

Partners

Goulburn Broken CMA

Parks Victoria

Department of Sustainability and Environment

Goulburn Murray Water

Central Murray County Council

Management of Arrowhead in the Murray River.

**From Barham to downstream of
the Hume Weir**

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1 The Problem

Arrowhead (*Sagittaria graminea*) poses a major threat to the Murray River, its associated wetlands and irrigation and drainage systems downstream of the confluence of the Ovens and Murray Rivers. Currently, the Shepparton and Murray Valley Irrigation Areas spend more than \$2 million per year on arrowhead control. The Goulburn Broken CMA, Department of Sustainability and Environment (DSE) and Goulburn Murray Water (G-MW) wish to implement a control program to contain and limit the establishment of the weed in the Murray Darling Catchment and wetlands. A trial program in the Murray River from Echuca to the Torrumbarry Weir has successfully limited the spread of the weed with no significant infestations establishing downstream. The University of Canberra through the EWater CRC has presented “Predicting the Spread of Arrowhead” seminar which considers effective management based on timing, flooding effects, “do nothing” versus intensive control scenarios, and analyses spread rates and population dynamics (Williams 2004).

Invasive modelling implemented by DSE clearly scientifically demonstrates the invasive capabilities of arrowhead to not only irrigation but also rivers and wetlands (Weiss 2003). Further the Broken Creek arrowhead control program has demonstrated success in limiting the spread of arrowhead while balancing impacts on water quality. The spread of infestations into the Barmah forest demonstrates the plants ability to infest natural ecosystems.

DSE has focused their weed management efforts on new and emerging weed species which have not reached the extent of their range. This has been clearly demonstrated to be the best value for money with any weed control program, to control the new or emerging weed species before controlling established species. Once an invasive weed has established it is far more costly and time consuming to continue a control program, rather than prevent the establishment of a weed species.

1.1 Incidence

Echuca to Torrumbarry Weir

In 1996 no arrowhead was observed in the Murray River when a survey was conducted from Echuca to Torrumbarry. However, by December 2002, 653 arrowhead sites had established and the area totalled 3.3 ha between Torrumbarry and Echuca. In conjunction with the Central Murray County Council, Goulburn-Murray Water embarked on a pilot program to control arrowhead. This has involved 3 applications of glyphosate per irrigation season for 2 years. The number of active sites has been reduced to 263 with the area being contained to 0.2 ha at the end of the 2006 control season.

Yarrawonga to Echuca

The section of the Murray River from Echuca to the Yarrawonga weir was surveyed in March 2006 and showed that 2.6 ha of arrowhead had established in the river proper (excluding the anabranches and other points

outside the regulators or that feed into the Murray River). No control has been undertaken in this part of the River.

