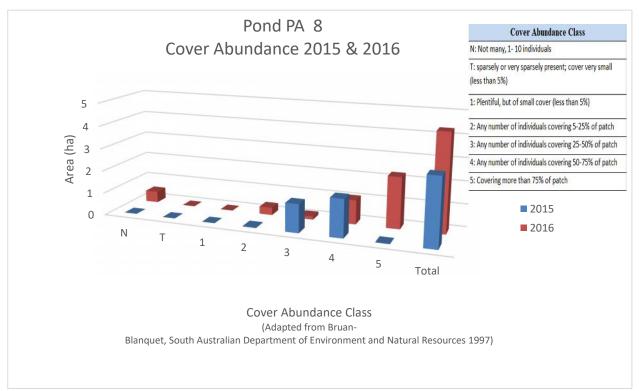


Chart 12: Cover Abundance changes

#### 3.4.4 Pond PA 9

A total of 0.94ha of vegetation was mapped during the 2016 survey. All vegetation was located on, or abutting the bunds (Figures 37~41).

There was more cover abundance scores of 4 (23.00%) and 5 (18.30%). This is a minor decrease for cover abundance score 4 (6.45%) and cover abundance score 5 (4.79%) when compared to the 2015 results.

The overall vegetation cover as a percentage of the total pond area is 2.15% (Table 14), a modest decrease of 1.1% (-0.44ha) compared to 2015. A visual representation of the changes between 2015 and 2016 is provided in Chart 13.

Table 14: Bund and pond cover abundance - Pond PA 9

		1					
	2016 Cover Abundance	В	Bund		Bund T		tal
Adapted from Bruan- Blanquet	(South Australian Department of Environment and Natural Resources 1997)	Area (m2)	%	Area (m2)	%		
N	Not many, 1- 10 individuals	2031	100.00%	2031	14.63%		
т	sparsely or very sparsely present; cover very small (less than 5%)	0	0.00%	0	0.00%		
1	plentiful, but of small cover (less than 5%)	0	0.00%	0	0.00%		
2	any number of individuals covering 5-25% of patch	0	0.00%	0	0.00%		
3	any number of individuals covering 25-50% of patch	1689	83.16%	1689	12.16%		
4	any number of individuals covering 50-75% of patch	3194	157.26%	3194	23.00%		
5	covering more than 75% of patch	2541	125.11%	2541	18.30%		
<u> </u>	Total	9,455	9,455 100.00%		100.00%		
			Pond Area	440,000			
Area with vegetation as % of Pond Area							

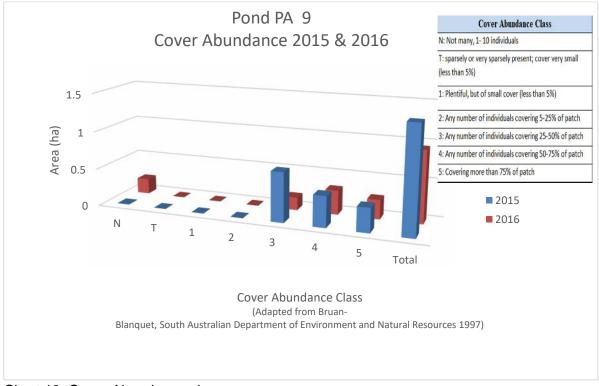


Chart 13: Cover Abundance changes

#### 3.4.5 Pond PA 10

A total of 0.08ha of vegetation was mapped during the 2016 survey. All vegetation was located on, or abutting the bunds (Figures 42~43).

What vegetation was present, the cover abundance varied from a few plants to a high degree of cover. High cover abundance was confined to the Bund. There was more cover abundance

scores of 4 (77.10%) and 5 (22.90%). This is a major increase for cover abundance score 4 (70.32%) and major decrease for cover abundance score 5 (60.31%) when compared to the 2015 results.

The overall vegetation cover as a percentage of the total pond area is 0.81% (Table 15), a decrease of 5.58% (-0.55ha) compared to 2015. A visual representation of the changes between 2015 and 2016 is provided in Chart 14.

Table 15: Bund and pond cover abundance - Pond PA 10

	,					
	2016 Cover Abundance	Bund		To	tal	
Adapted from Bruan-Blanquet	(South Australian Department of Environment and Natural Resources 1997)	Area (m2)	%	Area (m2)	%	
N	Not many, 1- 10 individuals	0	0.00%	0	0.00%	
Т	sparsely or very sparsely present; cover very small (less than 5%)	0	0.00%	0	0.00%	
1	plentiful, but of small cover (less than 5%)	0	0.00%	0	0.00%	
2	any number of individuals covering 5-25% of patch	0	0.00%	0	0.00%	
3	any number of individuals covering 25-50% of patch	0	0.00%	0	0.00%	
4	any number of individuals covering 50-75% of patch	623	77.10%	623	77.10%	
5	covering more than 75% of patch	185	22.90%	185	22.90%	
	Total	808	100.00%	808	100.00%	
	Pond Area	100,000				
	Pond Area	0.81				

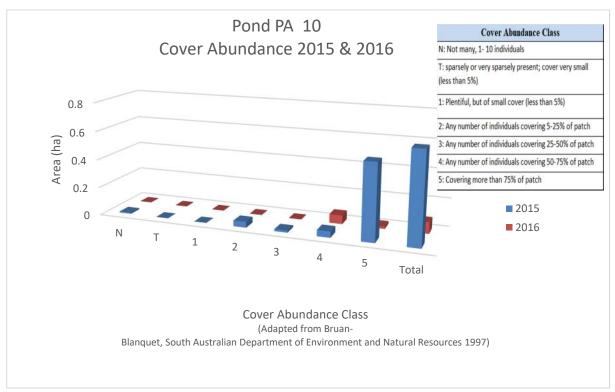


Chart 14: Cover Abundance changes

#### 3.4.6 Pond PA 11

A total of 1.39ha of vegetation was mapped during the 2016 survey. All vegetation was located on, or abutting the bunds (Figures 44~45).

Cover abundance scores on the bund were consistently high, ratings varied from 3~5 within the pond. There was more cover abundance scores of 3 (26.69%); 4 (36.95%) and 5 (31.48%). There was a major increase for cover abundance score 3 (22.47%) and 4 (32.66%) and major decrease for cover abundance score 5 (57.95%) when compared to the 2015 results.

The overall vegetation cover as a percentage of the total pond area is 6.66% (Table 16), a modest increase of 0.78% (0.16ha) compared to 2015. A visual representation of the changes between 2015 and 2016 is provided in Graph 15.

Table 16: Bund and pond cover abundance - Pond PA 11

2016 Cover Abundance		Bund		In Pond		Total	
Adapted from Bruan- Blanquet	(South Australian Department of Environment and Natural Resources 1997)	Area (m2)	%	Area (m2)	%	Area (m2)	%
N	Not many, 1- 10 individuals	0	0.00%	0	0.00%	0	0.00%
Т	sparsely or very sparsely present; cover very small (less than 5%)	0	0.00%	0	0.00%	0	0.00%
1	plentiful, but of small cover (less than 5%)	0	0.00%	0	0.00%	0	0.00%
2	any number of individuals covering 5-25% of patch	0	0.00%	682	12.99%	682	4.87%
3	any number of individuals covering 25-50% of patch	45	0.51%	3689	70.24%	3734	26.69%
4	any number of individuals covering 50-75% of patch	4486	51.33%	684	13.02%	5170	36.95%
5	covering more than 75% of patch	4208	48.15%	197	3.75%	4405	31.48%
	Total	8,739	100.00%	5,252	100.00%	13,991	100.00%
	Pond Area						
Area with vegetation as % of Pond Area					6.66%		

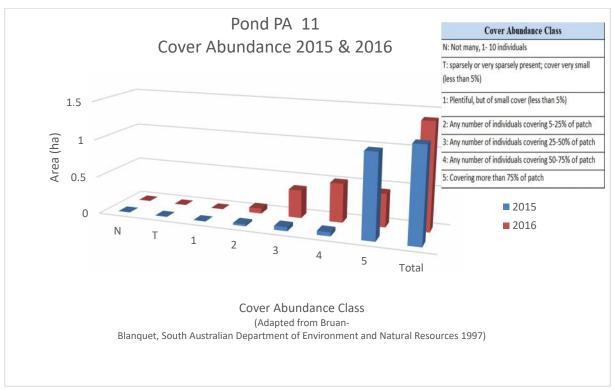


Chart 15: Cover Abundance changes

#### 3.4.7 Pond PA 12

A total of 0.36ha of vegetation was mapped during the 2016 survey. All vegetation was located on, or abutting the bunds (Figures 46~47).

The cover abundance score on the bund was confined to rating 5 (100%). This is the same rating as 2015.

The overall vegetation cover as a percentage of the total pond area is 3.07% (Table 17), a modest increase of 0.62% (0.07ha) compared to 2015. A visual representation of the changes between 2015 and 2016 is provided in Chart 16.

Table 17: Bund and pond cover abundance - Pond PA 12

	Cover Abundance Bund		То	tal	
Adapted from Bruan- Blanquet	(South Australian Department of Environment and Natural Resources 1997)	Area %		Area (m2)	%
N	Not many, 1- 10 individuals	0	0.00%	0	0.00%
Т	sparsely or very sparsely present; cover very small (less than 5%)	0	0.00%	0	0.00%
1	plentiful, but of small cover (less than 5%)	0	0.00%	0	0.00%
2	any number of individuals covering 5-25% of patch	0	0.00%	0	0.00%
3	any number of individuals covering 25-50% of patch	0	0.00%	0	0.00%
4	any number of individuals covering 50-75% of patch	0	0.00%	0	0.00%
5	covering more than 75% of patch	3688	100.00%	3688	100.00%
	Total	3688	100.00%	3688	100.00%
	Pond Area	120000			
	Pond Area	3.07%			

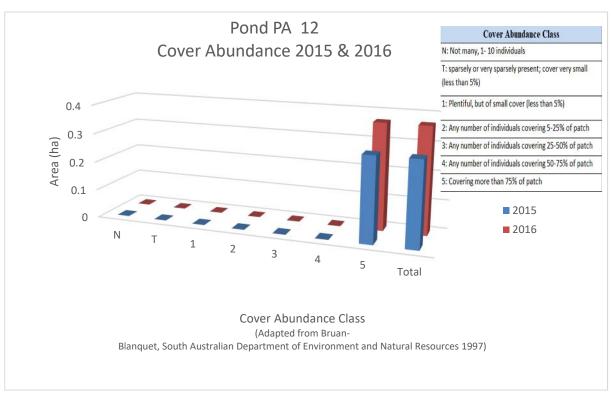
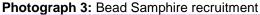
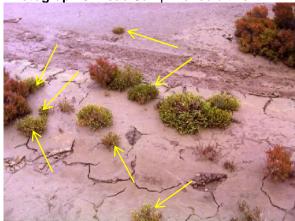


Chart 16: Cover Abundance changes

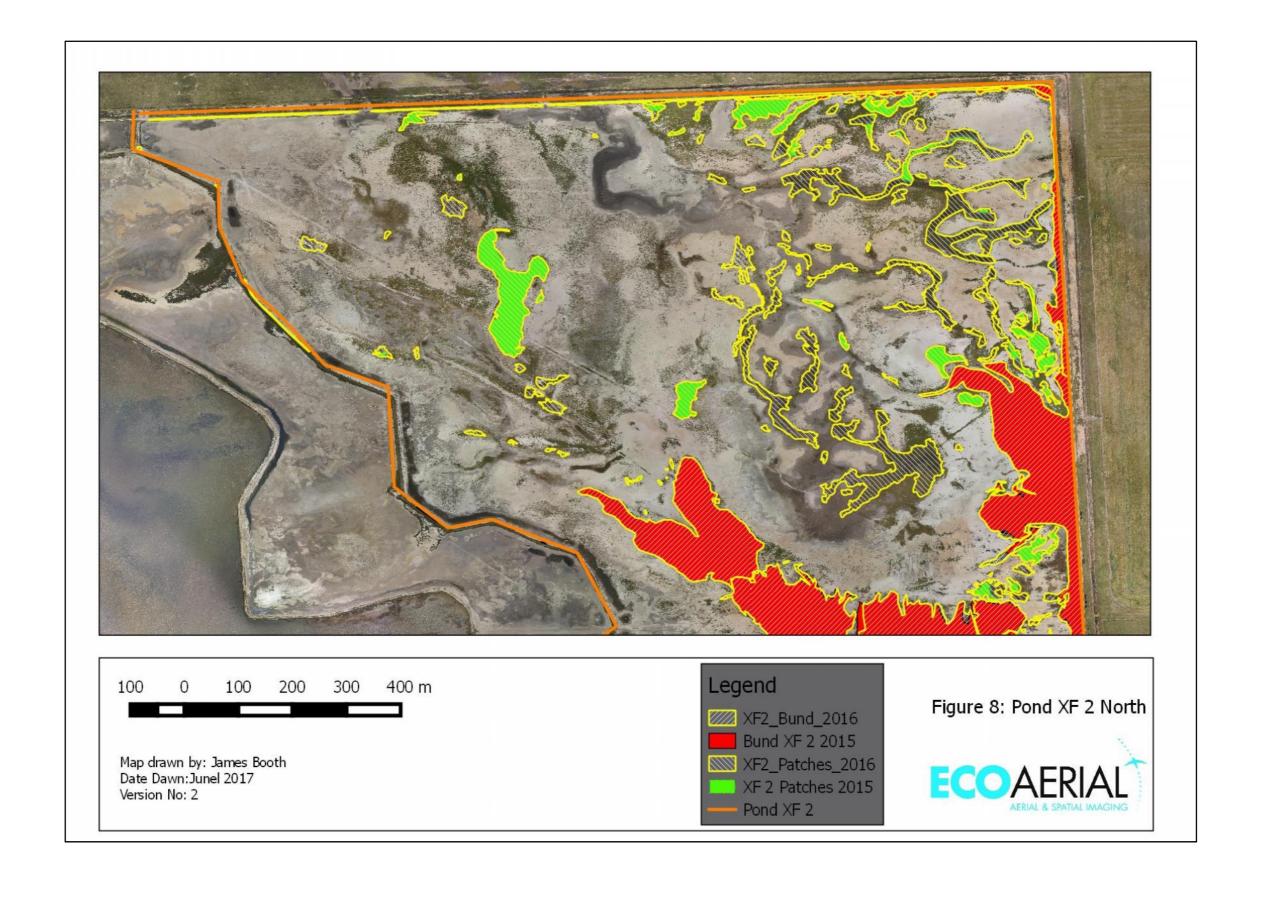
## 3.5 Bead Samphire

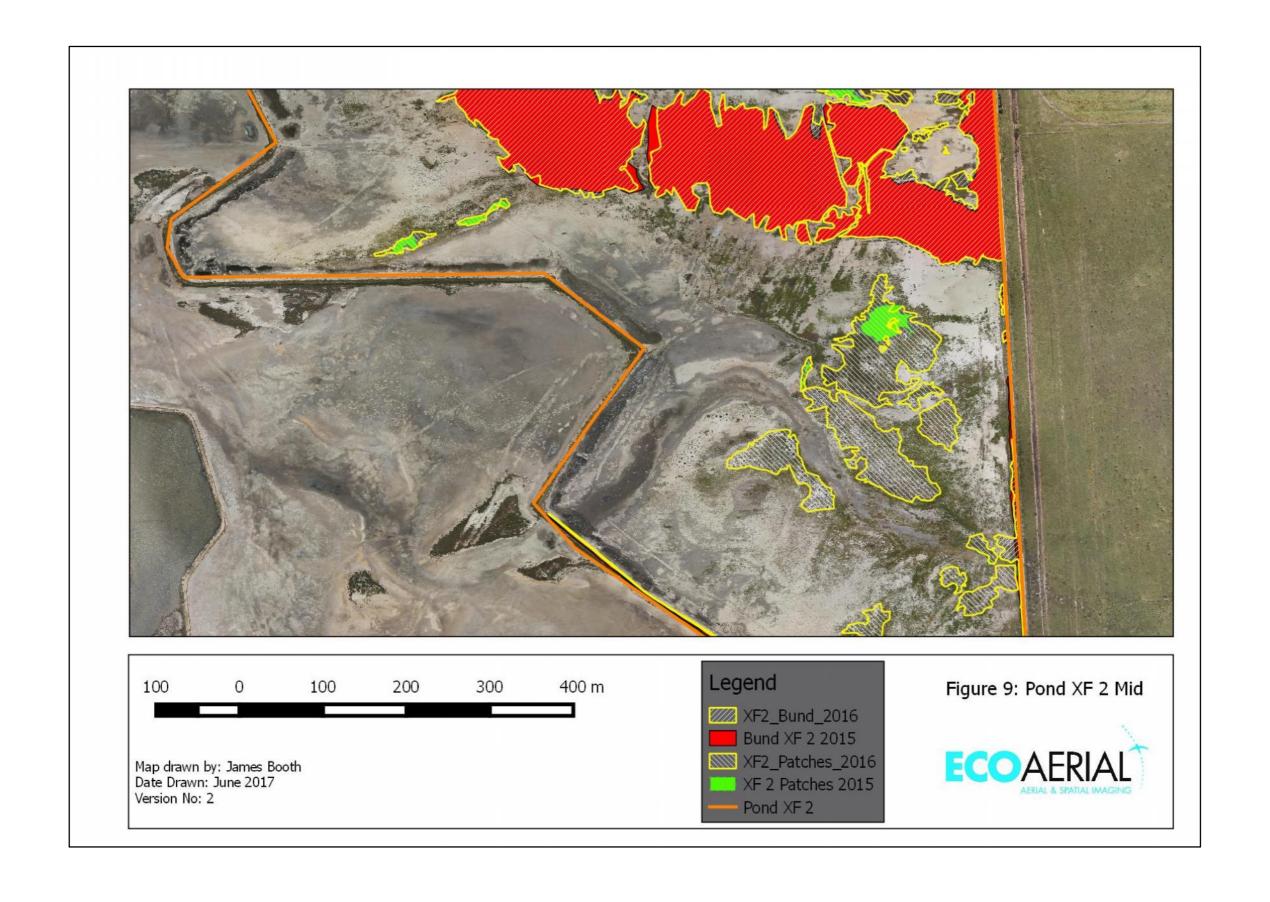
There has been no net loss in the patches of the EPBC listed Bead Samphire. All patches mapped in 2014 are still present and are of their previous extent. It was noted however that although there has been no increase in area or distribution, there has been considerable recruitment within the existing patches (refer to photograph 1 below). Patches assessed were located on the southern side of Middle Beach Road to the north of Section 4 and, within Section 3 near St Kilda. Figures 48~50 provides details of the location and extent of the patches.

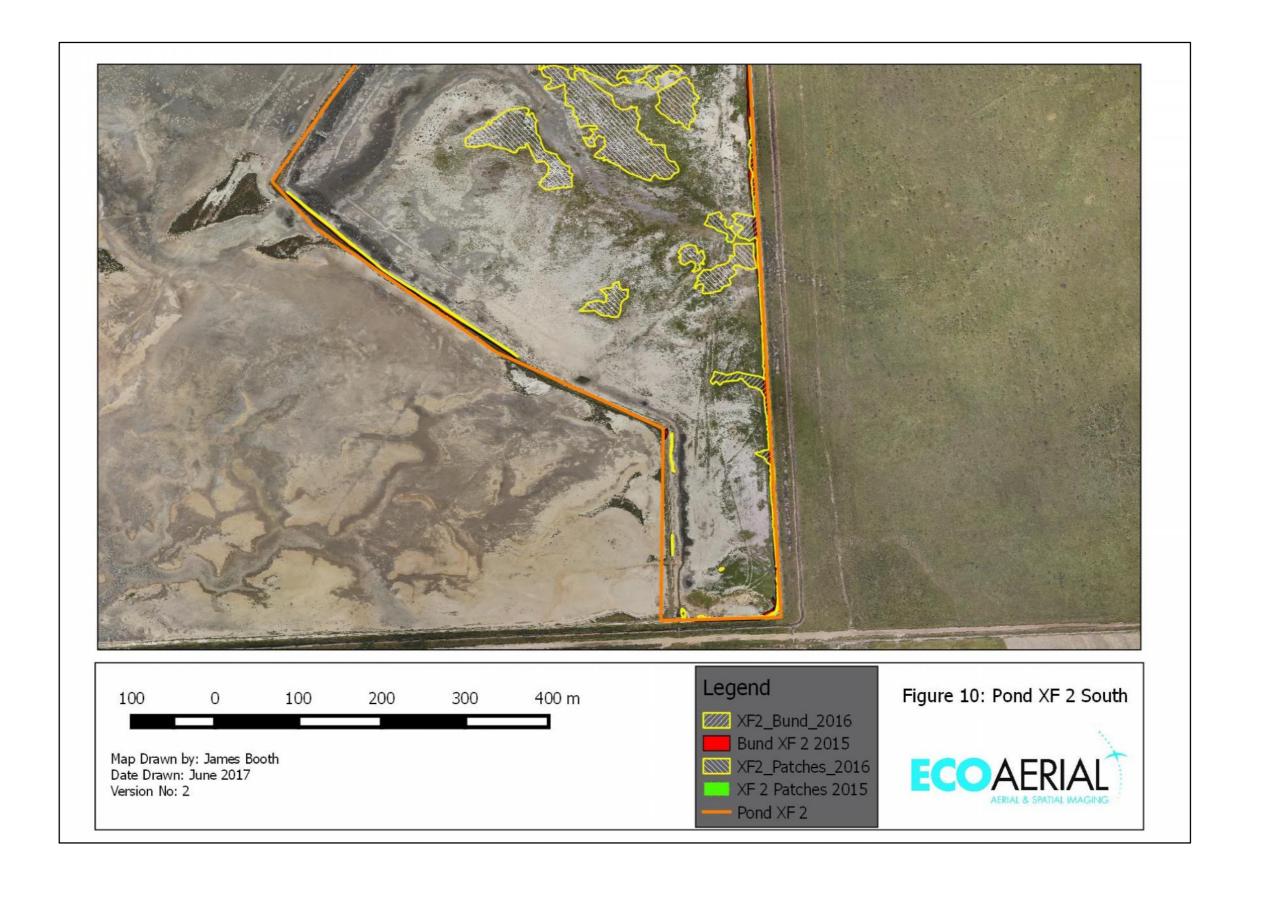


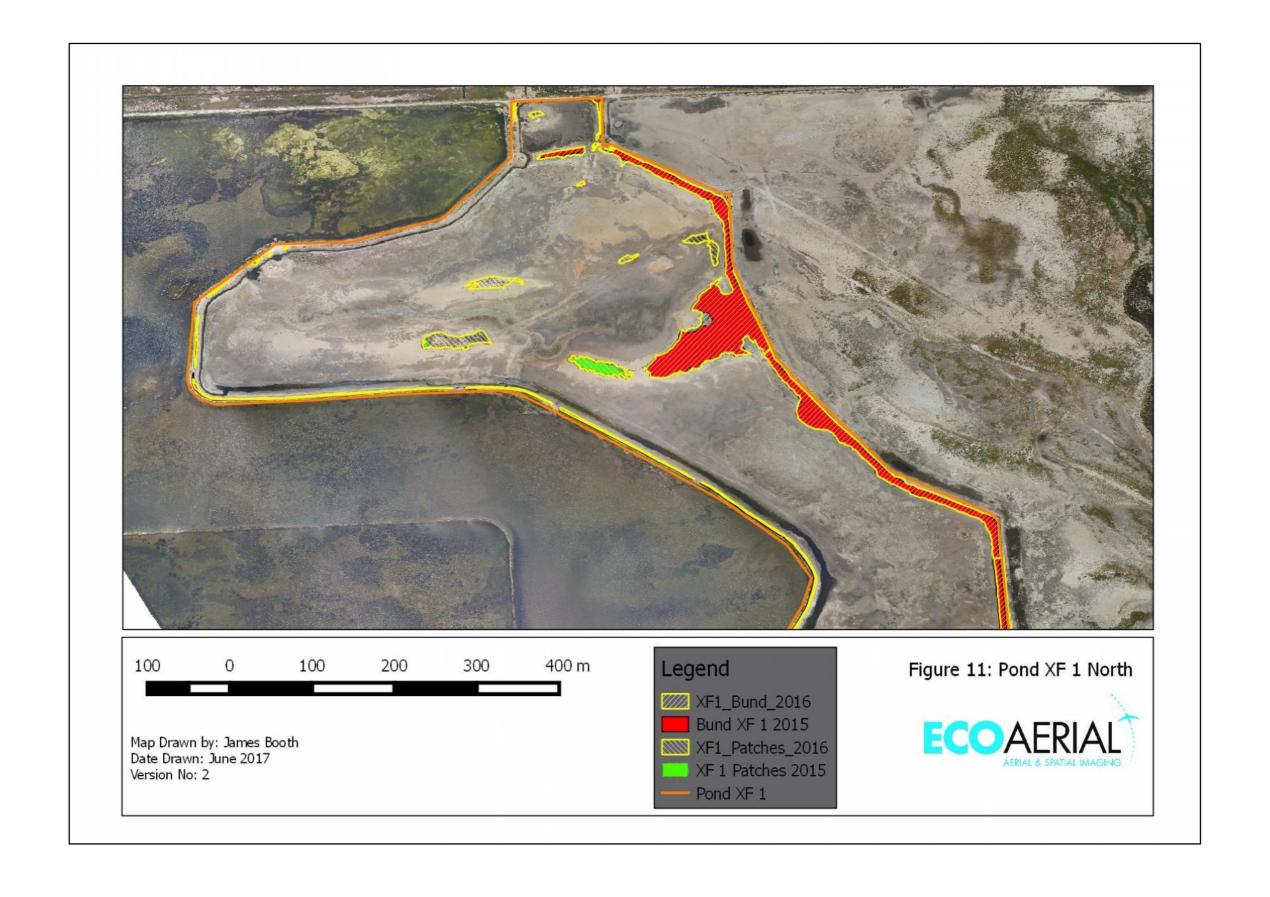


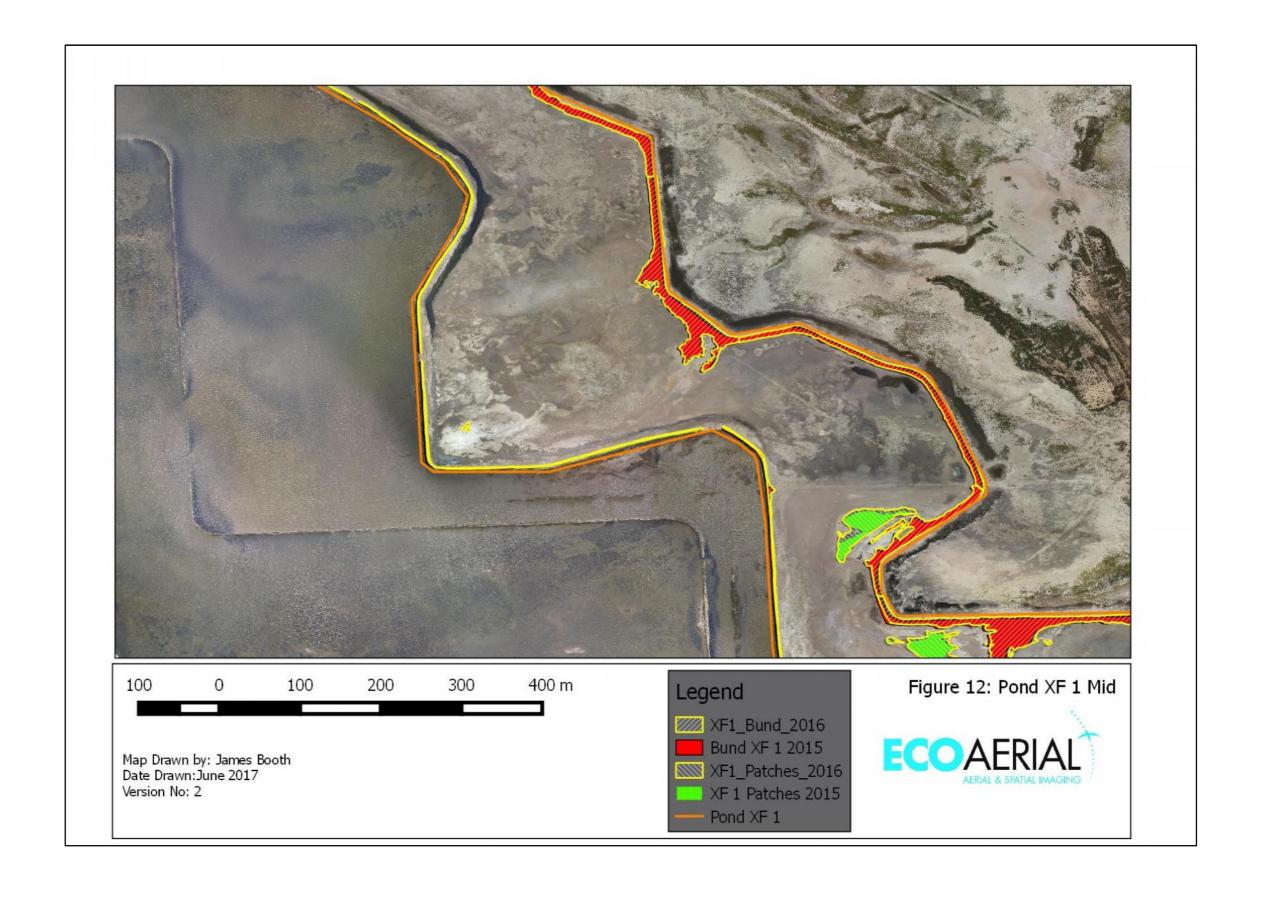
3.6 Vegetation Maps - Middle Beach (Section 4)

