



## Monitoring of Environmental Conditions at Warriewood Wetlands after the Introduction of Salvinia Weevil.



**Australian Government**



Report Prepared by Cecil Ellis

**Nature Navigation**

July 2016



## Table of Contents

<b>Monitoring of Environmental Conditions at Warriewood Wetlands after the Introduction of Salvinia Weevil</b> .....	<b>1</b>
1. Acknowledgments .....	3
2. Introduction:.....	3
3. Methods:.....	4
2.1 <i>Field Sampling</i> :.....	4
Table 1.....	4
Figure 1. Map of Sampling Locations .....	4
2.2 <i>Atmospheric Parameters</i> :.....	5
2.3 <i>Water Quality Parameters</i> : .....	5
2.4 <i>Nutrients</i> : .....	5
2.5 <i>Salvinia Weevil</i> : .....	5
3. Results: .....	6
3.1 <i>Presence of Salvinia Weevils</i> .....	6
No Release Site .....	6
Figure 2. Map showing No Release Sampling Site .....	6
Release Site 1 .....	7
Graph 9.....	7
Release Site 2 .....	8
Figure 3. Figure 2. Map showing Release Site 2.....	8
Graph 10.....	8
Release Site 3 .....	9
3.1 <i>Atmospheric Conditions</i> .....	10
3.1.1 Shading.....	10
3.1.2 Temperature .....	10
3.1.3 Rainfall.....	11
3.2 <i>Water Quality</i> .....	11
Discussion .....	11
Conclusion.....	12
Appendix A Weevil Count Results.....	13
Appendix B - Water Quality Parameters .....	14
Appendix C Atmospheric Conditions .....	15



## 1. Acknowledgments

Nature Navigation would like to acknowledge the traditional owners of Warriewood Wetlands, past present and future.

The Warriewood Wetlands Salvinia Weevil project was supported by Sydney Coastal Councils Group through funding from the Australian Government.

The staff of Northern Beaches Council that lead the management of Salvinia in Warriewood Wetlands in particular Jules Bellamy, David Lowery, Matt Hansen and Emma Griffen for assistance provided with field work.

## 2. Introduction:

Northern Beaches Council (formerly Pittwater Council) is responsible for the management of Warriewood wetlands on Sydney's Northern Beaches. Large areas of Warriewood Wetlands are affected by the invasive aquatic weed Salvinia (*Salvinia molesta*). Salvinia is a floating aquatic plant, endemic to Brazil and is considered a global aquatic weed. Salvinia forms a mat on the water surface, preventing light entering the water column, reducing photosynthesis and dissolved oxygen in the water column.

As a method of control, Northern Beaches Council planned the introduction of the Salvinia Weevil (*Cyrtobagous salviniae*) into Warriewood Wetlands. As a biocontrol the Salvinia Weevil feeds on the Salvinia plant. The adult weevil lays eggs in the Salvinia and the larvae, feed on the leaves and rhizome of the plant. This feeding reduces the plants mass which sinks into the water column killing the plant. The lifecycle of the Salvinia Weevil is dependent on temperature and the Northern Beaches Coastal Environment Centre aimed to use this knowledge as an opportunity to engage and educate the local community and schools by conducting a study as to whether the shading in the Warriewood Wetlands affected the success of the biocontrol of the Salvinia using the Salvinia Weevil.

Nature Navigation was engaged by Northern Beaches Council to monitor environmental factors in the Warriewood Wetlands between January and June 2016 at Salvinia Weevil release sites. Three release sites were monitored, additionally a non-release site was selected to observe whether the Salvinia Weevil was spreading through the wetlands and a downstream site was selected to observe if the Salvinia control was successful and whether there was a consequence changes downstream of the in the nutrient load after the breakdown of the Salvinia into the water column. A site upstream of the Warriewood Wetlands on Mullet Creek was monitored for upstream nutrient loads.

Salvinia infested with Salvinia weevil was introduced to two sites, Release Site 1 (20<sup>th</sup> January 2016) and Release Site 2 ( 3<sup>rd</sup> March 2016). No Salvinia Weevils were released at Release Site 3 during the study period.