Yarrowonga to the confluence of the Ovens and Murray Rivers

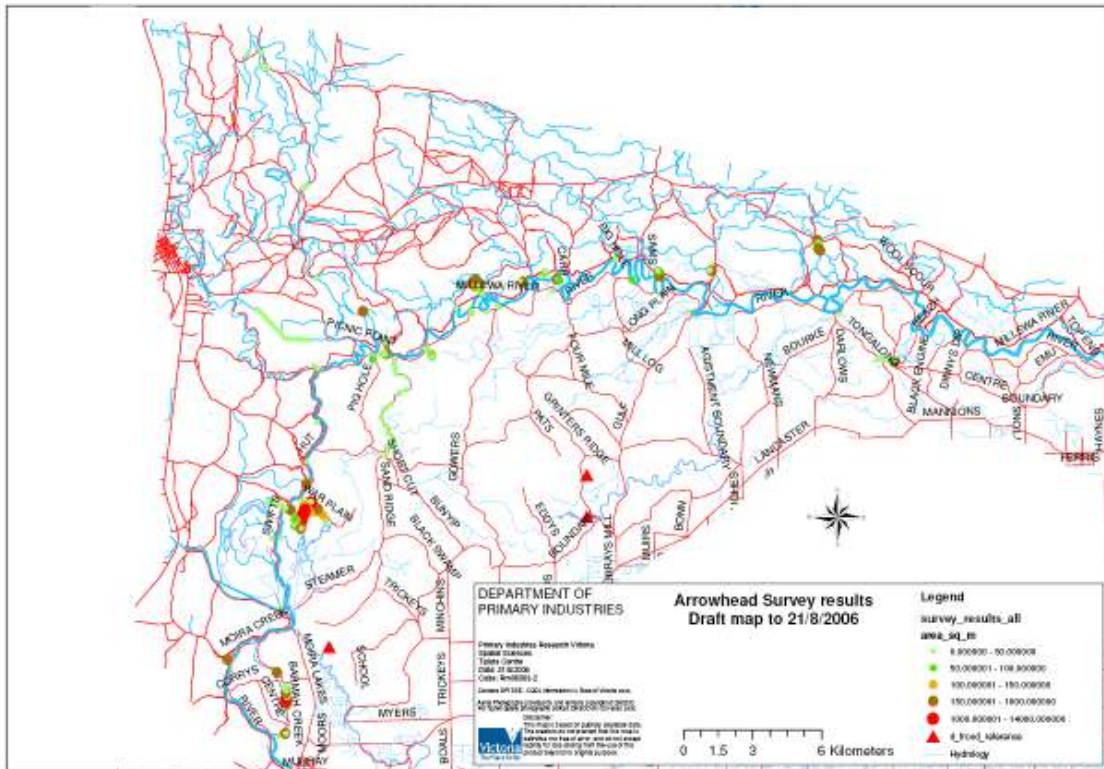
Arrowhead is known to exist in the upstream of Lake Mulwala, however the extent is unknown. Prior to the commencement of a control program the area would be surveyed and circulated to relevant agencies. This survey is scheduled to be implemented in October 2007. The impact of herbicide application on glyphosate trigger levels and on the potential decline on dissolved oxygen levels would be assessed as part of the program. This locality is believed to be the source of seed for potential down stream infestations and for the long term management of the weed to succeed this infestation must be controlled.

Confluence of the Ovens and Murray Rivers to downstream of the Hume Weir

This reach has not been surveyed recently however anecdotal evidence is that there is minimal or no infestations of arrowhead in this area of the river.

Barmah-Millewa Forest

In a survey conducted by the Department of Primary Industries of Victoria in the Barmah – Millewa Forest in July 2006 scattered infestations totalling to 5 ha were found within the RAMSAR listed Forest wetlands and waterways.



Arrowhead is frost sensitive and is seen to be significantly affected in the open irrigation channels and also exposed areas in the forests. This sensitivity is negated by forest canopy and rushes in some areas of the Barmah-Millewa Forest¹.

¹Maxwell, Richard. Spatial Sciences Group, Department of Primary Industries, VIC.

1.2 Arrowhead – an emerging aquatic weed

Since arrowhead was identified in 1962 in the Nine Mile Creek at Wunghnu, it has spread throughout the channel and drainage network and is now the most dominant and threatening aquatic weed in the Murray Valley (Cobram–Numurkah), Shepparton and Deniliquin-Finley Irrigation areas. It has also established in the Broken Creek, and Goulburn and Murray Rivers. Apart from restricting flow of water, it threatens native aquatic flora and fauna by reducing plant biodiversity by taking over the shallow margins of waterbodies, crowding out native species and reducing habitat diversity¹. The emerging infestations in the Ramsar listed Barmah – Millewa Forest wetlands and waterways is now considered to be the greatest ecological threat posed to this key “Living Murray” Icon site².