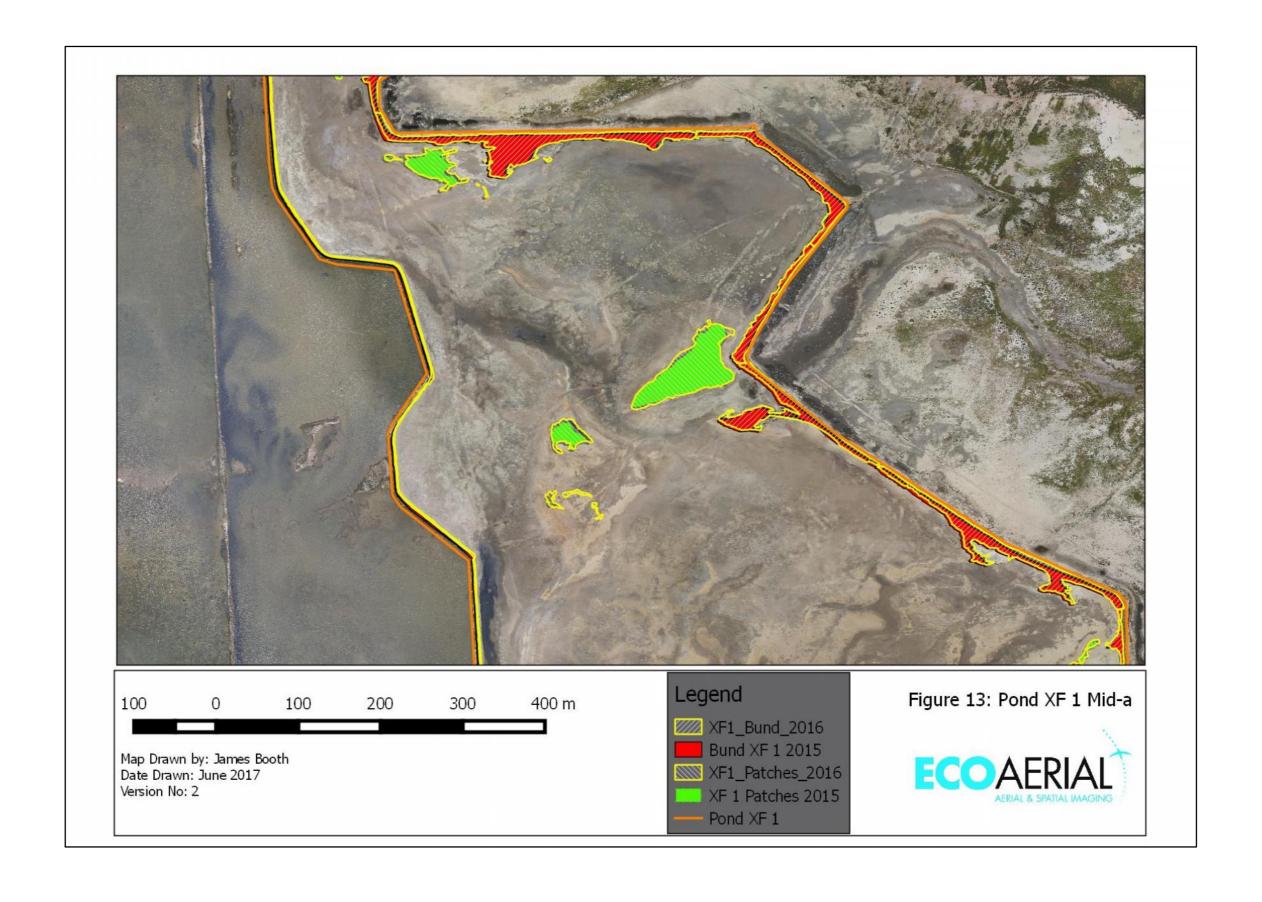


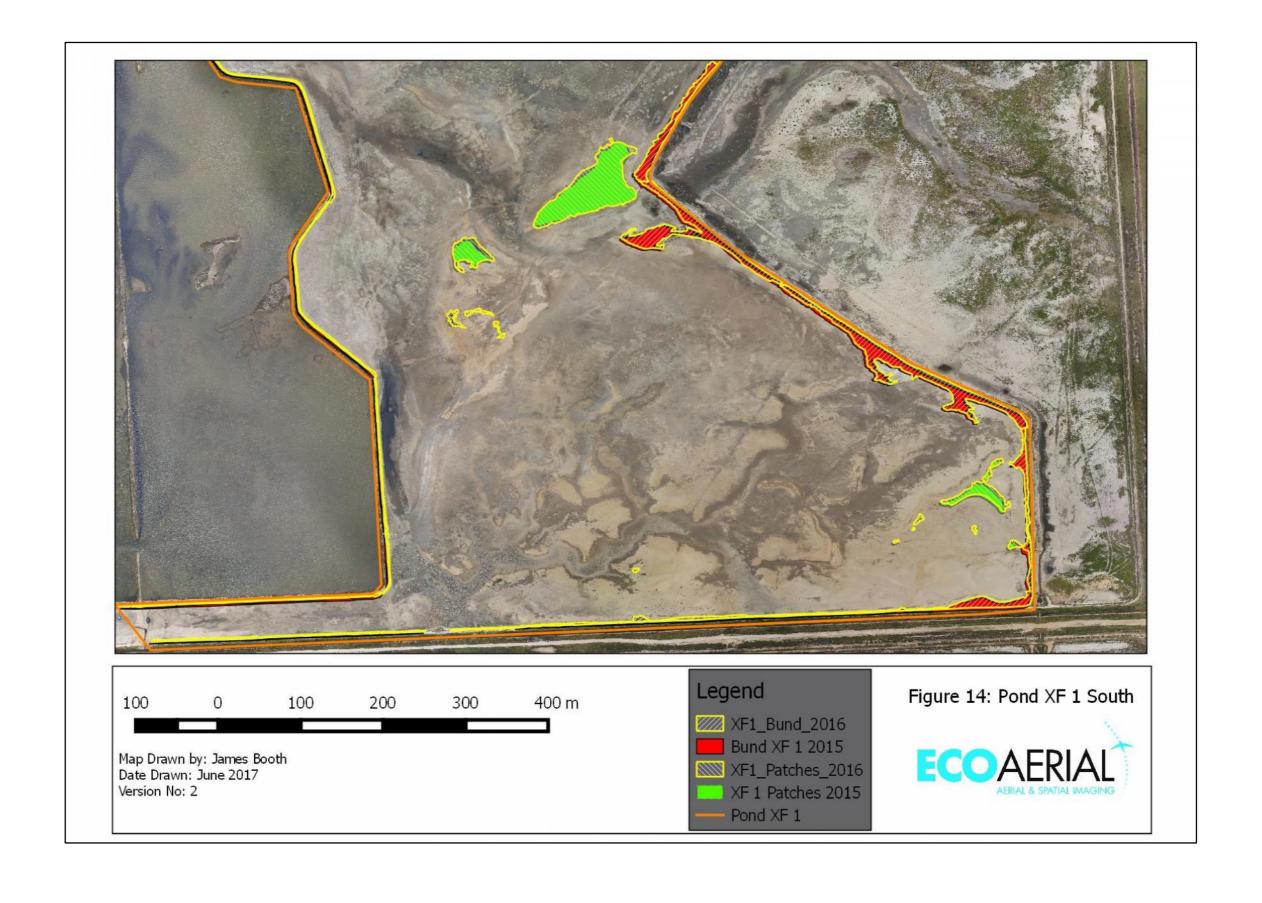


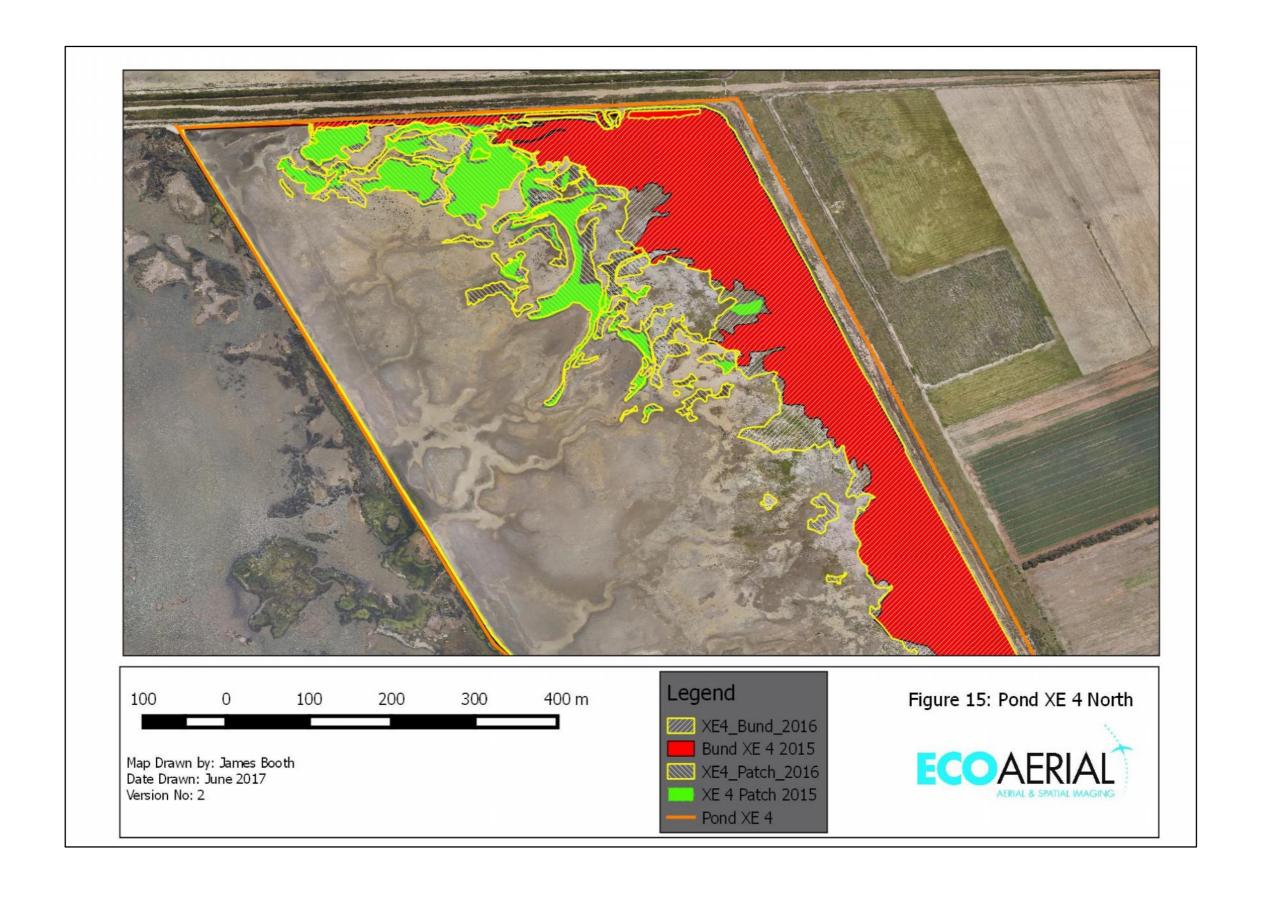


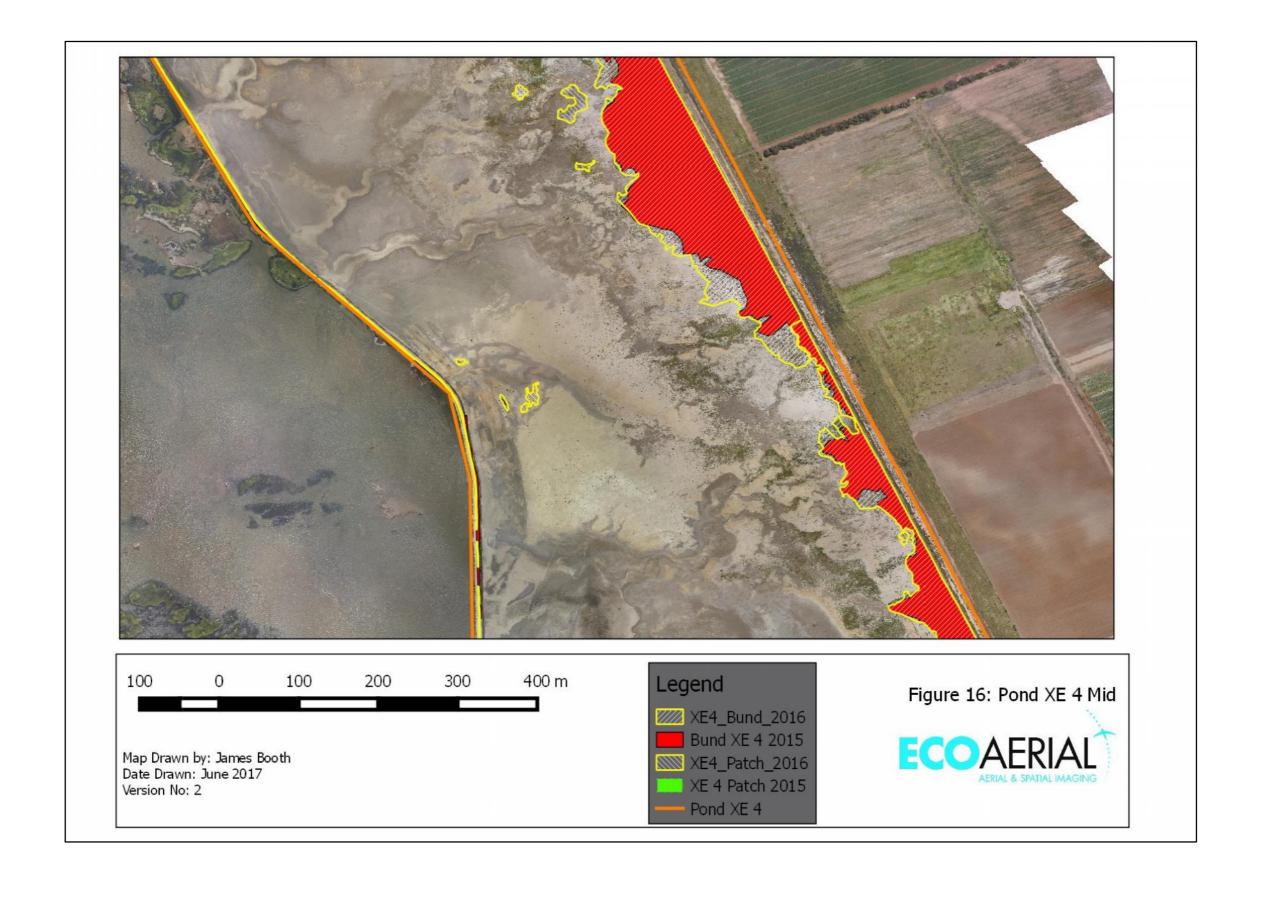


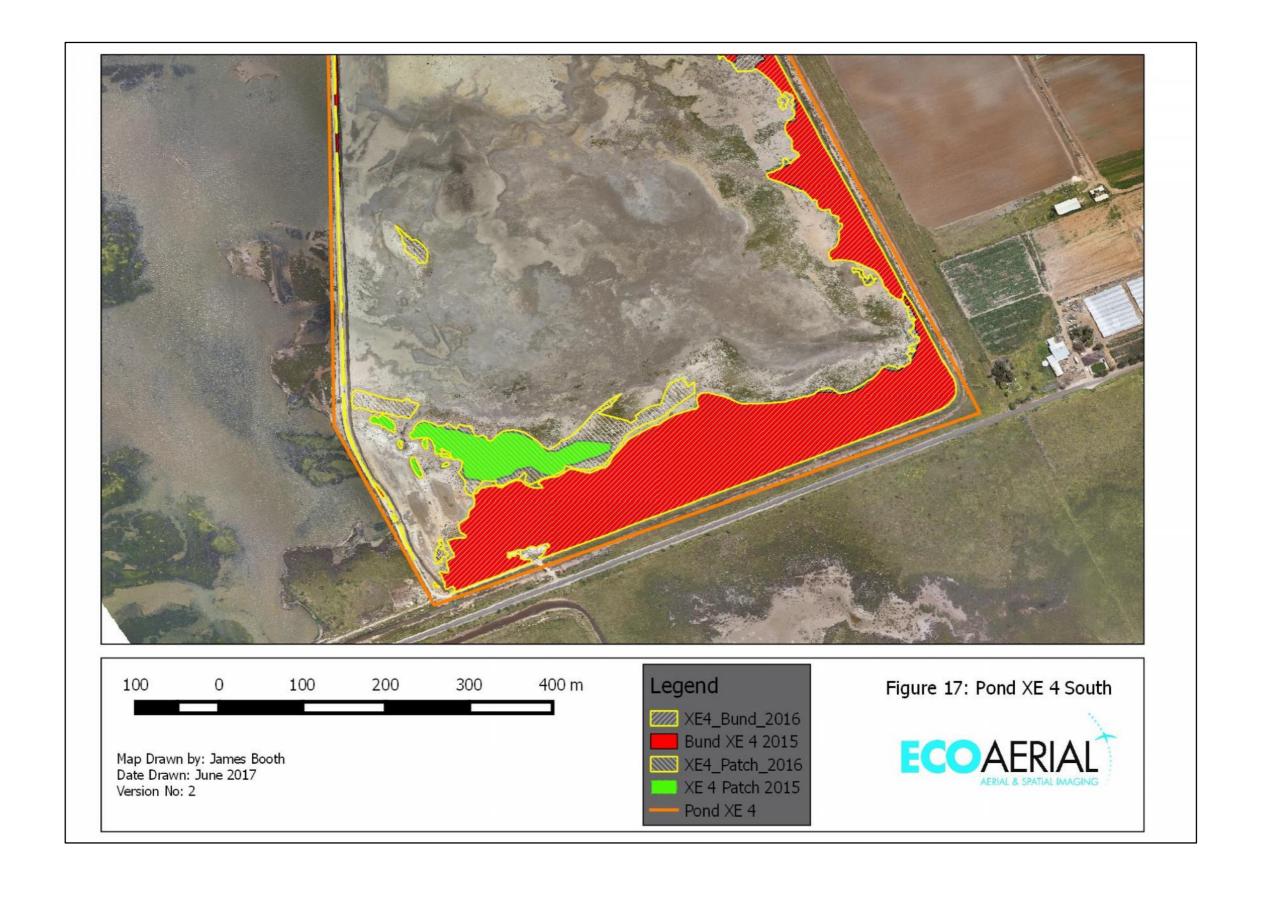




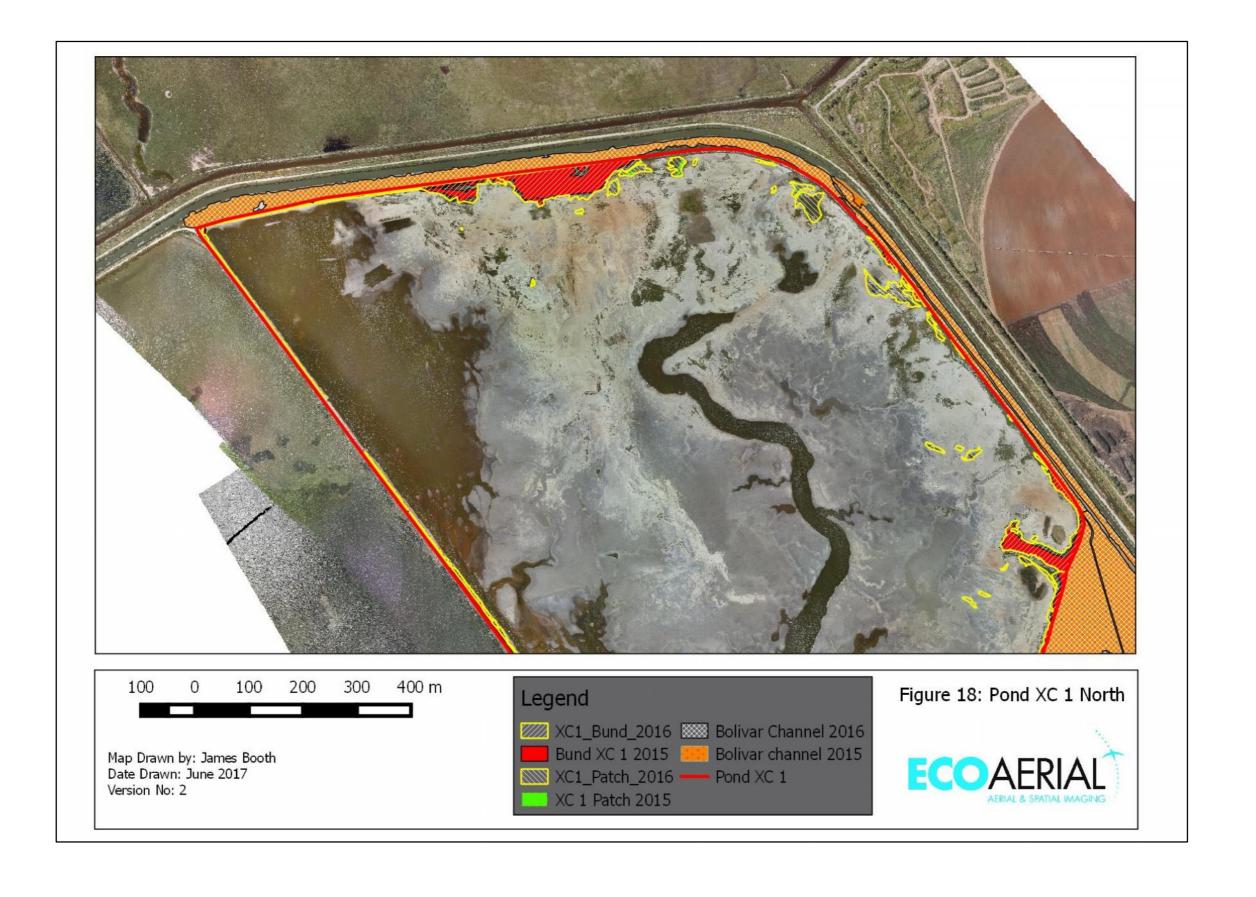


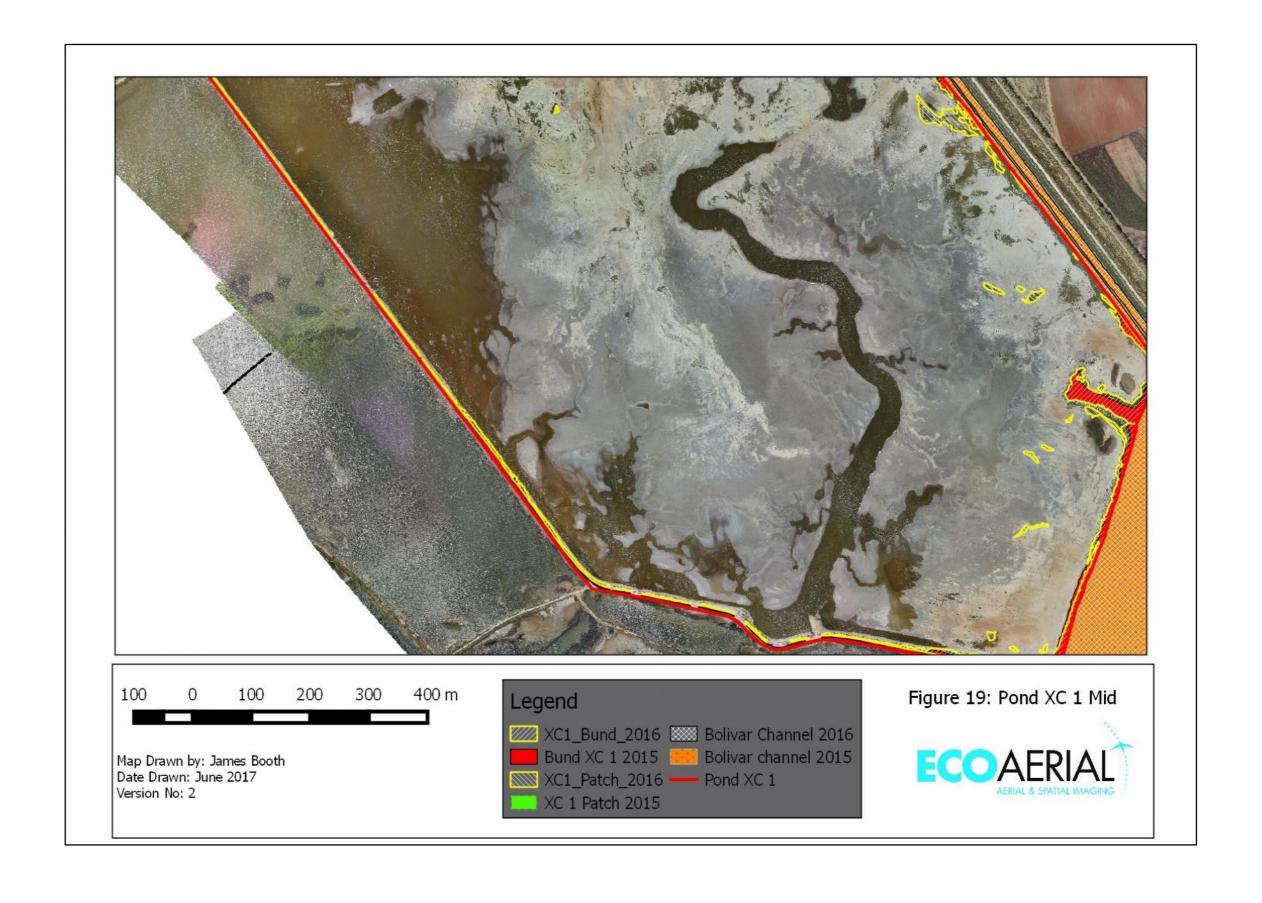


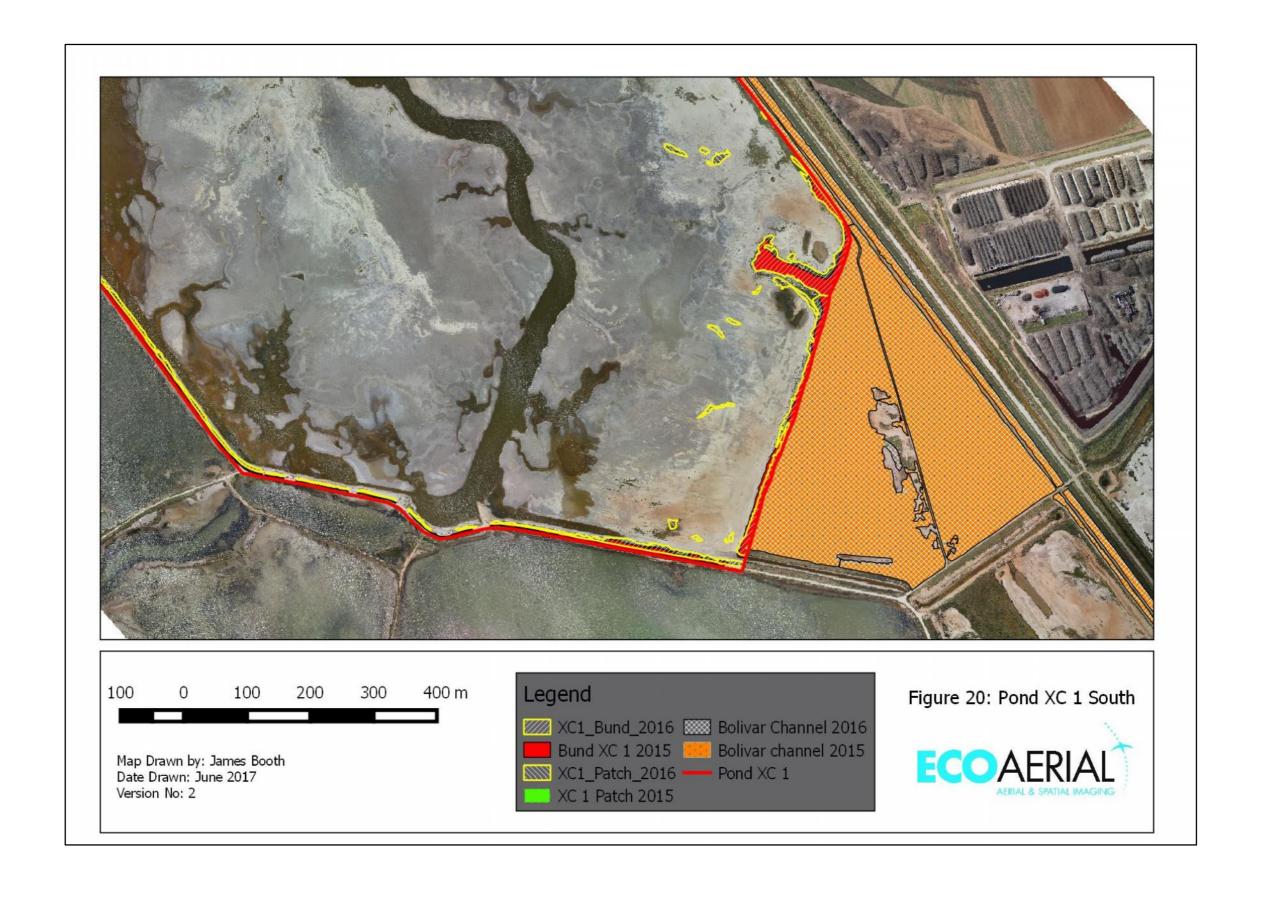


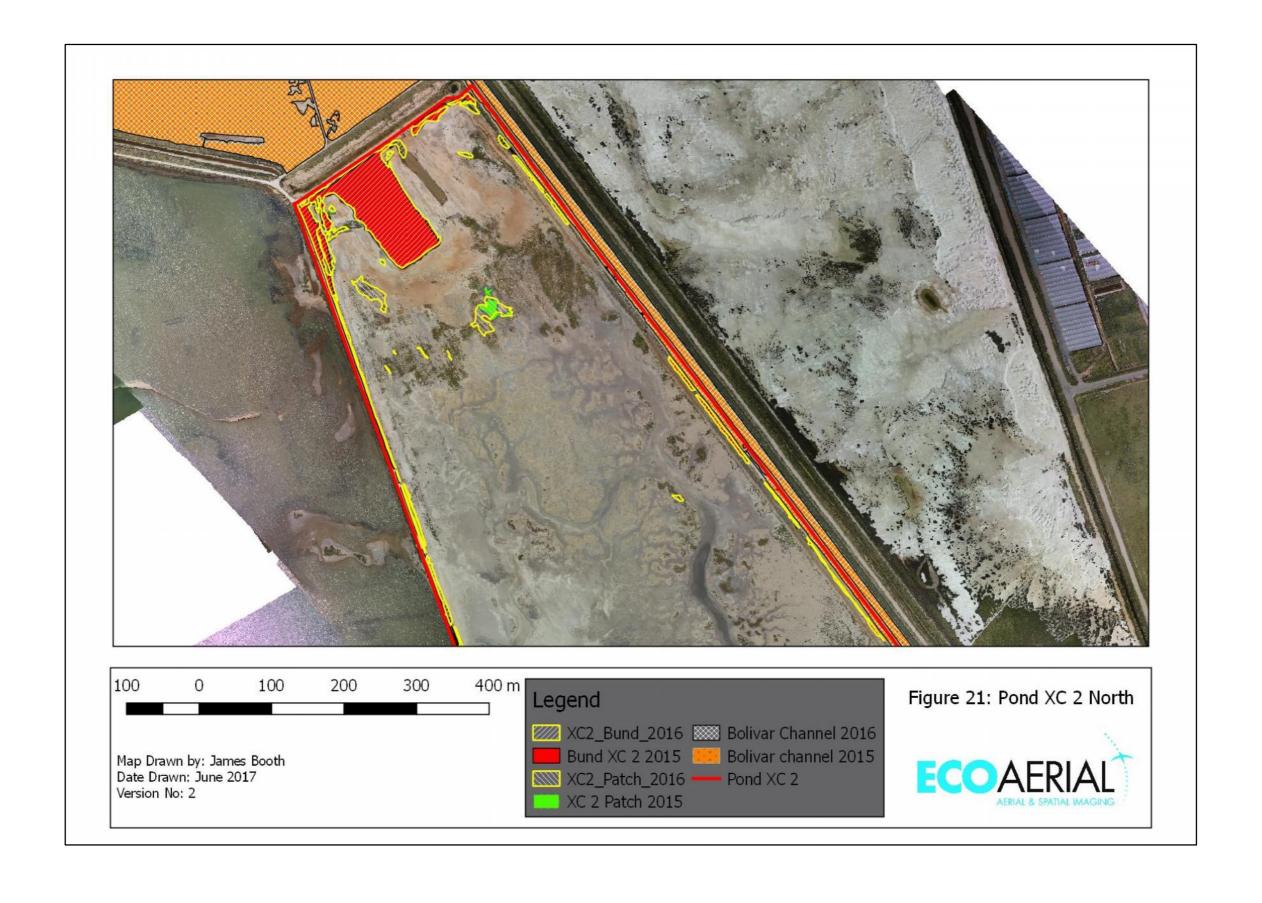


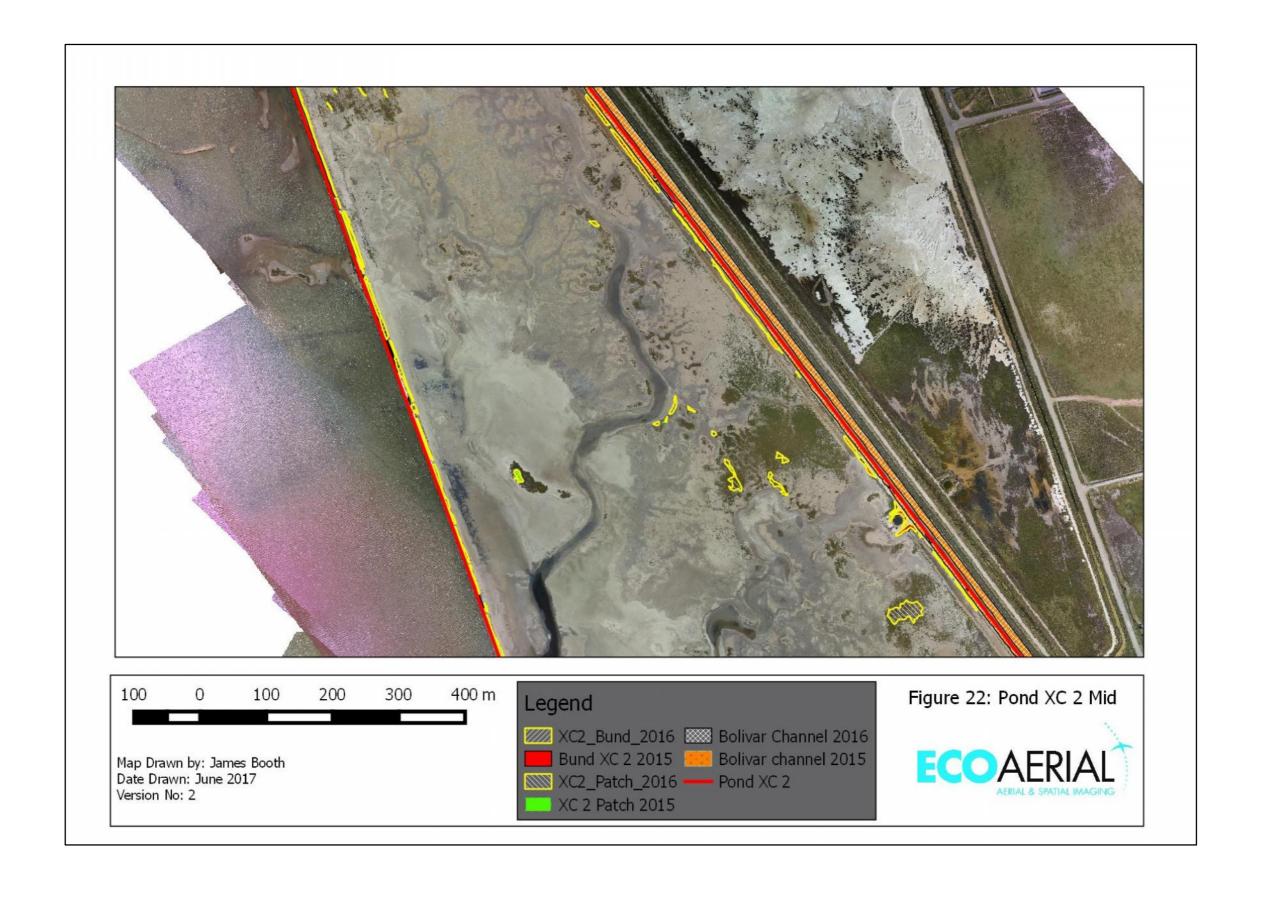
3.6 Vegetation Maps - Port Gawler (Section 3)