### 3. Methods:

#### 2.1 Field Sampling:

A total of five sites were sampled monthly between January and June 2016. At each site Nature Navigation:

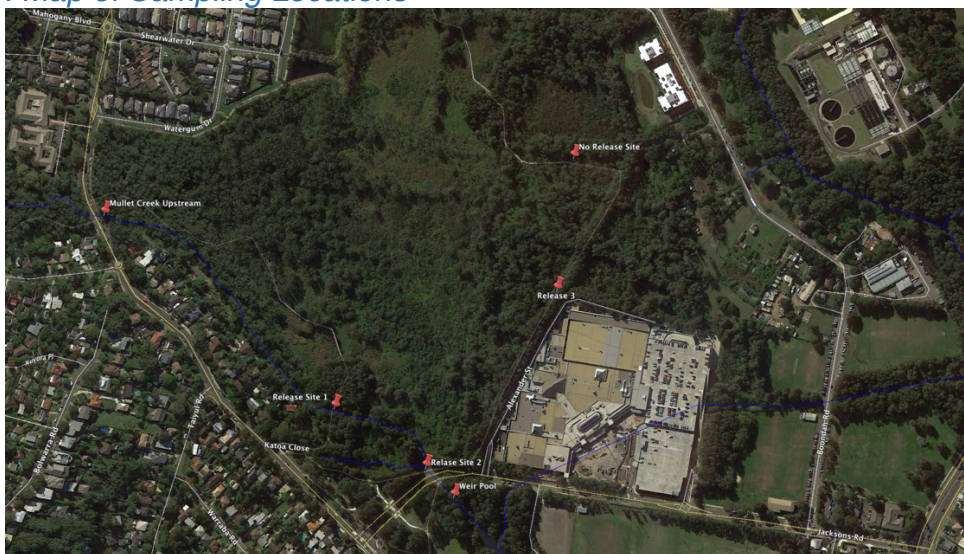
- collected water samples for analysis of nutrients
- used a Yeo-Kal multi parameter probe to measure water temperature, pH, conductivity, turbidity and dissolved oxygen;
- collected atmospheric parameters, understorey temperature using a Kestrel 2000 meter and over-storey vegetation density using a spherical forest densitometer.

An additional site was sampled upstream of Warriewood Wetlands at Mullet Creek for nutrient analysis, in the event of a significant die off of *Salvinia* from the water surface and its decay in the water column it was considered important to know how the nutrient load changed from upstream to downstream in the Warriewood Wetlands.

*Table 1. Site Details*

Site Code	Site Name	Site Description
WP	Weir Pool	Mullet Creek immediately downstream of Jacksons Rd and upstream of concrete weir.
RS1	Release Site 1	Mullet Creek downstream of walking track to the boardwalk, upstream of the floating yellow boom
RS2	Release Site 2	Pool upstream of Jacksons Rd
RS3	Release Site 3	Warriewood Wetlands at the bat colony, access from walking track between Wetlands and Shopping Centre
NR	No Release Site	Warriewood Wetlands 50m along the upstream boardwalk, access from walking track between Wetlands and Shopping Centre walking track between Wetlands and Shopping Centre

*Figure 1. Map of Sampling Locations*





## 2.2 Atmospheric Parameters:

Atmospheric parameters were recorded whilst in the area of shaded or unshaded salvinia at a study site. Understorey temperature was recorded, using a Kestrel 2000 meter and overstorey vegetation density using a spherical forest densitometer and recorded as a percentage (%) of cover. Rainfall data was recorded from Bureau of Meteorology Terrey Hills weather station (Station code: 66059) available at: [http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p\\_nccObsCode=136&p\\_display\\_type=dailyDataFile&p\\_startYear=&p\\_c=&p\\_stn\\_num=066059](http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_nccObsCode=136&p_display_type=dailyDataFile&p_startYear=&p_c=&p_stn_num=066059)

## 2.3 Water Quality Parameters:

Water samples and water measurements were taken before the Salvinia samples were collected, to avoid disturbance to the water column. Water temperature, pH, dissolved oxygen, conductivity and turbidity were determined in the field using a calibrated Yeo-Kal 611 multi-parameter water quality meter at all sites.

## 2.4 Nutrients:

Water samples were collected, using aseptic sampling techniques, for the analysis of total nitrogen (TN) and soluble reactive phosphate in 200mL PET plastics bottles, labelled with the site location and date. Sample bottles, were kept cool and away from light whilst being transported to a NATA accredited laboratory.

## 2.5 Salvinia Weevil:

The presence or absence of Salvinia weevils was adopted from a method described by Weeds NSW. The method used in this study was the collection a 1.25L volume of Salvinia from the sample site in a plastic container. The sample was transported to a 20L water tank. Around 90% of the Salvinia sample was submerged in a mesh container at the bottom of the tank and a small volume, approximately 20cm<sup>2</sup>, was floated on the surface, acting as refuge for the Salvinia Weevil. The Salvinia Weevil, a terrestrial beetle, will avoid submersion and will escape the submerged Salvinia and seek the surface refuge of floating Salvinia. After a minimum of 24 hours of submersion, the floating refuge Salvinia was removed to a large white shallow tray and the sample was examined for a period of 15minutes for the presence of Salvinia Weevil.