Arrowhead in Broken Creek near Numurkah, Victoria

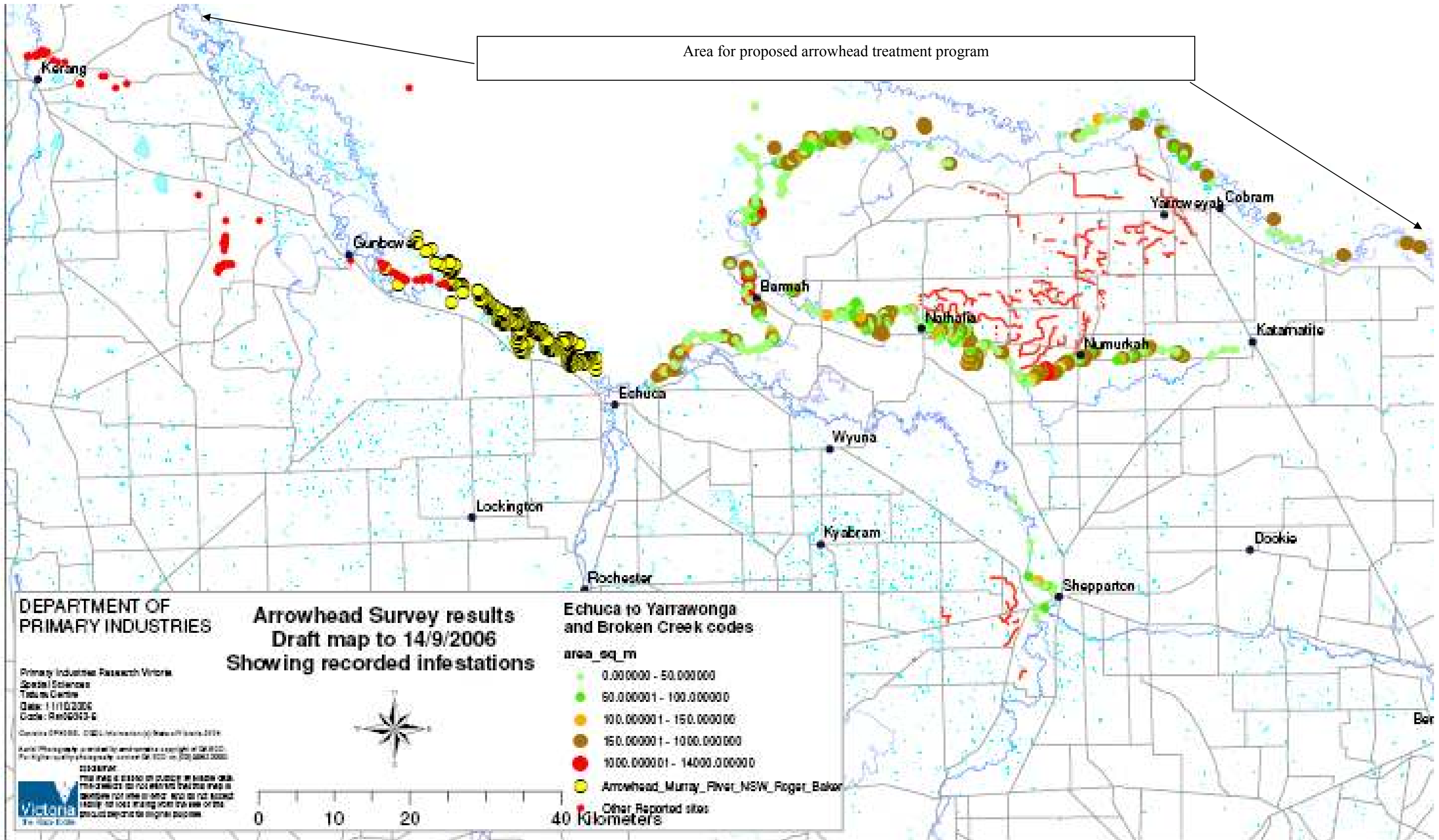
In the irrigation network, the erect forms of arrowhead choke channels, restrict water delivery and promote deposition of silt. In drains, arrowhead limits flow and in the case of a large rainfall event severe inundation may occur.

Goulburn Broken CMA, Department of Sustainability and Goulburn Murray Water has an ongoing commitment to research and development focusing on the impact and management of arrowhead. To date, these agencies have committed more than \$700K to research into management of the arrowhead.

²O'Connor, Red Gum Forest Ecologist, Department of Sustainability and Environment, Victoria.



Arrowhead in a channel near Cobram, Victoria



1.3 Characteristics

The characteristics of the plant are summarised in a pamphlet (Appendix 3)



Arrowhead in the Murray River near Gunbower

2 Endangered flora and fauna

An EPBC referral was completed and submitted to the Department of Environment and Heritage for the pilot project conducted between Echuca and Torrumbarry Weir, 2005-2007. The spray activities were not considered a “controlled action”, therefore approval was not necessary under the EPBC Act. Less than forty litres of glyphosate product per day used in a flow of 5-10 thousand megalitres per day, when calculated out in dispersal, would be far less than the minimum limits for aquatic life. This has been ratified by a water sampling procedure undertaken in the Murray River. Please refer to Appendix 4 for further details. There will also be an assessment of the amount of vegetation potentially decaying as a result of the treatment program to ensure that dissolved oxygen levels are not reduced below acceptable limits. If required, treatment of sections at a time or percentages of an infestation may be implemented.