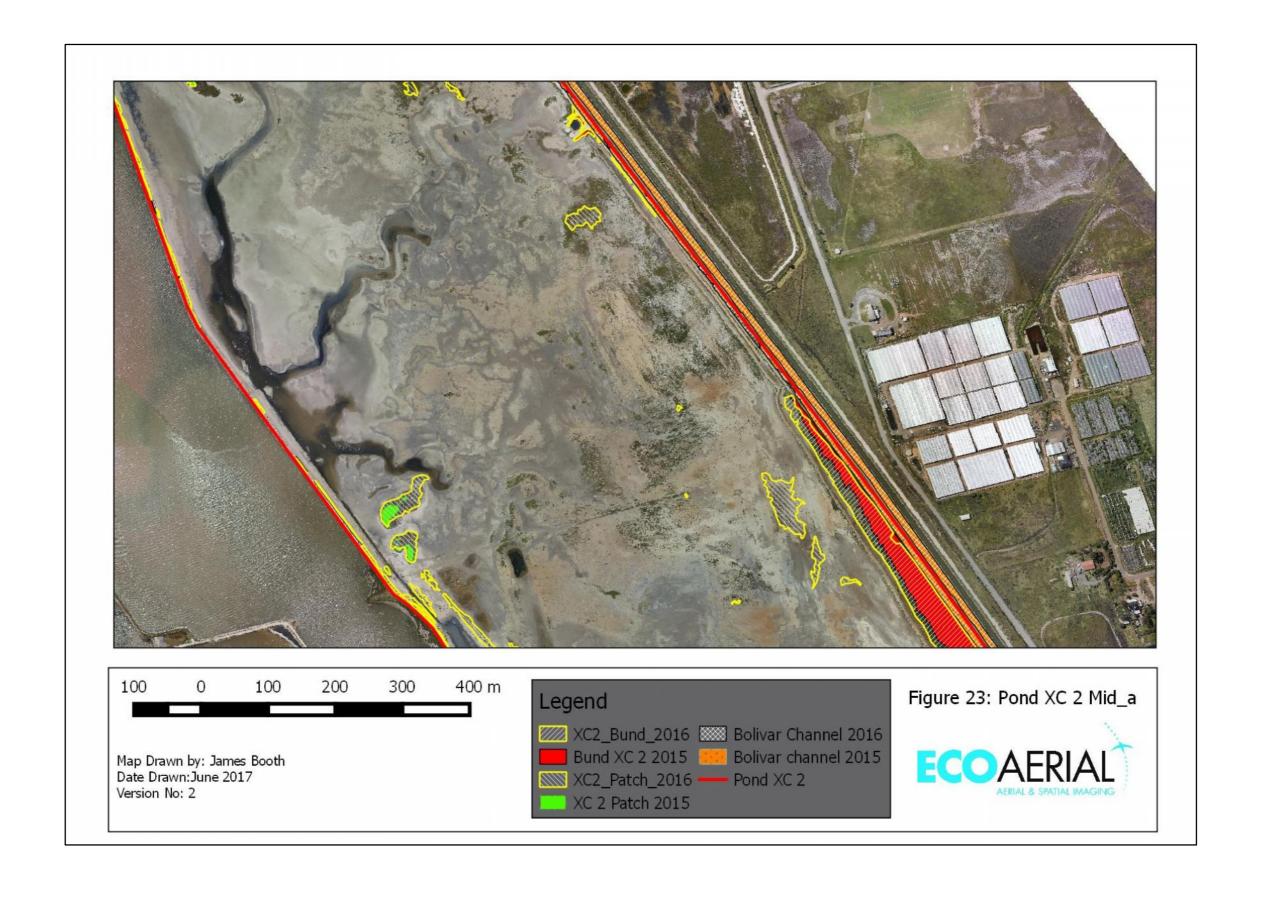


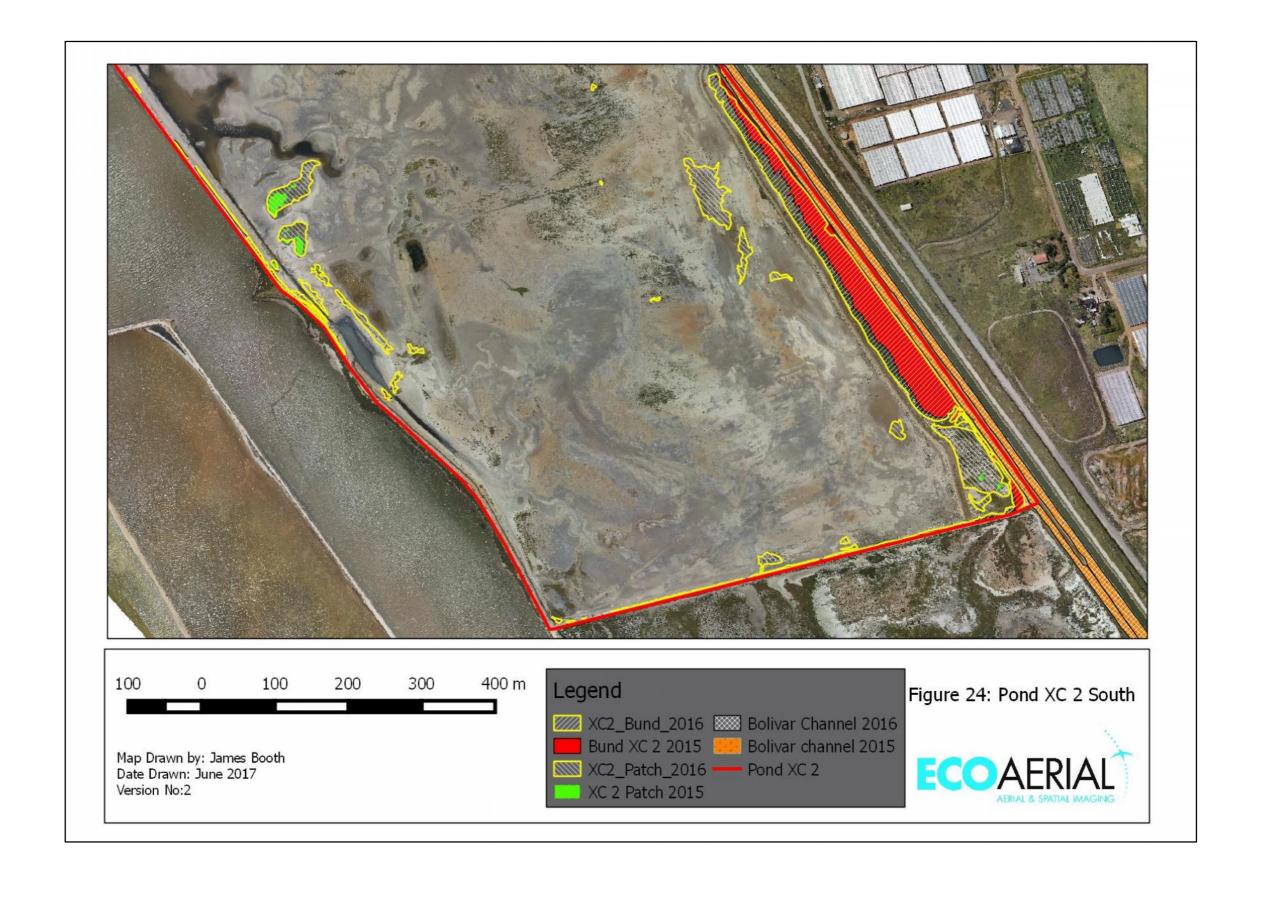


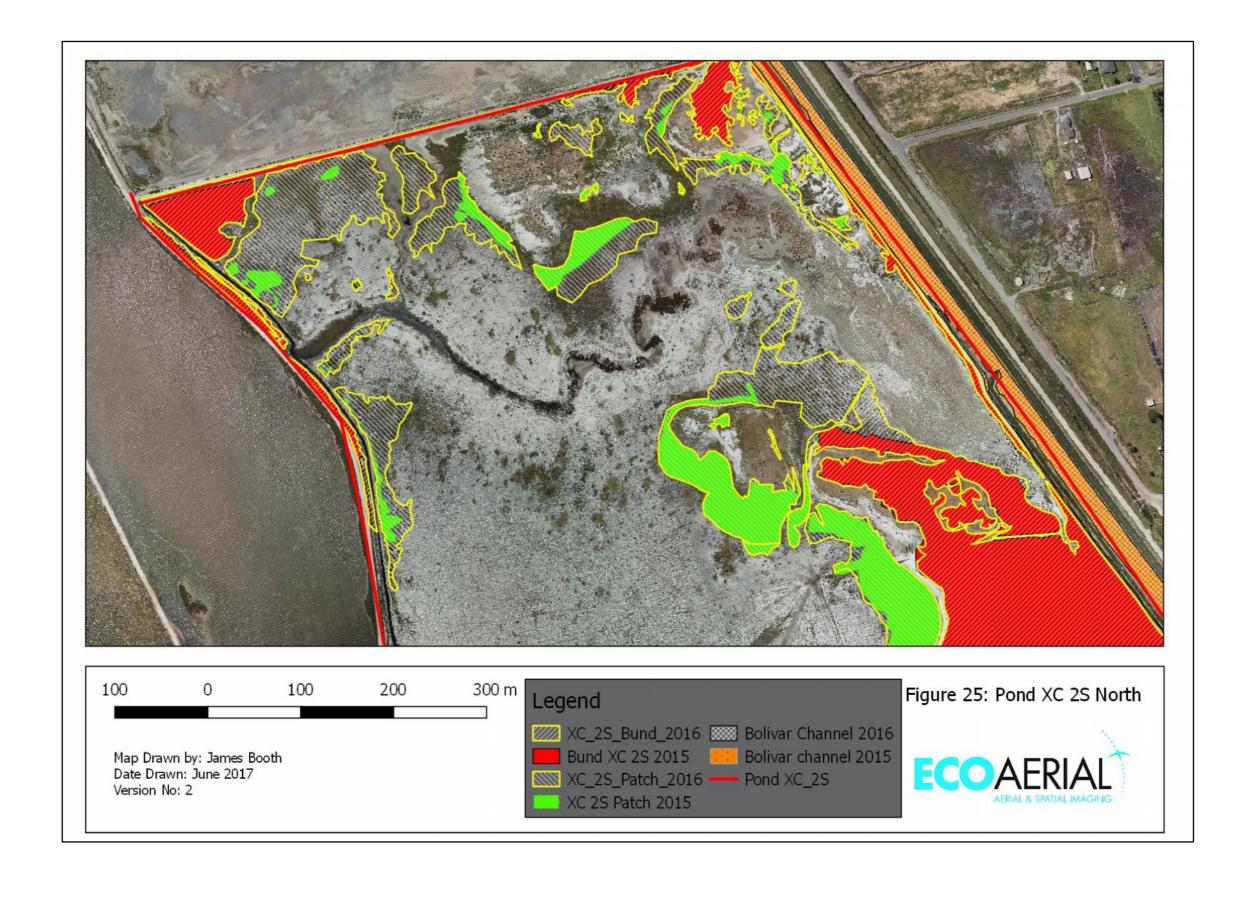


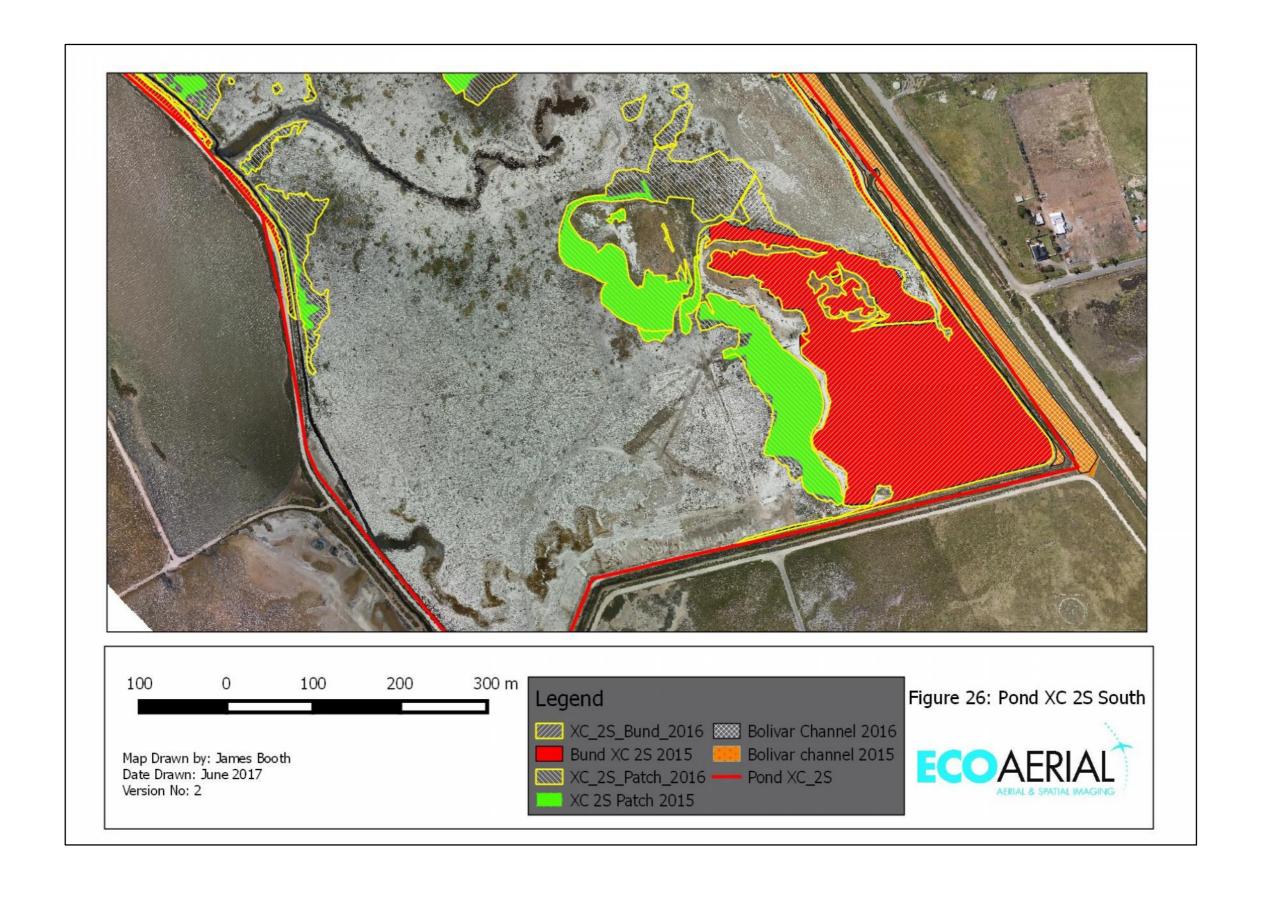


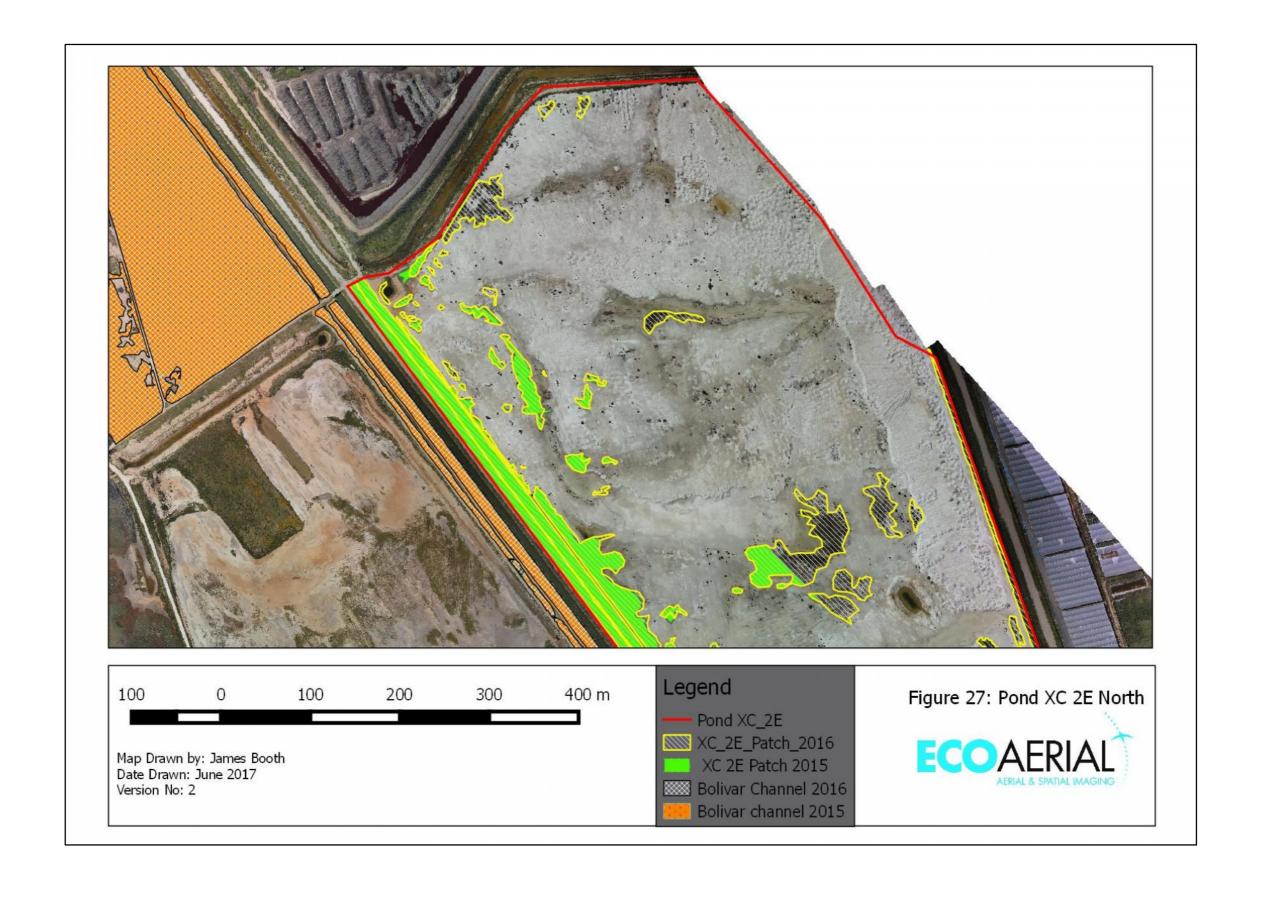


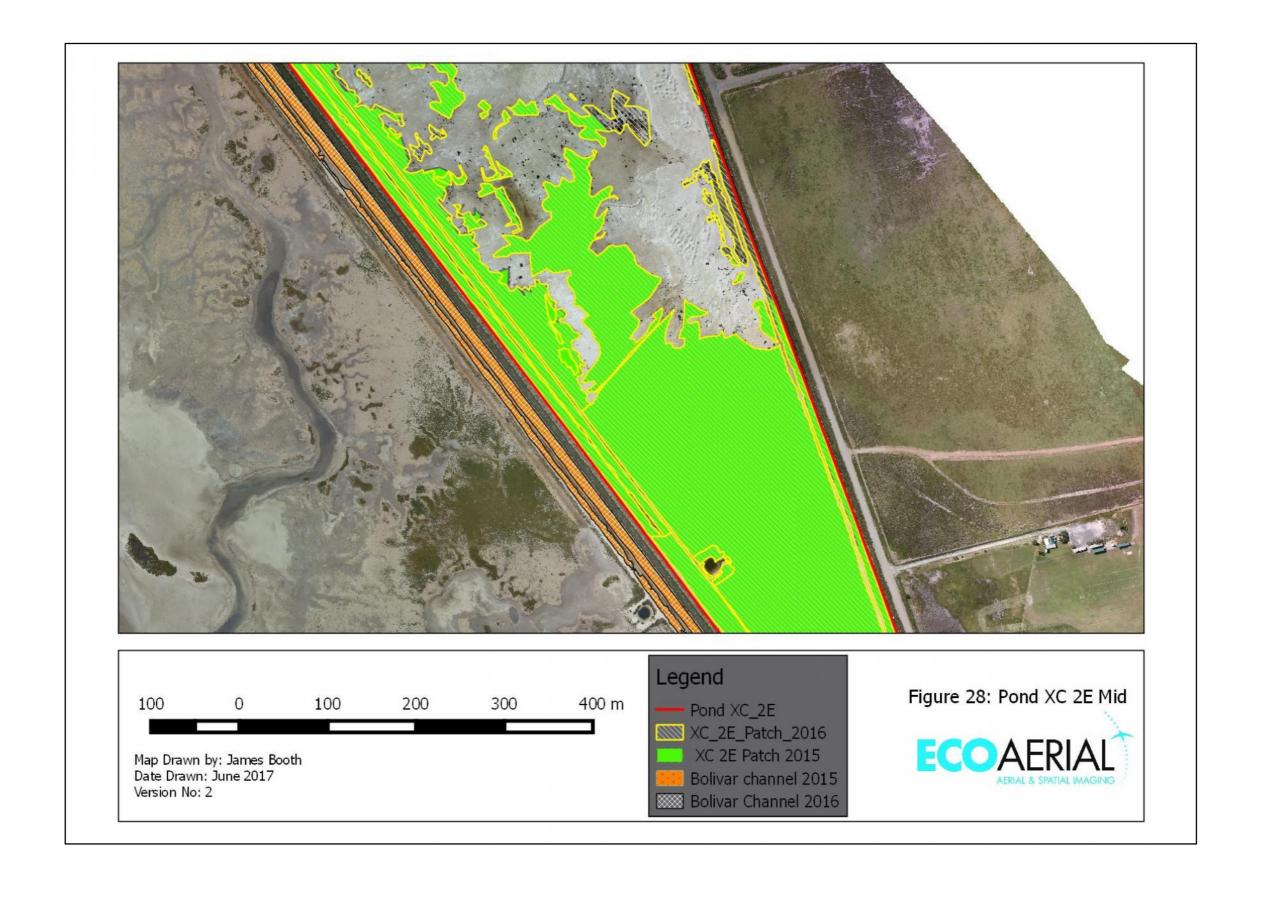


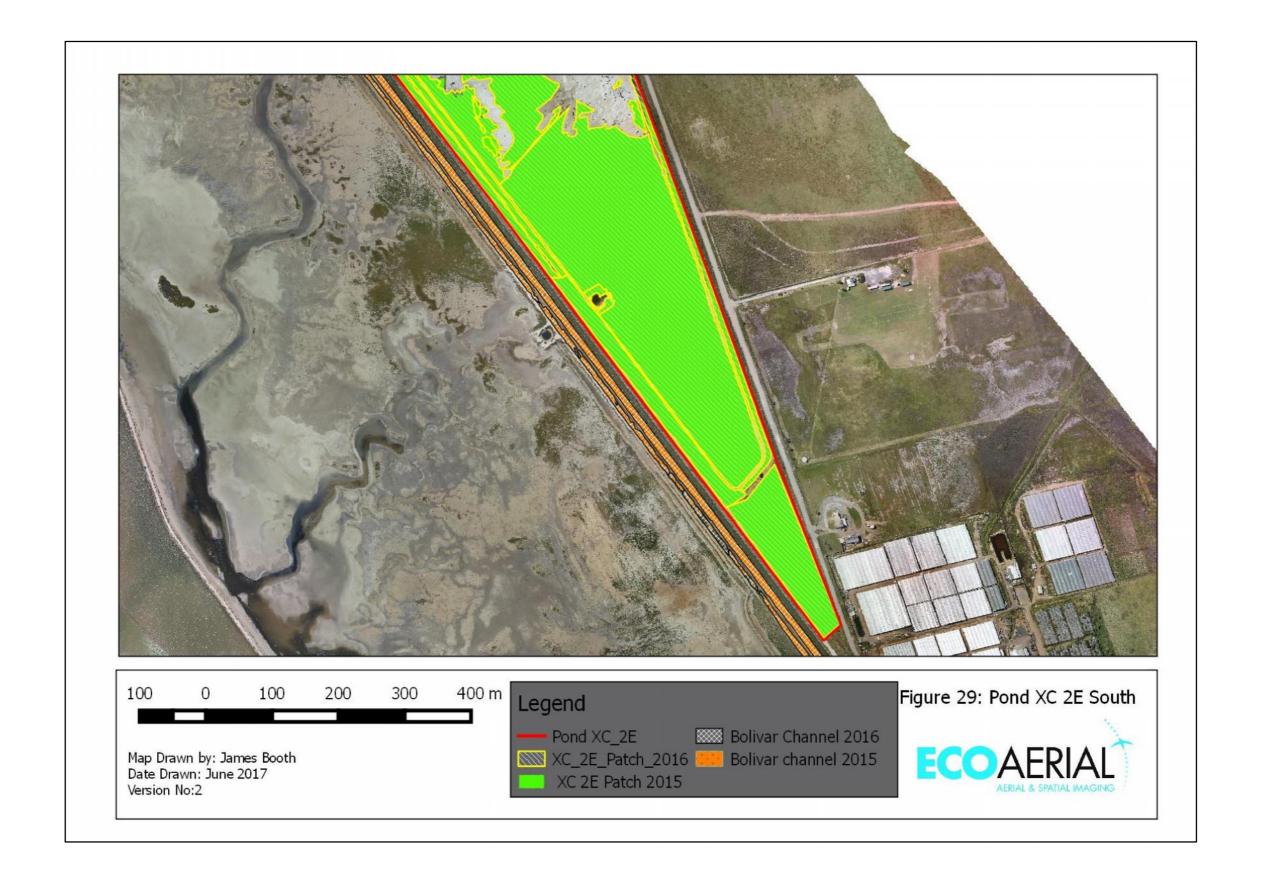




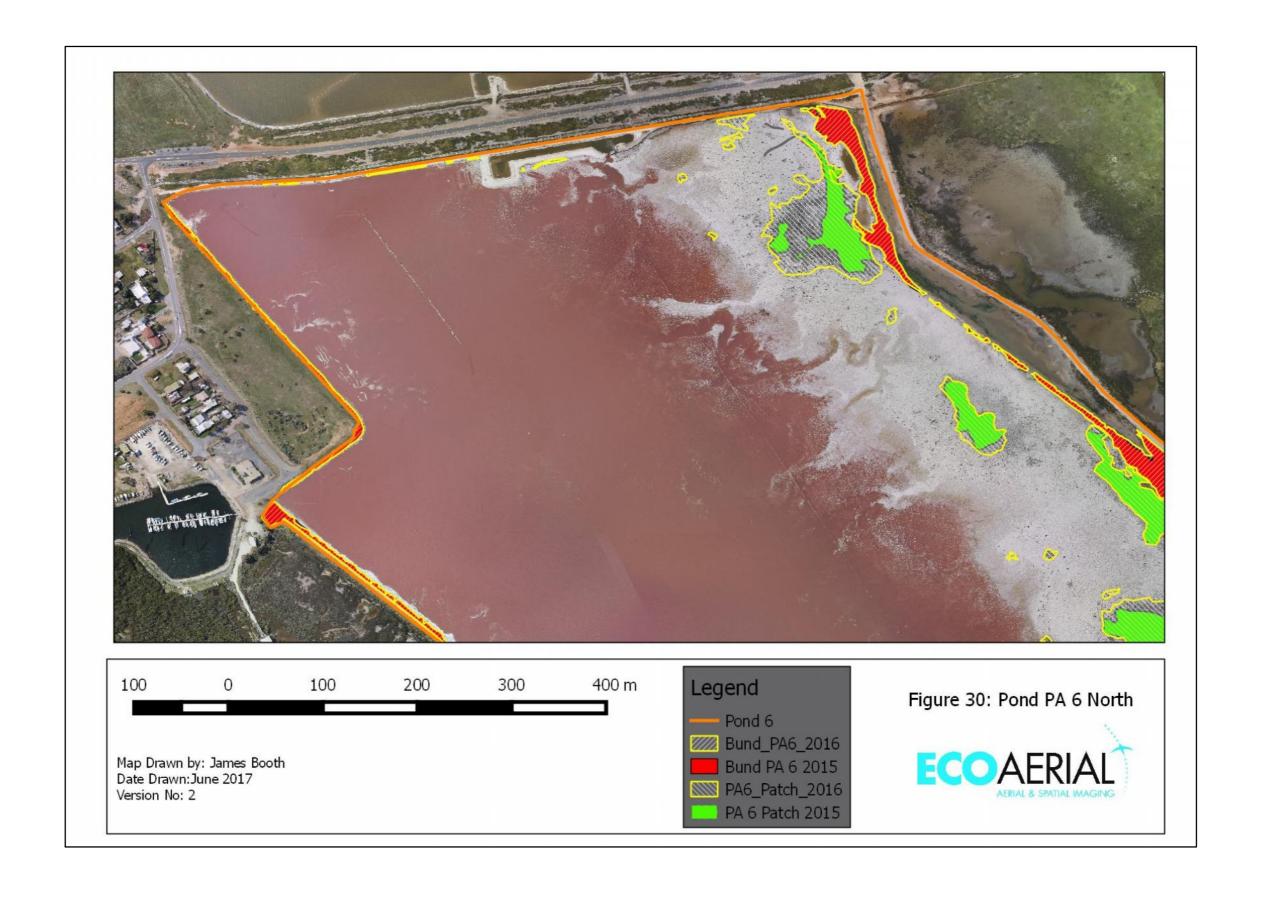


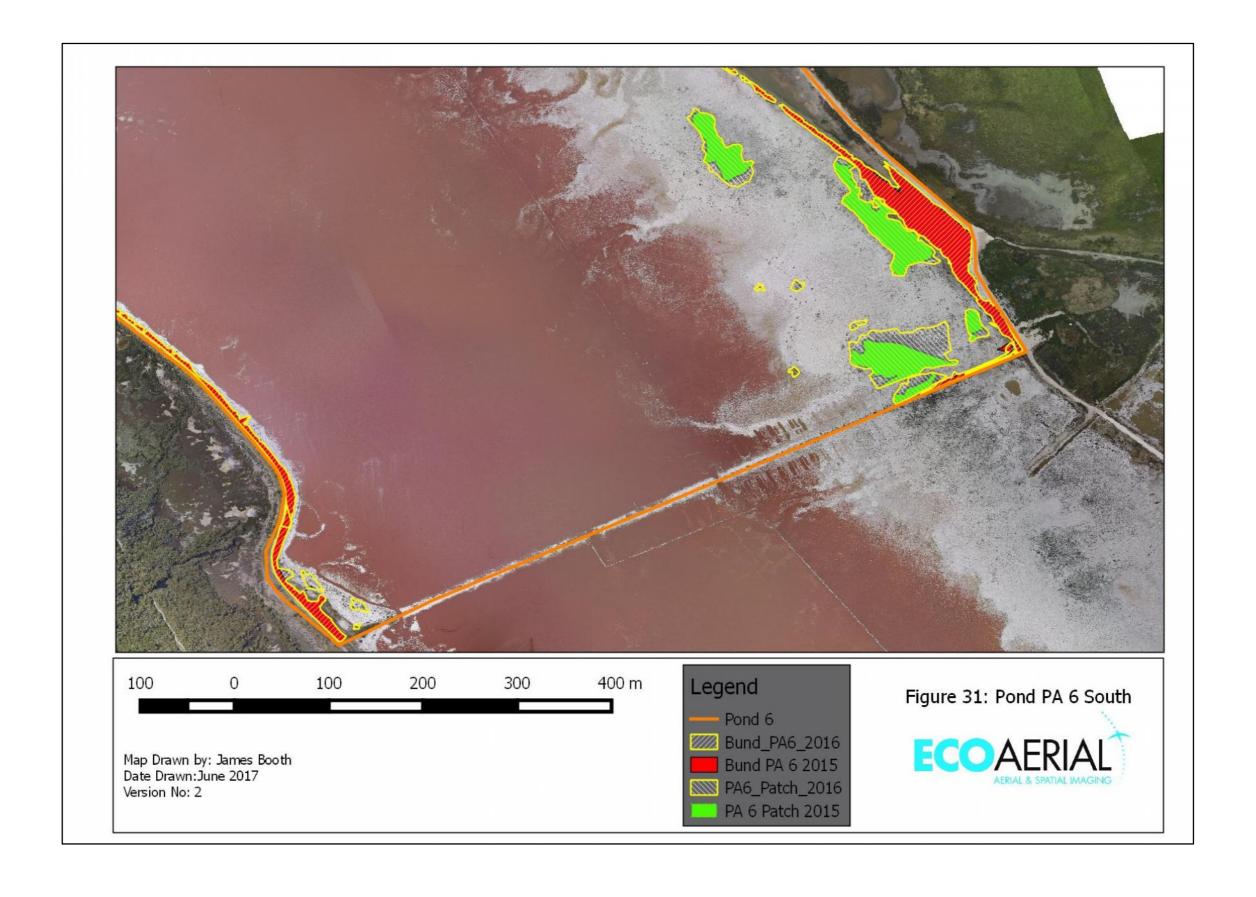


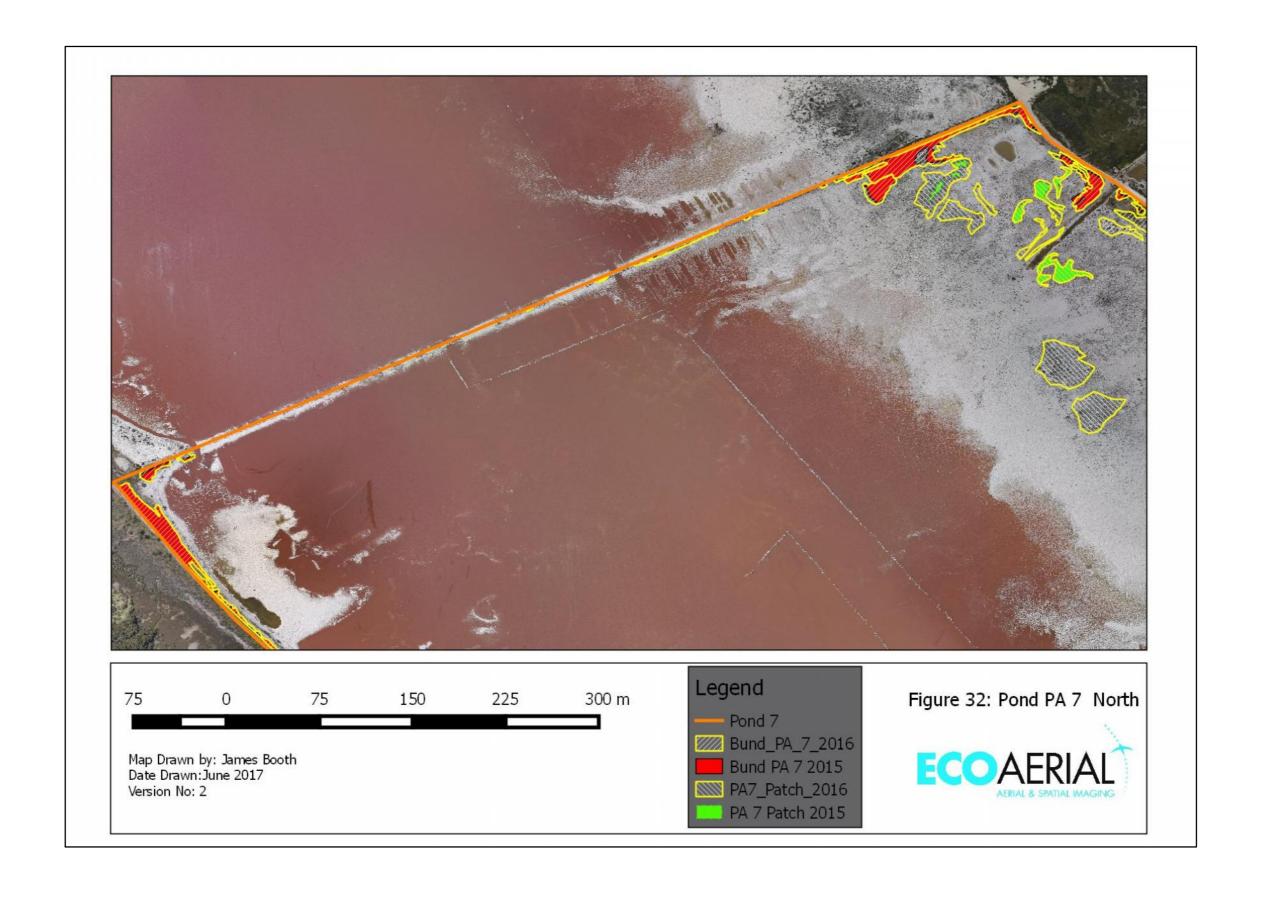


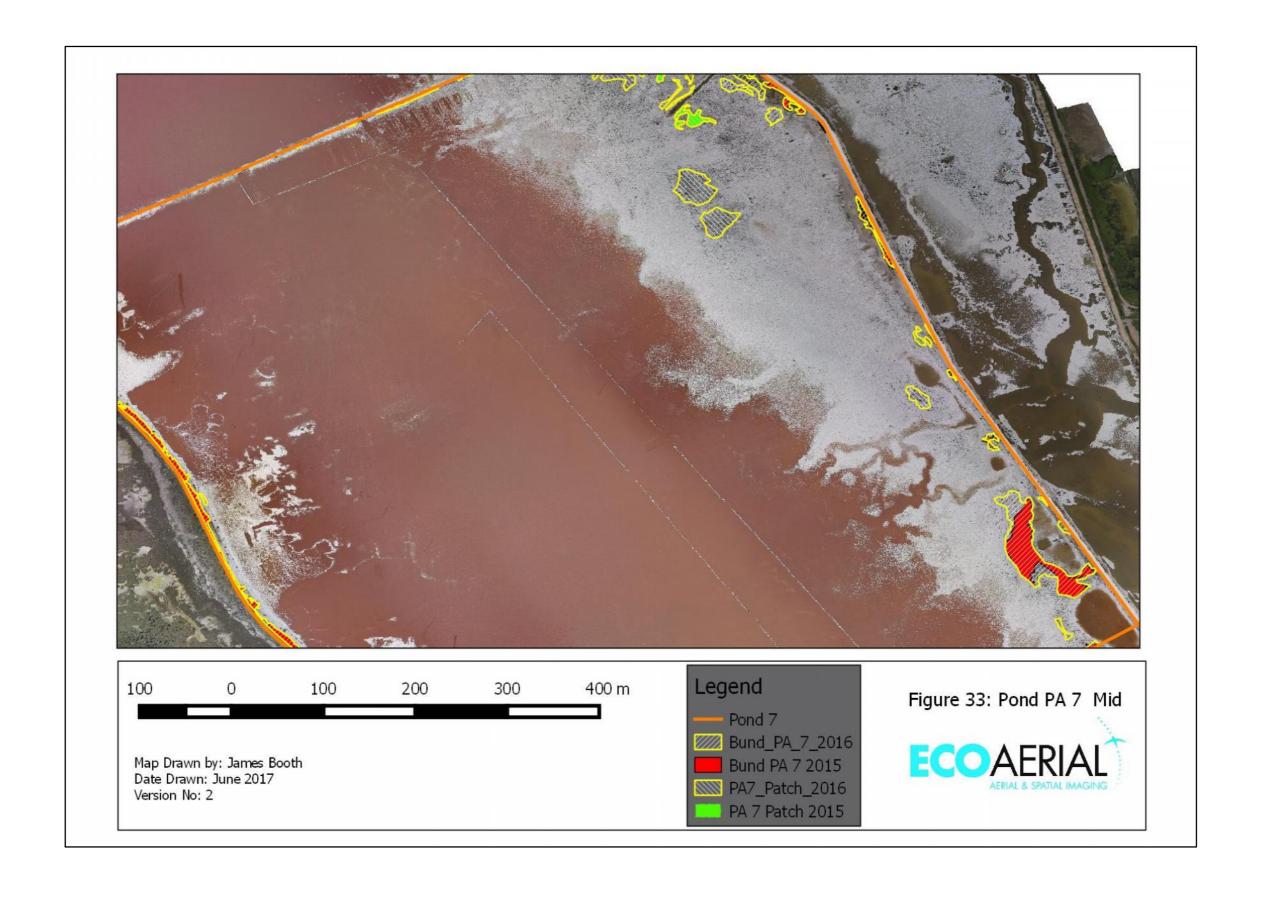


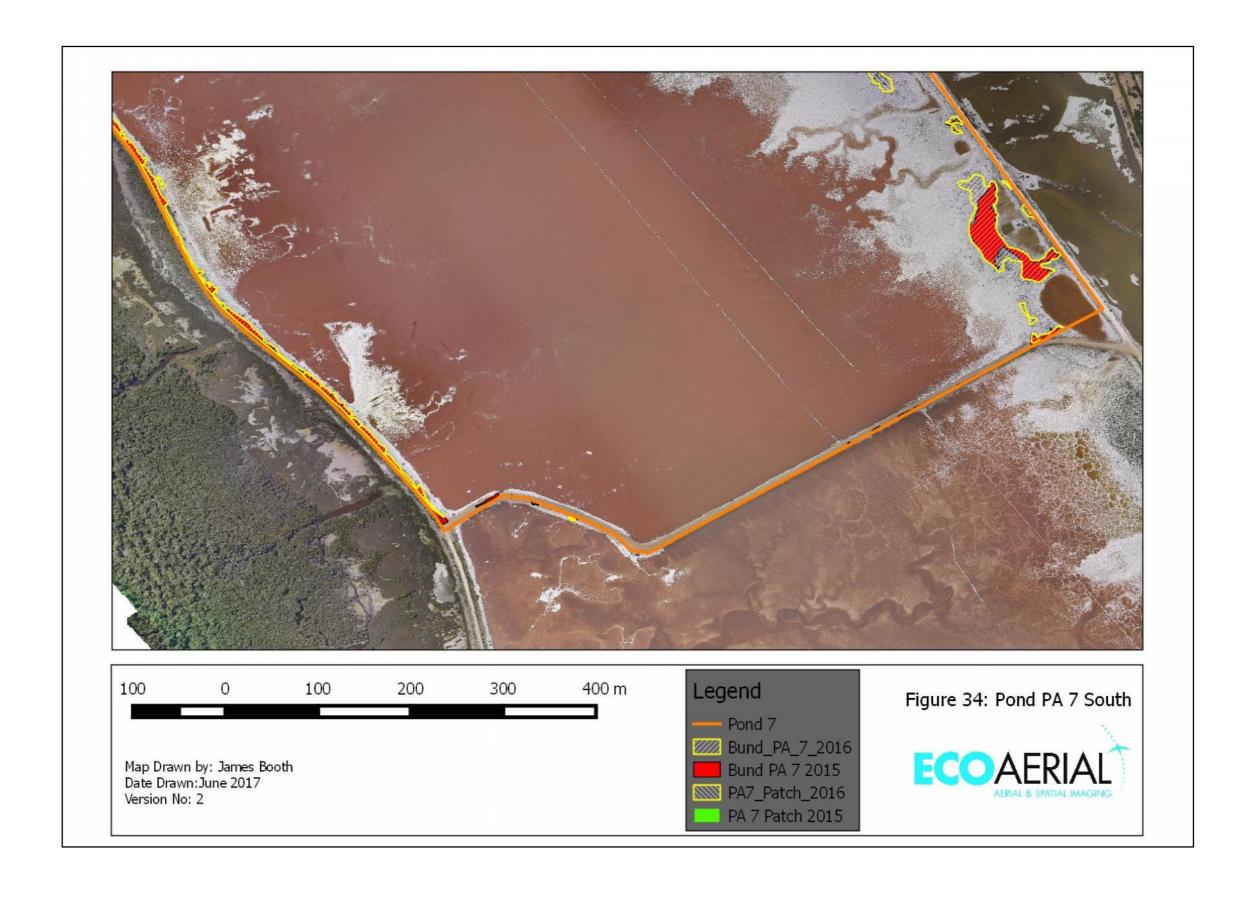
3.7 Vegetation Maps - St Kilda (Section 2)