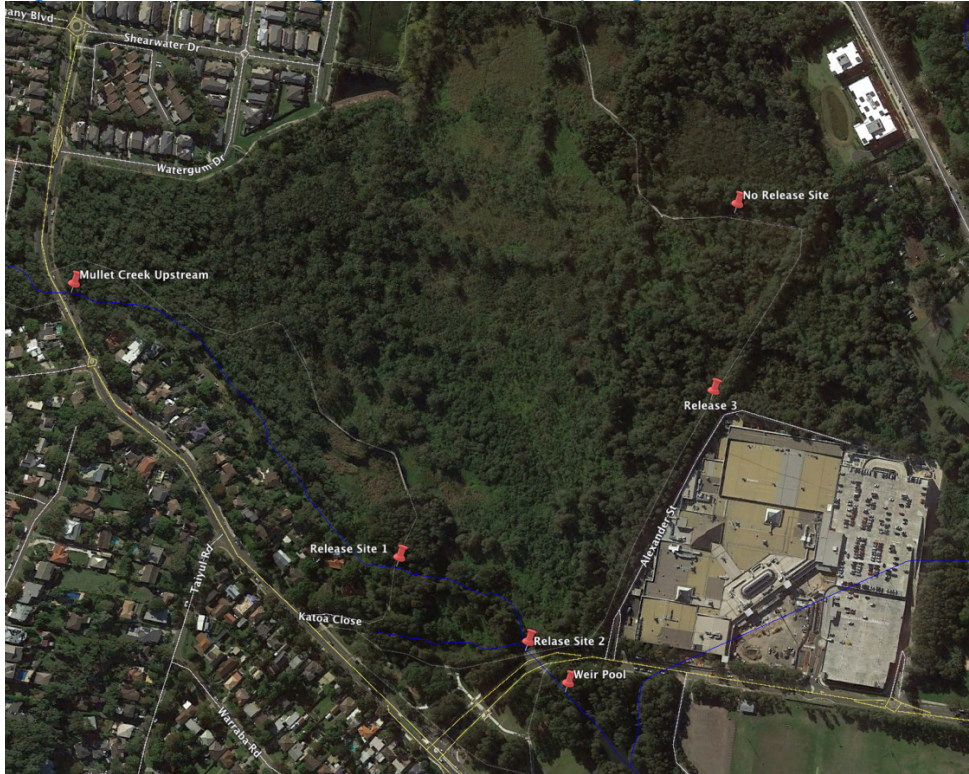
### 3. Results:

#### 3.1 Presence of Salvinia Weevils

##### *No Release Site*

The No Release Site was monitored to observe if the Salvinia Weevil were able to spread in distribution to other areas of Warriewood Wetlands affected by Salvinia. Salvinia Weevil was absent at the site during the study period.

