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TYPHA HERBICIDE EXPERIMENT: FORRESTDALE LAKE

DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT

Prepared by:

Ecoscape (Australia) Pty Ltd

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Direct all inquiries to:

Ecoscape (Australia) Pty Ltd
9 Stirling Highway • PO Box 50 North Fremantle WA 6159
Ph: (08) 9430 8955 Fax: (08) 9430 8977
mail@ecoscape.com.au

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		Name	Signature	Name	Signature	Date
0	A. Francis	A. Forest		A. Francis		14-6-04
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Typha Herbicide Experiment: Forrestdale Lake

This project was undertaken under the direction of Rod Martyn and Richard Reid from CALM Swan Coastal District with funding provided through the **Wetland Conservation Program (CALM)** and **Swan Coastal District Nature Conservation Section.**

Summary

Typha Herbicide Experiment: Forrestdale Lake

Bulrush *(Typha orientalis)* is an aggressive coloniser of wetland areas and has been present at Forrestdale Lake since the 1960's. Aerial photography shows a rapid increase in the area infested, particularly in recent years.

The Department of Conservation and Land Management commissioned Ecoscape to design and implement an experiment to test methods of controlling *Typha orientalis* at Forrestdale Lake. This project was undertaken under the direction of Rod Martyn and Richard Reid from CALM Swan Coastal District with funding provided through the **Wetland Conservation Program (CALM)** and **Swan Coastal District Nature Conservation Section.**

This report represents the results of a two stage experiment to determine the most effective approach for controlling *T. orientalis*. The first stage compared different concentrations of the herbicide glyphosate (1%, 3% and 5%), and the effect of adding a penetrant. While the second stage of the experiment tested the most appropriate time for control using the optimum concentration.

The following recommendations were made based upon the results of the study:

- Roundup® Biactive™ mixed at a 5% concentration was significantly more effective than a 1% or 3% for controlling *Typha* at Forrestdale Lake;
- Pulse® did not significantly increase the effectiveness of Roundup® Biactive™ for controlling *Typha* at Forrestdale Lake;
- Whilst leaves will die with 6 weeks of a herbicide application it takes a significantly longer time for the rhizomes to die;
- One herbicide application at the right concentration, at the right time, can kill *Typha orientalis* plants;
- Spraying a single application of 5% concentration of Roundup® Biactive™ prior to flowering at the start of Summer (e.g. October-December) was most cost effective timing for application as a follow up treatment during flowering (e.g. February) did not significantly increase the mortality of the *Typha*, and a single application in February was significantly less effective;
- Slashing is unnecessary for the control of *Typha* at Forrestdale Lake in terms of effectiveness of herbicide control as there was no difference in the mortality rate of *Typha* between areas that were slashed prior to the application of Roundup® Biactive™ and those that were left un-slashed; and
- Further study should be undertaken to determine what effects controlling *Typha* might have on Forrestdale Lake in terms of water quality and habitat loss.

1.0 Introduction

Typha Herbicide Experiment: Forrestdale Lake

1.1 Background

Forrestdale Lake Nature Reserve is one of the most important conservation reserves in south-western Australia (CALM, 2003). It is of international importance as a habitat and refuge for water birds. It is included on the List of Wetlands of International Importance (Ramsar) and is also included in the *Directory of Important Wetlands in Australia* (ANCA, 1996)

The key values of Forrestdale Lake Reserve identified by CALM (2005) are that it:

- is an internationally significant waterbird habitat which regularly supports over 1% of the known Australian population of the Long-toed Stint;
- is important for maintaining genetic and ecological diversity;
- is a particularly good representative of natural or near natural wetland characteristic of Wetlands on the Swan Coastal Plain before European settlement;
- has rich aboriginal heritage;
- is important for the protection of Rare, Threatened and Priority Flora and Fauna, and Threatened Ecological Communities;
- is representative of plant communities on the eastern side of the Swan Coastal Plain that have been heavily cleared; and
- provides natural and cultural values close to urban centres that provide opportunities for nature appreciation and education.

Of the 99 weeds recorded in the reserve, *Typha orientalis* is one of the four most threatening weeds and is a major management issue in Forrestdale Lake Reserve (CALM, 2005). *Typha orientalis* is an aggressive coloniser of wetland areas and has been present at Forrestdale Lake since the 1960's. Aerial photography shows a rapid increase in the area infested in Lake Forrestdale, particularly in recent years. This is possibly due to reduction in water levels caused by prolonged drought and increased levels of groundwater abstraction.

T. orientalis poses a major threat to the above identified values as it presents a significant fire hazard during summer which has the potential to considerably alter waterbird habitat (CALM, 2005).

The Forrestdale Lake Nature Reserve Management Plan 2005 (CALM, 2005) includes a Key Performance Indicator that the amount of *Typha orientalis* at Lake Forrestdale is to be reduced by at least 3% every three years. However control of this species is widely acknowledged to be difficult and many attempts have met with little success, and it is also important that control methods do not compromise the values identified for the Forrestdale Lake Nature Reserve.

The Department of Conservation and Land Management Officers Rod Martyn and Richard Reid from CALM Swan Coastal District contracted Ecoscape to design and implement an

experiment to test methods of controlling *Typha orientalis* at Forrestdale Lake. Funding for the study provided through both the **Wetland Conservation Program (CALM)** & through **Swan Coastal District Nature Conservation Section.**

1.2 Study Area

Forrestdale Lake is within Forrestdale Lake Nature Reserve, an A class reserve gazetted for the *Conservation of Flora and Fauna* and is located approximately 25 kilometres south-east of Perth, in the City of Armadale. The lake occupies 90% or 221 ha of the total Reserve area which is 243.6 ha, and is almost entirely bounded by Commercial Road (CALM 2003).