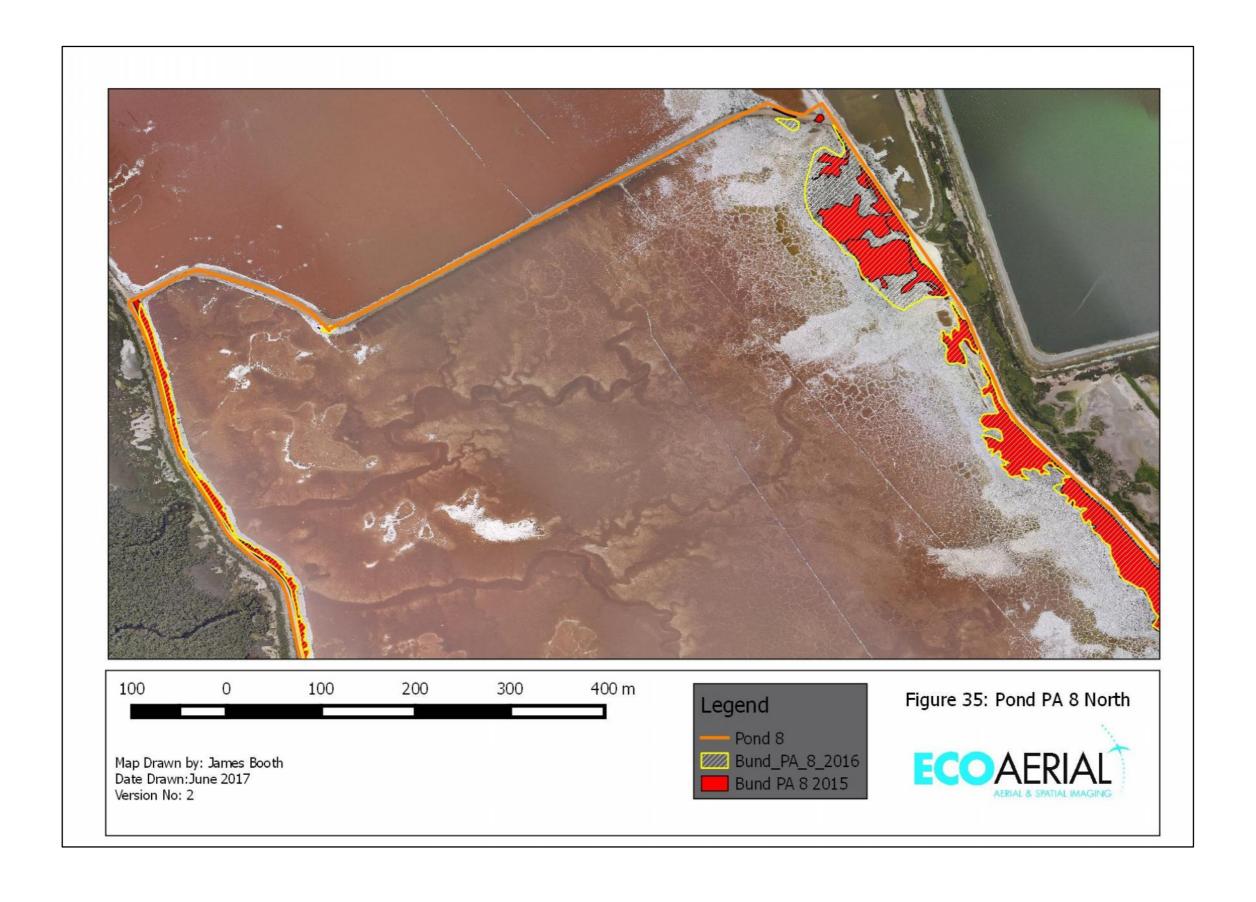


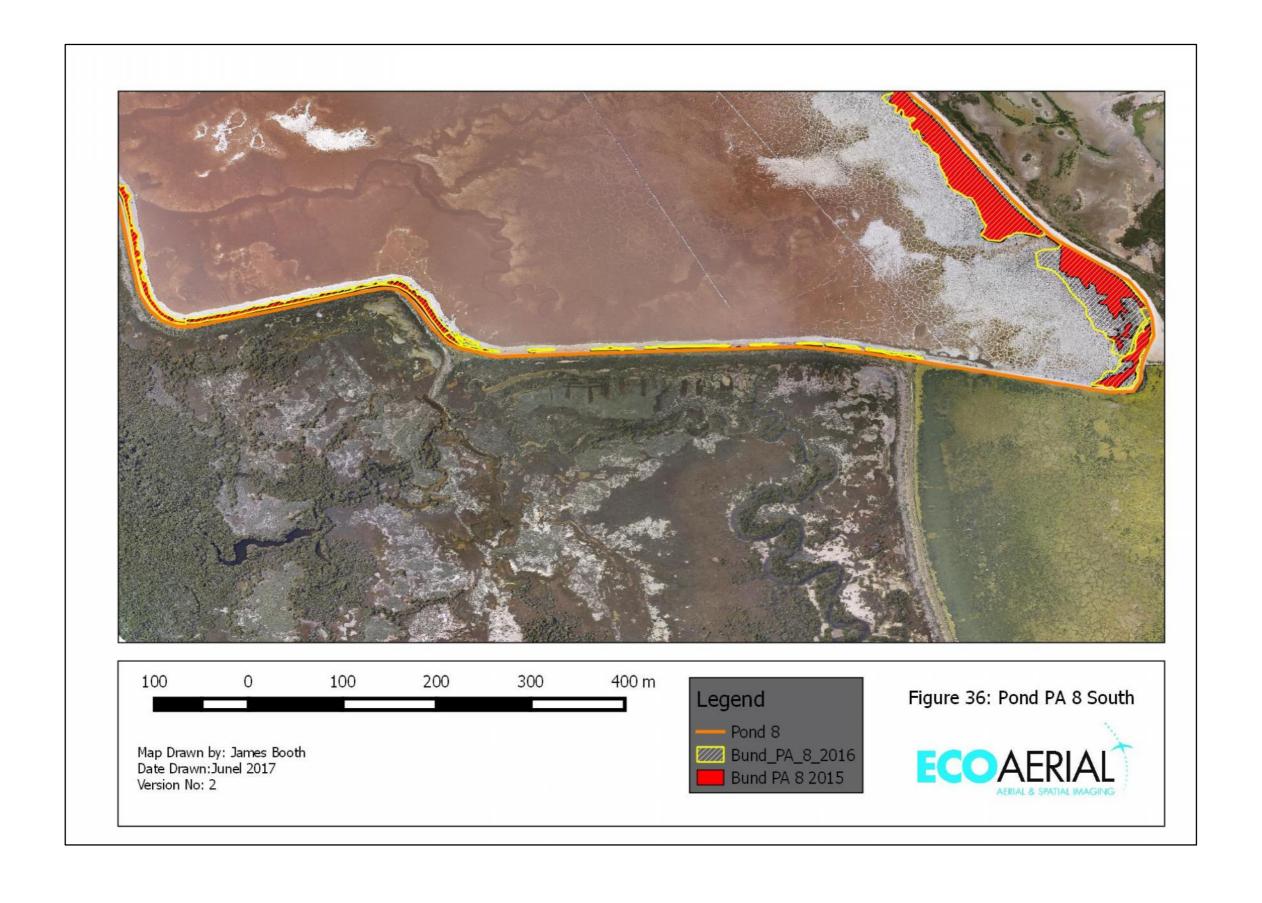


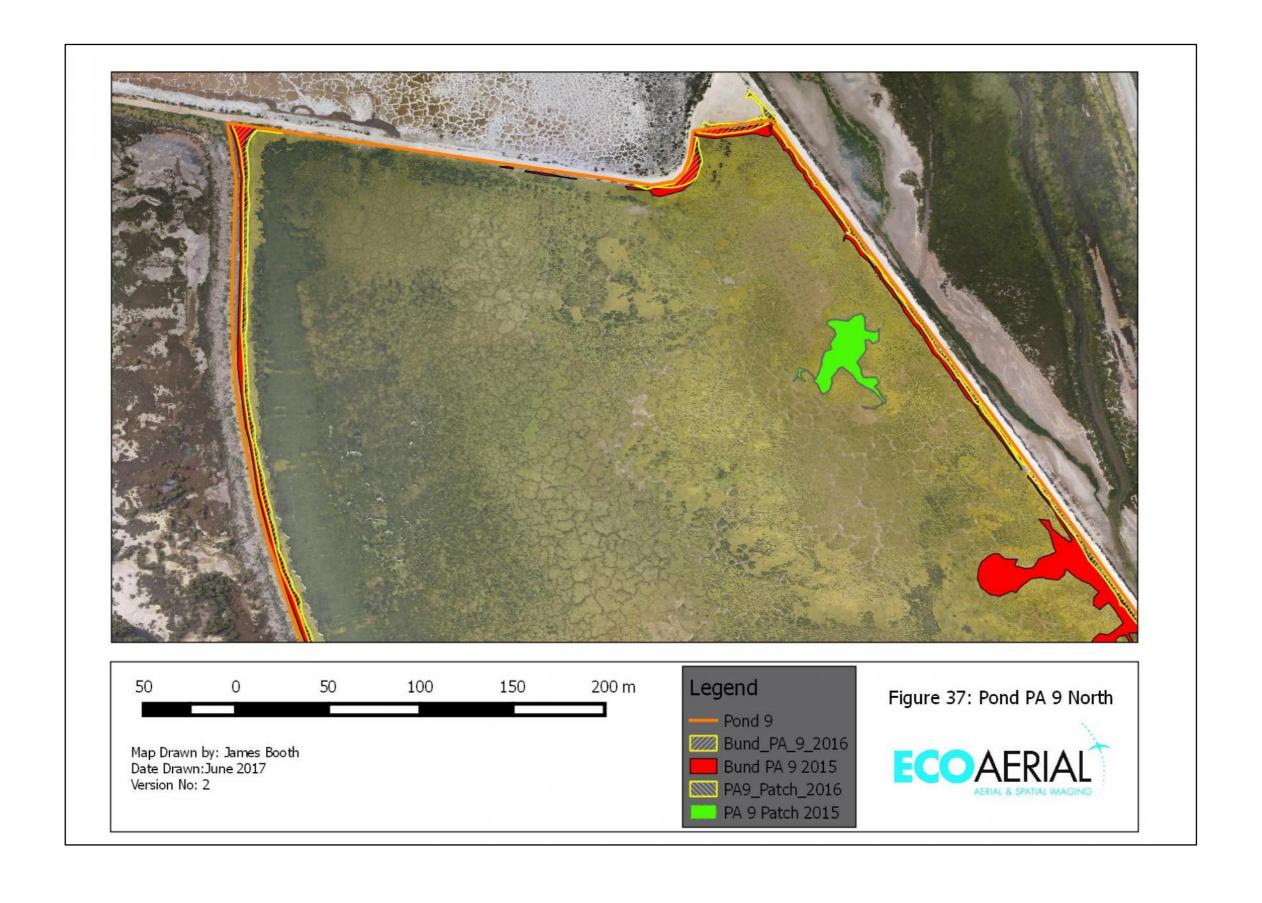


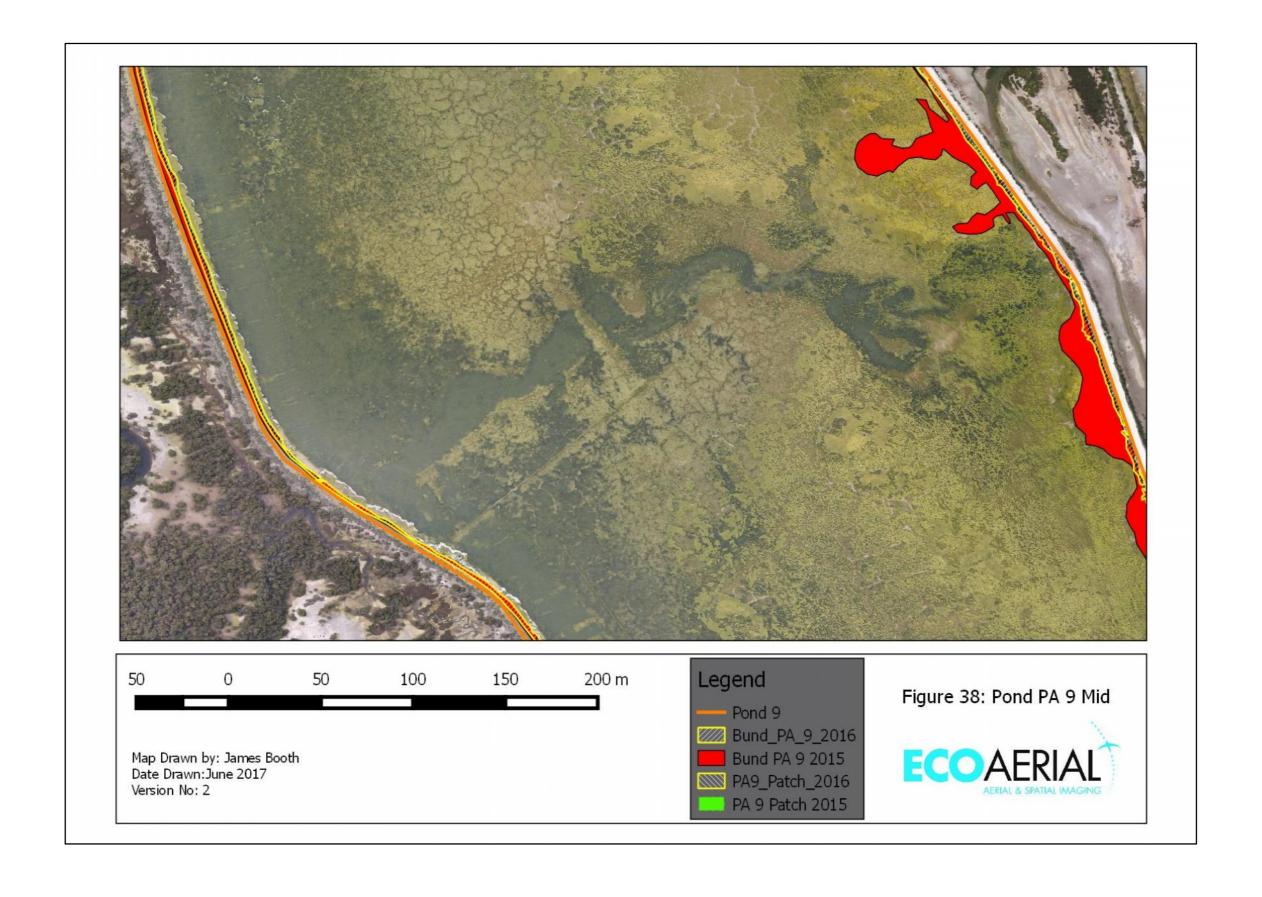


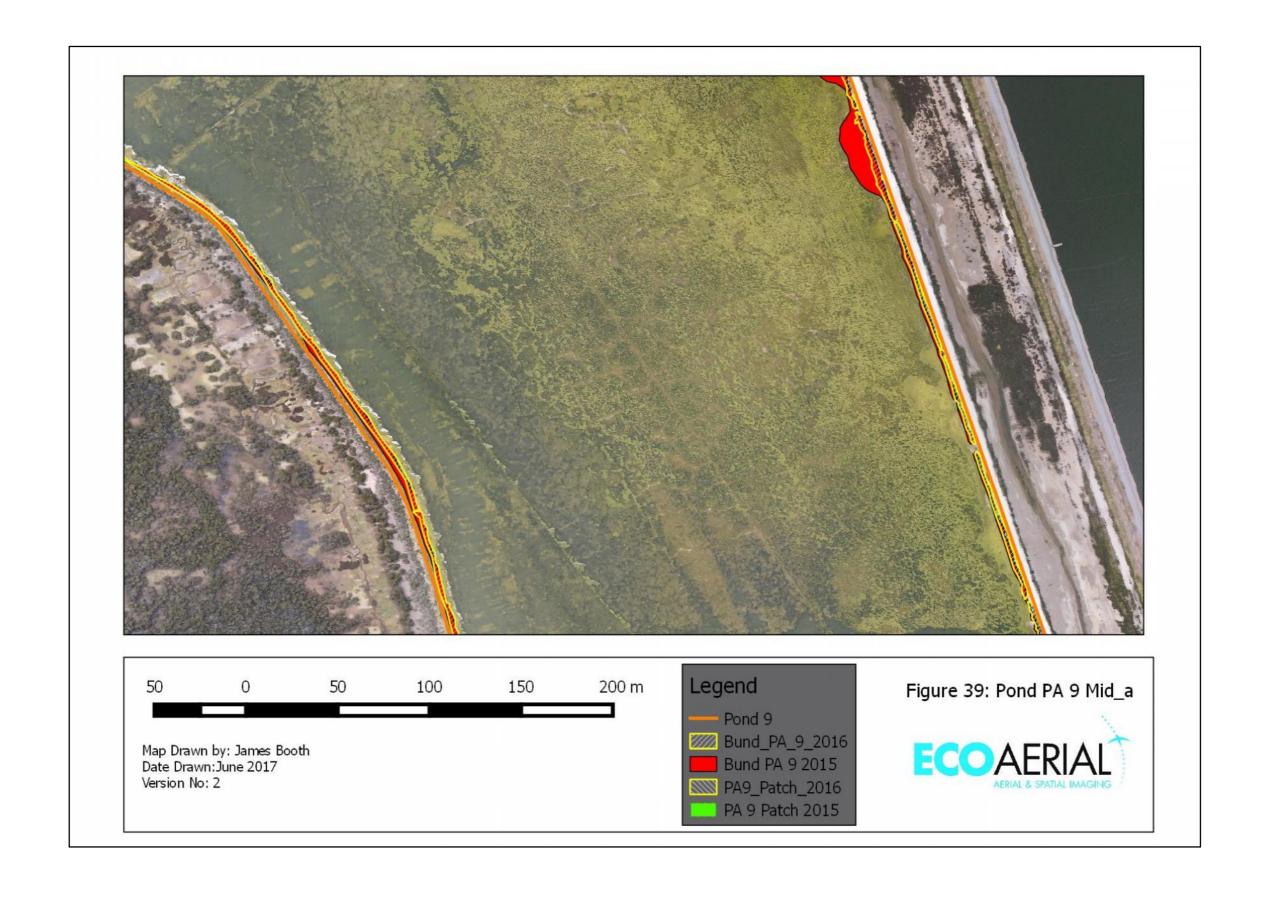


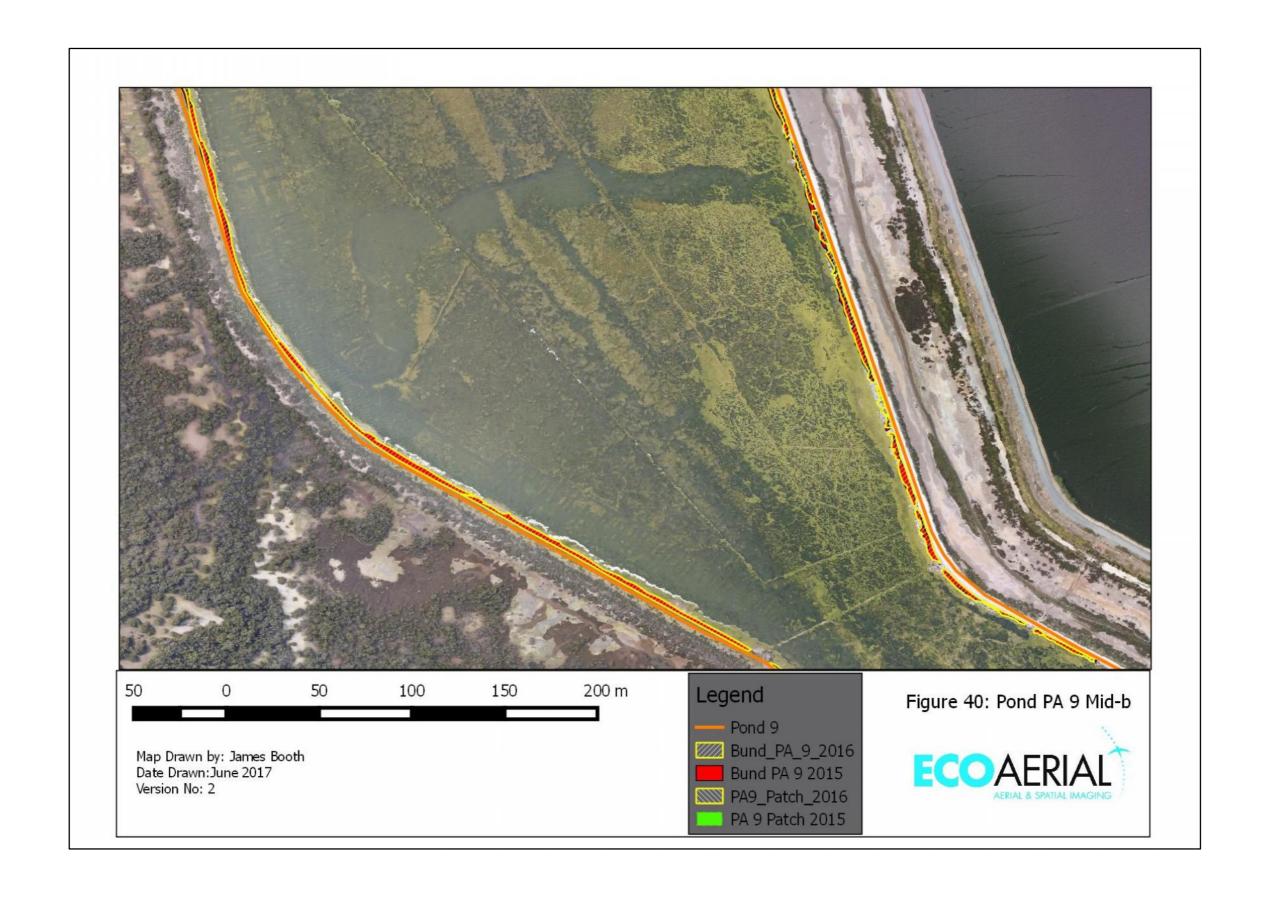


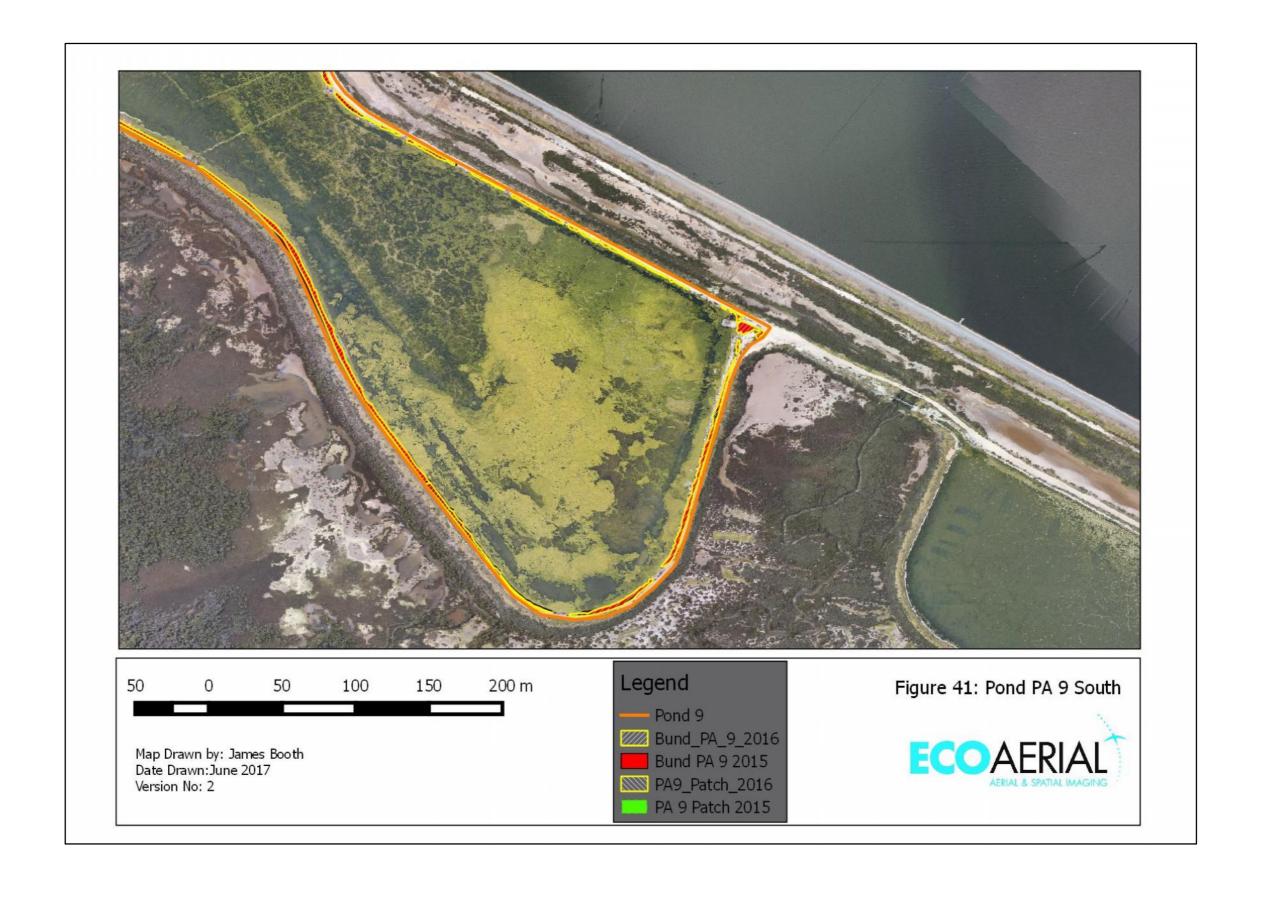


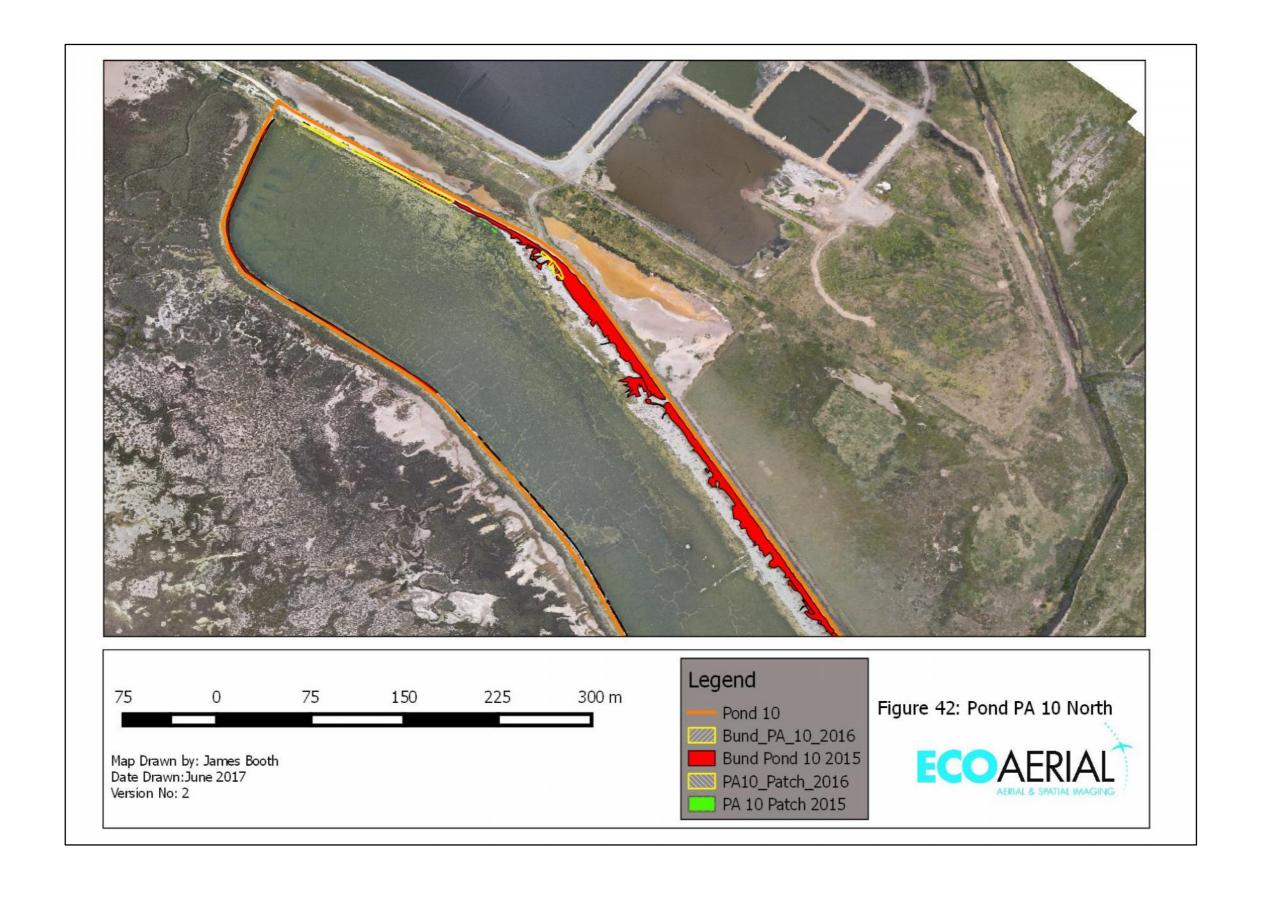


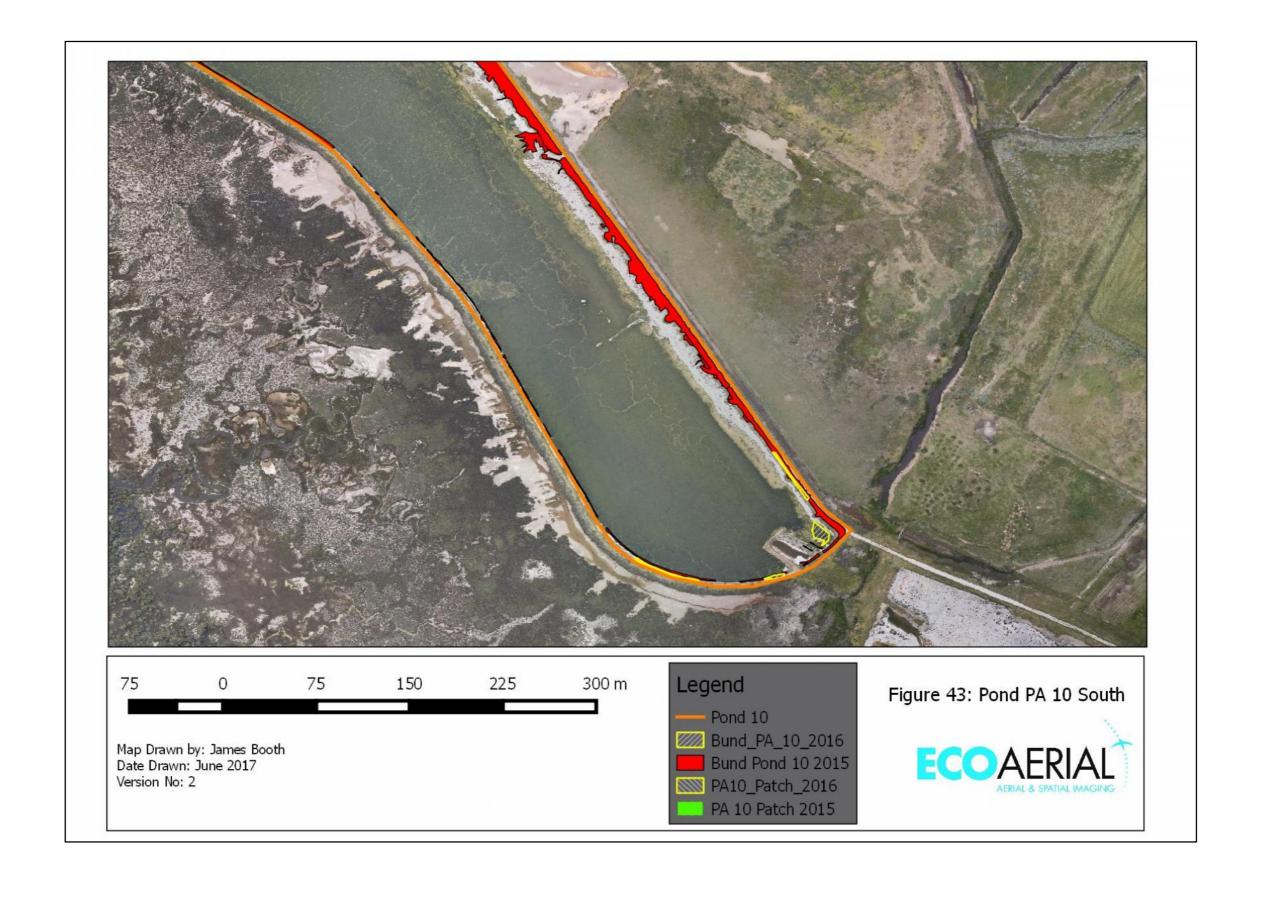


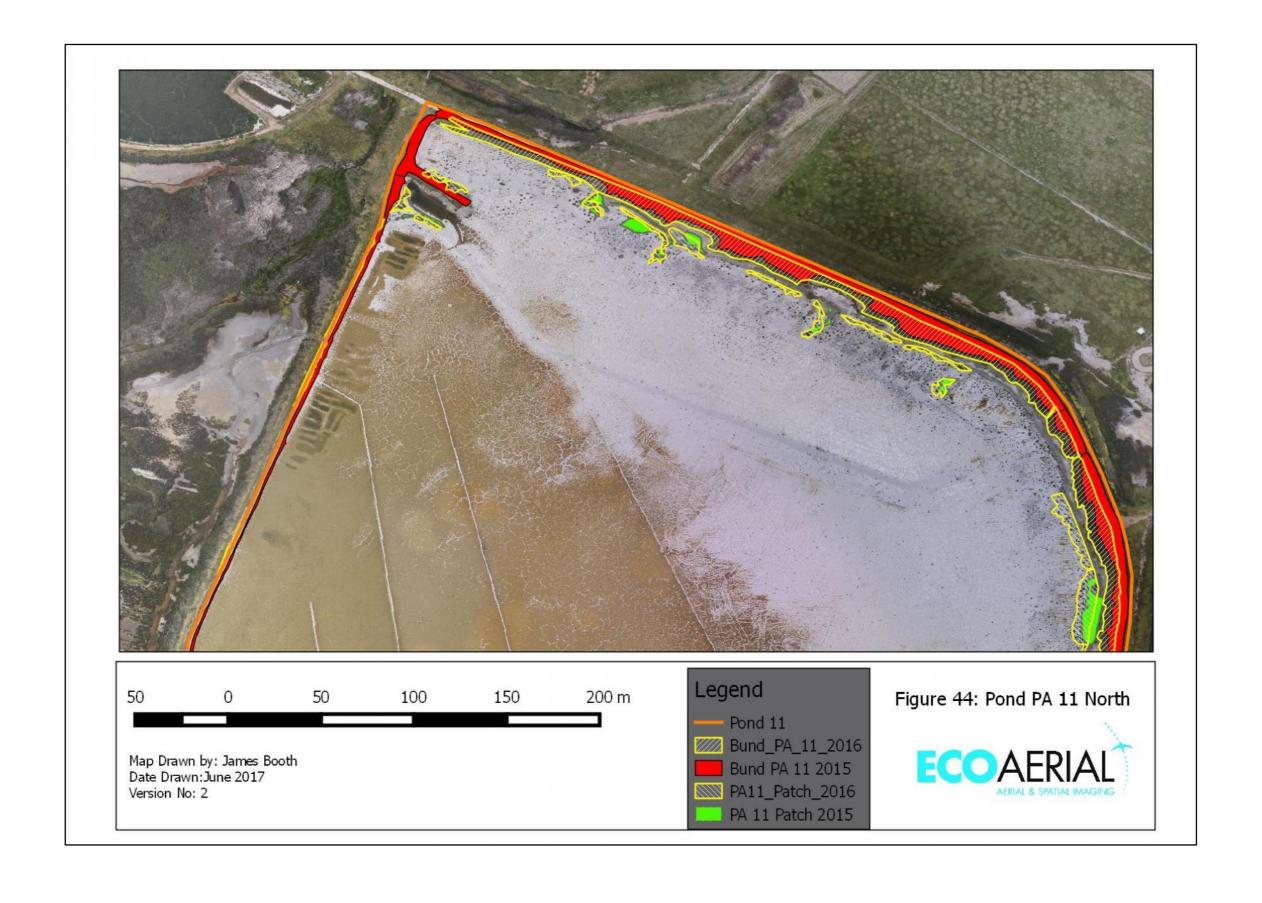


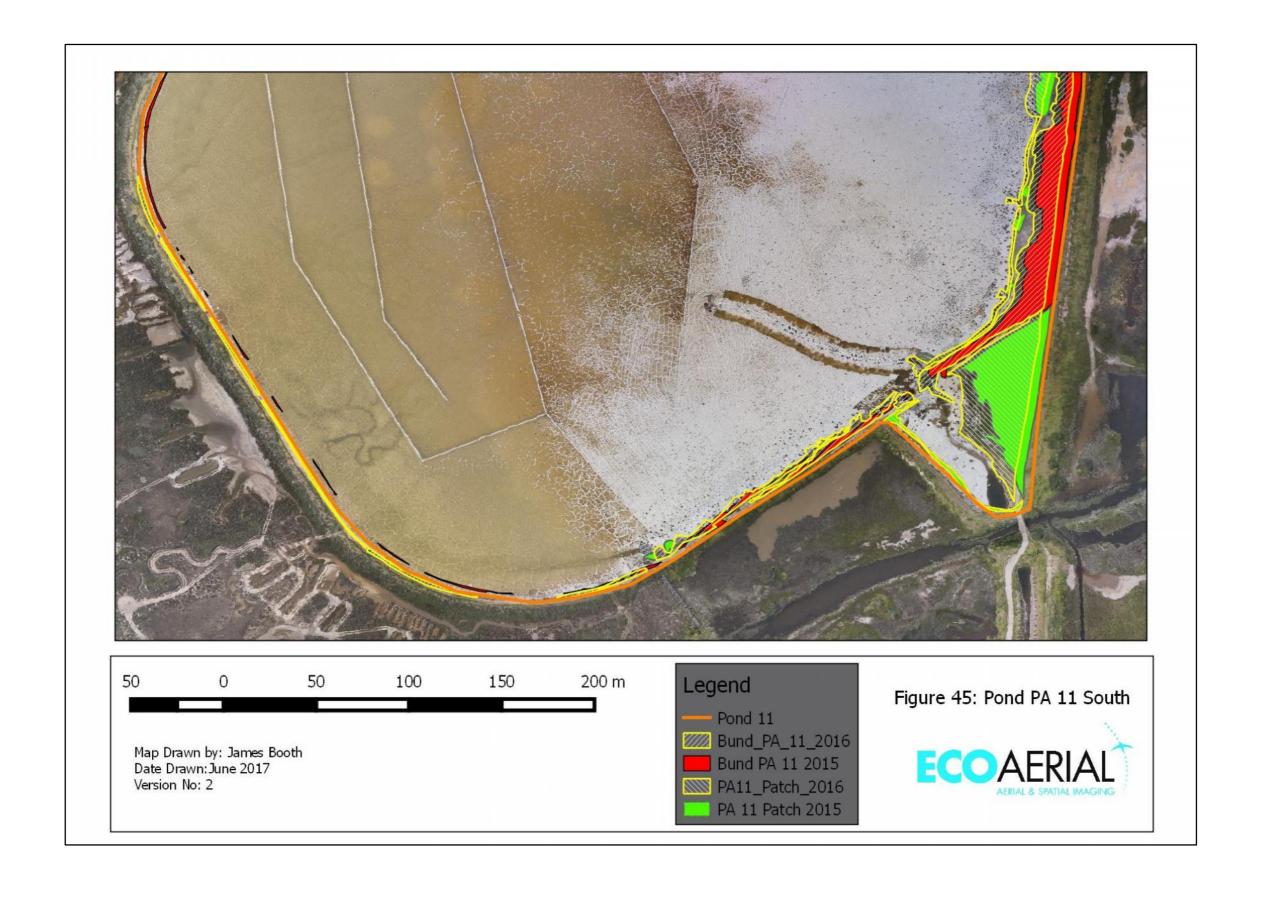


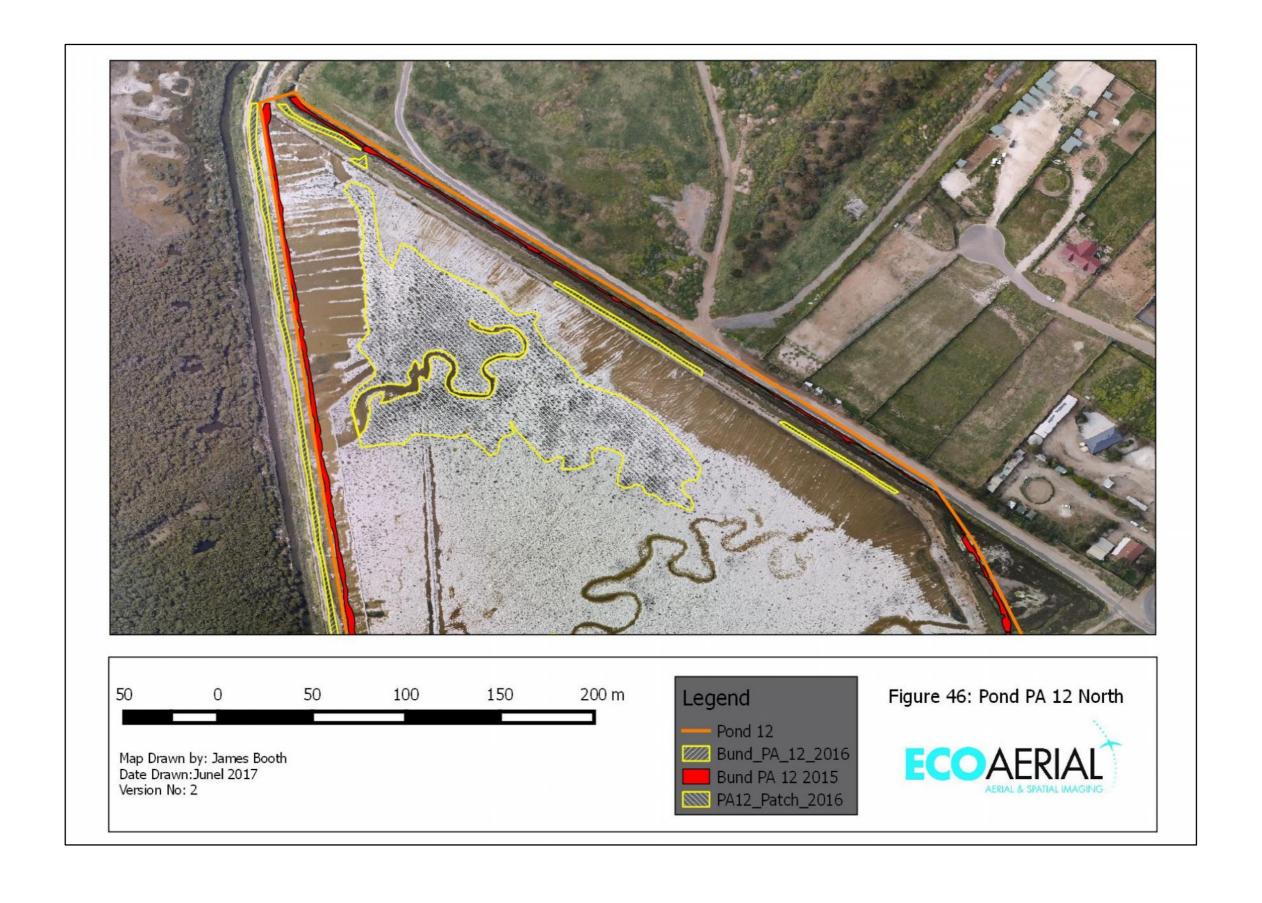


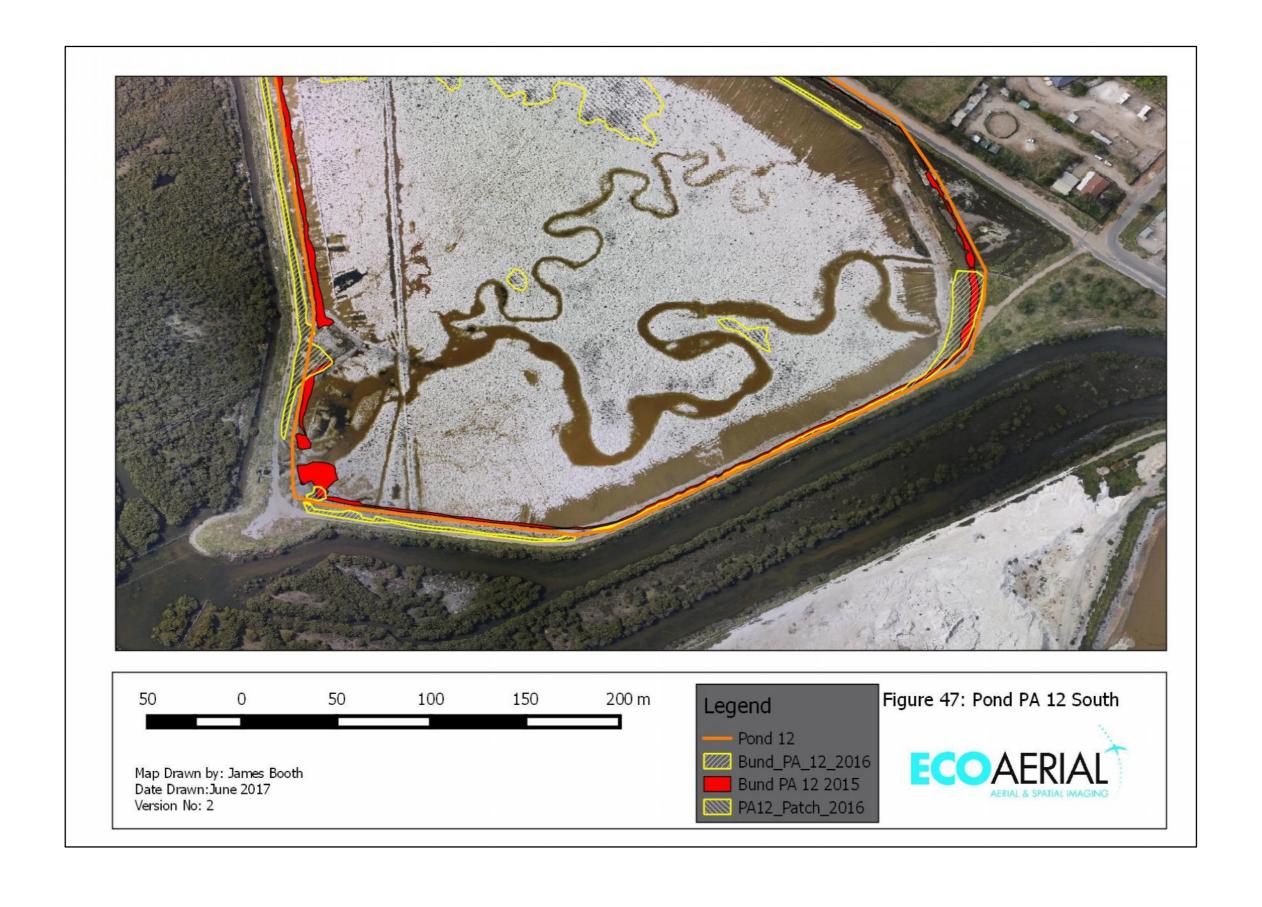




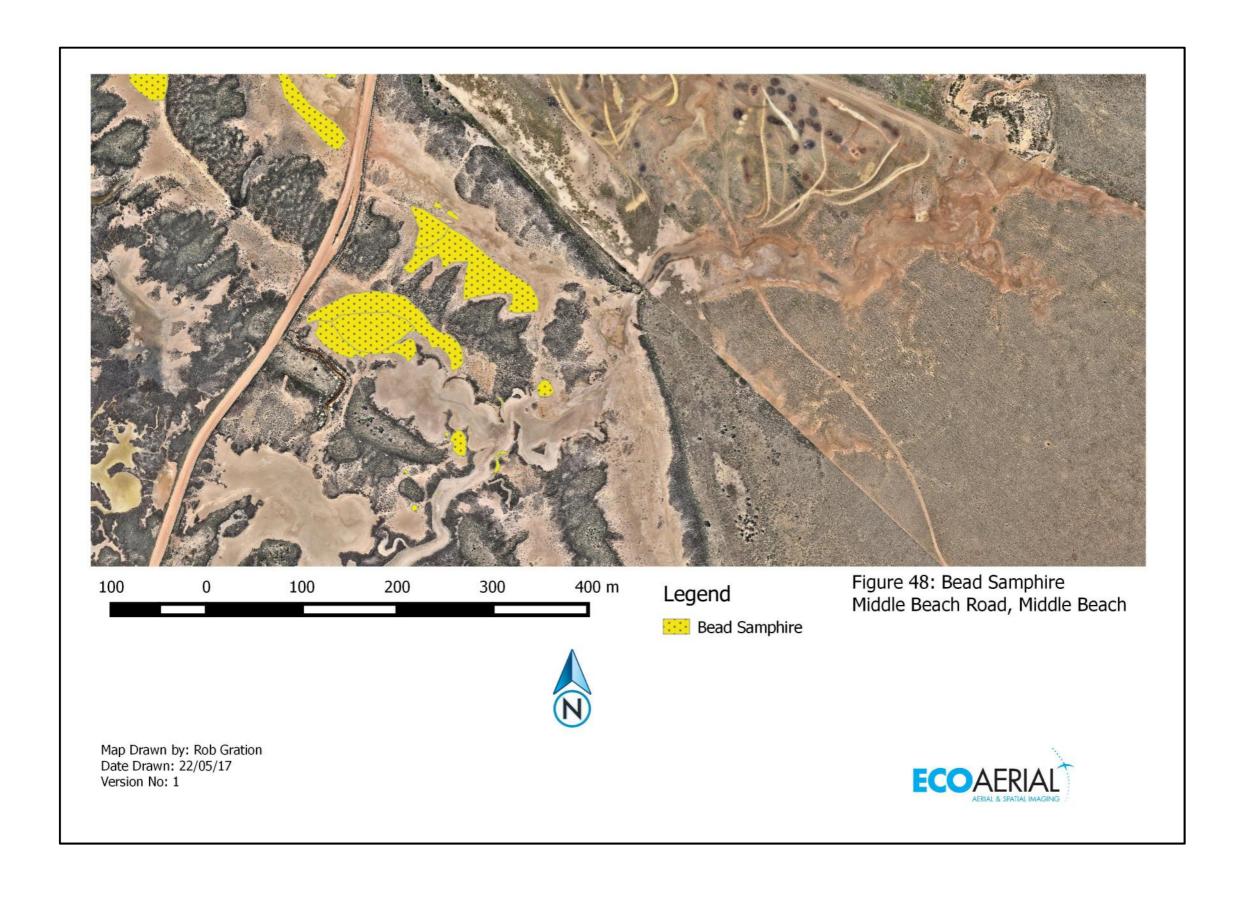


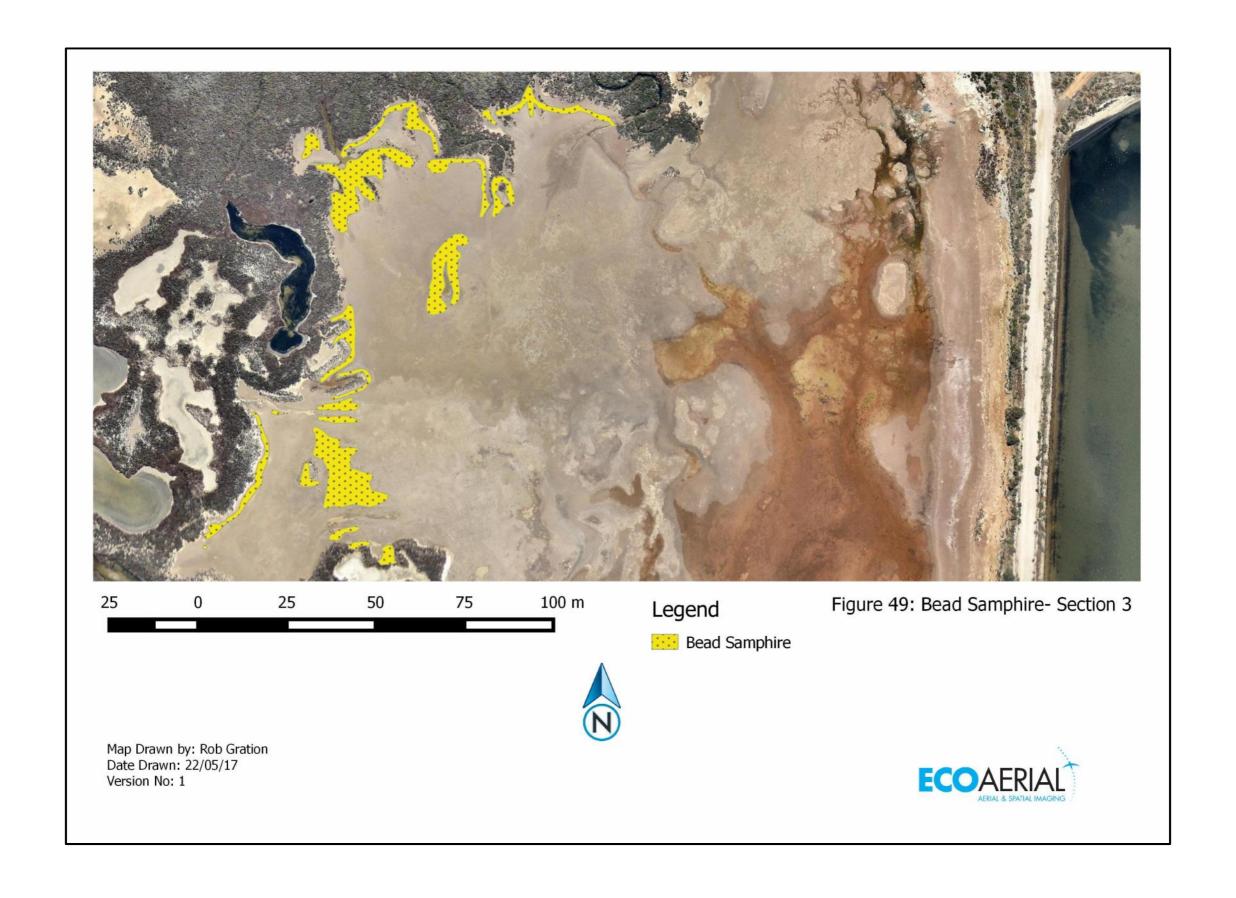


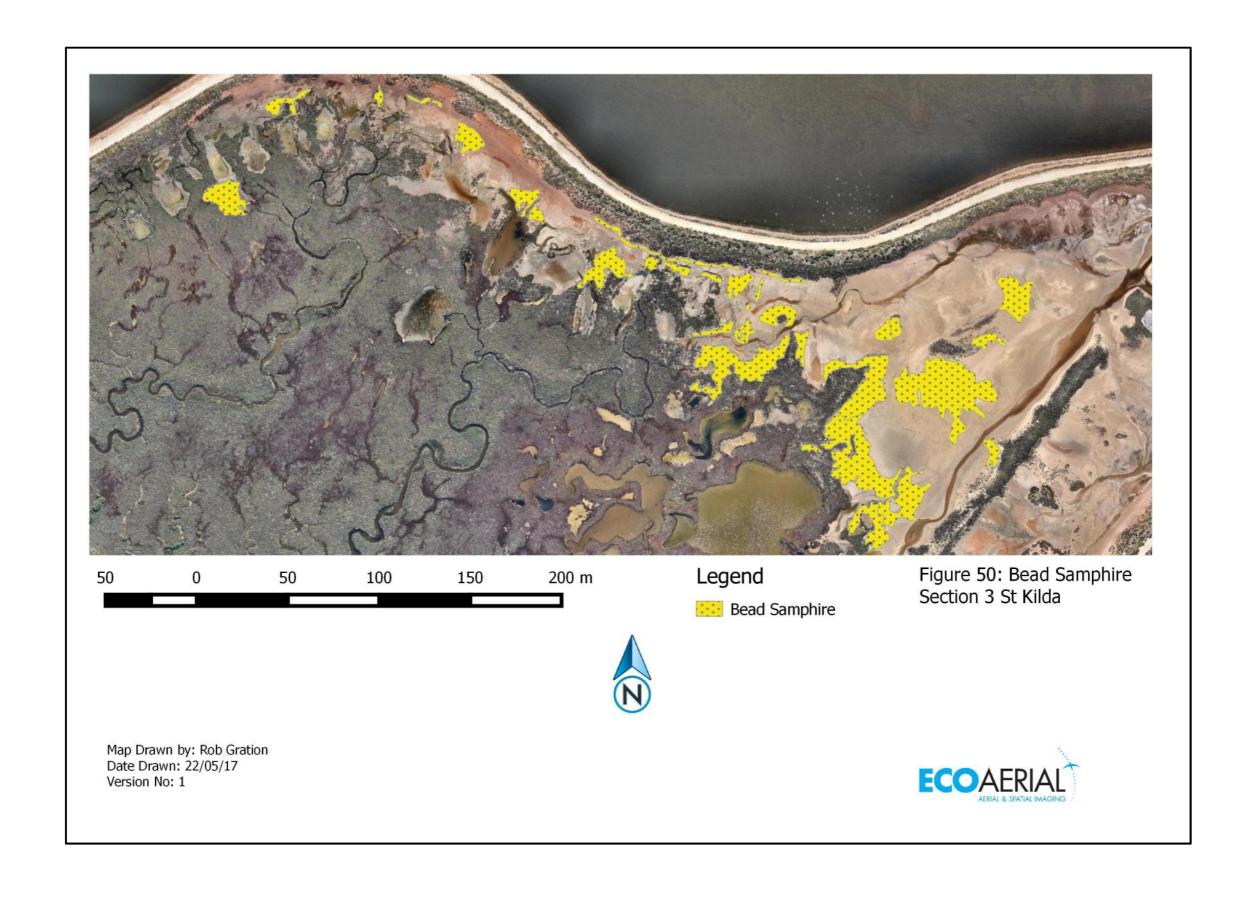




### 3.8 Bead Samphire Maps







### 4 Conclusion

A total of 148.65 hectares of Dryland Samphire and Samphire / Atriplex / Grassland was mapped across all ponds and bunds and, in sections adjacent to the Bolivar Channel. This is an increase of a 23.00ha when compared to the studies undertaken in 2015.

As was the case in 2015, a breakdown of mapped vegetation within each of the 3 sections indicated that there is a distinct pattern regarding the presence and extent of vegetation i.e. greater vegetation abundance is present on high ground / ridges and drainage lines.

The ponds assessed in the Middle Beach (Section 4) study area had the greatest area of vegetation, approximately 64.80ha when compared with 45.83 ha in the Port Gawler (Section 3) study area, 24.84ha adjacent to the Bolivar Channel and, 13.98ha in the St Kilda (Section 2) study area. All sections recorded an increase in the extent of vegetation since the 2015 mapping studies.

When the site was operating for the production of salt, the northern ponds were fed directly from the Gulf St Vincent and the salinity levels were consistent with sea water. As consequence salt marsh vegetation persisted adjacent to the ponds. As the ponds continue to dry, the results indicate that salt marsh continues to colonise the ponds and bunds. There continues to be a correlation between the high point in a pond and / or drainage lines with the presence of vegetation.

As was the case in 2015, the extent of colonisation was less in the Port Gawler and St Kilda study areas. There was a decrease in the extent of vegetation in Ponds 9 & 10, this is as a result of SA Water utilising more area of these ponds for denitrification trials.

Bead Samphire continues to persist within the previously mapped patches to the extent that recruitment is occurring.

In summarising, the holding pattern has **not** had any impact on the saltmarsh vegetation. The extent of the salt marsh continues to increase and Bead Samphire recruitment is occurring.

### 5 References

- Brett Lane and Associates & EcoAerial (2014). Dry Creek Self-Assessment draft version 2. Report for Ridley Corporation.
- Brett Lane and Associates (2013). Dry Creek Salt Fields Flora and Fauna Technical Report. Report for Ridley Corporation.
- Coleman, P. (2012). GIS layers for Tecticornia flabelliformis.
- Coops, N.R and McVicar T.R. (2008) Temporal analysis with remote sensing. CSIRO Publishing Collingwood.
- EcoAerial (2016). Dry Creek Vegetation Mapping. Report for Buckland Pty Ltd
- EcoAerial (2015a). Dry Creek Bead Samphire Survey. Report for Ridley Corporation
- EcoAerial (2015b). Dry Creek RPA Trials. Report for Ridley Corporation
- EcoAerial (2014). Dry Creek Vegetation Mapping. Report for Ridley Corporation
- Kelleway J, Williams RJ and Laegdsgaard P (2009). Chapter 10: Mapping, assessment and monitoring of saltmarshes. In: Australian Saltmarsh Ecology. (ed) N Saintilan. CSIRO Publishing, Victoria.
- Horning, N. Robinson, J.A, Sterling, J. E, Turner. W and Spector, S. (2010). Remote Sensing for Ecology and Conservation: A Handbook of Techniques. Oxford University Press: Oxford
- Jones, H.G. and Vaughan, R.A. (2010). Remote Sensing of Vegetation: Principals, Techniques and Applications. Oxford University Press. Oxford
- Carter, O. 2010. National Recovery Plan for the Bead Glasswort *Tecticornia flabelliformis*. Department of Sustainability and Environment, Melbourne.

### 6 Bibliography

- Adam P (2002). Saltmarshes in a time of change. Environmental Conservation 29(1): 39–61. Adam P (2009). Australian saltmarshes in global context. In: Australian Saltmarsh Ecology. (ed.) N Saintilan. CSIRO Publishing, Victoria.
- Bertness MD, Ewanchuk PJ and Silliman BR (2002). Anthropogenic modification of New England salt marsh landscapes. Proceedings of the National Academy of Sciences of the United States of America 99: 1395–1398.
- Billows CA (2006). Ecological responses to improved tidal flows into the Karaaf Wetlands, Breamlea, Victoria. Honours Thesis, School of Life and Environmental Sciences, Deakin University.

  http://www.ccmaknowledgebase.vic.gov.au/resources/Ecological\_Responses\_to\_Improved\_Tidal\_Flows\_into\_the\_Karaaf\_Wetlands.pdf
- Boorman LA (1999). Salt marshes present functioning and future change. Mangrove and Salt Marshes 3: 227–241.
- Carr, G. (2012a). Overview of coastal saltmarsh and mangrove vegetation in Victoria. In: Estuary plants and what's happening to them in south-east Australia. (eds) GR Sainty, J Hosking, G Carr and P Adam. pp. 377–397. Sainty Books, Potts Point, Australia.
- Carr, G. (2012b). Inventory of Victorian marine, estuarine and saltmarsh vascular plant species. In: Estuary plants and what's happening to them in south-east Australia. (eds) GR Sainty, J Hosking, G Carr and P Adam. pp. 398–421. Sainty Books, Potts Point, Australia.
- Caton B, Fotheringham D, Krahnert E, Pearson J, Royal M and Sandercock R (2009). Metropolitan Adelaide and Northern Coastal Action Plan. Prepared for the Adelaide and Mount Lofty Ranges NRM Board and Department for Environment and Heritage.
- Coops, N.R and McVicar T.R. (2008) Temporal analysis with remote sensing CSIRO Publishing Collingwood.
- Daly T (2013). Coastal saltmarsh. Primefact. NSW Department of Primary Industries.

  http://www.dpi.nsw.gov.au/ data/assets/pdf\_file/0007/459628/ Coastal-Saltmarsh-Primefact.pdf
- DSE (2009). EVC Benchmarks for the Index of Wetland Condition.

  http://www.dse.vic.gov.au/CA256F310024B628/0/0ADBB279A6493884CA2577ED000A65

  DA/\$File/IWC+Wetland+EVC+Benchmarks+November+2010.pdf
- Fairweather P (2011). Saltmarshes. In: Scientific Working Group (2011). The vulnerability of coastal and marine habitats in South Australia. Marine Parks, Department of Environment, Water and Natural Resources South Australia. http://www.environment.sa.gov.au/files/9071eaf1-ec1d-4bae-8f50- a0d20105319c/mp-gen-habitatvulnerabilityreport.pdf.
- Laegdsgaard P, Kellaway J, Williams RJ & Harty C (2009). Protection and management of coastal saltmarsh. In: Australian Saltmarsh Ecology. (ed) N Saintilan. CSIRO Publishing, Victoria.

- NSW DPI [Department of Primary Industries, NSW]. (undated). Management of coastal lakes and lagoons in New South Wales. Viewed: 29/4/2013. Available on the Internet at: http://www.dpi.nsw.gov.au/fisheries/habitat/aquatic-habitats/wetland/coastal- wetlands/management-of-coastal-lakes-and-lagoons-in-nsw
- NSW SC [NSW Scientific Committee] (2004). Coastal saltmarsh in the NSW North Coast, Sydney Basin and South East corner bioregions endangered ecological community listing. NSW Scientific Committee final determination. Viewed: 11/1/2013. Available on the Internet at: http://www.environment.nsw.gov.au/determinations/CoastalSaltmarshEndSpListing.htm
- OZCoasts (2012). Saltmarsh and sandflat areas. Viewed: 4/2/2013. Available on the Internet at:

  http://www.ozcoasts.gov.au/indicators/changes\_saltmarsh\_area.jsp
- State of the Environment Committee (2011). Australia state of the environment 2011. Independent report to the Australian Government Minister for Sustainability, Environment, Water, Population and Communities. Department of Sustainability, Environment, Water, Populations and Communities, Canberra.
- VSS [Victorian Saltmarsh Study] (2011). Mangroves and coastal saltmarsh of Victoria: distribution, condition, threats and management. Report to the Department of Sustainability and Environment, East Melbourne. (eds Boon PI, Allen T, Brook J, Carr G, Frood D, Hoye J, Harty C, McMahon A, Mathews S, Rosengren N, Sinclair S, White M & Yugovic J). Institute for Sustainability and Innovation, Victoria University, Melbourne.
- WSP (2013a). Stage 1 PEPR For Operational Closure Dry Creek Salt Fields Volume 1. Report for Ridley Corporation.
- WSP (2013b). Stage 1 PEPR For Operational Closure Dry Creek Salt Fields Volume 2. Report for Ridley Corporation.

# **Appendix A - Dry Creek Ecology Reports**

- Brett Lane and Associates (2014). Dry Creek Salt Field 'Holding Pattern' EPBC Act Self Assessment. Consultant's report to Ridley Land Corporation Limited, BL&A and EcoAerial, Melbourne
- 2. Brett Lane and Associates (2014). Dry Creek Salt Field Flora and Fauna Technical Report. Report for Ridley Corporation.
- 3. Brett Lane and Associates (2014). Dry Creek salt Field Closure EPBC Referral (Referral Form with Attachments 1 to 7). Report for Ridley Corporation.