*Figure 2. Map showing No Release Sampling Site*





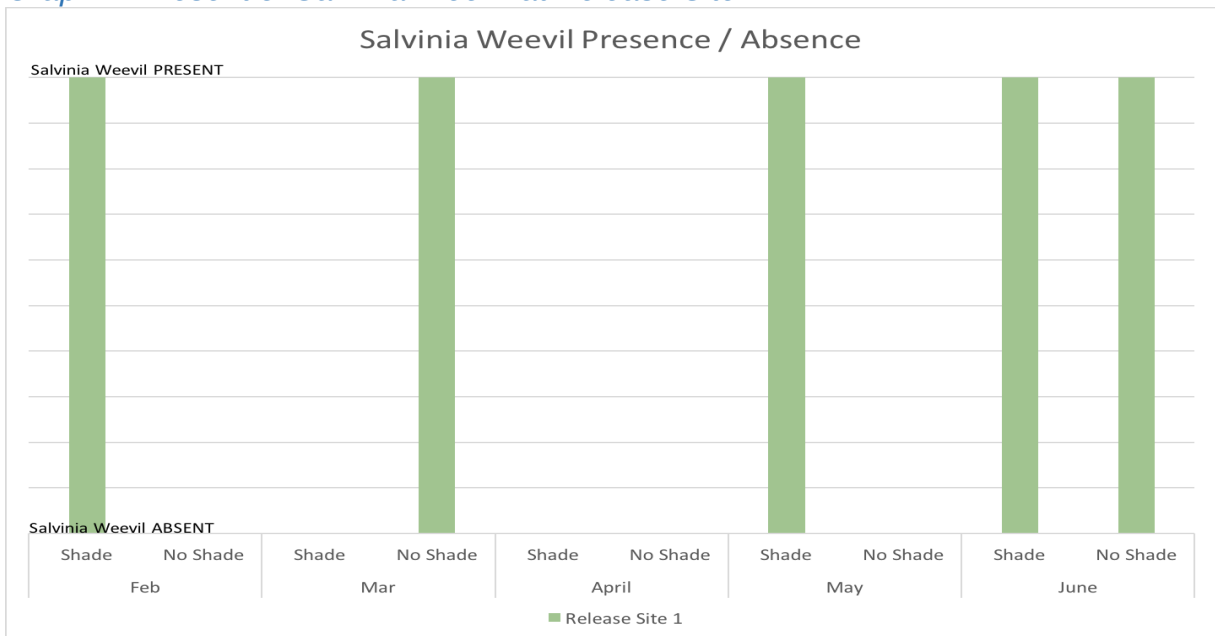
**Release Site 1**

Salvinia Weevil was introduced to Release Site 1, on 20<sup>th</sup> January 2016. The first sampling for this site was conducted one day after the release of the Weevil. Salvinia Weevil was present in both the shaded and unshaded areas of the sample site at the conclusion of the sampling. See Graph 9.

Figure 3. Map showing Release Site 1



Graph 1. Present of Salvinia Weevil at Release Site 1





**Release Site 2**

Salvinia Weevil was introduced to Release Site 2, on 3rd March 2016. Evidence of Salvinia control, in the creek to the south west of the main pool, was February sampling prior to introduction of the Salvinia Weevil.

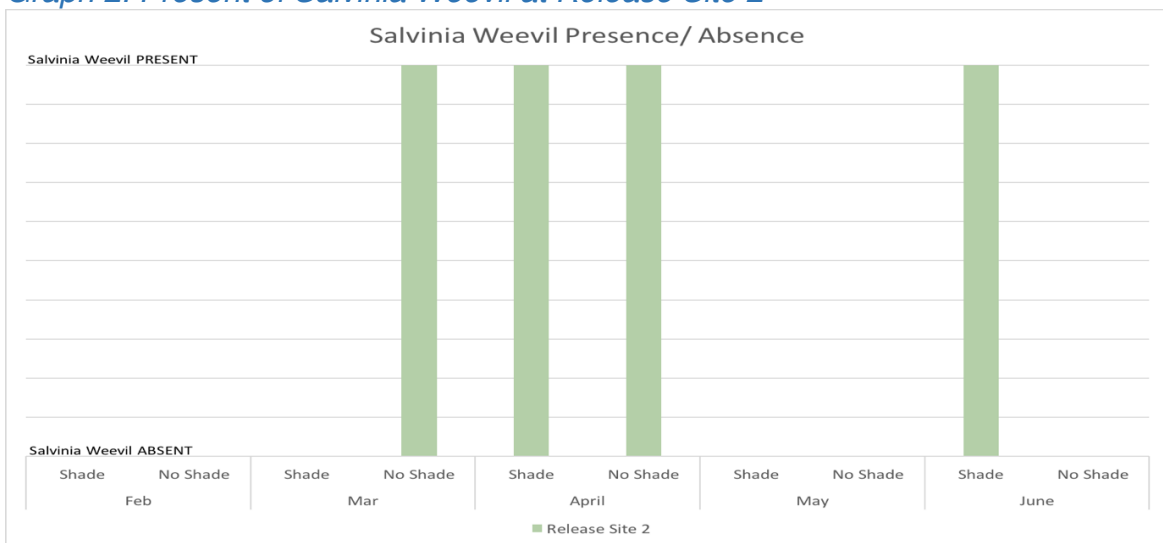
During the May and June sampling, no Salvinia was able to be sampled from the unshaded area, therefore no Salvinia Weevils were present in this location. The May and June sampling also found the shaded area of the site was dominated by the native aquatic plant Azolla and only small quantities of Salvinia were sampled.

Salvinia Weevil was recorded as present in June at the conclusion of the sampling, in the shaded area. See Graph 10.