The water levels at Forrestdale Lake are a reflection of groundwater levels, which in turn are reflected by rainfall, groundwater extraction, drainage, evaporation and evapotranspiration. The Perth region exhibits a Mediterranean type climate with wet mild winters and dry hot summers. Average rainfall is 875mm each year which generally occurs in the winter months (Seddon 1972). Since annual rainfall in the south west of Western Australia has declined by about 10% and falling water levels in Forrestdale Lake have contributed to the spread of *Typha orientalis* and its encroachment onto the lake (CALM 2005).

1.3 Variables Considered In Experiment Development

1.3.1 Herbicide Formulation

Herbicides may be the cheapest and most effective form of control of *Typha* at Forrestdale Lake. Repeated slashing and other mechanical methods have thus far failed to eradicate *Typha* from Forrestdale Lake. This is likely to be because of the high potential for vegetative reproduction of the rhizome. Any parts of the rhizome left in the soil have the potential to re-sprout. For effective, long-term control the rhizome must either be removed completely or killed. The former is likely to be very time consuming, expensive and may potentially damage the lake bed.

Due to the high conservation values of Forrestdale Lake, only herbicides registered for use in aquatic areas are likely to be accepted as a method to control *Typha*. Herbicides registered for use in wetland areas in Western Australia are (WRC, 2001):

- Glyphosate (Roundup® Biactive™, Roundup®,Rodeo®, Davison® Glyphosate 450®)
- Flauzifop-p-butyl (Fusilade®)
- Metasulfuron-methyl (Brushoff®, Ally®, Groper® and Escort®)
- Chlorsulfuron (Glean®, Siege®, Tackle®)
- Diquat (Aquacide® / Reglone®)

Of these, only glyphosate appears to have been used with any success to control *Typha*. 2,2-DPA has also shown to produce good results however this has not been approved for use by the Department of Environment.

The use of a penetrant such as Pulse® is used to enhance the uptake of the herbicide. The use of a penetrant was thought to be significant for *Typha* control as this weed has a waxy cuticle on its leaves which greatly inhibits its ability to absorb herbicides, particularly

Roundup® Biactive™, which tends to form droplets on the leaves which run off and are not absorbed.

Concentration of herbicides is an important variable to be tested. It is important to determine the amount of herbicide necessary to obtain an effective kill without exposing the wetland to excessive chemicals. The herbicide mixes tested were:

1. No Spray (control)
2. 3% concentration Roundup® Biactive™
3. 5% concentration Roundup® Biactive™
4. 1% concentration Roundup® Biactive™ plus Pulse®
5. 3% concentration Roundup® Biactive™ plus Pulse®
6. 5% concentration Roundup® Biactive™ plus Pulse®

1.3.2 Timing

Of the variables associated with *Typha* control, timing is likely to be the most critical and has not been adequately tested in WA. Most authorities recommend spraying *Typha* from late December to late February however this is based on recommendations from other states, such as Tasmania. This timing is after both the male and female flowers have opened but before the plant has begun to senesce. The rationale behind this is that carbohydrate levels in the rhizome are at their lowest while the plant is still actively growing thereby increasing the effectiveness of the herbicide.

While this may be true, it is essential to trial herbicide application at different times as:

1. WA has a unique climate and *Typha* may not respond in the same way at this time of the year.
2. Hormonal changes during flowering may inhibit effectiveness of the herbicide; and
3. Plant metabolism is beginning to slow down at this time, which may reduce growth and the plants' ability to absorb the herbicide.

The Timing of the treatments were;

1. prior to flowering (early December, 2004); and
2. during flowering (early February, 2005).

1.3.3 Mechanical Control

Various forms of mechanical control have been tried at Forrestdale Lake. Slashing has been used repeatedly in an attempt to control weeds and maintain fire access tracks.

While slashing removes the aboveground biomass, it does not kill the rhizomes and so is unlikely to be effective on its own. Mechanical control can be used in conjunction with spraying in the following ways:

1. Slashing to reduce biomass and then spraying once new seedlings have emerged (it is not appropriate to spray shortly after following slashing as glyphosate relies on the plant's ability to take up the herbicide which would be significantly reduced.
2. Mowing with a weed wiper. Mowing (to achieve a clean cut) with a wiper attached to the back of the implement may act to allow intake of the herbicide into the phloem before cohesion is lost.

Slashing may also be undertaken to facilitate access to the plants so that adequate herbicide coverage is obtained. This is not necessary at Forrestdale Lake as the height and density of Typha is sufficiently low as to maintain access in many areas.

Mechanical control has been included in the second stage of the experiment as an additional option to the timing.

1.4 Study Aims

This report represents the results of a two stage experiment to determine the most effective approach for controlling *T. orientalis*. The first stage compared different concentrations of the herbicide glyphosate, and the effect of adding a penetrant. While the second stage of the experiment tested the most appropriate time for control using the optimum herbicide concentration.

Phase 1-Concentration Experiment:

The aim of this experiment was to determine the most effective herbicide application rate for controlling *Typha orientalis*.

To determine the most effective herbicide formulation from amongst the following (if there were any differences):

1. No Spray (control)
2. 3% concentration Roundup® Biactive™
3. 5% concentration Roundup® Biactive™
4. 1% concentration Roundup® Biactive™ plus Pulse®
5. 3% concentration Roundup® Biactive™ plus Pulse®
6. 5% concentration Roundup® Biactive™ plus Pulse®

Additionally determine if the effectiveness of these formulations varied between plants >1m and <1m.

Phase 2- Timing Experiment:

The aim of this experiment was to determine the most effective timing for herbicide application to maximise the mortality of *Typha orientalis* at Forrestdale Lake.

To determine this, comparisons were made of the following variables to determine if there was a significant difference in the means of mortality between any of them:

- No treatment (control)
- sprayed in early December with a repeat treatment in early February
- sprayed in early December only
- sprayed in early February only

Additionally, significant differences in the mean mortality of *Typha orientalis* with the overall effect of using the mechanical technique of slashing were tested.