- Coleman, P (2012) 'Tereticornis flabelliformis of eastern Gulf St Vincent, South Australia –
  occurrence, threats, management options.' Consultant's report prepared for Adelaide and
  Mount Lofty Ranges NRM Board.
- 5. EcoAerial (2016). Dry Creek Vegetation Mapping. Report for Buckland Pty Ltd
- 6. EcoAerial (2014). Dry Creek Vegetation Mapping. Report for Ridley Corporation
- 7. EcoAerial (2015). Dry Creek Bead Samphire Survey. Report for Ridley Corporation
- 8. EcoAerial (2015). Trial of the Use of Remotely Piloted Aircraft at Decommissioned Salt Ponds. Report for Ridley Corporation
- EcoAerial (2013). Dry Creek Self-Assessment draft version 1.1. Report for Ridley Corporation
- 10. EBS 2013. December 2013 update on Ridley Corporation, Dry Creek Bird Survey (high tide survey). Monthly report prepared for Brett Lane and Associates.
- 11. EBS 2014a. January 2014 update on Ridley Corporation, Dry Creek Bird Survey (high tide survey). Monthly report prepared for Brett Lane and Associates.
- 12. EBS 2014b. February 2014 update on Ridley Corporation, Dry Creek Bird Survey (high tide survey). Monthly report prepared for Brett Lane and Associates.
- 13. EBS 2014c. February 2014 update on Ridley Corporation, Dry Creek Bird Survey (high tide survey). Monthly report prepared for Brett Lane and Associates.
- 14. EBS 2014d. March 2014 update on Ridley Corporation, Dry Creek Bird Survey (high tide survey). Monthly report prepared for Brett Lane and Associates.
- 15. EBS 2014e. April 2014 update on Ridley Corporation, Dry Creek Bird Survey (high tide survey). Monthly report prepared for Brett Lane and Associates.
- 16. Clemens, R; S; Kendall, B E; Guillet, J and Fuller, R A. 2012. Review of Australian shorebird survey data, with notes on their suitability for comprehensive population trend analysis. Stilt 62: 3-17.
- 17. Coleman, P S J 2012. Tecticornia flabelliformis of eastern Gulf St Vincent, South Australia: Occurrence, threats, management options. Prepared for the Adelaide and Mount Lofty Natural Resource Management (AMLR NRM) Board, Adelaide.
- 18. Coleman, P. 2013, Risk and opportunities: a briefing paper on coastal habitat and shorebird conservation in the light of potential closure of the Ridley Dry Creek Salt Field, report prepared for AMLR NRM Board by Delta Environmental Consulting, South Australia.
- 19. Coleman, P.S.J and Cook F.S. 2009, Habitat preferences of the Australian endangered Glasswort Tecticornia flabelliformis, Transactions of the Royal Society of South Australia 133 (2): 300-306.

- 20. Department of Environment and Heritage 2008. Adelaide and Mount Lofty Ranges South Australia, Threatened species profile, Department for Environment and Heritage (South Australia).
- Department of the Environment 2013, EPBC Act Protected Matters Search Tool. Department of the Environment, Canberra, viewed 15th July 2013, <a href="http://www.environment.gov.au">http://www.environment.gov.au</a>
- 22. Department of Environment, Water and Natural Resources (DEWNR) 2013a, Nature Maps, DEWNR, viewed 31st July 2013, <a href="https://www.naturemaps.sa.gov.au">www.naturemaps.sa.gov.au</a>
- 23. Department of Environment, Water and Natural Resources 2013b, Saltfields Creating the Adelaide International Bird Sanctuary. DEWNR, Adelaide.
- 24. Purnell, C., Diyan, M.A.A, Clemens, R., Berry, L and Oldland, J 2009, Shorebird Habitat Mapping Project: Gulf St Vincent. Birds Australia report for the Adelaide and Mount Lofty Ranges Natural Resources Management Board and the Department of the Environment, Water, Heritage and the Arts.
- 25. Purnell, C., Clemens, R., Peter, J. 2010, Shorebird Population Monitoring within the Gulf of St Vincent: July 2009 to June 2010 Annual Report. Birds Australia report for the Adelaide and Mount Lofty Ranges Natural
- 26. Purnell, C., Peter, J., Clemens, R. 2011, Shorebird Population Monitoring within the Gulf of St Vincent: July 2010 to June 2011 Annual Report. Birds Australia report for the Adelaide and Mount Lofty Ranges Natural Resources Management Board and the Department of the Environment, Water, Heritage and the Arts.
- 27. WSP (2013a). Stage 1 PEPR For Operational Closure Dry Creek Salt Fields Volume 1. Report for Ridley Corporation.
- 28. WSP (2013b). Stage 1 PEPR For Operational Closure Dry Creek Salt Fields Volume 2. Report for Ridley Corporation.

## **Appendix B - Pix4D Reports**

# **Quality Report**



Generated with Pix4Dmapper Pro version 3.0.13



Important: Click on the different icons for:

- Pleip to analyze the results in the Quality Report
- Additional information about the sections



Click here for additional tips to analyze the Quality Report

#### Summary



Project	adelaide 2 rgb
Processed	2016-10-18 21:45:11
Camera Model Name(s)  CanonEOS5DMarkIII_35mm_35.0_5760x3840 (RGB)	
Average Ground Sampling Distance (GSD)	7.6 cm / 2.99 in
Area Covered 10.4211 km² / 1042.11 ha / 4.0257 sq. mi. / 2576.45 acres	
Time for Initial Processing (without report) 01h:17m:51s	

#### **Quality Check**



? Images	median of 60599 keypoints per image	<b>O</b>
② Dataset	816 out of 850 images calibrated (96%), all images enabled	<b>O</b>
? Camera Optimization	6.8% relative difference between initial and optimized internal camera parameters	Δ
Matching	median of 20660.6 matches per calibrated image	<b>O</b>
? Georeferencing	yes, no 3D GCP	Δ

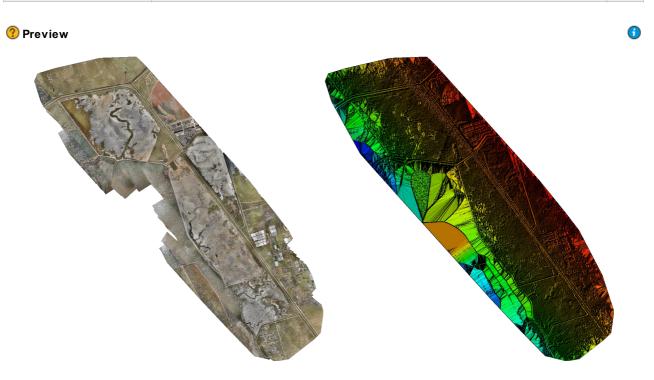


Figure 1: Orthomosaic and the corresponding sparse Digital Surface Model (DSM) before densification.

### **Calibration Details**

Number of Calibrated Images	816 out of 850
Number of Geolocated Images	849 out of 850

### Initial Image Positions



Figure 2: Top view of the initial image position. The green line follows the position of the images in time starting from the large blue dot.

Computed Image/GCPs/Manual Tie Points Positions

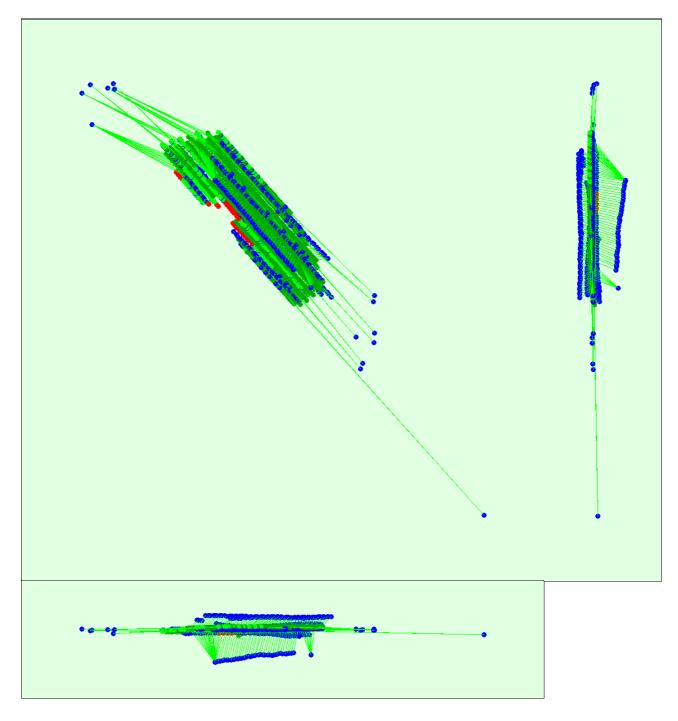


Figure 3: Offset between initial (blue dots) and computed (green dots) image positions as well as the offset between the GCPs initial positions (blue crosses) and their computed positions (green crosses) in the top-view (XY plane), front-view (XZ plane), and side-view (YZ plane). Red dots indicate disabled or uncalibrated images.

Overlap

U

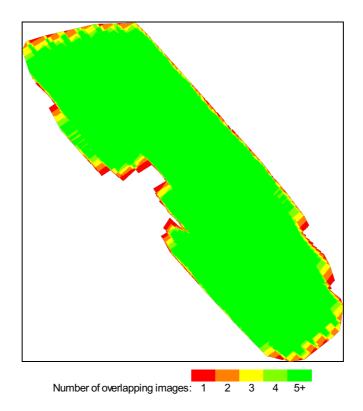


Figure 4: Number of overlapping images computed for each pixel of the orthomosaic.

Red and yellow areas indicate low overlap for which poor results may be generated. Green areas indicate an overlap of over 5 images for every pixel. Good quality results will be generated as long as the number of keypoint matches is also sufficient for these areas (see Figure 5 for keypoint matches).

### **Bundle Block Adjustment Details**

•

Number of 2D Keypoint Observations for Bundle Block Adjustment	15415475
Number of 3D Points for Bundle Block Adjustment	5208518
Mean Reprojection Error [pixels]	0.181

### Internal Camera Parameters

#### **☆** CanonEOS5DMarkIII\_35mm\_35.0\_5760x3840 (RGB). Sensor Dimensions: 37.109 [mm] x 24.740 [mm]

**(1)** 

EXIF ID: CanonEOS5DMarkIII\_35mm\_35.0\_5760x3840

	Focal Length	Principal Point x	Principal Point y	R1	R2	R3	T1	T2
Initial Values	5432.586 [pixel] 35.000 [mm]	2880.000 [pixel] 18.555 [mm]	1920.000 [pixel] 12.370 [mm]	0.000	0.000	0.000	0.000	0.000
Optimized Values	5802.082 [pixel] 37.381 [mm]	2887.307 [pixel] 18.602 [mm]	1902.982 [pixel] 12.260 [mm]	-0.090	0.095	-0.013	-0.000	0.000

	The number of Automatic Tie Points (ATPs) per pixel averaged over all images of the camera model is color coded between black and white. White indicates that, in average, more than 16 ATPs are extracted at this pixel location. Black indicates that, in average, 0 ATP has been extracted at this pixel location. Click on the image to the see the average direction and magnitude of the reprojection error for each pixel. Note that the vectors are scaled for better visualization.
--	--

### 2D Keypoints Table



Number of 2D Keypoints per Image		Number of Matched 2D Keypoints per Image
Median	60599	20661
Min	20158	91

Max	91096	49040
Mean	59671	18892

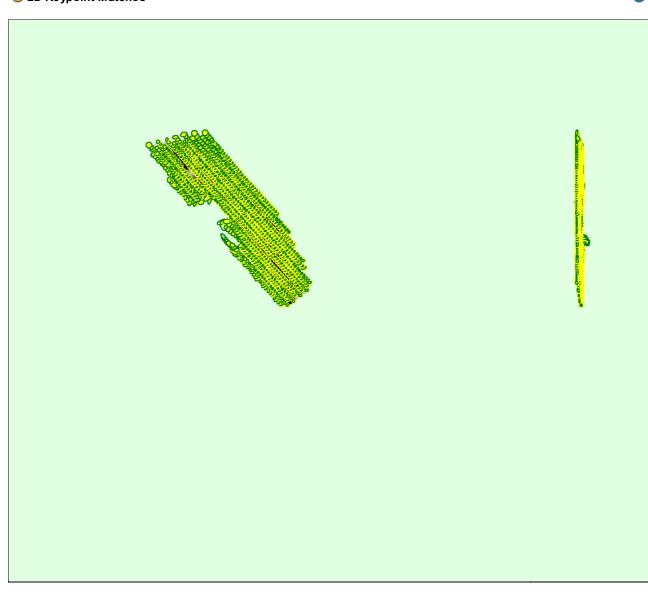
### 3D Points from 2D Keypoint Matches

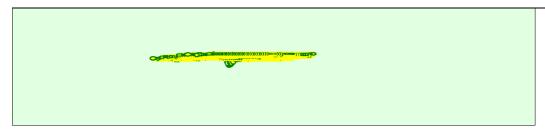
1

	Number of 3D Points Observed
In 2 Images	2954075
In 3 Images	1068547
In 4 Images	517353
In 5 Images	311702
In 6 Images	136123
In 7 Images	82334
In 8 Images	55489
In 9 Images	36191
In 10 Images	24178
In 11 Images	11080
In 12 Images	5494
In 13 Images	3163
In 14 Images	1789
In 15 Images	765
In 16 Images	176
In 17 Images	51
In 18 Images	8

### ② 2D Keypoint Matches







Uncertainty ellipses 50x magnified

Number of matches

25 222 444 666 888 1111 1333 1555 1777 2000

Figure 5: Computed image positions with links between matched images. The darkness of the links indicates the number of matched 2D keypoints between the images. Bright links indicate weak links and require manual tie points or more images. Dark green ellipses indicate the relative camera position uncertainty of the bundle block adjustment result.