2.1 Flora

Damage to endangered native flora along the edge of the river will be minimised by using a closely directed spot spraying technique, and it is anticipated that no off-target damage will occur. The herbicide will be applied from shallow bottom aluminium spray punt that allows close directed spray application. The product will be applied using a low-pressure spray pump fitted with a hand lance that incorporates a foam jet nozzle. The low pressure pump & foam jet nozzle minimises the fine droplets and produces a spray stream that allows for targeted specific application when spot sprayed.

2.2 Fauna

An “Assessment of Significance” (seven part test) has been applied to each fauna species to this project and one Endangered Ecological Community as highlighted by DECC and NSW Fisheries. Please refer to Appendix 1 for further details. The concentrations of glyphosate used for the control program will be well below the level of protection for freshwater aquatic ecosystems and will not impact on any aquatic fish species if they are present. The Southern Bell Frog (*Litoria raniformis*) is an endangered species that inhabits the lagoons and billabongs that are frequently subject to inundation along the Murray River. These frogs are rarely found in the fast flowing sections of the river proper. Spray operators will be trained to identify the frog and its call. Spray application will be suspended if frogs are located. Only glyphosate with an aquatic registration will be used in order to minimise the impact on any sensitive aquatic species. Goulburn Murray Water will liaise with the National Parks and Wild Life Service² and NSW Fisheries³ for location of known sites. Please refer to Appendix 1 for further details.



The Southern Bell Frog



Murray Cod



Trout Cod

² National Parks and Wild Life Service, Melanie Bannerman, ph. 02 6883 5342.

³ NSW Fisheries, Alison McLean, ph. 02 6042 4213.

3 Weed Control

A control program will be instigated by the following Victorian State agencies in conjunction with MDBC, Goulburn Broken Catchment Management Authority, Parks Victoria, Department of Sustainability and Environment, and Goulburn Murray Water. The works will commence in December 2007, and extend for up to twenty weeks annually. We anticipate that the program will be ongoing, given a favourable outcome at the end of the control period in May 2008, providing monitoring does not reveal any adverse impacts. G-MW will provide a project manager to manage the on-ground spray activities and ensure compliance with the management plan.

The most efficient and effective method of controlling arrowhead is with the use of glyphosate with an aquatic registration. Applications will be conducted at appropriate intervals during the summer period (3 intervals from December to May). Mechanical removal, hand pulling or other forms of control for this weed species have proven to be ineffective or not appropriate for the aquatic environment. Biological control of arrowhead is being investigated by Keith Turnbull Research Institute (KTRI) however it can take up to seven years for approval of control agents to be released and a further twenty to thirty years to establish numbers of the control agent to have a significant impact on the weed species. A long term approach must continue to be explored, however the short term spread of this weed species must also be addressed through the implementation of a spray control program.

If the Murray river and the associated lagoons continue to dry due to the effects of drought, this will assist the control of arrowhead as the plant will be exposed on dry land and will further minimise potential herbicide contamination in the waterways. More effective control will be implemented if the plant is exposed further due to lower water levels.

3.1 Product Information

Weedmaster Duo (or an equivalent product) which has an aquatic registration will be used for all spray treatment. The Label and MSDS information is listed on the Nufarm Web Site.

<http://www.nufarm.com.au/web/nufarmcomau/nufarmcomauhp.nsf/web/index.html>

3.2 Permits

A minor use permit from the Agricultural Products and Veterinary Medicines Association (APVMA) has been obtained for use of Weedmaster Duo at the elevated dose of up to 10 L per 100 L of water or 40 L/ha. The Permit can be found on the APVMA web site. <http://www.nra.gov.au/permits/permits.shtml>, Permit 6875.

All spray operators implementing the control program will have the minimum qualifications of; a Victorian Farm Chemical Users Certificate (Chem Cert card) or equivalent qualification, and possess an Agricultural Chemical Users Permit (ACUP) as issued by the Department of Primary Industries Victoria or equivalent qualification.