2.0 Method

Typha Herbicide Experiment: Forrestdale Lake

2.1 Phase 1- Concentration Experiment

A total of 30, 1x10 m plots were established at Forrestdale Lake (6 treatments, 5 replicates) and sprayed according to the following treatments on the 17th February.

- No Spray (C)
- 3% concentration Roundup® Biactive™ (3B)
- 5% concentration Roundup® Biactive™ (5B)
- 1% concentration Roundup® Biactive™ plus Pulse® (1BP)
- 3% concentration Roundup® Biactive™ plus Pulse® (3BP)
- 5% concentration Roundup® Biactive™ plus Pulse® (5BP)

The quadrats were positioned so that they had a similar density, distribution and alignment, and were situated near the inner margin of the infestation. Plots were established at least 10 metres apart to minimise the impact of incidental spray-drift. The location of the quadrats is shown in Figure 2.1. GPS references for the north-east corner of each quadrat are listed in Appendix One.

Herbicide was applied using a backpack sprayer. Coverage overlapped the boundaries of the quadrat by 0.5 – 1 m to ensure complete coverage. Weather conditions at the time were hot (over 40^0 C), and there was little breeze.

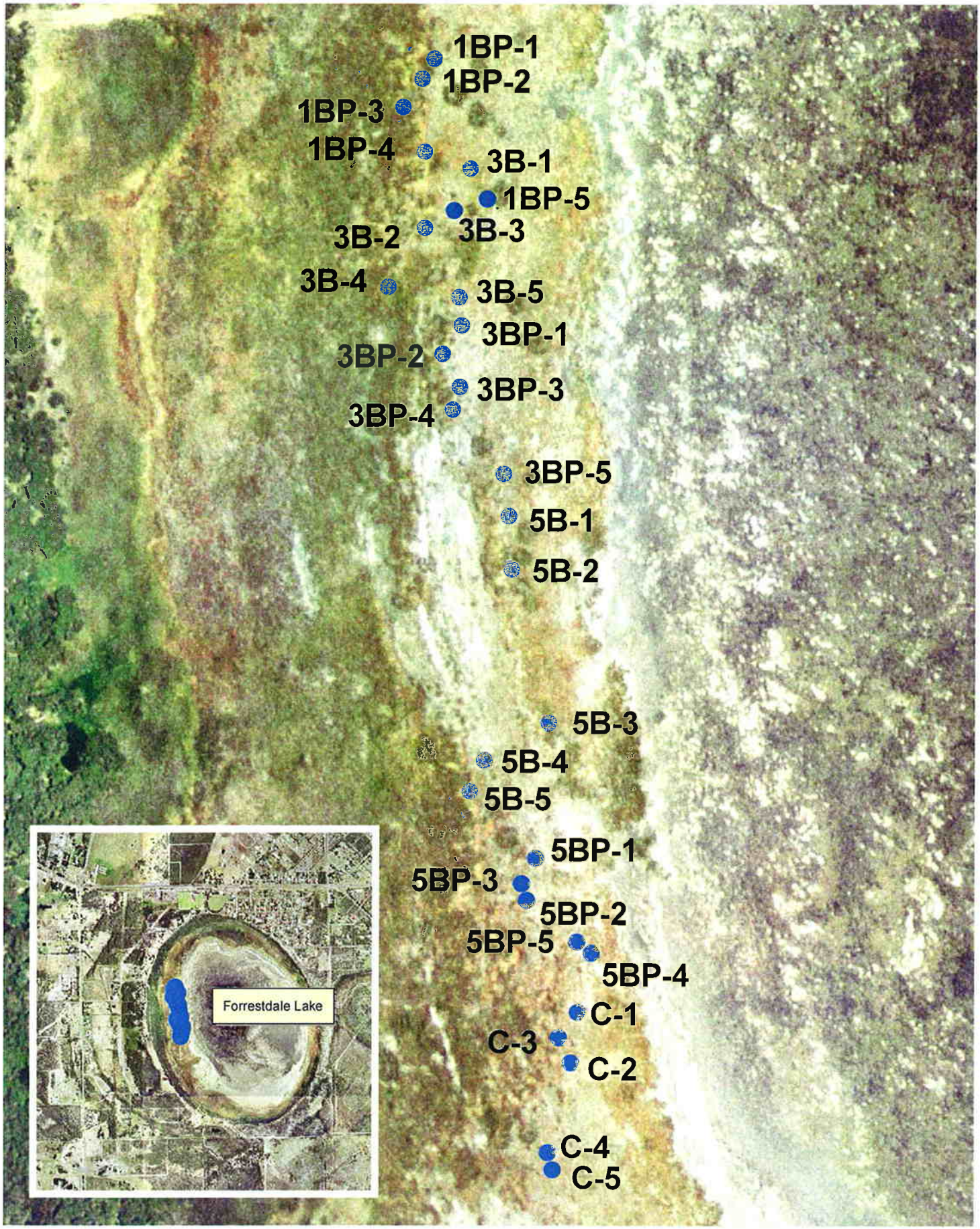
The quadrats were assessed on 2nd April, 2004. Counts were made of dead (brown stems to the ground) and alive (green visible on stems) in two size classes (>1m and <1m). Additionally 5 rhizomes from plants identified as 'dead' were excavated in each quadrat to determine if the rhizome had died and was rotten. Field data is included in Appendix One.

2.1.1 Analysis

The following statistical analysis of the proportion of *Typha* individuals classified as 'dead' was undertaken to determine the significance of the mean results.

1. Two sample T-test between all pairs of treatments
2. Two-factor Analysis of Variance (ANOVA) between a 3% and 5% concentration of Roundup® Biactive™, with and without the addition of Pulse®; and
3. Two Factor ANOVA between a 3% and 5% concentration of Roundup® Biactive™ and two different size classes <1 m & >1 m.
4.

Statistical Analysis was undertaken through Excel using the statistical program Analyse-it.