*Figure 4. Map showing Release Site 2*



*Graph 2. Present of Salvinia Weevil at Release Site 2*



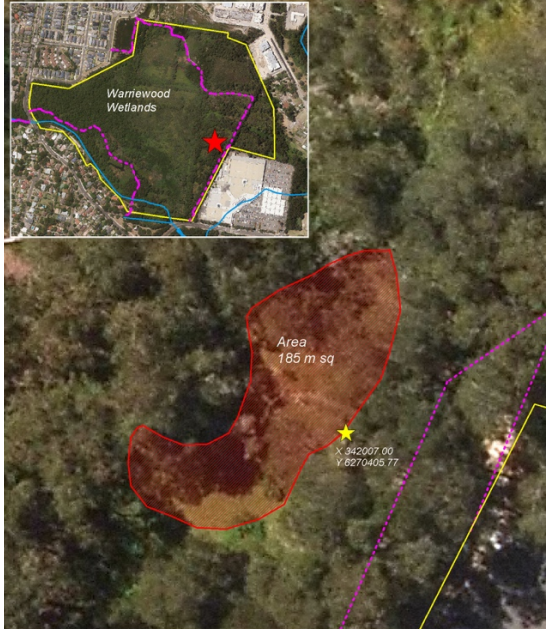




### Release Site 3

There was no *Salvinia Weevil* released at Release Site 3 during the study period. *Salvinia Weevil* was absent from the site during the period of the study.

Figure 5. Map showing Release Site 3





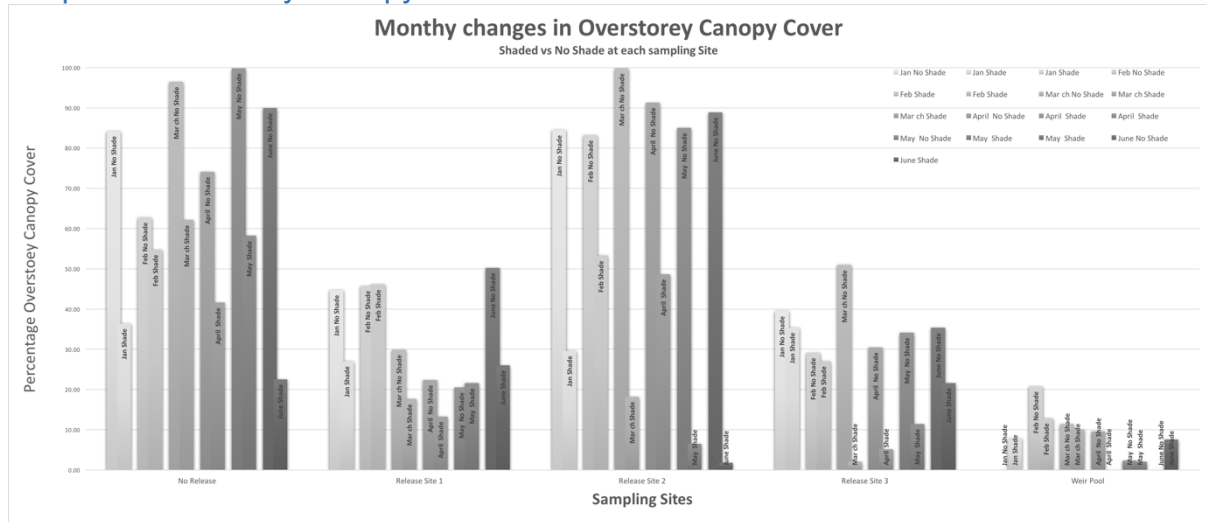
### 3.1 Atmospheric Conditions

Complete atmospheric condition results are available in Appendix A

#### 3.1.1 Shading

A difference in the percentage overstorey canopy cover between shaded and unshaded areas of each of the release sites can be seen across the sampling period at all sites.