#### ? Relative camera position and orientation uncertainties

6

	X[m]	Y[m]	Z[m]	Omega [degree]	Phi [degree]	Kappa [degree]
Mean	0.739	0.727	0.507	0.086	0.091	0.036
Sigma	0.322	0.323	0.282	0.039	0.039	0.022

#### **Geolocation Details**

**(1)** 

#### Absolute Geolocation Variance

6

Min Error [m]	Max Error [m]	Geolocation Error X[%]	Geolocation Error Y [%]	Geolocation Error Z [%]	
-	-15.00	3.14	1.26	27.04	
-15.00	-12.00	5.66	2.52	0.63	
-12.00	-9.00	8.81	9.43	0.63	
-9.00	-6.00	9.43	14.47	1.26	
-6.00	-3.00	11.95	9.43	1.26	
-3.00	0.00	12.58	10.06	9.43	
0.00	3.00	14.47	15.72	3.77	
3.00	6.00	9.43	11.95	2.52	
6.00 9.00		9.00 13.84	6.29	3.14	
9.00	12.00	4.40	7.55	5.66	
12.00	15.00	2.52	8.81	5.03	
15.00	-	3.77	2.52	39.62	
Mean [m] Sigma [m]		-0.574238	0.528389	-0.262366	
		8.190611	8.194439	32.654535	
RMS Error [m]		8.210716	8.211457	32.655589	

Min Error and Max Error represent geolocation error intervalsbetween -1.5 and 1.5 times the maximum accuracy of all the images. Columns X, Y, Z show the percentage of images with geolocation errors within the predefined error intervals. The geolocation error is the difference between the intial and computed image positions. Note that the image geolocation errors do not correspond to the accuracy of the observed 3D points.

#### Relative Geolocation Variance

6

Relative Geolocation Error	Images X[%]	Images Y[%]	Images Z [%]	
[-1.00, 1.00]	41.51	37.11	23.90	
[-2.00, 2.00]	74.21	72.33	45.91	
[-3.00, 3.00]	93.08	96.23	69.18	
Mean of Geolocation Accuracy [m]	5.000000	5.000000	10.000000	
Sigma of Geolocation Accuracy [m]	0.000000	0.000000	0.000000	

#### **Initial Processing Details** System Information CPU: Intel(R) Core(TM) i7-6700K CPU @ 4.00GHz Hardware GPU: NMDIA GeForce GTX 960 (Driver: 21.21.13.6909) Operating System Windows 10 Home, 64-bit **Coordinate Systems** Image Coordinate System WGS84 (egm96) Output Coordinate System WGS84 / UTM zone 54S (egm96) **Processing Options Detected Template** ∃ 3D Maps Full, Image Scale: 1 Keypoints Image Scale Aerial Grid or Corridor Advanced: Matching Image Pairs Advanced: Matching Strategy Use Geometrically Verified Matching: no Advanced: Keypoint Extraction Targeted Number of Keypoints: Automatic Calibration Method: Standard Internal Parameters Optimization: All Advanced: Calibration External Parameters Optimization: All Rematch: Auto, no Bundle Adjustment: Classic **Point Cloud Densification details Processing Options** Image Scale multiscale, 1/2 (Half image size, Default) Point Density Optimal 3 Minimum Number of Matches 3D Textured Mesh Generation Resolution: Medium Resolution (default) 3D Textured Mesh Settings: Color Balancing: no Advanced: 3D Textured Mesh Settings Sample Density Divider: 1 Advanced: Matching Window Size 7x7 pixels Advanced: Image Groups group1 Advanced: Use Processing Area yes Advanced: Use Annotations yes Advanced: Limit Camera Depth Automatically Time for Point Cloud Densification 02h:59m:43s Time for 3D Textured Mesh Generation 22m:35s Results

Number of Processed Clusters	2
Number of Generated Tiles	5
Number of 3D Densified Points	116622073
Average Density (per m <sup>3</sup> )	5.75

# DSM, Orthomosaic and Index Details

#### 1

#### **Processing Options**

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u	п	-)

DSMand Orthomosaic Resolution	1 x GSD (7.6 [cm/pixel])	
DSM Filters	Noise Filtering: yes Surface Smoothing: yes, Type: Sharp	
Raster DSM	Generated: yes Method: Inverse Distance Weighting Merge Tiles: yes	
Orthomosaic	Generated: yes Merge Tiles: yes GeoTIFF Without Transparency: no Google Maps Tiles and KML: no	
Time for DSMGeneration	01h:23m:43s	
Time for Orthomosaic Generation	02h:03s	

# **Quality Report**



Generated with Pix4Dmapper Pro version 3.0.13



Important: Click on the different icons for:

- Pelp to analyze the results in the Quality Report
- Additional information about the sections



Click here for additional tips to analyze the Quality Report

#### Summary



Project	adelaide area c rgb
Processed	2016-10-19 09:50:17
Camera Model Name(s)	CanonEOS5DMarkIII_35mm_35.0_5760x3840 (RGB)
Average Ground Sampling Distance (GSD)	7.54 cm / 2.96 in
Area Covered	13.9541 km <sup>2</sup> / 1395.41 ha / 5.3905 sq. mi. / 3449.92 acres
Time for Initial Processing (without report)	02h:13m:08s

#### **Quality Check**



? Images	median of 65087 keypoints per image	<b>②</b>
? Dataset	1015 out of 1069 images calibrated (94%), all images enabled, 4 blocks	Δ
? Camera Optimization	6.82% relative difference between initial and optimized internal camera parameters	<u> </u>
Matching	median of 14844.2 matches per calibrated image	<b>②</b>
@ Georeferencing	yes, no 3D GCP	<u> </u>







Figure 1: Orthomosaic and the corresponding sparse Digital Surface Model (DSM) before densification.

## **Calibration Details**

6

Number of Calibrated Images	1015 out of 1069
Number of Geolocated Images	1061 out of 1069

Initial Image Positions

a

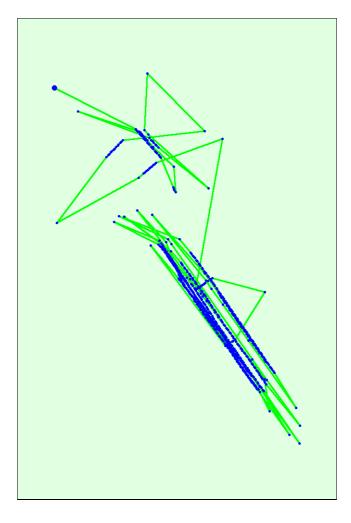


Figure 2: Top view of the initial image position. The green line follows the position of the images in time starting from the large blue dot.

? Computed Image/GCPs/Manual Tie Points Positions



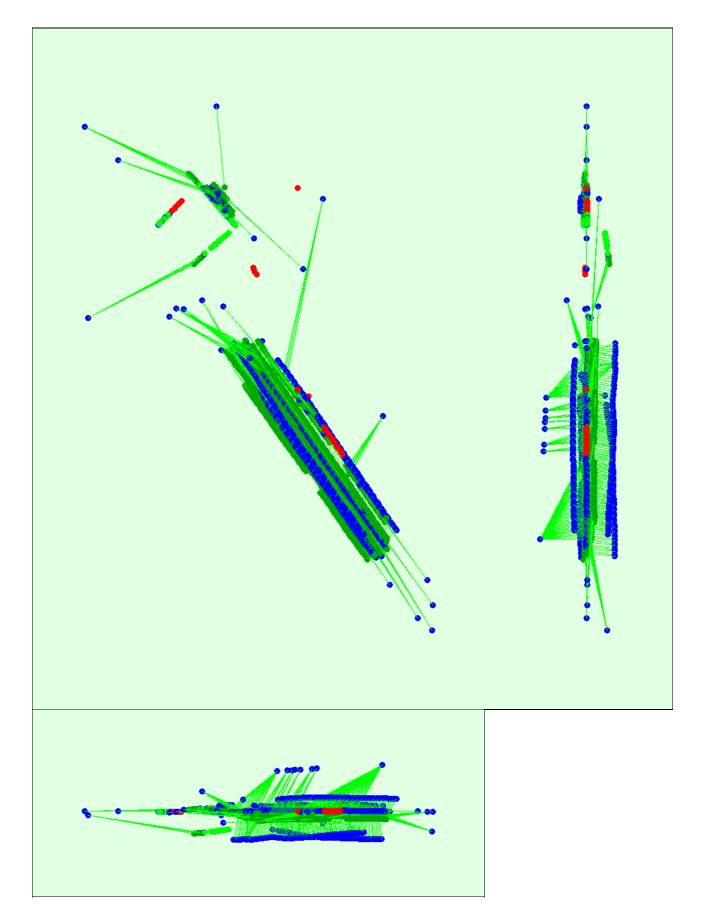


Figure 3: Offset between initial (blue dots) and computed (green dots) image positions as well as the offset between the GCPs initial positions (blue crosses) and their computed positions (green crosses) in the top-view (XY plane), front-view (XZ plane), and side-view (YZ plane). Red dots indicate disabled or uncalibrated images.

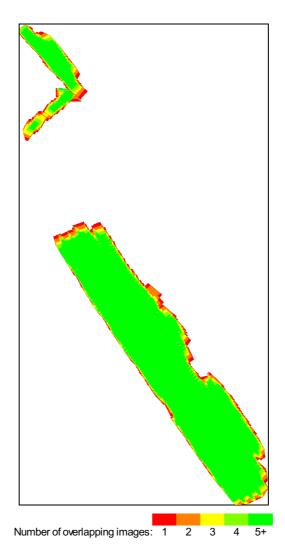


Figure 4: Number of overlapping images computed for each pixel of the orthomosaic.

Red and yellow areas indicate low overlap for which poor results may be generated. Green areas indicate an overlap of over 5 images for every pixel. Good quality results will be generated as long as the number of keypoint matches is also sufficient for these areas (see Figure 5 for keypoint matches).

# **Bundle Block Adjustment Details**



Number of 2D Keypoint Observations for Bundle Block Adjustment	15675964
Number of 3D Points for Bundle Block Adjustment	5732537
Mean Reprojection Error [pixels]	0.156

#### Internal Camera Parameters



EXIF ID: CanonEOS5DMarkIII\_35mm\_35.0\_5760x3840

	Focal Length	Principal Point x	Principal Point y	R1	R2	R3	T1	T2
Initial Values	5432.586 [pixel] 35.000 [mm]	2880.000 [pixel] 18.555 [mm]	1920.000 [pixel] 12.370 [mm]	0.000	0.000	0.000	0.000	0.000
Optimized Values	5803.473 [pixel] 37.389 [mm]	2879.473 [pixel] 18.551 [mm]	1904.736 [pixel] 12.271 [mm]	-0.089	0.092	-0.008	-0.000	0.000

1

The number of Automatic Tie Points (ATPs) per pixel averaged over all images of the camera model is color coded between black and white. White indicates that, in average, more than 16 ATPs are extracted at this pixel location. Black indicates that, in average, 0 ATP has been extracted at this pixel location. Click on the image to the see the average direction and magnitude of the reprojection error for each pixel. Note that the vectors are scaled for better visualization.

#### 2D Keypoints Table



	Number of 2D Keypoints per Image	Number of Matched 2D Keypoints per Image
Median	65087	14844
Min	20169	57
Max	95091	42282
Mean	62340	15444

#### 3D Points from 2D Keypoint Matches



	Number of 3D Points Observed
In 2 Images	3551568
In 3 Images	1131140
In 4 Images	533546
In 5 Images	323780
In 6 Images	78987
In 7 Images	43711
In 8 Images	27857
In 9 Images	18579
In 10 Images	12711
In 11 Images	4801
In 12 Images	2550
In 13 Images	1615
In 14 Images	958
In 15 Images	490
In 16 Images	138
In 17 Images	58
In 18 Images	30
In 19 Images	15
In 20 Images	2
In 21 Images	1

#### ② 2D Keypoint Matches



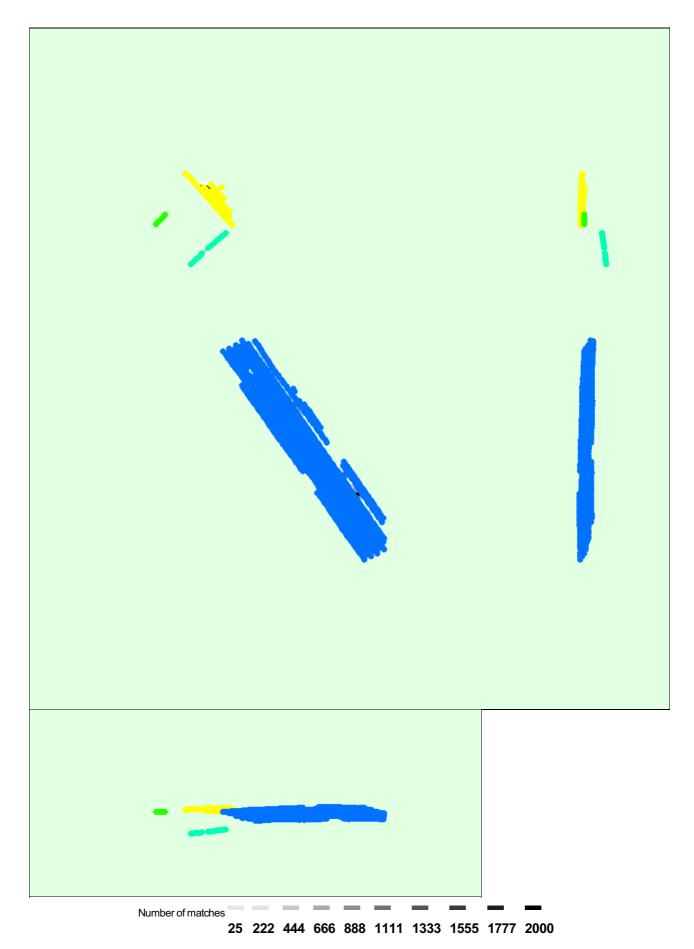


Figure 5: Computed image positions with links between matched images. The darkness of the links indicates the number of matched 2D keypoints between the images. Bright links indicate weak links and require manual tie points or more images.

#### ? Absolute Geolocation Variance

<b>①</b>

Min Error [m]	Max Error [m]	Geolocation Error X[%]	Geolocation Error Y [%]	Geolocation Error Z [%]
-	-15.00	28.00	4.00	0.00
-15.00	-12.00	8.00	3.00	1.00
-12.00	-9.00	6.00	1.00	3.00
-9.00	-6.00	10.00	6.00	4.00
-6.00	-3.00	9.00	7.00	8.00
-3.00	0.00	9.00	9.00	22.00
0.00	3.00	9.00	8.00	11.00
3.00	6.00	8.00	12.00	6.00
6.00	9.00	4.00	10.00	6.00
9.00	12.00	2.00	8.00	5.00
12.00	15.00	2.00	11.00	11.00
15.00	-	5.00	21.00	23.00
Mean [m]		-6.712179	5.508257	8.547414
Sigma [m]		11.665923	10.299550	13.884913
RMS Error [m]		13.459090	11.679967	16.304879

Min Error and Max Error represent geolocation error intervalsbetween -1.5 and 1.5 times the maximum accuracy of all the images. Columns X, Y, Z show the percentage of images with geolocation errors within the predefined error intervals. The geolocation error is the difference between the intial and computed image positions. Note that the image geolocation errors do not correspond to the accuracy of the observed 3D points.

#### Relative Geolocation Variance



Relative Geolocation Error	Images X[%]	Images Y[%]	Images Z [%]
[-1.00, 1.00]	25.00	29.00	61.00
[-2.00, 2.00]	52.00	55.00	78.00
[-3.00, 3.00]	67.00	75.00	86.00
Mean of Geolocation Accuracy [m]	5.000000	5.000000	10.000000
Sigma of Geolocation Accuracy [m]	0.000000	0.000000	0.000000

Images X, Y, Z represent the percentage of images with a relative geolocation error in X, Y, Z.

# **Initial Processing Details**



#### **System Information**

Hardware	CPU: Intel(R) Core(TM) i7-6700K CPU @ 4.00GHz RAM: 32GB GPU: NMDIA GeForce GTX 960 (Driver: 21.21.13.6909)
Operating System	Windows 10 Home, 64-bit

#### **Coordinate Systems**



Image Coordinate System	WGS84 (egm96)
Output Coordinate System	WGS84 / UTM zone 54S (egm96)

#### **Processing Options**



Detected Template	□ 3D Maps
Keypoints Image Scale	Full, Image Scale: 1
Advanced: Matching Image Pairs	Aerial Grid or Corridor
Advanced: Matching Strategy	Use Geometrically Verified Matching: no

Advanced: Keypoint Extraction	Targeted Number of Keypoints: Automatic
Advanced: Calibration	Calibration Method: Standard Internal Parameters Optimization: All External Parameters Optimization: All Rematch: Auto, no Bundle Adjustment: Classic

# **Point Cloud Densification details**

G

#### **Processing Options**

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Image Scale	multiscale, 1/2 (Half image size, Default)
Point Density	Optimal
Minimum Number of Matches	3
3D Textured Mesh Generation	yes
3D Textured Mesh Settings:	Resolution: Medium Resolution (default) Color Balancing: no
Advanced: 3D Textured Mesh Settings	Sample Density Divider: 1
Advanced: Matching Window Size	7x7 pixels
Advanced: Image Groups	group1
Advanced: Use Processing Area	yes
Advanced: Use Annotations	yes
Advanced: Limit Camera Depth Automatically	no
Time for Point Cloud Densification	03h:49m:
Time for 3D Textured Mesh Generation	22m:35s

#### Results

1

Number of Processed Clusters	5
Number of Generated Tiles	6
Number of 3D Densified Points	168581212
Average Density (per m <sup>3</sup> )	6.05

# **DSM**, Orthomosaic and Index Details

1

#### **Processing Options**

DSMand Orthomosaic Resolution	1 x GSD (7.54 [cm/pixel])
DSMFilters	Noise Filtering: yes Surface Smoothing: yes, Type: Sharp
Raster DSM	Generated: yes Method: Inverse Distance Weighting Merge Tiles: yes
Orthomosaic	Generated: yes Merge Tiles: yes GeoTIFF Without Transparency: no Google Maps Tiles and KML: no
Time for DSM Generation	02h:47m:29s
Time for Orthomosaic Generation	04h:22m:34s

# **Quality Report**



Generated with Pix4Dmapper Pro version 3.0.13



Important: Click on the different icons for:

- Pleip to analyze the results in the Quality Report
- Additional information about the sections



Click here for additional tips to analyze the Quality Report

#### Summary



Project	adelaide
Processed	2016-10-17 09:22:40
Camera Model Name(s)	CanonEOS5DMarkIII_35mm_35.0_5760x3840 (RGB)
Average Ground Sampling Distance (GSD)	7.38 cm / 2.9 in
Area Covered	11.9946 km² / 1199.46 ha / 4.6335 sq. mi. / 2965.46 acres
Time for Initial Processing (without report)	01h:37m:11s

#### **Quality Check**



? Images	median of 59215 keypoints per image	<b>②</b>
? Dataset	891 out of 893 images calibrated (99%), all images enabled	<b>O</b>
? Camera Optimization	8.1% relative difference between initial and optimized internal camera parameters	Δ
Matching	median of 16122.2 matches per calibrated image	<b>②</b>
@ Georeferencing	yes, no 3D GCP	<u> </u>





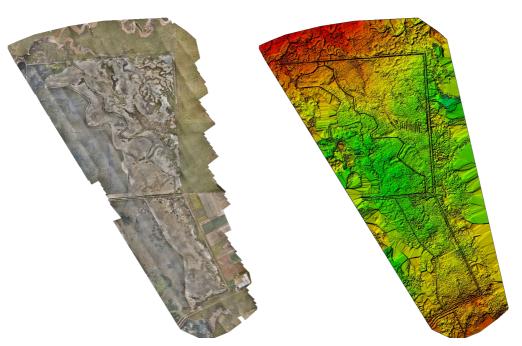


Figure 1: Orthomosaic and the corresponding sparse Digital Surface Model (DSM) before densification.

# **Calibration Details**

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Number of Calibrated Images	891 out of 893
Number of Geolocated Images	891 out of 893

Initial Image Positions

a

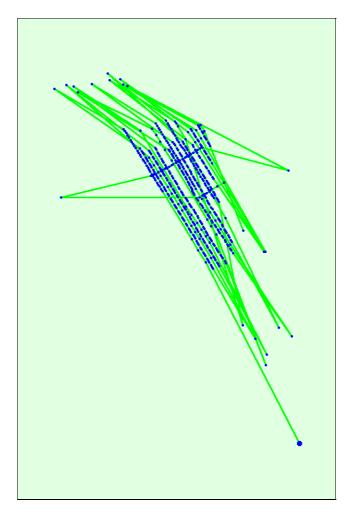
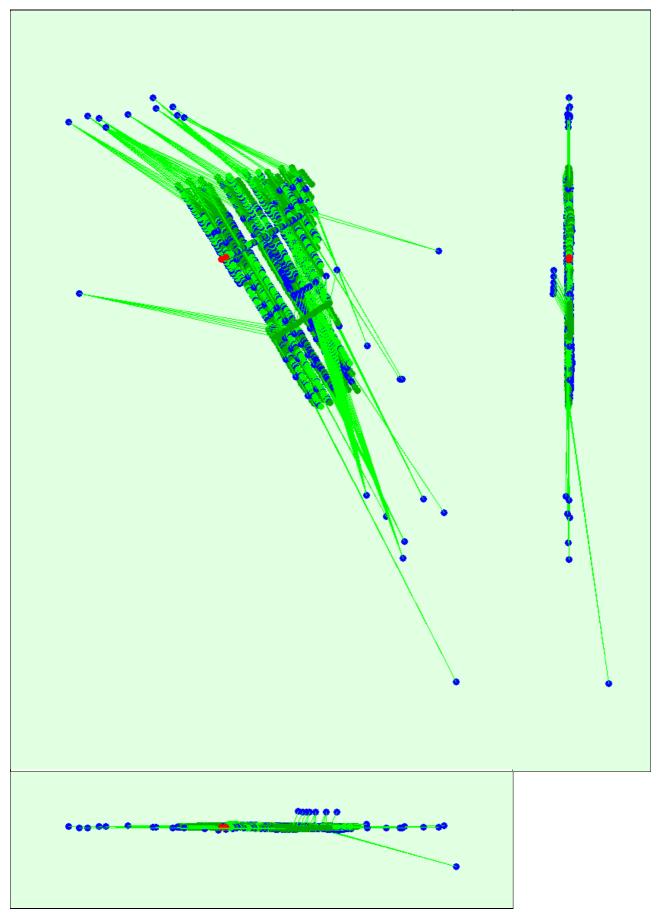


Figure 2: Top view of the initial image position. The green line follows the position of the images in time starting from the large blue dot.

Computed Image/GCPs/Manual Tie Points Positions

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Uncertainty ellipses 10x magnified

Figure 3: Offset between initial (blue dots) and computed (green dots) image positions as well as the offset between the GCPs initial positions (blue crosses) and their computed positions (green crosses) in the top-view (XY plane), front-view (XZ plane), and side-view (YZ plane). Red dots indicate disabled or uncalibrated images. Dark green ellipses indicate the absolute position uncertainty of the bundle block adjustment result.

	X[m]	Y[m]	Z[m]	Omega [degree]	Phi [degree]	Kappa [degree]
Mean	0.751	0.923	0.468	0.083	0.088	0.031
Sigma	0.270	0.256	0.195	0.042	0.030	0.015

Overlap

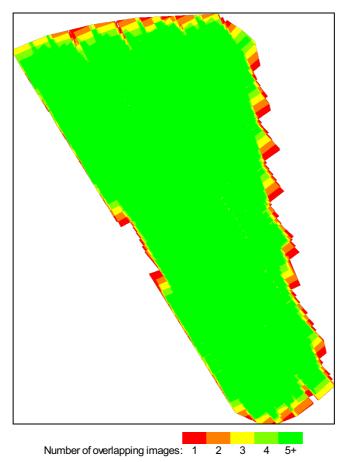


Figure 4: Number of overlapping images computed for each pixel of the orthomosaic.

Red and yellow areas indicate low overlap for which poor results may be generated. Green areas indicate an overlap of over 5 images for every pixel. Good quality results will be generated as long as the number of keypoint matches is also sufficient for these areas (see Figure 5 for keypoint matches).

# **Bundle Block Adjustment Details**

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Number of 2D Keypoint Observations for Bundle Block Adjustment	14513368
Number of 3D Points for Bundle Block Adjustment	4795084
Mean Reprojection Error [pixels]	0.223

#### Internal Camera Parameters

**☆** CanonEOS5DMarkIII\_35mm\_35.0\_5760x3840 (RGB). Sensor Dimensions: 37.109 [mm] x 24.740 [mm]

**(1)** 

EXIF ID: CanonEOS5DMarkIII\_35mm\_35.0\_5760x3840

	Focal Length	Principal Point x	Principal Point y	R1	R2	R3	T1	T2
Initial Values	5432.586 [pixel] 35.000 [mm]	2880.000 [pixel] 18.555 [mm]	1920.000 [pixel] 12.370 [mm]	0.000	0.000	0.000	0.000	0.000
Optimized Values	5873.027 [pixel] 37.838 [mm]	2887.166 [pixel] 18.601 [mm]	1910.074 [pixel] 12.306 [mm]	-0.092	0.096	-0.007	-0.000	0.000
Uncertainties (Sigma)	1.405 [pixel] 0.009 [mm]	1.203 [pixel] 0.008 [mm]	1.029 [pixel] 0.007 [mm]	0.001	0.005	0.010	0.000	0.000

The number of Automatic Tie Points (ATPs) per pixel averaged over all images of the camera model is color coded between black and white. White indicates that, in average, more than 16 ATPs are extracted at this pixel location. Black indicates that, in average, 0 ATP has been extracted at this pixel location. Click on the image to the see the average direction and magnitude of the reprojection error for each pixel. Note that the vectors are scaled for better visualization.

#### 2D Keypoints Table



	Number of 2D Keypoints per Image	Number of Matched 2D Keypoints per Image
Median	59215	16122
Min	20018	82
Max	88865	48449
Mean	57049	16289

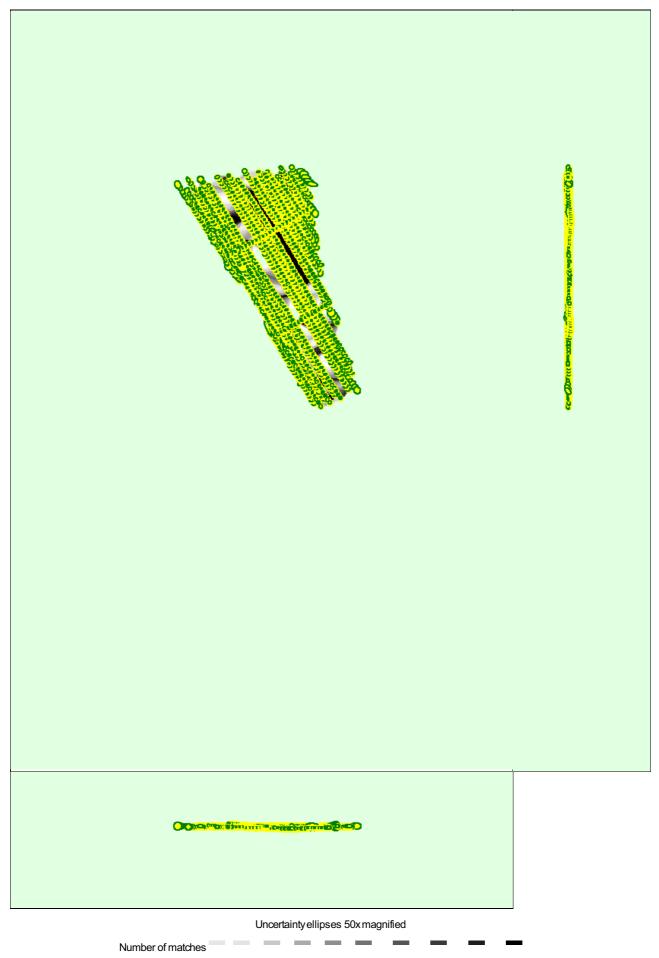
#### 3D Points from 2D Keypoint Matches



	Number of 3D Points Observed
In 2 Images	2600563
In 3 Images	986923
In 4 Images	522295
In 5 Images	341540
In 6 Images	131658
In 7 Images	79847
In 8 Images	54701
In 9 Images	37580
In 10 Images	24540
In 11 Images	7653
In 12 Images	3814
In 13 Images	2136
In 14 Images	1128
In 15 Images	446
In 16 Images	154
In 17 Images	85
In 18 Images	21

#### 2D Keypoint Matches





25 222 444 666 888 1111 1333 1555 1777 2000

Figure 5: Computed image positions with links between matched images. The darkness of the links indicates the number of matched 2D keypoints between the images. Bright links indicate weak links and require manual tie points or more images. Dark green ellipses indicate the relative camera position uncertainty of the bundle block adjustment result.

#### Relative camera position and orientation uncertainties

	X[m]	Y[m]	Z[m]	Omega [degree]	Phi [degree]	Kappa [degree]
Mean	0.674	0.667	0.452	0.082	0.087	0.030
Sigma	0.256	0.277	0.187	0.040	0.030	0.014

## Geolocation Details

#### Absolute Geolocation Variance

4	-	
•		
	•	
v	•	

Min Error [m]	Max Error [m]	Geolocation Error X[%]	Geolocation Error Y [%]	Geolocation Error Z [%]					
-	-15.00	12.75	30.43	0.00					
-15.00	-12.00	6.38	3.19	0.87					
-12.00	-9.00	7.25	4.35	5.22					
-9.00	-6.00	8.12	2.32	10.14					
-6.00	-3.00	6.96	4.06	9.86					
-3.00	0.00	7.83	3.48	22.03					
0.00	3.00	9.57	3.77	25.22					
3.00	6.00	6.09	2.90	11.59					
6.00	9.00	8.70	3.77	9.86					
9.00	12.00	8.41	3.48	4.93					
12.00	15.00	4.64	4.64	0.29					
15.00	-	13.33	33.62	0.00					
Mean [m]		0.034471	-0.158053	-0.002233					
Sigma [m]		12.239987	26.602240	5.372834					
RMS Error [m]		12.240035	26.602709	5.372835					

Min Error and Max Error represent geolocation error intervalsbetween -1.5 and 1.5 times the maximum accuracy of all the images. Columns X, Y, Z show the percentage of images with geolocation errors within the predefined error intervals. The geolocation error is the difference between the intial and computed image positions. Note that the image geolocation errors do not correspond to the accuracy of the observed 3D points.

#### Relative Geolocation Variance



Relative Geolocation Error	Images X[%]	Images Y[%]	Images Z [%]
[-1.00, 1.00]	25.51	11.01	93.91
[-2.00, 2.00]	52.46	24.06	100.00
[-3.00, 3.00]	73.91	35.94	100.00
Mean of Geolocation Accuracy [m]	5.000000	5.000000	10.000000
Sigma of Geolocation Accuracy [m]	0.000000	0.000000	0.000000

Images X, Y, Z represent the percentage of images with a relative geolocation error in X, Y, Z.