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Typha Herbicide Experiment: Forrestdale Lake

Phase 1 - Location of quadrats

50 0 50 100 Meters

Scale 1:2000 @A4

CALM

Figure 2.1

Nov 2005

Phase 2- Timing Experiment

A total of 20, 1x10 m plots were established at Forrestdale Lake (6 treatments, 5 replicates). Fence droppers were placed in the corner of each quadrat. One dropper in each quadrat was tagged (the western most dropper closest to the centre of the trial area). Each quadrat was tagged according to the treatment type and replicate number:

- "X" indicating no spray treatment;
- "S04" indicating the spray treatment in December 2004; and
- "S05" indicating the spray treatment in February 2005.

The quadrats were positioned so that they have a similar density, distribution and alignment, and are situated near the inner margin of the infestation. Quadrats were sprayed according to the following treatments on the 3rd December 2004 with the follow up treatment on the 4th February 2005.

- No Spray (control) (X/X)
- December and February (S04/S05)
- December only (S04/X); and
- February only (X/S05)

There were also replicates of each treatment in areas slashed prior to spray application and those that were left un-slashed.

Again plots were established at least 10 metres apart to minimise the impact of incidental spray-drift.

Plot locations were marked using a handheld GPS to locate a permanent stake in the north-east corner. The location of the quadrats is shown in Figure 2.2. GPS references for the north-east corner of each quadrat are listed in Appendix Two.

Herbicide was applied using a power sprayer. Coverage overlapped the boundaries of the quadrat by 0.5 – 1 m to ensure complete coverage.

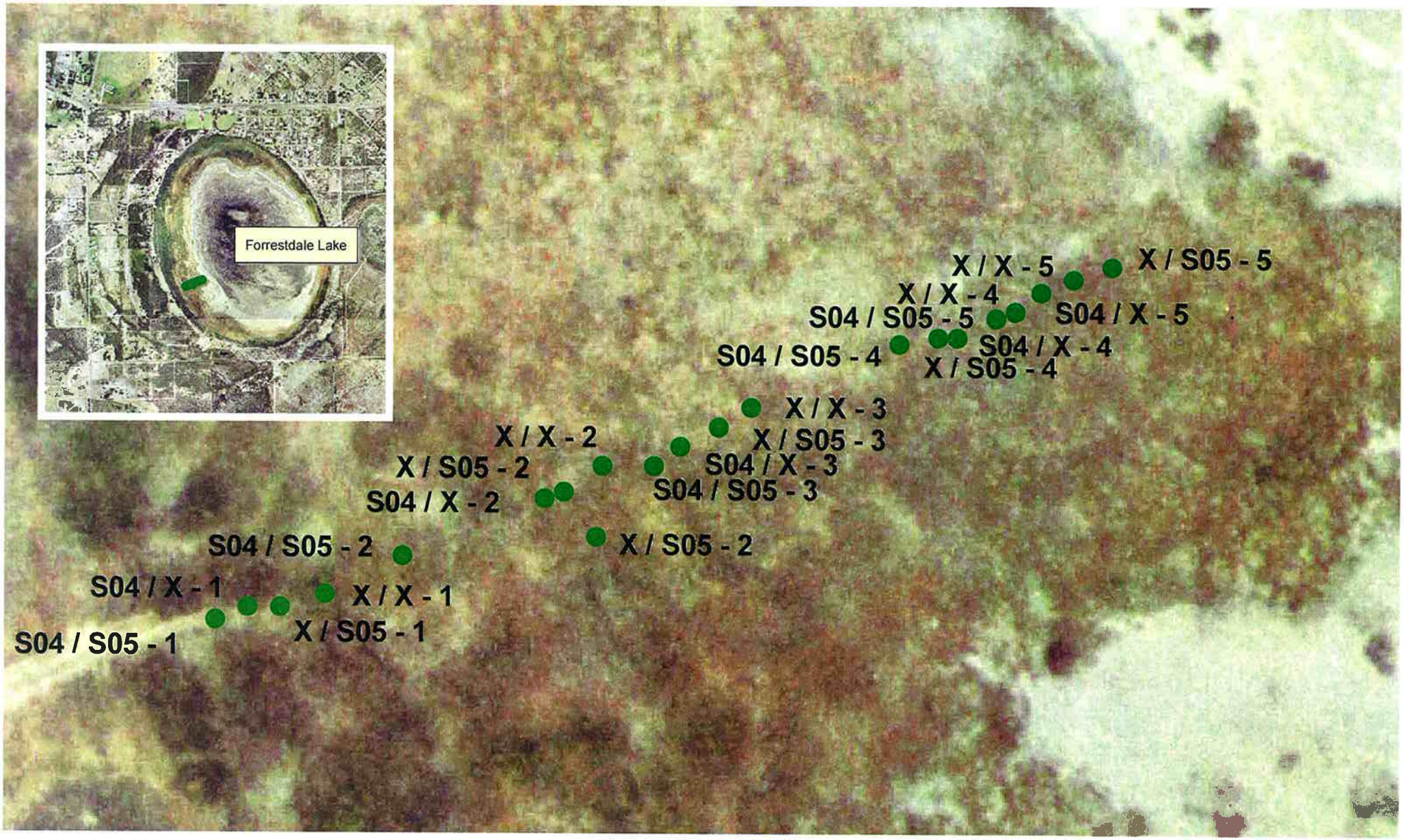
The quadrats were assessed on the 11th of October, 2005. Counts were made of the amount of dead (brown to the ground) and alive (green visible) stems in each quadrat as well as the total amount found to be <1m and >1m in height. Field data is included in Appendix Two.

2.1.2 Analysis

The following statistical analysis of the proportion of *Typha* individuals classified as 'dead' was undertaken to determine the significance of the mean results.

1. Two sample T-test between all pairs of treatments
2. Two-factor ANOVA between
    a. Timing of the spray treatment; and
    b. Effect of slashing prior to spraying; and
3. One-way ANOVA between the replicates that were slashed prior to the spray treatment and those that were not

Statistical Analysis was undertaken through Excel using the statistical program Analyse-it.