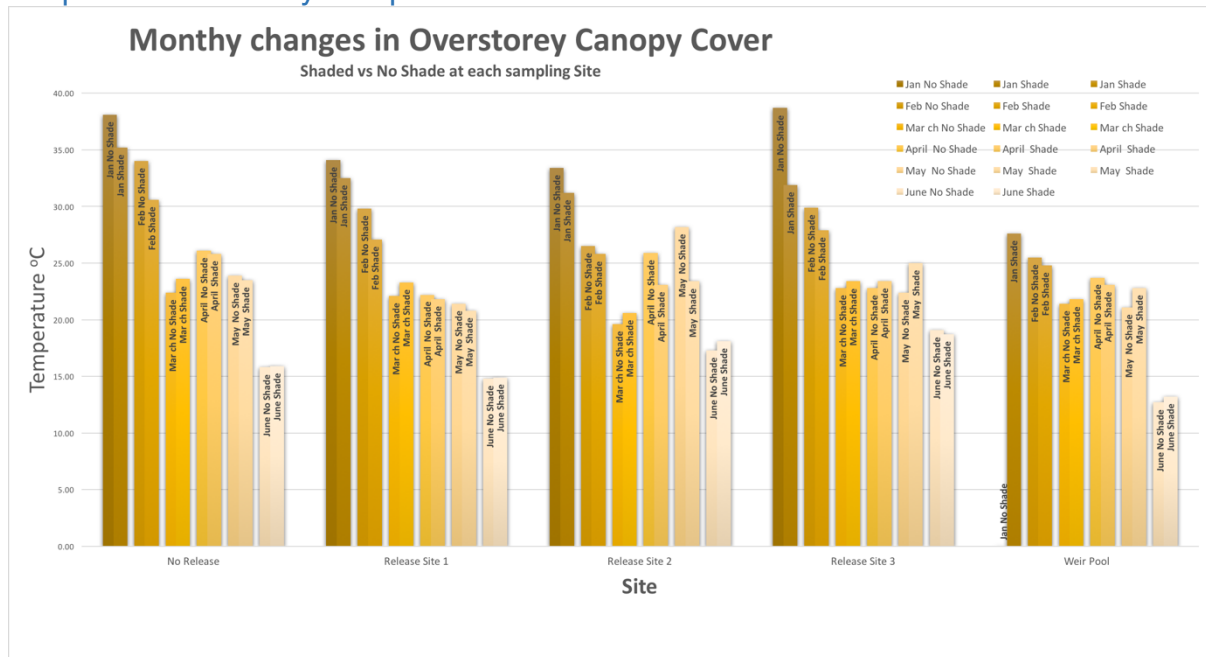
Graph 3. Overstorey Canopy Cover



#### 3.1.2 Temperature

There does not appear to be a clear difference in temperature between shaded and unshaded sites.

Graph 4. Understorey Temperature

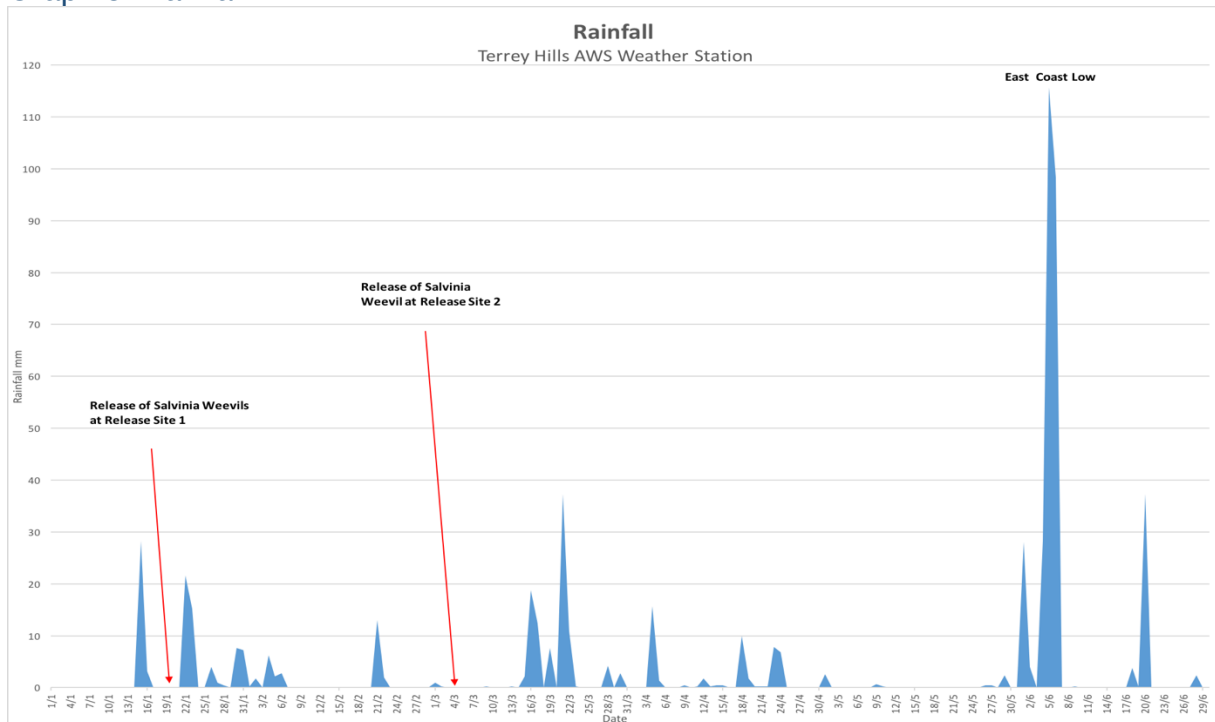




### 3.1.3 Rainfall

Rainfall during the period of the study. A significant East Coast Low resulted in very high rainfalls and flooding around Warriewood Wetlands on 5<sup>th</sup> and 6<sup>th</sup> May 2016.