# Initial Processing Details

### System Information

Hardware	CPU: Intel(R) Core(TM) i7-6700K CPU @ 4.00GHz RAM: 32GB GPU: NMDIA GeForce GTX 960 (Driver: 21.21.13.6909)
Operating System	Windows 10 Home, 64-bit

Image Coordinate System	WGS84 (egm96)
Output Coordinate System	WGS84 / UTM zone 54S (egm96)

#### **Processing Options**

1

Detected Template	⊜ 3D Maps
Keypoints Image Scale	Full, Image Scale: 1
Advanced: Matching Image Pairs	Aerial Grid or Corridor
Advanced: Matching Strategy	Use Geometrically Verified Matching: no
Advanced: Keypoint Extraction	Targeted Number of Keypoints: Automatic
Advanced: Calibration	Calibration Method: Standard Internal Parameters Optimization: All External Parameters Optimization: All Rematch: Auto, no Bundle Adjustment: Classic

## **Point Cloud Densification details**

1

#### **Processing Options**

a

Image Scale	multiscale, 1/2 (Halfimage size, Default)
Point Density	Optimal
Minimum Number of Matches	3
3D Textured Mesh Generation	yes
3D Textured Mesh Settings:	Resolution: Medium Resolution (default) Color Balancing: no
Advanced: 3D Textured Mesh Settings	Sample Density Divider: 1
Advanced: Matching Window Size	7x7 pixels
Advanced: Image Groups	group1
Advanced: Use Processing Area	yes
Advanced: Use Annotations	yes
Advanced: Limit Camera Depth Automatically	no
Time for Point Cloud Densification	03h:25m:24s
Time for 3D Textured Mesh Generation	26m:13s

#### Results

A

Number of Processed Clusters	2
Number of Generated Tiles	6
Number of 3D Densified Points	140530658
Average Density (per m <sup>3</sup> )	7.21

# DSM, Orthomosaic and Index Details

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#### **Processing Options**

**(1)** 

DSM and Orthomosaic Resolution	1 x GSD (7.38 [cm/pixel])
DSM Filters	Noise Filtering: yes Surface Smoothing: yes, Type: Sharp
Raster DSM	Generated: yes Method: Inverse Distance Weighting Merge Tiles: yes

# **Appendix C - Cover Abundance Spreadsheets**

## Pond XE 4

	2015 Cover Abundance	Ви	ınd	In P	ond	То	tal			Bund 201	5		In Pond 20	015			Bund 201	6		In Pond 2	016
Adapted																					
	(South Australian Department of Environment and	A = = ( = 2)	0/	A 40 5 / 5 33	0/	A === (== 2)	0/				Ca			C (				6		•	
Blanquet N	Natural Resources 1997) Not many, 1- 10 individuals	Area (m2)	0.00%	Area (m2)	% 0.18%	Area (m2) 81	0.03%		id	Area sq	Cover / Abundance	id	Area sq /m	Cover / Abundance		id	Area sq	Cover / Abundance	id	Area sq /m	Cover / Abundance
- IN	sparsely or very sparsely present; cover very small (less than	· '	0.00%	/4	0.16/0	01	0.03/	-	Ia	/m	Abulluance	10	/m	Abulluance	<del>                                     </del>	10	/m	Abundance	10	/m	Abundance
т	5%)	56	0.03%	6644	15.75%	6700	2.72%		0	3067	4	0	1014	3		0	4221	4	0	2541	
1	plentiful, but of small cover (less than 5%)	0	0.00%	1169	2.77%	1169	0.47%		1	218	5	1	7299	5		1	133850	5	1	8665	
2	any number of individuals covering 5-25% of patch	607	0.30%	14040	33.29%	14647	5.94%		2	112530	4	2	681	2		2	21791	4	2	1252	
3	any number of individuals covering 25-50% of patch	1181	0.58%	1372	3.25%	2553	1.04%		3	19634	5	3	197	2		3	66543	5	3	1828	
4	any number of individuals covering 50-75% of patch	115757	56.67%	10925	25.90%	126682	51.40%		4	65765	5	4	180			4	0	5	4	104	
5	covering more than 75% of patch	86672	42.43%	7956	18.86%	94628	38.39%		5	56	T	5	385			5	20	T	5	767	
	Tota	204280	100.00%	42180	100.00%	246460	100.00%		6	20	3	6	17			6	55	3	6	631	
				h-t'0/	Pond Area	1150000 21.43%		-	7	55	3	7	269 63			7	7	3	7	24 4037	
		Ar	ea with vege	tation as % c	of Pond Area	21.43%			8	27	IN A	8	73	2		8	27 18	IN A	8	4037 2982	
									10	18	4	10	201	1	-	10	105	4	10	1691	
									11	105	3	11	208			11	71	3	11	1401	
	2016.6				_			-						_			, -				
	2016 Cover Abundance	Bu	ınd	In P	ond	То	tal		12	71	4	12	389	5		12	44	4	12	7645	
Adapted																					
	(South Australian Department of Environment and	A ( 2)	0,	A ( 2)	0,1	A (	0/				_		-	_	] [						
Blanquet	Natural Resources 1997)	Area (m2)	%	Area (m2)	%	Area (m2)	%		13		4	13 14	89	3		13	85	4	13	212	
N	Not many, 1- 10 individuals sparsely or very sparsely present; cover very small (less than	27	0.01%	2108	3.05%	2135	0.72%		14	85	3	14	18	5	-	14	69	3	14	400	
т	5%)	20	0.01%	8167	11.81%	8187	2.74%		15	69	3	15	650	1		15	59	3	15	40	
1	plentiful, but of small cover (less than 5%)	0	0.00%	18744	27.10%	18744	6.28%	-	16		3	16	318		1	16	282	3	16	16775	
2	any number of individuals covering 5-25% of patch	1005	0.44%	17948	25.95%	18953	6.35%		17		5	17	289			17	176	5	17	76	
3	any number of individuals covering 25-50% of patch	1409	0.61%	3015	4.36%	4424	1.48%		18	178	3	18	89			18	164	3	18	50	
4	any number of individuals covering 50-75% of patch	26264	11.45%	1765	2.55%	28029	9.39%	-	19	148	3	19	24	3		19	73	3	19	35	
5	covering more than 75% of patch	200569	87.47%	17426	25.19%	217995	73.04%		20	54	3	20	75	2		20	3	3	20	503	
	Tota	229294	100.00%	69173	100.00%	298467	100.00%		21	3	3	21	3228	2		21	146	3	21	1562	
					Pond Area	1150000			22	120	3	22	99	1		22	359	3	22	238	
		Ar	ea with vege	tation as % o	of Pond Area	25.95%			23	290	3	23	2952	T		23	121	3	23	242	
									24		2	24	493			24	576	2	24	745	
									25		2	25	1169	I		25	199	2	25	1827	
		5:4	15	16	Ha					20.428		26	81	2		26	230	2	26	201	
		Dif	246460	298467	5.2007							27 28	170 12				22.0204		27	127	
												28	169	IN T			22.9294		28 29	190 818	
												30	45	N N					30	1287	
												31	7539	2					31	403	
												32	38	5					32	631	
												33	212						33	85	
												34	396						34	39	
														ı — — .					25	882	
												35	32	4					35		
												36	9823	4					36	736	
												36 37	9823 73	2					36 37	736 2029	
												36 37 38	9823 73 50	2 2					36 37 38	736 2029 1094	
												36 37 38 39	9823 73 50 35	2 2 2					36 37 38 39	736 2029 1094 242	
												36 37 38 39 40	9823 73 50 35 503	2 2 2 3					36 37 38 39 40	736 2029 1094 242 164	
												36 37 38 39 40 41	9823 73 50 35 503 1070	2 2 2 3 3 4					36 37 38 39 40 41	736 2029 1094 242 164 147	
												36 37 38 39 40 41 42	9823 73 50 35 503 1070 155	2 2 2 2 3 4					36 37 38 39 40 41 42	736 2029 1094 242 164 147 276	
												36 37 38 39 40 41 42 43	9823 73 50 35 503 1070 155	2 2 2 3 4					36 37 38 39 40 41 42 43	736 2029 1094 242 164 147 276 1810	
												36 37 38 39 40 41 42	9823 73 50 35 503 1070 155 61 304	2 2 2 3 4 T					36 37 38 39 40 41 42 43	736 2029 1094 242 164 147 276 1810	
												36 37 38 39 40 41 42 43	9823 73 50 35 503 1070 155 61 304 674	2 2 2 3 4 1 1					36 37 38 39 40 41 42 43 44	736 2029 1094 242 164 147 276 1810 769	
												36 37 38 39 40 41 42 43 44	9823 73 50 35 503 1070 155 61 304	4 2 2 2 3 4 1 1 1					36 37 38 39 40 41 42 43	736 2029 1094 242 164 147 276 1810 769 76	
												36 37 38 39 40 41 42 43 44 45	9823 73 50 35 503 1070 155 61 304 674 1238	4 2 2 2 3 4 1 1 1 1 1 2 2 2 2 2 3 3 4 4 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1					36 37 38 39 40 41 42 43 44 45	736 2029 1094 242 164 147 276 1810 769	

# Pond XF 1

	2015 Cover Abundance	В	Bund	In P	ond	Tota	al	<del></del> -	Bund 2015	5		In Pond 2	015		Bund 20:	16	In Pond 2016		
Adapted from Bruan- Blanquet	(South Australian Department of Environment and Natural Resources 1997)	Area (m2)	%	Area (m2)	%	Area (m2)	%			Cover/			Cover/			Cover/			Cover/
N	Not many, 1- 10 individuals	11	0.02%	21	0.15%	32	0.05%	id	Area sq /m	Abundance	id	Area sq /m	Abundance	id	Area sq /m	Abundance	id	Area sq /m	Abundance
т	sparsely or very sparsely present; cover very small (less than 5%)	0	0.00%	٥	0.00%	0	0.00%	0	2289	4	0	1013	5		2915	4	0	1083	
1	plentiful, but of small cover (less than 5%)	0	0.00%	0	0.00%	0	0.00%	 1	300	2	1	84		1	515	2	1	2160	
2	any number of individuals covering 5-25% of patch	630	1.16%	0	0.00%	630		2	697	3	2	3	N N	2	625	3	2	96	
3	any number of individuals covering 25-50% of patch	2862	5.26%	3306	23.12%	6168	8.98%	3	138	4	3	41	. 4	3	159	4	3	22	
4	any number of individuals covering 50-75% of patch	20549	37.76%	8546		29095		4	42	3	4	. 7	' N	4	78	3	4	27	
5	covering more than 75% of patch	30365	55.80%	2427	16.97%	32792		5	76	3	5	2114	3	5	148	3	5	4	
	Total	54417	100.00%	14300		68717	100.00%	6	91	3	6	62	2 3	6	120	3	6	6836	
			otations of the		Pond Area	1160000		7	293		7	1 7	N N	7	328		7	1348	
		Area v	with vegetati	on as % of	rond Area	5.92%		8	125 183		8	18	) 5 N	8	198 245		8	202 1311	
								 10	285		10	6148	γ IN β Δ	10			10		
								11	160		11			11	276	4	11	17	
	2016 Cover Abundance	В	Bund	In P	ond	Tota	al	12	330	3	12	48	3 4	12	361	3	12	2663	i
Adapted																			
from Bruan-	(South Australian Department of Environment and	Area		Area															
Blanquet	Natural Resources 1997)	(m2)		(m2)	%	Area (m2)	%	13	160		13			13	195	4	13	77	
N	Not many, 1- 10 individuals	12	0.02%	2782	14.43%	2794	3.50%	14	189	4	14	86	4	14	288	4	14	41	<u> </u>
_	sparsely or very sparsely present; cover very small (less than				0.000/		0.000/	4.5	25.6		4-							_	
1 1	5%) plentiful, but of small cover (less than 5%)	0	0.00% 0.00%	0	0.00% 0.00%	0	0.00%	15 16	256 112		15 16	2223	5	15		3	15		
2	any number of individuals covering 5-25% of patch	1103		0	0.00%	1103		 17	136		10	1.43		16 17		3	16 17		
3	any number of individuals covering 3-25% of patch	3411	5.64%	6857	35.57%	10268		 18	230			1.40	,	18		3	18		
4	any number of individuals covering 50-75% of patch	23539	38.90%	6106		29645		 19	180					19		-	19		
5	covering more than 75% of patch	32451	53.62%	3531	18.32%	35982		20	342					20			20		
	Total	60516	100.00%	19276	100.00%	79792	100.00%	21	188	3				21	202	3	21	56	
					Pond Area	1160000		22	285					22	335	4	22	1410	
		Area v	with vegetati	on as % of	Pond Area	6.88%		23	278					23			23		
								24	150					24			24		
			45	46				25	45	3				25		3	25		
		Dif	<b>15</b> 68717	<b>16</b> 79792	Ha 1.1075			 26 27	17 11	3 N				26		3 N	26		
		J11	00/1/	19192	1.10/5	]		28	50					27		2	27	3/	
								29	118					29		2			
								30	359					30		4		1.9276	
								31	11473	5				31	12352	5			
								32	5342					32		5			
								33	5278					33		4			
								34	3269					34		5			
								35 36	2668					35		5			
								36	6471 2533					36		- 4			
								38	1416					38		Δ			
								39	2940					39		4			
								40	4362					40		5			
								41	718					41		5			
									5.4585					42	15	3			
														43					
															6.0516				

# Pond XF 2

	2015 Cover Abundance	В	Bund	In P	ond	Tota	al			Bund 201	5		In Pond 2	015			Bund 201	16		In Pond 2	016
Adapted from Bruan-	(South Australian Department of Environment and	Area		Area																	
Blanquet	Natural Resources 1997)	(m2)	%	(m2)	%	Area (m2)	%			Area sq	Cover/		Area sq	Cover/			Area sq	Cover /		Area sq	Cover/
N	Not many, 1- 10 individuals sparsely or very sparsely present; cover very small (less tha			409	0.87%	436	0.18%	j	id		Abundance	id	/m	Abundance		id	/m	Abundance	id	/m	Abundan
T 1	5%) plentiful, but of small cover (less than 5%)	32593 0	0.00%	8002	17.00%	8002	3.25%		0	16 33	3	:	14157 1 2817	3		0	39 581		1	14385 2739	<u> </u>
2	any number of individuals covering 5-25% of patch any number of individuals covering 25-50% of patch	30696 50289	15.39% 25.21%	10228 9894			16.60% 24.41%		3	33 581	2	:	2 592 3 1235			2	224 75		3	839 1235	
4 5	any number of individuals covering 50-75% of patch covering more than 75% of patch	7266 78625			7.76% 30.08%	10917 92782	4.43% 37.63%		4 5	58 17	3		4006			4	27 973		4	4050 672	
	To			47062		246558	100.00%		6 7	57 224	T 2		5 64 7 197	. 4		6 7	1028 4571	Т	6	64 197	
		Area	with vegetati						8	75 27	2 N		3 199 9 47	) 1		8	64 185	2		199	
									10	895	5	10	840	) 1		10	168 231		10	916	5
	2016 Cover Abundance	Е	Bund	In P	ond	Tota	al		12		5	12				12	149		12		i
Adapted from Bruan-	(South Australian Department of Environment and	Area		Area																	
Blanquet N	Natural Resources 1997) Not many, 1- 10 individuals	(m2) 185	0.09%	(		Area (m2) 2212	% 0.81%		13 14		5	13			!	13 14	64 242	3	13 14	46 1244	
т	sparsely or very sparsely present; cover very small (less that 5%)	an 1071	0.52%				0.61%		15		3	1		5 1		15	257	3	15	1726	5
1 2	plentiful, but of small cover (less than 5%) any number of individuals covering 5-25% of patch	5990	0.00% 2.92%				3.45% 7.65%		16 17	149	3	10				16 17	7149 105		16		
3	any number of individuals covering 25-50% of patch any number of individuals covering 50-75% of patch	157667 39338	76.76% 19.15%	20768 4182		178435 43520	65.70% 16.02%		18 19			15				18 19	137 76560	5	18 19		
5	covering more than 75% of patch To	1143 tal 205394	0.56%			15638 271600	5.76% 100.00%		20 21	257	3	20				20 21	165 73		20		
			with vegetati		Pond Area	2280000			22	105	3	2:	2 544	1 2		22		3	22	912	
									24 25	72815	5	24	4 73	3 2		24			24	156	5
		Dif	<b>15</b> 246558	<b>16</b> 271600	Ha 2.5042				26 27	37	4	20	5 112			26 27	37440 19		26	112	
		J.,	2-10330	271000	2.3042				28	6738	3	28	3 428	3 2		28	82	3	28	518	3
									30 31	394	4	30	2081			30	1558	4	30	2081	
									32	37440	3	32	2 38	8 1		31 32	37	3	31	428	
									33 34	82	3	3:	4 356	j 2		33 34	4186	3	33	30	0
									35 36	691	T 3	3:	5 16	i N		35 36	43 84		35	404	ĺ
										19.9496		3:	3 2303	3 2			20.5394		37	814	i
												39	37	, v					39 40	34	
												4:	2 325						41		
												4:	346						43	46	
												4:	5 554	1					45	109	
												4	7 28	3 4					47	54	
												49	9 46	5 S					48	444	
												5:	1 67	, 3					50	13	
												53	2 84 3 62	2					52 53	501	
												53 54 54 55 56	4 54 5 (	5 4					54 55	40	0
												56	5 169 7 162		i				56 57	110	)
												58	4.7224						58 59	506	5
																			60 61	181	
																			62 63	371	
																			64 65	545	
																			67	321	
																			68 69	4799	
																			70 71	99	
																			72 73	2008	3
																			74 75	521	
																			76 77	651	
																			78 79		
																			80 81	479 325	6
																			82	491 140	)
																			84	186 2652	2
																			86 87	101 670	)
																			88	744 672	1
																			90 91	1088 5210	0
																			92 93	536 830	)
																			94 95	442 712	2
																			96 97	78 109	9
																			98 99	1202 200	!
																			100	15225 190	)
																			102 103	101 34	ı.
																			104	461 541	
																			106	2337	1
																			108	25	
																			110	12624	
																			112	9923	1
																			113 114 115	2384	
																			116	720	)
																			118	1356	5
																			119	2247	1

# Pond XC 1

	2015 Cover Abundance	В	Bund	In P	ond	Tota	al		Bund 201	.5	ı	n Pond 201	5		Bund 201	5	lr	n Pond 201	.6
	(South / Laoth dhan Dopar timont of Environment and	Area (m2)	%	Area (m2)	%	Area (m2)	%			Cover/			Cover/			Cover/			Cover /
N	Not many, 1- 10 individuals	8	0.03%	370	48.88%	378	1.42%	id	Area sq /m	Abundance	id	Area sq /m	Abundan ce	id	Area sq /m	Abundan ce	id	Area sq /m	Abundan ce
т	sparsely or very sparsely present; cover very small (less than 5%)	0	0.00%	0	0.00%	0	0.00%	0	1862		0	88	5		0 2256		0	1705	
1	plentiful, but of small cover (less than 5%)	0	0.00%	0	0.00%	0	0.00%	1	165		1	. 62	2		1 94	_	1	754	
2	any number of individuals covering 5-25% of patch	219		62	8.19%	281		2	94	'	2	237	3		2 272	<u> </u>	2	706	
3	any number of individuals covering 25-50% of patch	666	2.57%	237	31.31%	903		3	33		3	189	N		3 49	<u> </u>	3	464	Į
4	any number of individuals covering 50-75% of patch	3763		0	0.00%	3763		4	50	4	4	113	N		4 511		4	55	
5	covering more than 75% of patch	21229	82.01%	88		21317	80.01%	5	1752	5	5	55	N		5 407	Į	5	13	Į
	Total	25885	100.00%	757		26642	100.00%	6	325		6	13	N		6 3563		6	59	
					Pond Area	1320000		7	558			0.0757			7 10800	<del></del>	7	142	
		Area	with vegetation	on as % of	Pond Area	2.02%		8	225						8 264		8	472	
								9	2158						9 597		9	69	
								10	8919						10 321		10	000	
								11	138	5					11 13	5	11	2163	2
	2016 Cover Abundance	В	und	In P	ond	Tota	al	12	227	3					12 73	3	12	505	2
Adapted																]			
	(South Australian Department of Environment and	Area		Area														l '	1
Blanquet	Natural Resources 1997)	(m2)	%	(m2)	%	Area (m2)	%	13	219						13 16		13	69	
N	Not many, 1- 10 individuals	4087	12.82%	591	6.57%	4678	11.44%	14	214	3					14 901	. 3	14	16	2
т	sparsely or very sparsely present; cover very small (less than 5%)	0	0.00%	0	0.00%	0	0.00%	15	291	. 4					15 5238	4	15	72	2
1	plentiful, but of small cover (less than 5%)	0	0.00%	0	0.00%	0	0.00%	16	8	N					16 4087	N	16	151	2
2	any number of individuals covering 5-25% of patch	16	0.05%	5995	66.63%	6011	14.71%	17	73	4					17 81	. 4	17	160	2
3	any number of individuals covering 25-50% of patch	1238	3.88%	706	7.85%	1944	4.76%	18	16	4					18 131	. 4	18	97	2
4	any number of individuals covering 50-75% of patch	21336	66.93%	0	0.00%	21336	52.20%	19	645	1 -1					19 1011	. 5	19	52	2
5	covering more than 75% of patch	5203	16.32%	1705	18.95%	6908	16.90%	20	3995	5					20 532	5	20	86	2
	Total	31880	100.00%	8997	100.00%	40877	100.00%	21	3918	5					21 287	5	21	348	2
					Pond Area	1320000			2.5885						22 280	5	22	248	2
		Area	with vegetation	on as % of	Pond Area	3.10%									23 96	5	23	228	2
															3.188	3		0.8997	
				15	16	На													
			Dif	26642	40877	1.4235													

# Pond XC 2

	2015 Cover Abundance	Е	Bund	In F	ond	Tota	al			Bund 201	5		In Pond 20	)15			Bund 2016		li	n Pond 20:	16
Adapted from Bruan- Blanquet	(South Australian Department of Environment and Natural Resources 1997)	Area (m2)	%	Area (m2)	%	Area (m2)	%				Cover /			Cover/				Cover/			Cover/
N	Not many, 1- 10 individuals	223	0.67%	121	3.80%	344	0.94%	5	id	Area sq /m	Abundance	id	Area sq /m	Abundance		id	Area sq /m	Abundan ce	id	Area sq /m	Abundan ce
т	sparsely or very sparsely present; cover very small (less than 5%)	0	0.00%	782	24.57%	782	2.13%		0	132	2	,	220	Т Т	. [	0	540	2	0	115	]   5 T
1	plentiful, but of small cover (less than 5%)	0	0.00%	1364		1364			1	613		1	15	2		1	980	5	1	30	
2	any number of individuals covering 5-25% of patch	333	0.99%	257	8.07%	590	1.61%	5	2	12	2	2	11	N		2	241	2	2	13	3 N
3	any number of individuals covering 25-50% of patch	1165	3.48%	94		1259			3	100	4	3	3 45	T		3	8	4	3	62	<u>2</u> T
4	any number of individuals covering 50-75% of patch	1956	5.84%	494		2450			4	200	N	4	1 16	N		4	25	N	4	139	
5	covering more than 75% of patch	29836	89.03%	71		29907	81.50%	-	5	8	4	5	5 5	N		5	42	4	5	94	4
	Total	33513	100.00%	3183		36696	100.00%	5	6	25		6	30	4		6	72	4	6	13	3 4
			***		Pond Area	1240000			7	26 47		7	7 13	4		7	228	4	7	5	5 4
		Area	with vegetation	on as % or	Pond Area	2.96%		_	8	206			3 30	N 2		8	364 109	5	8	25	) N
									10			10	1	Т		10	_	Δ	10	42	<u> </u>
									11			11		1		11		2	11	55	
	2016 Cover Abundance	В	und	In P	ond	Tot	al		12			12		N		12		N	12	172	
Adapted	2020 50101 11001100					130									1		1,3			1/2	1
	(South Australian Department of Environment and	Area		Area																	
	Natural Resources 1997)	(m2)	%	(m2)	%	Area (m2)	%		13	39	4	13	3 4	N		13	272	4	13	4438	3 N
N	Not many, 1- 10 individuals	386	0.90%	6380	33.02%	6766	10.88%		14	45	3	14	1 7	N		14	67	3	14	261	L N
	sparsely or very sparsely present; cover very small (less than																				
T	5%)	0	0.00%	302	1.56%	302	0.49%		15			15		4		15		4	15		
1	plentiful, but of small cover (less than 5%)	0	0.00%	2016	10.43%	2016	3.24%		16			16		2	-	16		2	16	78	
3	any number of individuals covering 5-25% of patch any number of individuals covering 25-50% of patch	1403 35524	3.27% 82.86%	240 68	1.24% 0.35%	1643 35592	2.64% 57.23%		17 18			17 18		3		17 18	73 273	4	17 18	68 162	_
4	any number of individuals covering 50-75% of patch	3048	7.11%	8941	46.27%	11989	19.28%	1	19			19		IN N		18	_	3	19		
5	covering more than 75% of patch	2509	5.85%	1376	7.12%	3885	6.25%		20			20		2		20		2	20	127	
	Total	42870	100.00%	19323	100.00%	62193	100.00%		21			21		N		21	_	3	21	247	
		•			Pond Area	1240000			22	69	4	22		4		22		4	22	301	
		Area	with vegetation	on as % of	Pond Area	5.02%			23	15	4	23		4		23	162	4	23	217	7 4
									24			24		5		24	231	4	24	1090	) 5
			15	16	На				25		5	25		1		25		5	25	1961	
		Dif	36696	62193	2.5497				26		5	26		4		26		5	26	37	_
									27			27		4		27		4	27	778	
									28 29			28 29		4		28		4	28 29		
									30		5	30			<del> </del>	29 30			30		_
									31		3	31				31	_	3	31	33	
									32			32				32		4	32		+
									33	110	5		0.3183			33		5	33		
									34							34		4	34	35	5 4
									35							35		3	35	61	
									36							36		3	36		
									37			-				37			37		
									38		N 2	-				38			38		
									39 40							39 40			39 40	114 1112	
									40							40			40	31	_
									42			<del> </del>				41			41	2861	
									43		N	<u> </u>				43			43	628	
									44		3					44			44	174	
									45							45			45		
									46							46	156	5		1.9323	3
									47		3										
									48	9	4	1									

## Pond XC 2E

	2015 Cover Abundance	Bu	nd	Tota	1		Bund 2015		Ir	n Pond 201	5		Bund 2016		In	Pond 201	.6
Adapted					-						-						
from Bruan- Blanquet	(South Australian Department of Environment and Natural Resources 1997)	Area (m2)	%	Area (m2)	%			Cover /			Cover/			Cover /			Cover /
	Not many, 1- 10 individuals				0.200/			Abundan		•	Abundan			Abundan		Area sq	Abundan
N	sparsely or very sparsely present; cover very small (less than	503	0.29%	503	0.29%	id	/m	ce	id	/m	ce	id	/m	ce	id	/m	ce
T	5%) plentiful, but of small cover (less than 5%)	140	0.08%	140	0.08%	(	4602	5	0	0	0	0	6011	5	0	0	0
2	any number of individuals covering 5-25% of patch	1455 22706	0.84% 13.06%	1455 22706	0.84%		9392 2 12492	5				1	9392 12492	5			
3	any number of individuals covering 25-50% of patch	16408	9.43%	16408	9.43%		12600	3				3	12600	3			
4	any number of individuals covering 50-75% of patch	88662	50.98%	88662	50.98%	4	88116	4				4	88116	4			
5	covering more than 75% of patch  Total	44043 173917	25.32% 100.00%	44043 173917	25.32% 100.00%	5	266	5				5	266 26	5			
	Total		Pond Area	410000	100.0078		7 357	3				7	357	3			
	Area with vegetation	on as % of I	Pond Area	42.42%			3 54	3				8	54				
						10	506	N A				9	11	N			
						11	+	5				10 11		5			
	2016 Cover Abundance	Bu	nd	Tota	1	12		2				12		2			
Adapted	2010 COVET / Wallauffee											12	10090				
from Bruan-	(South Australian Department of Environment and	Area															
Blanquet N	Natural Resources 1997) Not many, 1- 10 individuals	(m2)	% F 169/	Area (m2)	% F 16V	13		2 N				13		2			
IN	sparsely or very sparsely present; cover very small (less than	8981	5.16%	8981	5.16%	14	· /3	N				14	78	N			
Т	5%)	37	0.02%	37	0.02%	15		5				15		5			
2	plentiful, but of small cover (less than 5%) any number of individuals covering 5-25% of patch	940	0.54% 18.62%	940 32385	0.54% 18.62%	16		N				16		N			
3	any number of individuals covering 5-25% of patch	32385 28934	18.62% 16.64%	32385 28934	18.62%	12		N N				17 18		N			
4	any number of individuals covering 50-75% of patch	88722	51.01%	88722	51.01%	19		N				19					
5	covering more than 75% of patch	48492	27.88%	48492	27.88%	20		N				20		N			
	Total	208491	100.00% Pond Area	208491 410000	100.00%	22		1 N				21 22		1 N			
	Area with vegetation			50.85%		23		3				23		3			
						24		2				24		2			
		Dif	15	16	Ha	25	+	5 N				25					
		Dif	173917	208491	3.4574	26		N N				26 27					
						28		5				28		5			
						29		5				29					
						30	+	N N				30 31		N			
						32		N				32		N			
						33		1				33		1			
						34		2 N				34		2			
						36		5				35 36		5			
						37	7 67	2				37		2			
						38		1				38		1			
						39	102					39 40	375 140	1			
						4:	+	2				41		2			
						42		2				42					
						43		3				43 44					
						45		5				44					
						46	5 14	4				46					
						47		3				47		3			
						48		N 2				48 49					
						50	375					50					
						5:						51					
						52						52 53					
						54						54					
						55		-				55	124	1			
						56						56 57					
						58	+					57					
							17.4656					59	107	2			
												60 61					
												62					
												63	289	2			
												64 65					
												66		2			
												67	1277				
												68 69		2			
												70	129				
												71	142	2			
												72 73					
												73 74					
												75	2122	2			
												76 77		2			
												78	1894	2			
													20.8491				

## Pond XC 2S

	2015 Cover Abundance	В	Bund	In P	ond	Tota	al		Bund 201	.5	lı	n Pond 201	5		Bund 2016	5	ı	n Pond 201	16
Adapted from Bruan- Blanquet	(South Australian Department of Environment and Natural Resources 1997)	Area (m2)	%	Area (m2)	%	Area (m2)	%			Cover/			Cover/			Cover/			Cover/
N	Not many, 1- 10 individuals	0	0.00%	149	0.48%	149	0.15%	id	Area sq	Abundance	id		Abundan ce	id	_	Abundan ce	:	Area sq	Abundan ce
N N	sparsely or very sparsely present; cover very small (less than	-	0.0076	143	0.46/6	143	0.13/6	 IQ	/m	Abulluance	Ia	/m	Ce	10	/m	i ce	id	/m	
т	5%)	0	0.00%	0	0.00%	0	0.00%	0	56500	4	0	1156	4		58007	4	0	3935	5 4
1	plentiful, but of small cover (less than 5%)	0	0.00%	0	0.00%	0	0.00%	 1	2348	4	1	64	3	- 1	2354	4	1	144	
2	any number of individuals covering 5-25% of patch	826	1.17%	3444	11.12%	4270	4.22%	2	2924	. 5	2	117	3	2	3069	5	2	487	7 3
3	any number of individuals covering 25-50% of patch	5228	7.43%	11361	36.69%	16589	16.38%	3	826	2	3	252	2		1603	2	3	1698	3 2
4	any number of individuals covering 50-75% of patch	59249	84.25%	15850		75099		4	54		4	47		4	5515	3	4	75	5 2
5	covering more than 75% of patch	5021	7.14%	165		5186		5	5174		5	1240		į	1306	3	5	3052	
	Total	70324	100.00%	30969		101293	100.00%	 6	1193		6	144		(	71	5	6	186	
					Pond Area	490000		 7	71		7	124			7 1281	5	7	32	
		Area	with vegetation	on as % of	Pond Area	20.67%		 8	833		8	167		8	3 401	5	8	3 42	
								 9	401	l .	9	296		9	12		9	110	
									7.0324		10			10	494	4	10		1
											11	1217					11		
											12	148	5				12	16563	3 3
	2016 Cover Abundance	Е	Bund	In P	ond	Tota	al				13	115	4		7.4113		13	13126	j 4
Adapted	(O. al. A. de l'en Bernette de François de la	١.																	
from Bruan-	(South Australian Department of Environment and	Area	%	Area	%	A wa a / wa 2)	%				1.4	11	_				1		
Blanquet N	Natural Resources 1997) Not many, 1- 10 individuals	(m2) 0	0.00%	(m2) 191	0.27%	Area (m2) 191	0.13%				14 15						14		
IN .	sparsely or very sparsely present; cover very small (less than	1	0.00%	191	0.27/6	191	0.13/0				13	20	3				15	1/9	1 3
т	5%)	0	0.00%	0	0.00%	0	0.00%				16	6	5				16	. 8f	5 5
1	plentiful, but of small cover (less than 5%)	0	0.00%	0	0.00%	0	0.00%				17	101	2				17		2
2	any number of individuals covering 5-25% of patch	1603	2.16%	10333	14.44%	11936	8.19%				18	43	4				18		4
3	any number of individuals covering 25-50% of patch	6821	9.20%	17042	23.82%	23863	16.38%				19	803	3				19		+
4	any number of individuals covering 50-75% of patch	60867	82.13%	26996	37.73%	87863	60.32%				20	8589	3				20		3
5	covering more than 75% of patch	4822	6.51%	16990	23.74%	21812	14.97%				21	12079	4				21	960	) 4
	Total	74113	100.00%	71552	100.00%	145665	100.00%				22	341	2				22	93	3 2
					Pond Area	490000					23	179	3				23	31	3
		Area	with vegetation	on as % of	Pond Area	29.73%					24	63	3				24	41	1 3
											25	36	N				25	70	) N
			15	16	На						26						26	1027	/ 2
		Dif	101293	145665	4.4372						27						27		
											28						28		_
											29						29		
											30		<del></del>				30		
												3.0969					31		
																	32		
																	33		
																		7.2653	j

## **Bolivar Channel**

	2015 Cover Abundance	Bu	nd	Tota	al		Channel 20	15			Channel 2	016
Adapted from Bruan- Blanquet	(South Australian Department of Environment and Natural Resources 1997)	Area (m2)	%	Area (m2)	%			Cover/				Cover/
N	Not many, 1- 10 individuals	0	0.00%	0	0.00%	id	Area sq /m	Abundance		id	Area sq /m	Abundance
т	sparsely or very sparsely present; cover very small (less than 5%)	0	0.00%	0	0.00%	0	10010	5	5	0	10232	5
1	plentiful, but of small cover (less than 5%)	0	0.00%	0	0.00%	1	40	3	3	1	352	3
2	any number of individuals covering 5-25% of patch	0	0.00%	0	0.00%	2	187	3	3	2	785	3
3	any number of individuals covering 25-50% of patch	252	0.10%	252	0.10%	3	24	4	ļ	3	170	4
4	any number of individuals covering 50-75% of patch	67	0.03%	67	0.03%	4	170	5	<u> </u>	4	2111	5
5	covering more than 75% of patch	246584	99.87%	246584	99.87%	5	137	5	<u> </u>	5	3416	5
	Total	246903	100.00%	246903	100.00%	6	1985	5	5	6	1613	5
			Pond Area	287000		7	3392	5	5	7	485	5
	Area with vegetation	on as % of	Pond Area	86.03%		8	43	4	ļ	8	2326	4
						9	1547	5	5	9	57309	5
	2016 Cover Abundance	Bu	nd	Tota	al	10	241	5	5	10	77734	5
	(South Australian Department of Environment and	Area										
•	Natural Resources 1997)	(m2)		Area (m2)	%	11	25	3	3	11		3
N	Not many, 1- 10 individuals	0	0.00%	0	0.00%	12	2333	5	5	12	15003	5
_	sparsely or very sparsely present; cover very small (less than		0.000/		0.000/	4.2	F.C000	-			40404	_
1	5%)	0	0.00%	0	0.00%	13	56888	5	<u>)</u>	13	42181	5
1	plentiful, but of small cover (less than 5%)	0	0.00%	0	0.00%	14	76936	5				
3	any number of individuals covering 5-25% of patch any number of individuals covering 25-50% of patch	35875	0.00% 14.44%	35875	0.00%	15 16	32254 16493	5	<u>)</u>			
	any number of individuals covering 50-75% of patch	35875 2496					44198	5	<u> </u>			
5	covering more than 75% of patch	210084		210084		17			<u>'l</u>		24.0455	
Total	Total		100.00%				24.6903				24.8455	
iotai	Total		Pond Area									
	Area with vegetation											
	Area with vegetation	Jii u3 /0 UI	JIIU AIEG	30.37/0								
			15	16	Ha							
		Dif	246903									

	2015 Cover Abundance	В	und	In P	ond	То	tal		Bund 201	15		n Pond 201	5		Bund 2016	i	Ir	Pond 201	.6
	(South Australian Department of Environment and Natural Resources 1997)	Area (m2)	%	Area (m2)	%	Area (m2)	%			Cover/			Cover/			Cover/			Cover/
N	Not many, 1- 10 individuals	42	0.22%	22	0.14%	64	0.18%	id	Area sq /m	Abundance	id	Area sq /m	Abundan ce	id	Area sq /m	Abundan ce	id	Area sq /m	Abundan ce
Т	sparsely or very sparsely present; cover very small (less than 5%)	0	0.00%	0	0.00%	0	0.00%	0	4121	1 5	5 (	38	3	0	4213	5	0	2907	3
1	plentiful, but of small cover (less than 5%)	0	0.00%	0	0.00%	0	0.00%	1	59	9 2	2 1	. 7	N	1	59	2	1	4453	. N
2	any number of individuals covering 5-25% of patch	134	0.70%	4690	29.82%	4824	13.88%	2	75	5 2	2 2	4801	4	2	107	2	2	606	. 4
3	any number of individuals covering 25-50% of patch	7093	37.28%	5672	36.06%	12765	36.73%	3	203	3 4	1 3	2298	3	3	200	4	3	9	3
4	any number of individuals covering 50-75% of patch	7635	40.13%	5345	33.98%	12980	37.35%	4	7432	2 4	1 4	4184	2	4	7658	4	4	5904	. 2
5	covering more than 75% of patch	4121	21.66%	0	0.00%	4121	11.86%	5	461	1 3	3 5	5	N	5	569	3	5	998	, N
	Total	19025	100.00%	15729	100.00%	34754	100.00%	6	4610	) :	3 6	1	N	6	4885	3	6	372	. N
					Pond Area	530000		7	157	7 3	3	506	2	7	157	3	7	98	. 2
		Area w	ith vegetatio	on as % of I	Pond Area	6.56%		8	1865	5	3 8	9	N	8	1865	3	8	11407	N
								9	33	3 N	1 9	3336	3	9	33	N	9	146	3
								10	3	3 1	1	544	4	10	3	N	10	112	4
								11	6	5 N	ı	1.5729		11	6	N	11	128	. 3
	2016 Cover Abundance	В	und	In P	ond	То	tal		1.9025	5				12	110	2	12	81	3
Adapted																			
from Bruan-	(South Australian Department of Environment and	Area		Area		Area													
Blanquet	Natural Resources 1997)	(m2)	%	(m2)	%	(m2)	%							13			13		
N	Not many, 1- 10 individuals	42	0.21%	17230	61.60%	17272	36.02%							14	15	3	14	43	3
т	sparsely or very sparsely present; cover very small (less than 5%)	0	0.00%	0	0.00%	0	0.00%							15	83	3	15	67	3
1	plentiful, but of small cover (less than 5%)	0	0.00%	0	0.00%	0	0.00%										16	67	3
2	any number of individuals covering 5-25% of patch	276	1.38%	6002	21.46%	6278	13.09%								1.9983		17		
3	any number of individuals covering 25-50% of patch	7594	38.00%	4022	14.38%	11616	24.22%										18		
4	any number of individuals covering 50-75% of patch	7858	39.32%	718	2.57%	8576	17.88%										19		
5	covering more than 75% of patch	4213	21.08%	0	0.00%	4213	8.79%										20		
	Total	19983	100.00%	27972	100.00%	47955	100.00%											2.7972	
					Pond Area	530000													
		Area w	ith vegetation	on as % of I	Pond Area	9.05%													
			4.	46															
		D:t	15	16	Ha														
		Dif	34754	47955	1.3201														

	2015 Cover Abundance	В	und	In Po	ond	Tota	al			Bund 20	15		In Pond 2	015		Bund 201	16		In Pond 20	16
Adapted																				
	(South Australian Department of Environment and	Area	.,	Area							l									
Blanquet	Natural Resources 1997)	(m2)	%	(m2)	%	Area (m2)	%			A ** 0 0 0 0	Cover/		A #00.00	Cover/		A ***	Cover /		A ****	Cover /
	Not many, 1- 10 individuals	170	1.51%	19	1.46%	189	1.51%		id	Area sq /m	Abundance	id	Area sq /m	Abundance	id	Area sq /m	Abundance	id	Area sq /m	Abundance
	sparsely or very sparsely present; cover very small (less than 5%)		0.00%	0	0.00%	0	0.00%		0	1249	9 4	0	66	j 2	0	1646	. 4	,	121	2
	plentiful, but of small cover (less than 5%)	27		0	0.00%	27			1		7 N	1	96	3	1	20		1	. 247	3
	any number of individuals covering 5-25% of patch	2354	20.97%	229		2583		-	2	-	7 N	2	38		2	13		2	128	3
3	any number of individuals covering 25-50% of patch	5081	45.25%	801	61.66%	5882	46.95%	-	3		7 N	3	107	2	3	7	N	3	95	2
4	any number of individuals covering 50-75% of patch	3458	30.80%	250	19.25%	3708	29.60%		4		7 N	4	213	4	4	187	N	4	79	4
5	covering more than 75% of patch	138		0	0.00%	138			5	138		5	16		5	1110	5	5	497	4
	Total	11228	100.00%	1299	100.00%	12527			6	1110		6	115		6	261	_	6	39	3
					Pond Area				7	25		7	14	N	7	671		7	131	N
		Area v	with vegetation	on as % of F	ond Area	1.84%	1		8	65		8	5	N N	8	392		8	120	N
							-		10	40 <sub>4</sub>	1	10	21 55		10	284 570		10	42 1051	2
									10	602		10			10			10		3
	2016 Cover Abundance	D	und	In Po	and	Tot	-al		12	489		12			12	482				2
Adapted	2016 Cover Abundance	Ь	unu	III P	ona	100	.dl		12	40:	4	12	30	2	12	482	. 4	12	514	
	(South Australian Department of Environment and	Area		Area																
	Natural Resources 1997)	(m2)	%	(m2)	%	Area (m2)	%		13	553	3 4		0.1299		13	39	4	13	24	2
	Not many, 1- 10 individuals	6594	44.87%	251	4.08%	6845	32.82%	-	14	12					14		_	14		2
	sparsely or very sparsely present; cover very small (less than																			
	5%)	0	0.00%	0	0.00%	0	0.00%		15		4 3				15	238	3	15		2
	plentiful, but of small cover (less than 5%)	0	0.00%	0	0.00%	0	0.00%		16	9	9 N				16	4545	+	16		2
	any number of individuals covering 5-25% of patch	1483	10.09%	3692	59.94%	5175	24.81%		17	9	9 N				17	159	_	17		2
	any number of individuals covering 25-50% of patch	1605	10.92%	1598	25.95%	3203	15.36%		18		1 N				18				0.6159	
	any number of individuals covering 50-75% of patch covering more than 75% of patch	3905	26.57%	618 0	10.03%	4523	21.69% 5.32%		19 20		4 N				19	192				
5	Total	1110 14697	7.55% 100.00%	6159	0.00%	1110 20856	100.00%		20		o N				20 21					
	Total	14037	100.0076		Pond Area	680000	100.00%		22						22					
		Areav	with vegetation			3.07%			23						23					
		704	Trende tata		0.1.47.1.64				24						24					
			15	16	На				25	103	3 2				25	132	2			
		Dif	12527	20856	0.8329				26	14	4 N				26	75	N			
									27	1:	1				27		N			
									28		4 3				28		_			
									29		2 N				29		-			
									30						30					
									31		1				31					
								-	33						32 33					
									34		6 N				33					
								-	35		<u> </u>				35					
								-	36						36					
									37						37					
								-	38	488						1.4697				
									39	78	3									
									40											
									41		+									
									42											
										1.122	8									