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Typha Herbicide Experiment: Forrestdale Lake

Phase 2 - Location of quadrats

20 0 20 40 60 80 Meters

Scale 1: 800 @ A4

CALM

Figure 2.2

Nov 2005

3.0 Results

Typha Herbicide Experiment: Forrestdale Lake

3.1 Phase 1- Concentration Experiment

3.1.1 Descriptive Statistics

Descriptive statistics for each treatment are given below, with mean, inter-quartile range, maximum and minimum plotted in Figure 3.1.

Table 3.1 Descriptive Statistics for each concentration treatment

	C	1BP	3B	3BP	5B	5BP
Mean	0.036	0.491	0.714	0.749	0.874	0.879
Standard Error	0.016	0.048	0.050	0.050	0.044	0.044
Median	0.017	0.516	0.726	0.745	0.897	0.895
Standard Deviation	0.036	0.107	0.112	0.112	0.098	0.098
Sample Variance	0.001	0.011	0.012	0.013	0.010	0.010
Kurtosis	-3.059	4.003	2.566	1.724	-0.457	1.040
Skewness	0.460	-1.908	-1.340	0.087	-0.810	-0.976
Range	0.076	0.272	0.299	0.315	0.241	0.257
Minima	0.000	0.306	0.531	0.593	0.729	0.727
Maxima	0.076	0.578	0.830	0.908	0.970	0.983
95% Confidence Level	0.045	0.132	0.139	0.139	0.122	0.122

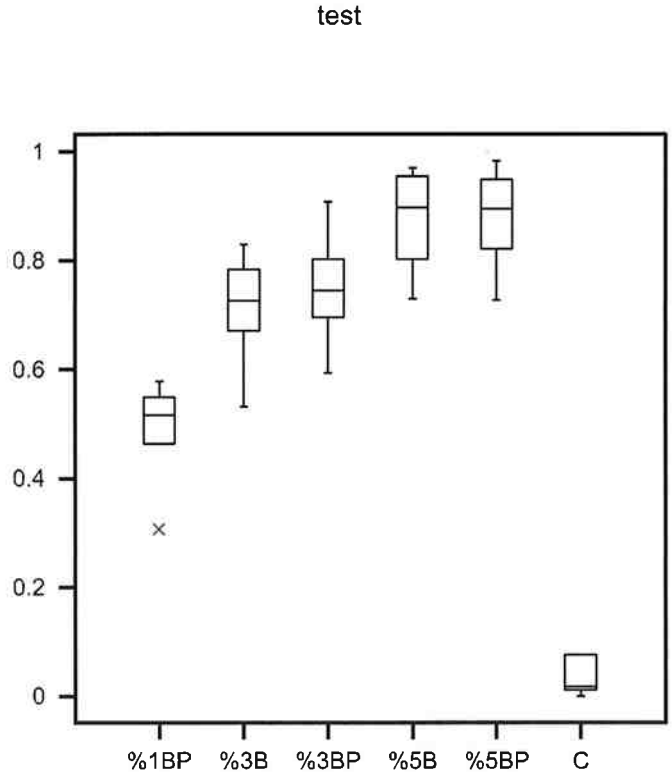

Figure 3.1 Box plot showing mean, inter-quartile range, maxima and minima of mortality rates for each concentration treatment.

3.1.2 Two Sample T-test

Table 3.3 shows the results of the two-sample t-test undertaken between all treatments. There was a highly significant statistical difference (P<0.001) between the control group and all other groups.

Table 3.3 Results of t-test analysis between the different concentrations

	C	1%BP	3%B	3%BP	5%B	5%BP
C		<0.001**	<0.001**	<0.001**	<0.001**	<0.001**
1%BP	<0.001**		0.012*	0.006*	<0.001*	<0.001**
3%B	<0.001**	0.012*		0.640	0.043*	0.038*
3%BP	<0.001**	0.006*	0.640		0.097	0.087
5%B	<0.001**	<0.001**	0.043*	0.097		0.941
5% BP	<0.001**	<0.001**	0.038*	0.087	0.941	

** is significant to 0.001

* is significant to 0.05

3.1.3 Two-factor ANOVA (concentration & penetrant)

The results of the two-factor analysis of variance between concentration and the addition of the penetrant Pulse® is shown in Table 3.3 below. There was no significant difference (P=0.683) between treatments with Pulse® added and those without, however a significant difference (P=0.007) was observed between treatments with different concentrations of Roundup® Biactive™.

Table 3.5 Results of two-factor ANOVA between 3% & 5% concentrations of Roundup® Biactive™, with and without the addition of Pulse®.

Source of Variation	*Sum Sq.*	*df*	*Mean Square*	*F*	*P-value*	*F crit*
Pulse®	0.001915	1	0.001915	0.17258	0.683347	4.493998063
Conc.	0.104993	1	0.104993	9.460396	0.007238	4.493998063
Interaction	0.001098	1	0.001098	0.098892	0.757226	4.493998063
Within	0.17757	16	0.011098			

3.1.4 Two-factor ANOVA (concentration and size class)

The results of the two-factor analysis of variance between concentration and size class are shown in Table 3.4. There was no significant difference in mortality between size classes (P=0.322), and a weak relationship was observed between different concentrations within size classes (P=0.078).

Table 3.6 Results of two-factor ANOVA between 3% & 5% concentrations of Roundup® Biactive™ between <1m & >1m size classes.

Source of Variation	*Sum Sq.*	*df*	*Mean Sq*	*F*	*p-value*	*F crit*
Conc.	0.187409248	1	0.187409	3.538283	0.078294	4.493998063
Size class	0.055431222	1	0.055431	1.04654	0.321525	4.493998063
Interaction	0.0092727	1	0.009273	0.175068	0.681208	4.493998063
Within	0.847458463	16	0.052966			

3.2 Phase 2- Timing Experiment

3.2.1 Descriptive Statistics

Descriptive statistics for each treatment are given below, with mean, inter-quartile range, maximum and minimum plotted in Figure 3.2.