Graph 5. Rainfall



### 3.2 Water Quality

Physical and chemical Water Quality parameters to observe changes when a die off of Salvinia occurred.

Complete water quality results are available in Appendix B

### Discussion

Warriewood Wetlands is an urban wetland that requires management of aquatic weeds. Northern Beaches Council identified the management of Salvinia through the use of the Salvinia Weevil, a biocontrol, as an opportunity to educate the community and as an opportunity to study whether the Salvinia Weevil has a preference for shaded or unshaded areas of the Salvinia infestation in Warriewood Wetlands.

The results show that Salvinia Weevil was observed in areas of both shaded and unshaded at release sites at the conclusion of the study period.

The complex nature of the vegetation through Warriewood Wetlands and the changes to this vegetation presented by seasonal and significant natural events including flooding and east coast systems result in constant changes in shading and corresponding understory temperatures throughout the year.



This study was able to observe one site, Release Site 1, with a Salvinia Weevil release for six months of the study period. This site showed no significant trend in temperature differences in the understorey temperatures between shaded and unshaded sites and that the release weevils were present at both shaded and unshaded areas of the site.

Release Site 2 was treated with other Salvinia management practices prior to the release of Salvinia Weevils in March. The unshaded area of this site was absent of Salvinia infestation at the conclusion of the study and unable to support the Salvinia Weevil. The shaded areas of Release Site 2 showed a marked decrease in the infestation of Salvinia with the native aquatic plant Azolla replacing a large area of Salvinia matt. The small amounts of Salvinia in the shaded area were observed to support the biocontrol, with the Salvinia Weevil recorded as present at the time at the conclusion of the study.

### Conclusion

The limited number of release sites during the study period and the confounding factors of herbicide application at Release Site 2; heavy rainfall and flooding of the wetland area during the May east coast low event and the limit of the study period of six months does not allow for any significant conclusions to be drawn from the data. It should be noted, that at the conclusion of the study period, both sites that received Salvinia infested with Salvinia Weevil, Release Site 1 and Release Site 2, were supporting Salvinia Weevil both in both shaded and unshaded areas.

All other sites were found to be absent of Salvinia Weevils, showing that there was no spread of the Salvinia Weevil from the release sites to other areas of Salvinia infestation in Warriewood Wetlands.

The physical and chemical water quality parameters collected are not conclusive in that they were monitored to capture changes should the Salvinia Weevil introduction cause a large scale die off of the Salvinia, this event did not occur. The water quality results may be useful in future assessments of Warriewood Wetlands or if future Salvinia Weevil introductions occur and monitoring is required.



## Appendix A Weevil Count Results

	Jan		Feb		Mar		April		May		June	
	Shade	No Shade	Shade	No Shade	Shade	No Shade	Shade	No Shade	Shade	No Shade	Shade	No Shade
No Release	0	0	0	0	0	0	0	0	0	0	0	0
Release Site 1	0	0	2	0	0	1	0	0	2	0	1	1
Release Site 2	0		0	0	0	1	3	1	0	*	1	*
Release Site 3	0	0	0	0	0	0	0	0	0	0	0	0