Mapped From Brann-   South Australian Department of Environment and   Nea   (nr.)   %   Area (nr.)   A		2015 Cover Abundance	Bur	nd	Tota	I		Bund 20	15		In Pond 20	015		Bund 2016	5	li	n Pond 20:	16
Not many, 1-11 individuals	from Bruan-			%	Area (m2)	%			Cover/									
T   594)	N			0.18%	53	0.18%	id		Abundance	id			id	_		id		
2 any number of individuals covering 5-69% of patch 313 1.09% 131 1.09% 3 131 1.09% 3 132 1.09% 3 3 8 mg marker of individuals covering 5-69% of patch 125-70 4.216% 3 22.016% 3 22.016% 4 7 N N 4 265 N N 1 N N 1 N 1 N 1 N 1 N 1 N 1 N 1 N	т		0	0.00%	0			0 39	9 2	0	0	0	0	3328	2	0	,	0 0
3 any number of individuals covering 25-60% of patch 12579 42.16% 12579 42.16% 1579 42.16%	1	plentiful, but of small cover (less than 5%)	0	0.00%	0	0.00%		1 67	7 3				1	20	3			
## ary number of individuals covering 5075% of patch    Secure   S	2	any number of individuals covering 5-25% of patch	313	1.05%	313	1.05%		2 90	3				2	976	3			
5 covering more than 75% of patch  122 0.41% 5 34 4  For all 2898   100.00% 2898   100.00%   2988   100.00%   100.00%   2988   100.00%   100.00%   2988   100.00%   10	3	any number of individuals covering 25-50% of patch	12579	42.16%	12579	42.16%		3 22	2 N				3	805	N			
Total   29388   100,00%   29888   100,00%   5   3556   4	4	any number of individuals covering 50-75% of patch	16771	56.21%	16771	56.21%		4	7 N				4	265	N			
Total   29888   100,00%   29888   100,00%   29888   100,00%   2988   2988	5	covering more than 75% of patch	122	0.41%	122	0.41%		5 34	1 4				5	78	4			
Area with vegetation as % of Pond Area 5.63%		Total	29838	100.00%	29838	100.00%		6 3556	5 4				6	16	4			
Supering			F	ond Area	530000			7 20	) N				7	121	N			
2016 Cover Abundance  Bund  Total  Adapted from (South Australian Department of Environment and Natural Resources 1997)  Not many, 1-10 individuals 1997   Natural (Natural Resources 1997)  To sparsely or very sparsely present, cover very small (less than 5%)   0, 000%   0, 000%   15   4   N   11   12   5   16   Ha   12   17   46   18   19   19   45   3   19   45   3   19   4   19   19		Area with vegetati	on as % of F	ond Area	5.63%			8 936	5 4				8	45	4			
2016 Cover Abundance  Bund  Total  12 81 4  13 1748 4  11 1748 4  12 1748 4  13 7328 4  N Notimany, 1-10 individuals  To sparsely present cover very small (loss than 5%)  1 plentiful, but of small cover (less than 5%)  1 plentiful, but of small cover (less than 5%)  2 any number of individuals covering 25% of patch  3 any number of individuals covering 25% of patch  4 any number of individuals covering 50.5% of patch  1 plentiful, but of small covering for 5% of patch  3 any number of individuals covering 50.5% of patch  1 plentiful, but of small covering 50.5% of patch  3 any number of individuals covering 50.5% of patch  4 any number of individuals covering 50.5% of patch  5 overing more than 75% of patch  1 plentiful, but of small covering 50.75% of patch  1 plentiful, but of small covering 50.75% of patch  3 any number of individuals covering 50.75% of patch  3 any number of individuals covering 50.75% of patch  4 any number of individuals covering 50.75% of patch  5 overing more than 75% of patch  5 overing more than 75% of patch  Area with vegetation as % of freed Area  15 16 Ha  29 35000  15 4 N  10 12 5 5 5 66 4  11 10 13 4  12 81 4  13 16 4  13 7328 4  14 17 7388 4  14 7867 5  15 16 Ha  29 99 3 3  14 12 12 5  15 16 Ha  29 99 3 3  20 216 3								9 804	1 3				9	46	3			
2016 Cover Abundance								10 258	3				10	77	3			
Adapted from   South Australian Department of Environment and Natural Resources   New (m2)   %   New (m2)   %   New (m2)   %   13   15   4   122   5   13   15   4   N   13   7328   4   14   7867   5   5   14   7867   5   5   15   3829   N   15   3829   N								11 13	3 4				11	163	4			
Bruan-Blanquet   1997		2016 Cover Abundance	Bui	nd	Tota	al		12 83	4				12	1748	4			
N   Not many, 1-10 individuals   S020   11.65%   S020   S0			Area (m2)	%	Area (m2)	%		13 16	5 4				13	7328	4			
T   Sparsely or very sparsely present, cover very small (less than 5%)	N	Not many, 1- 10 individuals		11.65%		16.82%		14 122	2 5				14					
1 plentiful, but of small cover (less than 5%) 0 0.00% 0 0.00% 16 47 4 2 any number of Individuals covering 52-50% of patch 3328 7.72% 3328 11.15% 17 46 5 5 17 446 5 5 17 14780 5 5 18 63 4 18 35 4 1	Т	sparsely or very sparsely present; cover very small (less than 5%)	0		0			15 4	1 N				15	3829	N			
2 any number of individuals covering 5-25% of patch 3328 7.72% 3328 11.15% 17 46 5	1	plentiful, but of small cover (less than 5%)	0	0.00%	0	0.00%		16 47	7 4				16	1290	4			
3 any number of individuals covering 25-50% of patch 1380 3.20% 1380 4.62% 4 any number of individuals covering 50-75% of patch 10731 24.89% 10731 35.96% 5 covering more than 75% of patch 10731 43106 100.00% 43106 100.00% 10701 43106 100.00% 43106 100.00% 10701 43106 100.00% 43106 100.00% 10701 43106 100.00% 43106 100.00% 10701 4310 43106 100.00% 10701 43106 100.0	2	any number of individuals covering 5-25% of patch	3328	7.72%	3328			17 46	5 5				17					
4       any number of individuals covering 50-75% of patch       10731       24.89%       10731       35.96%       19       129       3       19       45       3         5       covering more than 75% of patch       22.647       52.54%       22.647       75.90%       20       1066       3       20       216       3         Total       43106       100.00%       43106       100.00%       21       2883       3       3       4.31       3         Pond Area       530000       22       7014       4	3	any number of individuals covering 25-50% of patch				4.62%	I I	I	5 4				18					
Total 43106 100.00% 43106 100.00% 21 2883 3	4	any number of individuals covering 50-75% of patch	10731	24.89%		35.96%		19 129	9 3				19					
Pond Area         53000         22         7014         4           Area with vegetation as % of Pond Area         8.13%         23         3606         4           15         16         Ha         25         979         3           Dif         29838         43106         1.3268         26         2696         3           27         311         4         4         4         4         4           28         2467         3         3         4	5	covering more than 75% of patch	22647	52.54%		75.90%							20					
Area with vegetation as % of Pond Area 8.13% 23 3606 4 24 1140 3 25 1140 3 27 1140 3 28 24 1140 3 28 24 1140 3 28 24 1140 3 25 1140 3 28 24 1140 3 24 1140 3 1140 3 24 1140 3 24 1140 3 24 1140 3 24 1140 3 24 1140 3 24 1140		Total	43106	100.00%	43106	100.00%		21 2883	3					4.31				
24 1140 3				Pond Area	530000			22 7014	4									
24 1140 3		Area with veget	ation as % of	Pond Area	8.13%			23 3606	5 4									
Dif         29838         43106         1.3268         26         2696         3           27         311         4           28         2467         3           29         566         4           30         556         4								24 1140	3									
27 311 4 2 28 2467 3 2 29 566 4 2 3 3 3 556 4				15	16	На		25 979	3									
28     2467     3       29     566     4       30     556     4			Dif	29838	43106	1.3268			3									
28     2467     3       29     566     4       30     556     4								27 31:	4									
29 566 4 30 556 4																		
30 556 4									5 4									
J1																		

	2015 Cover Abundance		Bund	In F	ond	Tota	al		Bund 201	15		n Pond 20	15		Bund 2016	5		In Pond 20	016
	(South Australian Department of Environment and Natural Resources 1997)	Area (m2)	%	Area (m2)	%	Area (m2)	%			Cover/			Cover/			Cover/			Cover/
N	Not many, 1- 10 individuals	50	0.39%		0.00%	50	0.36%	id	Area sq /m	Abundance	id	Area sq /m	Abundan ce	id	Area sq /m	Abundan ce	id	Area sq /m	Abundance
	sparsely or very sparsely present; cover very small (less than																		
	5%)	(	0.00%		0.00%	0	0.00%		0 216		(	970		0	208				
1	plentiful, but of small cover (less than 5%)	(	0.00%		0.00%	0	0.00%		276	5 5		0.097	7	1	1428	-		0	
	any number of individuals covering 5-25% of patch	6541	0.00%		0 0.00%	6541	47.10%		2 5	N N				2	804				
	any number of individuals covering 25-50% of patch	3119		970		4089			3 21 4 1536					3	453 386				
	any number of individuals covering 50-75% of patch covering more than 75% of patch	3206	1	3/	0.00%	3206	23.09%		5 1008					- 4	482				
- 3	Total	12916		97		13886			6 493						875				
	1000	12310	100.0070		Pond Area	440000	100.0070		7 386					7	245				
		Areav	vith vegetatio			3.16%			8 482						196				
		711041	Vitil Vegetatio	11 43 70 01	- Chia / trea	0.2070			9 990					9	420				
								1	0 245					10	20				
								1	1 177					11					
	2016 Cover Abundance	Е	Bund	In F	ond	Tot	al	1	2 400	4	ļ.			12	29	4			
Adapted																			
	(South Australian Department of Environment and	Area																	
Blanquet	Natural Resources 1997)	(m2)	%			Area (m2)	%	1	3 20					13	4	3			
N	Not many, 1- 10 individuals	2031	100.00%			2031	14.63%	1	4 114	1 4				14	110	4			
	sparsely or very sparsely present; cover very small (less than																		
Т	5%)	0	0.00%			0	0.00%	1	5 29	4				15	73	4			
	plentiful, but of small cover (less than 5%)	0	0.00%			0	0.00%		6 4	1 4				16					
	any number of individuals covering 5-25% of patch	0	0.00%			0	0.00%	1						17					
	any number of individuals covering 25-50% of patch	1689	83.16%			1689	12.16%		8 67					18					
	any number of individuals covering 50-75% of patch	3194	157.26%			3194	23.00%		9 29	3				19	109				
5	covering more than 75% of patch	2541	125.11%			2541	18.30%		0 3	B N				20	145				
Total	Total	9455	100.00%		<u> </u>	9455	100.00%	2						21	232				
					Pond Area	440000			2 89					22					
		Area v	vith vegetatio	n as % of	Pond Area	2.15%			3 81		•			23					
			45	46	1 11-	1			4 122					24					
		Dif	15	16	Ha 0.4421				5 11 6 154					25	517				
		זוטו	13886	945	-0.4431	]				`				26		+			
									7 140 8 176					27					
									9 10		1			28 29					
									0 279					30	67	•			
								3						30	268				
					-				2 2144					32					
									3 488					32	02				

	2015 Cover Abundance	В	Bund	In P	ond	Tota	al		Bund 201	.5	ı	n Pond 201	15			Bund 2016	;	ı	n Pond 201	L6
	(South Australian Department of Environment and Natural Resources 1997)	Area (m2)	%	Area (m2)	%	Area (m2)	%			Cover/		_	Cover/				Cover/			Cover/
N	Not many, 1- 10 individuals	61	0.98%	22	15.49%	83	1.30%	id	Area sq /m	Abundance	id	Area sq /m	Abundan ce		id	Area sq /m	Abundan ce	id	Area sq /m	Abundan ce
Т	sparsely or very sparsely present; cover very small (less than 5%)	0	0.00%	0	0.00%	0	0.00%	0	529	5	0	81	3	8	0	86	5			
1	plentiful, but of small cover (less than 5%)	0	0.00%	0	0.00%	0	0.00%	1	. 7	4	1	3	2		1	. 42	4			$\vdash$
2	any number of individuals covering 5-25% of patch	372	5.96%	39	27.46%	411	6.44%	2	. 18	4	2	18	N		2	161	4			$\Box$
3	any number of individuals covering 25-50% of patch	64	1.02%	81	57.04%	145	2.27%	3	3	4	3	4	N		3	80	4			
4	any number of individuals covering 50-75% of patch	433	6.93%	0	0.00%	433	6.78%	4	8	5	4	36	2	•	4	99	5			
5	covering more than 75% of patch	5314	85.11%	0	0.00%	5314	83.21%	5	53	4		0.0142			5	271	4		0	1
	Total	6244	100.00%	142	100.00%	6386	100.00%	6	29	4					6	69	4			
					Pond Area	100000		7	5	4										
		Area v	with vegetati	on as % of	Pond Area	6.39%		8	41	. 4						0.0808				
								9	5	4										
								10		1										
								11	143	4										
	2016 Cover Abundance	В	und	In P	ond	Tota	al	12	49	4										
Adapted from Bruan-Blanquet	(South Australian Department of Environment and Natural Resources 1997)	Area (m2)	%	Area (m2)	%	Area (m2)	%	13	36	4										
N	Not many, 1- 10 individuals	0	0.00%	0	0.00%	0	0.00%	14	1	1 1										
Т	sparsely or very sparsely present; cover very small (less than 5%)	0	0.00%	0	0.00%	0	0.00%	15												
1	plentiful, but of small cover (less than 5%)	0	0.00%	0	0.00%	0	0.00%	16		1										
2	any number of individuals covering 5-25% of patch	0	0.00%	0	0.00%	0	0.00%	17		1										
3	any number of individuals covering 25-50% of patch	0	0.00%	0	0.00%	0	0.00%	18	137	2										
4	any number of individuals covering 50-75% of patch	623	77.10%	0	0.00%	623	77.10%	19	7	N										
5	covering more than 75% of patch	185	22.90%	0	0.00%	185	22.90%	20	1	N										
Total	Total	808	100.00%	0	0.00%	808	100.00%	21	. 4	N										
	Pond Area		•	•	•	100000		22	. 6	N										
	Area with vegetation as % of Pond Area					0.81%		23	1	3										
								24	36	3										
			15	16	Ha			25		N										
		Dif	6386	808	-0.5578			26	1	N										
								27	1	N										
								28	1	N										
								29		N										
									0.6244											

	2015 Cover Abundance	В	Bund	In P	ond	Tota	al		Bund 201	.5		In Pond 20	15		Bund 20	16		In Pond 20	16
	(South Australian Department of Environment and Natural Resources 1997)	Area (m2)	%	Area (m2)	%	Area (m2)	%			Cover/			Cover/			Cover/			Cover/
N	Not many, 1- 10 individuals	0	0.00%	0	0.00%	0	0.00%	id	Area sq /m	Abundance	id	Area sq /m	Abundance	id	Area sq /m	Abundance	id	Area sq /m	Abundance
	sparsely or very sparsely present; cover very small (less than															1			ı
Т	5%)	0	0.00%	0	0.00%	0	0.00%	0	3699	5	C	37	3		0 353	. 5	5 0	145	3
1	plentiful, but of small cover (less than 5%)	0	0.00%	0	0.00%	0	0.00%	1	570	5	1	. 6	4		1 3613	. 5	1	. 53	4
2	any number of individuals covering 5-25% of patch	0	0.00%	255	6.84%	255	2.07%	2	65	5	2	73	3		2 246	5	5 2	83	3
3	any number of individuals covering 25-50% of patch	11	0.13%	510	13.67%	521	4.22%	3	1	4	3	44	4		3 108	3 4	3	71	4
4	any number of individuals covering 50-75% of patch	341	3.96%	188	5.04%	529	4.29%	4	3	4	4	79	3		4 124	4	4	2977	3
5	covering more than 75% of patch	8257	95.91%	2777	74.45%	11034	89.42%	5	2	4	5	17	4		5 109	4	5	194	4
	Total	8609	100.00%	3730	100.00%	12339	100.00%	6	2	4	E	104	2		6 76	4	1	285	2
					Pond Area	210000		7	12	4	7	43	4		7 53	3 4	7	29	4
		Area	with vegetation	on as % of	Pond Area	5.88%		8	7	4	8	53	2		8 67	4	1 8	106	2
								9	11	3	g	299	3		9 45	3	9	427	3
								10	13	4	10	98	2		10 9:	. 4	10	291	2
								11	. 33	4	11	. 20	4		11 94	4	11	. 83	4
	2016 Cover Abundance	В	und	In P	ond	Tota	al	12	14	. 4	12	13	4		12 3244	1 4	12	. 82	4
Adapted from Bruan-Blanquet	(South Australian Department of Environment and Natural Resources	Area (m2)	%	Area (m2)	%	Area (m2)	%	13	31	4	13	14	4		13 63		13		4
N	Not many, 1- 10 individuals	0	0.00%	0	0.00%	0	0.00%	14	185	4	14	31	4		14 457	4	14	61	4
T	sparsely or very sparsely present; cover very small (less than 5%)	0	0.00%	0	0.00%	0	0.00%	15	197	5	15	22	3			5	15		3
1	plentiful, but of small cover (less than 5%)	0	0.00%	0	0.00%	0	0.00%	16	28	4	16	2583	5			4	16	92	5
2	any number of individuals covering 5-25% of patch	0	0.00%	682	12.99%	682	4.87%	17	10	4	17	194	5			4	17	59	5
3	any number of individuals covering 25-50% of patch	45	0.51%	3689	70.24%	3734	26.69%	18	3496	5		0.373				5	18	46	5
4	any number of individuals covering 50-75% of patch	4486	51.33%	684	13.02%	5170	36.95%	19	230	5						5	5		
5	covering more than 75% of patch	4208	48.15%	197	3.75%	4405	31.48%		0.8609						0.8739	<del>.</del>		0.5252	
Total	Total	8739	100.00%	5252	100.00%	13991	100.00%												
					Pond Area	210000													
		А	rea with vegeta	ation as % o	f Pond Area	6.66%													
			15	16	На														
		Dif	12339	13991	0.1652														

## Pond PA 12

2015		Bund		Total		Bund 2015			In Pond 2015			Bund 2016			In Pond 2016			
Adapted from Bruan-Blanquet	(South Australian Department of Environment and Natural Resources 1997)	Area (m2)	%	Area (m2)	%				Cover/			Cover/			Cover/			Cover/
N	Not many, 1- 10 individuals	0	0.00%	0	0.00%		id	Area sq /m	Abundance	id	Area sq /m	Abundance	id	Area sq /m	Abundan ce	id	Area sq /m	Abundan ce
т	sparsely or very sparsely present; cover very small (less than 5%)	0	0.00%	0	0.00%		0	988	5	0	C	C	C	1109	5	0	13752	4
1	plentiful, but of small cover (less than 5%)	0	0.00%	0	0.00%		1	208	5				1	133	5	1	197	3
2	any number of individuals covering 5-25% of patch	0	0.00%	0	0.00%		2	302	5				2	1632	. 5	2	96	3
3	any number of individuals covering 25-50% of patch		0.00%	0	0.00%		3	213	5				3	61	. 5		1.4045	)
4	any number of individuals covering 50-75% of patch	0	0.00%	0	0.00%		4	580	5				4	340	5			
5	covering more than 75% of patch	2937	100.00%	2937	100.00%		5	83	5				5	241	. 5			
	Total	2937	100.00%	2937	100.00%		6	77	5				6	137	5			
			Pond Area	120000			7	119	5				7	35	5			
	Area with vegetation	on as % of	Pond Area	2.45%			8	100										
							9	176	5									
							10	91	5									
								0.2937						0.3688				
2016																		
	Cover Abundance	Bu	nd	Tota	al													
Adapted from Bruan-Blanquet	(South Australian Department of Environment and Natural Resources 1997)	Area (m2)	%	Area (m2)	%													
N	Not many, 1- 10 individuals	0	0.00%	0	0.00%			15	16	На								
Т	sparsely or very sparsely present; cover very small (less than 5%)	0	0.00%	0	0.00%		Dif	2937	3688	0.0751								
1	plentiful, but of small cover (less than 5%)	0	0.00%	0	0.00%													
2	any number of individuals covering 5-25% of patch		0.00%	0	0.00%													
3	any number of individuals covering 25-50% of patch		0.00%	0	0.00%													
4	any number of individuals covering 50-75% of patch		0.00%	0	0.00%													
5	covering more than 75% of patch	3688	100.00%	3688														
Total	Total	3688	100.00%	3688 120000	100.00%													
	Pond A																	
	Area with vegeta	tion as % o	f Pond Area	3.07%														

**EcoAerial** 

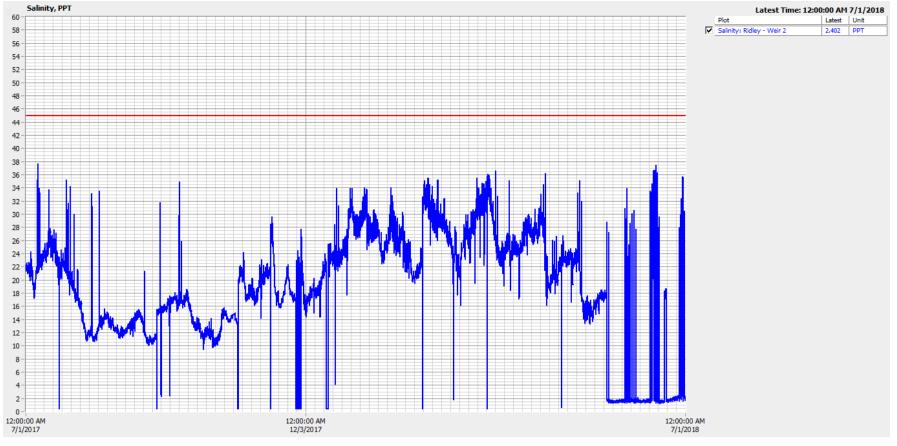
**PO Box 1088 Newport, 3015** 

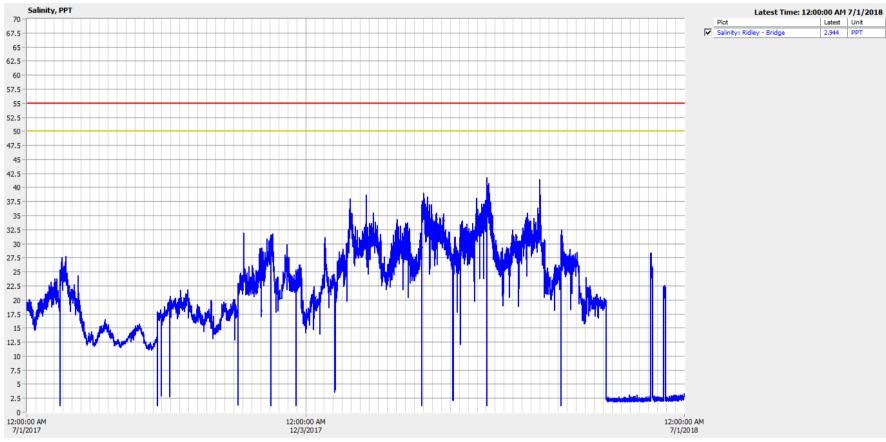
Phone: 61 3 9315 2031

Email: rob@ecoaerial.com.au



# Appendix G – Licensed Water Discharges (into SA Water Outfall and into Gawler River)







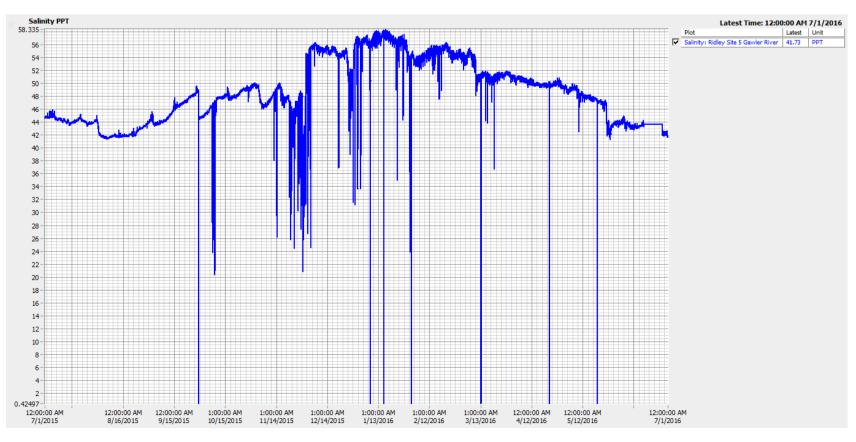
#### Gawler River 2017-2018



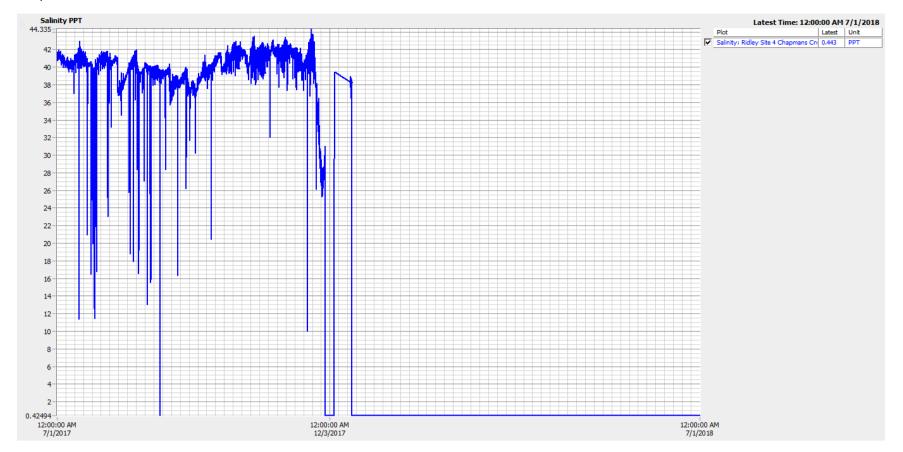
#### Gawler River 2016-2017



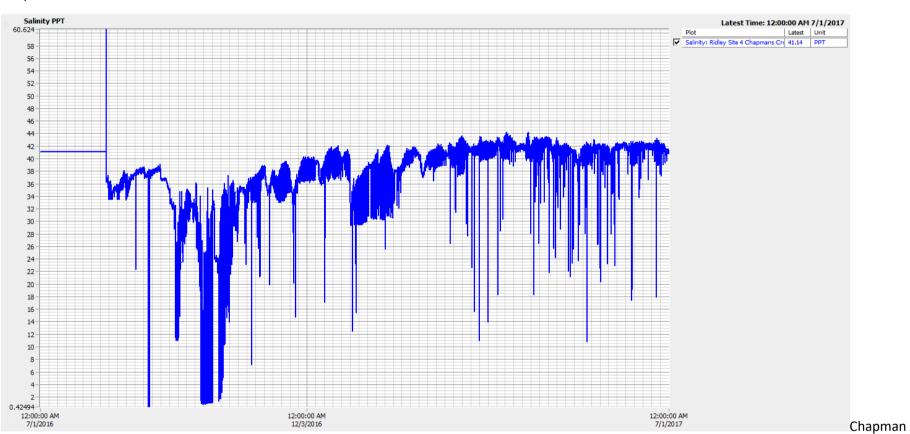
## Gawler River 2015-2016



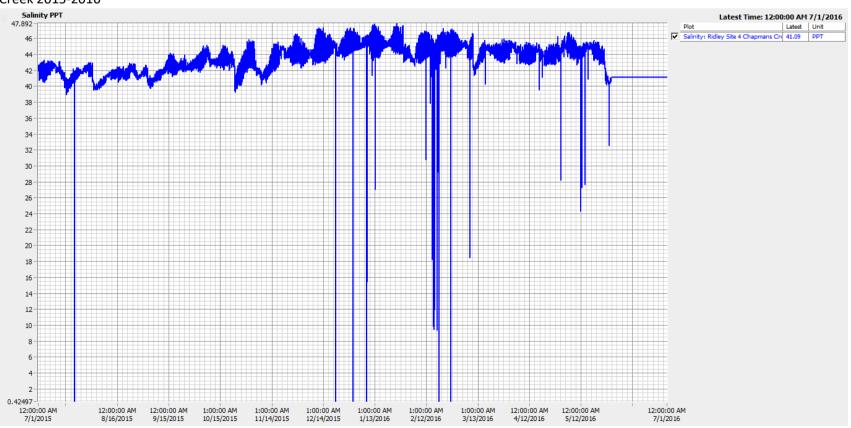
#### Chapman Creek 2017 - 2018



### Chapman Creek 2016 - 2017







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**Buckland Dry Creek Pty Ltd** (ACN 114 007 153; ABN 82 114 007 153)

# **Appendix H - Water Bores**

BORE WATER USE vs LICENCE ALLOCATIONS - JULY 2017-JUNE 2018																		
	Water Meter Readings							Monthly Use Bores 1-5, 8 (kL)					Combined 1,177,2		Monthly Use Bores 6-7 (kL)		Combined allocation 850,000 kL	
Month	1	3	4	5	6	7	8	1	3	4	5	8	Cumulative Use Bores 1-5 (kL)	Remaining from Allocation (kL)	6	7	Cumulative Use Bores 6 - 7 (kL)	Remaining from Allocation (kL)
2016 June	383463	137533	764911	501139	90110	2633150	23933							1,177,255				850,000
2016 July	385591	141651	819012	501139	90110	2633150	28130	2,128	4,118	54,101	1	4,197	64,544	1,112,711	-	-	-	850,000
2016 August	385966	143999	878481	501139	90110	2633150	30500	375	2,348	59,469	1	2,370	129,106	1,048,149	-	-	-	850,000
2016 September	386274	143999	939240	501139	133090	2633150	36690	308	-	60,759	-	6,190	196,363	980,892	42,980	-	42,980	807,020
2016 October	386582	143999	1,000,000	501139	157170	2633150	40350	308	-	60,760	1	3,660	261,091	916,164	24,080	-	67,060	782,940
2016 November	386890	143999	1027470	501139	177890	2633150	45321	308	-	27,470	-	4,971	293,840	883,415	20,720	-	87,780	762,220
2016 December	386890	144019	1,068,329	501139	181259	2633156	49080	-	20	40,859	-	3,759	338,478	838,777	3,369	6	91,155	758,845
2017 January	386890	144019	1093329	501139	262618	2633156	55440	-	-	25,000	-	6,360	369,838	807,417	81,359	-	172,514	677,486
2017 February	390162	144019	1144623	501139	316699	2633150	68440	3,272	-	51,294	-	13,000	437,404	739,851	54,081	- 6	226,589	623,411
2017 March	391920	144019	1187495	501139	344104	2633150	73526	1,758	-	42,872	-	5,086	487,120	690,135	27,405	-	253,994	596,006
2017 April	393661	144019	1230265	501139	344104	2633150	83670	1,741	-	42,770	-	10,144	541,775	635,480	-	-	253,994	596,006
2017 May	395556	144009	1277283	501139	344104	2633150	87080	1,895	- 10	47,018	-	3,410	594,088	583,167	-	-	253,994	596,006
2017 June	396694	144009	1306231	501139	344104	2633150	88166	1,138	-	28,948	-	1,086	625,260	551,995	-	-	253,994	596,006

Table 1: Licenced Wells and Water Allocations

Local name	Well unit number	Well depth	Well area	Aquifer	Туре	Allocation and Licence
A Row						T1
Number 1 bore	6628 - 19184	156 metres	NAP	T1	submersible	combined allocation
G Row						1,177,255 kilolitres
Number 3 bore	6628 - 14027	153 metres	NAP	T1	submersible	Water Licence 211790
D Row						
Number 4 bore	6628 - 4356	119 metres	NAP	T1	shaft	
E Row						
Number 5 bore	6628 - 13020	149 metres	NAP	T1	submersible	
Front Gate						T1
Number 6 bore	6628 - 13170	165 metres	DC	T1	submersible	combined allocation
Storm Pit						850,255 kilolitres
Number 7 bore	6628 - 18042	162 metres	DC	T1	submersible	Water Licence 211788
Champans Ck						T3
T3 bore	6528 - 2005	364 metres	NAP	T3	submersible	allocation
						1,200,000 kilolitres
						Water Licence 211790

Note: The above table includes extraction from Bore 8. This draws from the T1 aquifer. Even including this bore, the Use does not exceed the allocation

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**Buckland Dry Creek Pty Ltd** (ACN 114 007 153; ABN 82 114 007 153)

# **Appendix I - Birds**

The two Brett Lane & Associates Pty Ltd Reports are provided as separate files:

- Report 13061 (1.15) Dry Creek Technical Report 180821 FINAL.pdf
- Report 13061 (2.9) EPBC Act 2018 Self Assessment for Dry Creek Salt Field 181024

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**Buckland Dry Creek Pty Ltd** (ACN 114 007 153; ABN 82 114 007 153)

# Appendix J - Trial Filling in H Row

#### **Filling Trial In H Row**

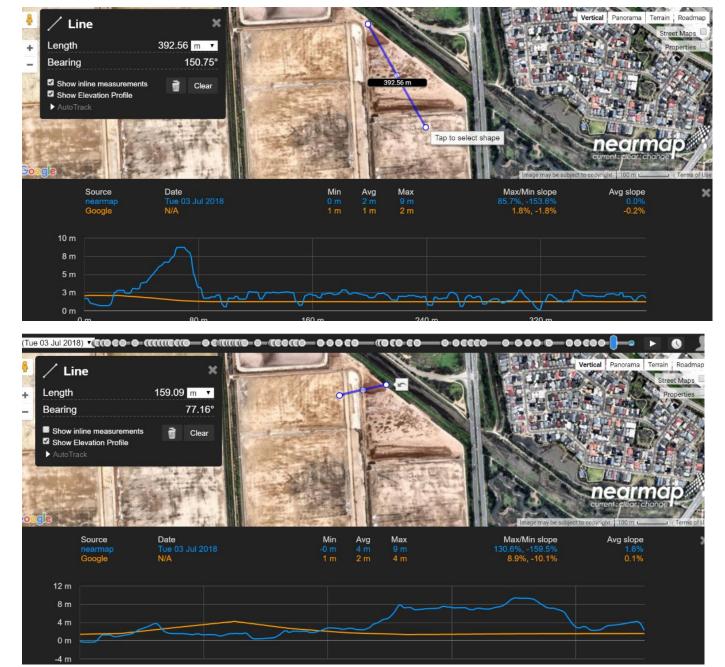
#### Work to 30 June 2018

This document provides preliminary information on the trial. The processes and outcomes of the trial will be reported formally, as required by the PEPR, and the 2018-2019 PEPR compliance report will contain a compliance review of the trial.

The following Nearmaps photo was taken on 3 July 2018 and illustrate progress made with the trial in the northern end of H Row.Area of fill. This shows that the trial had just commenced by 30 June 2018



The next figures show that the fill as placed in the 200 m2 area reached an elevation of about 9 m AHD above the top of the base drainage layer at about 3 m AHD. The level information from Nearmaps is very approximate. The impression from the photo of the fill mound (see further below) is that the top of the mound is more like 4 m above placed base filter / drainage layer – not 6 m.



The purpose of the trial is to develop and test / demonstrate:

- The effectiveness of the construction techniques
- The procedures to control and document the environmental and geotechnical quality of materials used for the filling
- The procedures to control and document the compaction of the filling
- The geotechnical performance of the filling and the ground below
- The environmental impact on groundwater of the filling
- The control of environmental impacts of the filling process (eg: noise, dust etc)

This photo taken on 4 July 2018 shows the fill placed for the base filter / drainage layer



This photo taken on 4 July 2018 shows the 2000 m2 mound of imported fill placed on the base filter / drainage layer



This photo taken on 4 July 2018 provides a view to the north east from the south west corner of the area on which the base filter / drainage layer had been placed and was in the process of being compacted by a small sheepsfoot roller – visible in the photo