Table 3.2 Descriptive Statistics for each timing treatment

	X/X	S04/S05	S04/X	X/S05
Mean	0.276	0.997	0.994	0.338
Standard Error	0.0383	0.0018	0.0046	0.0342
Median	0.262	1.000	1.000	0.327
Standard Deviation	0.1212	0.0057	0.0145	0.1083
Sample Variance	0.0147	0.0000	0.0002	0.0117
Kurtosis	-0.0563	1.6954	5.1495	1.6856
Skewness	-0.2263	-1.8204	-2.3358	-0.5675
Range	0.38	0.01	0.04	0.40
Minimum	0.19	0.99	0.96	0.11
Maximum	0.43	1.0000	1.0000	0.5100
Confidence Level (95.0%)	0.44	0.001	0.001	0.32

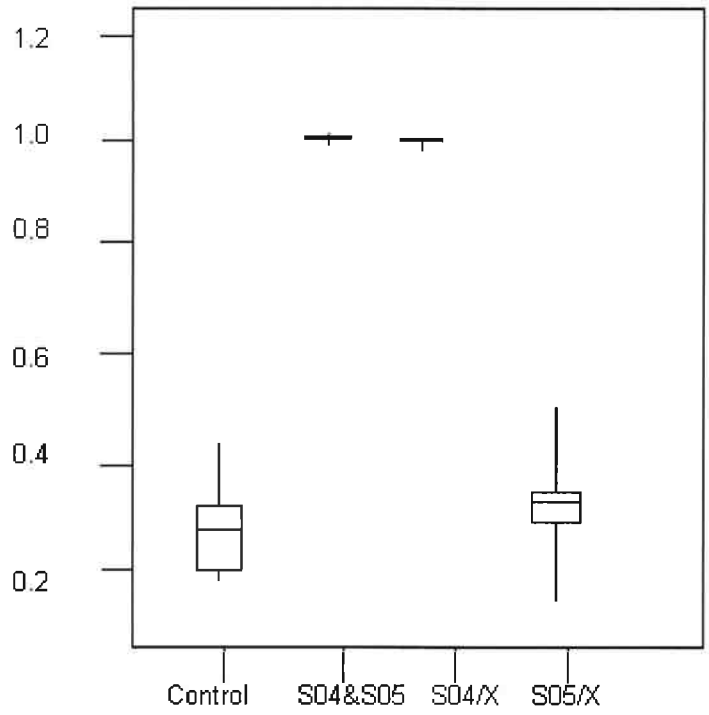

Figure 3.2 Box plot showing mean, inter-quartile range, maxima and minima of mortality rates for each timing treatment.

3.2.2 Two Sample T-test

Table 3.4 shows the result of the two-sample t-test undertaken between all treatments. There was a highly significant difference between the control treatment (No spray) and the treatment of spraying in February only (X/S05) with all other groups.

Table 3.4 Results of t-test analysis between the different times of spray application

	No Spray (X/X)	Dec and Feb (S04/S05)	Dec only (S04/X)	Feb only (X/S05)
No Spray(X/X)		<0.0001*	<0.0001*	0.1606
Dec and Feb (S04/S05)	<0.0001*		0.5044	<0.0001*
Dec only (S04/X)	<0.0001*	0.5044		<0.0001*
Feb only (X/S05)	0.1606	<0.0001*	<0.0001*	

*is significant to 0.001

3.2.3 Two-factor ANOVA (timing treatment and slashed & un-slashed)

The results of the two-factor analysis of variance between the timing of the spray treatment and the effects of slashing are shown in table 3.7. There was no significant difference in the percentage of mortality between the slashed and un-slashed replicates among the timing treatments (p=0.0470, α=0.001), however a significant difference (p=<0.0001, α=0.001) was observed between the timing of spray treatments.

Table 3.7 Results of two-way ANOVA between different timing & slashing treatments

Source of Variation	*Sum Sq*	*df*	*Mean Sq*	*F*	*p-value*	*F crit*
Slashed & un-slashed	0.045	1	0.045	9.56	0.0041	12.62
Timing treatment	4.757	3	1.586	333.38	<0.0001	6.59
Interaction	0.042	3	0.014	2.96	0.0470	6.59
Within cells	0.152	32	0.005			
Total	4.997	39				

α=0.001

3.2.4 One-way ANOVA (slashed & un-slashed)

The results of the one-way ANOVA between the replicates that were slashed and un-slashed are shown in table 3.8. There was no significant difference (p=0.5582, α=0.001) in the mortality rate between the replicates that were slashed prior to the spray treatment and those left un-slashed.

Table 3.8 Results of one-way ANOVA between slashed and un-slashed replicates

Source of Variation	*Sum Sq*	*df*	*Mean Sq*	*F*	*p-value*	*F crit*
Slashed & un-slashed	0.045	1	0.045	0.35	0.5582	12.61
Within cells	4.952	38	0.130			
Total	4.997	39				

α=0.001

4.0 Discussion & Conclusions

Typha Herbicide Experiment: Forrestdale Lake – Phase 1

4.1 Concentration of Roundup® Biactive™

A significant difference was observed between the means of observed mortality between the control and all concentrations of herbicide ($P<0.001$). Similarly a significant difference was observed between a 1% concentration of Roundup® Biactive™ plus Pulse® and all other treatments ($P<0.05$).

These results indicate that increasing the concentration of herbicide results in a greater proportion of apparent mortality (stems completely browning off), however the significance becomes weaker as the concentration increases. A significantly higher mortality rate is therefore not expected at concentrations higher than 5%.

Conclusions:

Increasing the concentration of glyphosate increases the effectiveness of the herbicide formulation.

A 5% concentration of Roundup® Biactive™ is the most effective in controlling *Typha* and this concentration should be used for management in this area.

4.2 Addition of Pulse®

The addition of the penetrant Pulse® appeared to a small but not statistically significant difference to the effectiveness of Roundup® Biactive™ ($P=0.683$).