3.3 Measures to minimise exceedence of water quality limits, and effect on native flora and fauna.

The following measures will be adopted to minimise contamination of water and the effect on native flora and fauna:

- Glyphosate use will be limited to less than 40 L during any day of treatment,
- Spraying will not be carried out in windy conditions to reduce spray drift into waters and vegetation, as per the AgVet Chemical Users Course guidelines. These are part of a national accreditation program in AgVet chemical use, and all operators will have completed this training program.
- The herbicide will be applied from shallow bottom aluminium spray punt that allows close directed spray application,
- The product will be applied using a low-pressure spray pump fitted with a hand lance that incorporates a foam jet nozzle. The low pressure pump & foam jet nozzle eliminates the fine droplets and produces a spray stream that allows for targeted specific application when spot sprayed,
- Product will be applied when there is minimal activity on the river, which minimises the potential herbicide contamination as a result of wave action,
- If Arrowhead is found in amongst other vegetation, i.e. Cumbungi or Phragmites, then spraying must be undertaken with extreme care to ensure that minimum amount of potential habitat is disturbed,
- Spraying will not be conducted during local flooding or when the river rises,
- Monitoring will carried out by taking water samples at surface and 1 metre depths, upstream 50 metres, spraying zone and 50 metres downstream and analysed for glyphosate (to be conducted at one site per season).
- All sites should be mapped (using GPS).

4 Water quality

Using the most stringent trigger levels for Aquatic Life, and the Drinking and Irrigation Water Limits, the amount of glyphosate that will be applied to control arrowhead will be less than 1% of the respective limits. The terms of reference, concentrations used, river flow rates and information used for calculations are shown below.

4.1 Water quality limits for aquatic life, and irrigation & drinking water

Limits- aquatic life, irrigation & drinking water	Trigger Values for Aquatic Ecosystems in fresh water (mg/L)				Limit for irrigation water (mg/L) ^{#2}	Limit for Drinking water (mg/L) ^{#3}
	Level of protection (% species) ^{#1}					
	99%	95%	90%	80%		
Glyphosate (mg/L)	0.37	1.2	2	3.6	0.1	0.1
Amount of glyphosate product required to match respective limit (L)	5139	16667	27778	50000	1389	1389
Daily flow in section of Murray treated with glyphosate for arrowhead control (Megalitres) ^{#4}	3000	Sample calculation				
Conversion Megalitres to Litres (L)	3.00E+09					
Area of Arrowhead to be controlled (Ha) ^{#5}	0.415					
Rate of glyphosate to be used (L/Ha) ^{#6}	40					
Amount of glyphosate used (L)	16.6					
Percentage of product entering water (%) ^{#7}	100%					
Active ingredient of glyphosate (g/L) ^{#8}	360					
Amount of glyphosate entering water (g)	5976					
Concentration of glyphosate in water assuming complete mixing (mg/L)	0.001992					

^{#1} The trigger values derived using the statistical distribution methods were calculated at four different protection levels. The protection level signifies the percentage of species expected to be protected. The decision to apply a certain protection level to a specific ecosystem is the prerogative of each particular jurisdiction or catchment manager, in consultation with community and stake holders. Extracted from Australian and New Zealand Guidelines for Fresh and Marine Water Quality, 2000.

^{#2} The Australian and New Zealand Guidelines for Fresh and Marine Water Quality, 2000 do not list a trigger value for glyphosate in irrigation water. However, the hazard from residues at maximum concentration likely to be found

in irrigation water are termed 'low' in the case of glyphosate. Goulburn Murray Water commissioned an external Biocides Audit on its herbicide use; the consultants deem that 0.1 mg/l was an appropriate safety margin for irrigation water based on scientific literature and available information. The label rate of glyphosate in terrestrial situations for annual weeds is 2-3 l/ha (700-1.4 L/ 100 L) which equates to 2520 mg/L. As calculated above, the concentration of glyphosate used for Arrowhead control will be less than 0.002 mg/L. This figure would probably further diminish as a result of the turbid water which caused inactivation of the active ingredient.