## Appendix B - Water Quality Parameters

	No Release	Release Site 1	Release Site 2	Release Site 3	Weir Pool	Mullet Creek Upstream
Date	21/01/2016	21/01/2016	21/01/2016	21/01/2016	21/01/2016	21/01/2016
Temp oC	24.1	24.16	24.5	22.64	22.49	NA
Dissolved Oxygen mg/L	1.6	1.2	16	0.7	1	NA
Conductivity	491	320	322	414	321	NA
pH	6.4	6.66	6.59	6.41	6.65	NA
Turbidity NT	115.9	0.4	0	76.8	0.2	NA
SRP mg/L	Not requested	Not requested	Not requested	Not requested	Not requested	Not requested
TN mg/L	5.17	0.82	0.71	3.79	0.93	Not requested
Date	29/02/2016	29/02/2016	29/02/2016	29/02/2016	29/02/2016	29/02/2016
Temp oC	22.63	22.7	22.87	24.26	22.49	NA
Dissolved Oxygen mg/L	4.4	1.2	2.1	0.7	1.3	NA
Conductivity	35	26	24	32	560	NA
pH	6.6	6.66	6.83	6.38	6.86	NA
Turbidity NT	30.1	24	0	60	34.3	NA
SRP mg/L	0.006	0.031	0.04	0.006	0.043	0.015
TN mg/L	7.89	0.79	0.82	8.46	0.9	0.73
Date	22/03/2016	22/03/2016	22/03/2016	22/03/2016	22/03/2016	22/03/2016
Temp oC	19.5	18.8	19	19	18.6	NA
Dissolved Oxygen mg/L	5.2	5.8	5.1	1.4	6	NA
Conductivity	281	225	2225	401	227	NA
pH	6.47	6.68	6.66	6.26	6.7	NA
Turbidity NT	4.5	4.3	8.2	3.5	4.1	NA
SRP mg/L	0.009	0.057	0.063	0.005	0.053	0.053
TN mg/L	0.57	1.12	1.29	1.33	1.1	1.12
Date	18/04/2016	18/04/2016	18/04/2016	18/04/2016	18/04/2016	18/04/2016
Temp oC	19.7	18.32	20.62	19.27	18.18	NA
Dissolved Oxygen mg/L	5.5	2.1	4.1	2.3	3	NA
Conductivity	433	309	307	443	310	NA
pH	6.57	6.75	6.75	6.42	6.67	NA
Turbidity NT	8	3.8	6.1	8.3	0.5	NA
SRP mg/L	0.003	0.027	0.025	0.007	0.023	0.022
TN mg/L	1.17	0.7	0.6	1.24	0.62	0.55
Date	16/05/2016	16/05/2016	16/05/2016	16/05/2016	16/05/2016	16/05/2016
Temp oC	16.86	15.52	16.61	16.77	14.79	NA
Dissolved Oxygen mg/L	5.2	1.5	3.4	2.4	2.5	NA
Conductivity	4311	326	311	416	315	NA
pH	6.36	6.66	6.59	6.49	6.66	NA
Turbidity NT	6.8	14.7	0	13.8	5.1	NA
SRP mg/L	0.003	0.024	0.01	0.004	0.011	0.018
TN mg/L	1.25	0.89	0.61	1.62	0.6	0.66
Date	15/06/2016	15/06/2016	15/06/2016	15/06/2016	15/06/2016	15/06/2016
Temp oC	12.03	12.01	13.56	12.31	11.85	NA
Dissolved Oxygen mg/L	4	5.3	2.9	2.9	5.6	NA
Conductivity	302	302	421	306	297	NA
pH	6.57	6.81	6.77	6.55	6.79	NA
Turbidity NT	1	0	1.8	4.8	0.2	NA
SRP mg/L	0.008	0.007	0.026	0.003	0.02	0.004
TN mg/L	0.9	0.66	1.14	1.03	0.68	0.72



## Appendix C Atmospheric Conditions

	Date	Unshaded Area		Shade Area	
		Air Temp oC	TOTAL % Shading	Air Temp oC	TOTAL % Shading
No Release	21/01/2016	38.1	84.24	35.2	36.40
Release Site	21/01/2016	34.1	44.72	32.5	27.04
Release Site	21/01/2016	33.4	84.50	31.2	29.64
Release Site	21/01/2016	38.7	39.52	31.9	35.36
Weir Pool	21/01/2016			27.6	7.80
No Release	29/02/2016	34	62.75	30.6	54.77
Release Site	29/02/2016	29.8	45.76	27.1	46.11
Release Site	29/02/2016	26.5	83.20	25.8	53.30
Release Site	29/02/2016	29.9	29.12	27.9	27.04
Weir Pool	29/02/2016	25.5	20.80	24.8	12.83
No Release	22/03/2016	22.4	96.46	23.6	62.14
Release Site	22/03/2016	22.1	29.90	23.3	17.68
Release Site	22/03/2016	19.6	99.84	20.6	18.20
Release Site	22/03/2016	22.8	50.96	23.4	2.08
Weir Pool	22/03/2016	21.4	11.44	21.8	10.05
No Release	18/04/2016	26.1	74.10	25.8	41.60
Release Site	18/04/2016	22.2	22.36	21.8	13.26
Release Site	18/04/2016	25.9	91.26	23.1	48.62
Release Site	18/04/2016	22.8	30.42	23.4	5.20
Weir Pool	18/04/2016	23.7	9.62	23.1	0.00
No Release	16/05/2016	23.9	99.84	23.5	58.24
Release Site	16/05/2016	21.4	20.54	20.8	21.58
Release Site	16/05/2016	28.2	85.02	23.4	6.50
Release Site	16/05/2016	22.4	34.16	25	11.44
Weir Pool	16/05/2016	21.1	2.34	22.8	2.08
No Release	15/06/2016	15.8	89.96	15.9	22.53
Release Site	15/06/2016	14.8	50.27	14.9	26.00
Release Site	15/06/2016	17.3	88.92	18.1	1.82
Release Site	15/06/2016	19.1	35.36	18.7	21.58
Weir Pool	15/06/2016	12.7	0.00	13.2	7.63