Conclusion:

The addition of the penetrant Pulse® does not appear to significantly increase the effectiveness of Roundup® Biactive™ for controlling *Typha*.

4.3 Size-class effects

A two-factor ANOVA was undertaken to determine if different concentrations of Roundup® Biactive™ produced different observed mortalities between two size classes of *Typha* (0-1m; <1m). No significant difference was observed between mortality of different size classes ($P=0.32$), suggesting that resistance to Roundup® Biactive™ did not increase with size or age.

Conclusion:

There is no difference in *Typha* susceptibility to Roundup® Biactive™ between plants less than or greater than 1m.

4.4 Apparent mortality vs actual mortality

In phase 1 of the experiment mortality rates were calculated by examining the aboveground parts of the stem. A *Typha* stem was classified as 'dead' when no green was observed on any part of the stem. Examination of the rhizomes of *Typha* that had been classified as 'dead', found that in all cases they had survived 6 weeks following spraying and that the number of shoots arising from the rhizome decreased with increased concentration.

However this is an indication that it takes more than 6 weeks for the plants to die rather than an indication that a single application will not kill a plant as Phase 2 (which measured mortality many months after herbicide application) did find that plants were killed by a single application.

Conclusion:
Whilst leaves will die with 6 weeks of a herbicide application it takes a significantly longer time for the rhizomes to die.

One herbicide application at the right concentration, at the right time, can kill *Typha orientalis* plants.

4.5 Timing

A significant difference was observed between the mean mortality of *Typha* within the control treatment, and the other spray treatments ($p=<0.0001$, $\alpha=0.001$), except for the treatment of spraying in February only which was ineffective. Similarly, a significant difference was also observed between the treatment of spraying in February only and the other spray treatments ($p=<0.0001$, $\alpha=0.001$), except the control.

No significant difference was found between the mortality rates of *Typha* sprayed in December and again in February, compared to only being sprayed in December ($p=0.5044$, $\alpha=0.001$).

These results indicate that the best time to spray Roundup® Biactive™ in this case is just the once in December. However, a follow up treatment in February, would ensure the maximum rate of rhizome mortality.

Conclusion:
Spraying a single application of 5% concentration of Roundup® Biactive™ prior to flowering at the start of Summer (e.g. October-December) was most cost effective timing for application as a follow up treatment during flowering (e.g. February) did not significantly increase the mortality of the *Typha*, and a single application in February was significantly less effective.

4.6 Mechanical Control

No significant difference was found between the mortality rates of *Typha* that was slashed prior to the spray treatments and those left un-slashed ($p=0.5582$, $\alpha=0.001$).

A Two-factor ANOVA was also conducted to determine if the effect of slashing was connected to the timing of the spray treatment. The results showed that there was no significant difference between the interaction of the *Typha* that was slashed and un-slashed with any of the different timing of spraying treatments ($p=0.0470$, $\alpha=0.001$).

Since the stands of *Typha* at Forrestdale Lake are already at a relatively low height and density, which facilitates access for appropriate control, the results indicate that slashing prior to the application of the herbicide Roundup® Biactive™ would be unnecessary.

Conclusion:

There was no difference in the mortality rate of *Typha orientalis* between areas that were slashed prior to spraying of Roundup® Biactive™ and those that were left un-slashed.

5.0 Recommendations

Typha Herbicide Experiment: Forrestdale Lake

5.1 Phase 1- Concentration Experiment

The following recommendations are made based upon the results of the study:

- A 5% concentration of Roundup® Biactive™ should be used when undertaking herbicide control of *Typha* at Forrestdale Lake;
- Pulse® should not be used with Roundup® Biactive™ for controlling *Typha* at Forrestdale Lake;

5.2 Phase 2- Timing Experiment

The following recommendations are made based on the results of this study:

- A 5% concentration of Roundup® Biactive™ should be applied once prior to flowering (November - early December), to gain the best result in *Typha* mortality at Forrestdale Lake
- Slashing prior to application of Roundup® Biactive™ is unnecessary for the control of *Typha* at Forrestdale Lake; and
- Further study should be undertaken to determine what effects the control of *Typha* would have on Forrestdale Lake in terms of water quality and habitat loss.

References

Typha Herbicide Experiment: Forrestdale Lake

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Seddon, G (1972) *Sense of Place: A Response to an Environment, the Swan Coastal Plain Western Australia,* University of Western Australia Press, Perth.

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Appendix One: Field Data-Phase 1

Typha Herbicide Experiment: Forrestdale Lake

Treatment: 1% Roundup® Biactive™ plus Pulse® (1BP)

Replicate	Easting	Northing	Corner	Direction	Dead		Alive		No Dead rhizomes
					<1m	>1m	<1m	>1m	
1BP-1	399290	6441788	NE	270	2	35	9	75	0
1BP-2	399204	6441777	NE	300	5	58	4	42	0
1BP-3	399196	6441776	NE	300	6	63	2	57	0
1BP-4	399207	6441750	NE	270	4	60	5	55	0
1BP-5	399223	6441748	NE	270	9	41	5	42	0

Treatment: 3% Roundup® Biactive™ (3B)

Replicate	Easting	Northing	Corner	Direction	Dead		Alive		No Dead rhizomes
					<1m	>1m	<1m	>1m	
3B-1	399231	6441731	NE	290	18	99	6	18	0
3B-2	399217	6441724	NE	300	8	68	0	23	0
3B-3	399205	6441719	NE	300	0	60	7	46	0
3B-4	399191	6441695	NE	300	4	95	3	36	0
3B-5	399219	6441691	NE	290	8	69	6	23	0

Treatment: 3% Roundup® Biactive™ plus Pulse® (3BP)

Replicate	Easting	Northing	Corner	Direction	Dead		Alive		No Dead rhizomes
					<1m	>1m	<1m	>1m	
3BP-1	399220	6441680	NE	295	8	62	6	42	0
3BP-2	399213	6441669	NE	295	5	68	0	25	0
3BP-3	399219	6441655	NE	270	6	113	4	40	0
3BP-4	399217	6441647	NE	290	8	101	3	30	0
3BP-5	399237	6441621	NE	280	9	110	1	11	0

Treatment: 5% Roundup® Biactive™ (5B)

Replicate	Easting	Northing	Corner	Direction	Dead		Alive		No Dead rhizomes
					<1m	>1m	<1m	>1m	
5B-1	399239	6441605	NE	270	18	80	0	3	0
5B-2	399240	6441584	NE	265	34	96	1	6	0
5B-3	399255	6441523	NE	270	8	120	0	27	0
5B-4	399229	6441508	NE	280	8	105	7	35	0
5B-5	399224	6441496	NE	255	4	109	3	10	0

Treatment: 5% Roundup® Biactive™ plus Pulse® (5BP)

Replicate	Easting	Northing	Corner	Direction	Dead		Alive		No Dead rhizomes
					<1m	>1m	<1m	>1m	
5BP-1	399249	6441470	NE	260	12	92	5	13	0
5BP-2	399244	6441459	NE	270	7	111	1	1	0
5BP-3	399246	6441453	NE	270	15	121	6	10	0
5BP-4	399266	6441436	NE	255	3	98	5	33	0
5BP-5	399272	6441432	NE	240	15	105	1	7	0

Treatment: Control (C) – No Spray

Replicate	Easting	Northing	Corner	Direction	Dead		Alive		No Dead rhizomes
					<1m	>1m	<1m	>1m	
C-1	399266	6441409	NE	260	1	1	17	102	0
C-2	399259	6441399	NE	280	0	9	12	99	0
C-3	399263	6441389	NE	280	0	0	3	105	0
C-4	399254	6441353	NE	265	0	2	14	119	0
C-5	399256	6441347	NE	280	0	12	10	136	0

Appendix Two:
Field Data-Phase 2

Typha Herbicide Experiment: Forrestdale Lake

Treatment: Control-No spray

	Slashed						
Replicate	**Easting**	**Northing**	**Corner**	**#Alive**	**# Dead**	**Total #**	
						< 1m	**>1m**
X/X-1	399252	6441111	NE	178	50	12	216
X/X-2	399295	6441131	NE	197	10	21	186
X/X-3	399318	6441140	NE	112	32	15	129
X/X-4	399356	6441154	NE	92	36	26	102
X/X-5	399374	6441162	NE	95	35	117	13

	Un-slashed						
Replicate	**Easting**	**Northing**	**Corner**	**#Alive**	**#Dead**	**Total #**	
						< 1m	**>1m**
X/X-1	399252	6441111	NE	123	29	15	137
X/X-2	399295	6441131	NE	70	52	12	110
X/X-3	399318	6441140	NE	149	51	0	200
X/X-4	399356	6441154	NE	134	98	0	232
X/X-5	399374	6441162	NE	120	89	11	198

Treatment: Sprayed in Dec 2004 and Feb 2005

	Slashed						
Replicate	**Easting**	**Northing**	**Corner**	**#Alive**	**# Dead**	**Total #**	
						< 1m	**> 1m**
S04/S05-1	399235	6441107	NE	0	9	9	0
S04/S05-2	399264	6441117	NE	0	14	14	0
S04/S05-3	399303	6441131	NE	0	16	16	0
S04/S05-4	399341	6441150	NE	0	67	47	21
S04/S05-5	399359	6441155	NE	0	18	18	0

	Un-slashed						
Replicate	**Easting**	**Northing**	**Corner**	**#Alive**	**#Dead**	**Total #**	
						< 1m	**> 1m**
S04/S05-1	399235	6441107	NE	1	89	45	45
S04/S05-2	399264	6441117	NE	1	80	81	0
S04/S05-3	399303	6441131	NE	0	80	80	0
S04/S05-4	399341	6441150	NE	0	119	36	83
S04/S05-5	399359	6441155	NE	0	115	103	12

Treatment: Sprayed in Dec 2004 only

	Slashed						
Replicate	**Easting**	**Northing**	**Corner**	**#Alive**	**# Dead**	**Total #**	
						< 1m	**> 1m**
S04/X-1	399240	6441109	NE	0	13	13	0
S04/X-2	399286	6441126	NE	0	24	24	0
S04/X-3	399307	6441134	NE	1	22	23	0
S04/X-4	399347	6441151	NE	0	76	53	23
S04/X-5	399363	6441158	NE	0	45	45	0

	Un-slashed						
Replicate	**Easting**	**Northing**	**Corner**	**#Alive**	**#Dead**	**Total #**	
						< 1m	**> 1m**
S04/X-1	399240	6441109	NE	0	61	52	9
S04/X-2	399286	6441126	NE	0	36	36	0
S04/X-3	399307	6441134	NE	3	143	88	58
S04/X-4	399347	6441151	NE	0	77	54	23
S04/X-5	399363	6441158	NE	0	116	23	93

Treatment: Sprayed in Feb 2005 only

	Slashed						
Replicate	**Easting**	**Northing**	**Corner**	**#Alive**	**# Dead**	**Total #**	
						< 1m	**> 1m**
X/S05-1	399245	6441109	NE	109	45	16	138
X/S05-2	399289	6441127	NE	227	28	51	204
X/S05-3	399313	6441137	NE	62	34	48	48
X/S05-4	399350	6441151	NE	107	45	106	46
X/S05-5	399368	6441160	NE	69	32	81	20

	Un-slashed						
Replicate	**Easting**	**Northing**	**Corner**	**#Alive**	**#Dead**	**Total #**	
						< 1m	**> 1m**
X/S05-1	399245	6441109	NE	168	141	0	309
X/S05-2	399294	6441120	NE	80	35	6	109
X/S05-3	399313	6441137	NE	137	142	0	279
X/S05-4	399350	6441151	NE	91	62	15	138
X/S05-5	399368	6441160	NE	104	53	16	141