#3 The limit has been extracted from the Australian Drinking Water Guidelines, the limit is based on 10% of the Acceptable Daily Intake which is 1 mg/L

#4 During the treatment period (December to April) water flows in the Torrumbarry and Yarrawonga areas to be treated ranged between 2270-16000 ML/D, in the past 2 years. The average flows for Torrumbarry were 7474 ML/D and for Yarrawonga 8955 ML/D. The calculations above use the conservative figure of 3000 ML/day. Appendix 3 shows the daily flows for the past 2 years.

#5 A survey of the Murray River in April 2007 showed that the area of arrowhead is approximately 0.415 ha.

#6 Arrowhead is a very difficult aquatic weed to control and an elevated dose of glyphosate is necessary for satisfactory control. A permit from the APVMA for use at 40 L/Ha has been granted. The volume of glyphosate product required to control 0.5 ha equates to 20 L. The permit can be viewed at <http://www.nra.gov.au/permits/permits.shtml>, Permit 6875

#7 A worst case scenario has been used in the calculations, with the assumption that all product used enters the water. In general situation, we assume that 20% of the product enters the water.

#8 The glyphosate product will have an aquatic registration and contains 360 g/L of glyphosate present as the isopropylamine salt.

4.2 Arrowhead control around pump suctions

According to the survey conducted in April 2007, no irrigation water pump suctions were located within 10 m of an arrowhead infestation. If an infestation was established close to an irrigation water pump suction the respective owners would be notified by phone or a letter giving details of the spray program and the likely time of application. Goulburn -Murray Water currently notifies all potable water diverters (eg. Lower Murray Water, Coliban Water, etc) on our channel systems 48 hours prior to spraying any section 500 metres upstream of these offtakes. We will implement the same notification system on the Murray River whilst undertaking the arrowhead control program.

4.3 Water sampling

Although we do not expect any detectable glyphosate residues to be present after spray application, we will conduct a sampling program in a particular site in order to verify our procedures on an annual basis. Please refer to Appendix 4 for water sampling results from the 2006-07 control season.

A minimum of one test per spray crew will be implemented annually. Dependant on funding, water sampling will be carried out independently of the spray program without the operators being aware of the monitoring that is to take place, to ensure test results are representative of the on-ground implementation program.

Further to these water sampling procedures, a visual inspection program will also be conducted to verify any herbicide effects on fauna. A minimum of twenty infestation sites per spray season will be revisited twelve to twenty-four hours after the spray application. These sites will be actively searched for the presence of dead or distressed animals (fish and frogs in particular). Any animals found will be reported to DPI Fisheries and DECC as appropriate and the animals will be collected and tested for glyphosate. This inspection program will be documented and incorporated into a report provided to DPI Fisheries and DECC in June annually.

5 Public Response

Holiday makers (house boats, campers and speed boats enthusiasts) utilize the Murray River for leisure activities which coincide with the Christmas / New Year period, the Australia Day and Labour Day long weekends. Arrowhead control will not be implemented during these periods. If the situation arises when holiday makers are close to an arrowhead infestation, spraying will be postponed. The location of the site will be located by GPS and treated at a later date.

If concern was raised by the public, Goulburn-Murray Water would respond in an open frank manner and endeavour to explain the background and necessity of adopting these control measures. General information will be provided to explain the situation. A pamphlet is available to provide general information regarding weed control issues and control measures.

To date all people enquiring about the control program, once understanding the purpose and intent, see the program as essential to protect the health of the river and its environment for the long term conservation of the river's biodiversity and access for recreational activities.

Appendix 1: Test of Significance (Seven Part Test)

Eight aquatic species were identified in the project area by DECC and NSW Fisheries as having potential impacts on their populations or ecological communities.

They are;

- Silver Perch (*Bidyanus bidyanus*),
- Trout Cod (*Maccullochella macquariensis*),
- Southern Pygmy Perch (*Nannoperca australis*),
- the River Snail (*Notopala sublineata*),
- Murray Hardyhead (*Craterocephalus fluviatilis*),
- the western populations of the Purple Spotted Gudgeon (*Mogurnda adspersa*),
- Murray Cod (*Maccullochella peelii peelii*), and
- the Southern Bell Frog (*Litoria reniformis*).

Table 1. Species information.

Species	Silver Perch (<i>Bidyanus bidyanus</i>)	Trout Cod (<i>Maccullochella macquariensis</i>)	Southern Pygmy Perch (<i>Nannoperca australis</i>)	River Snail (<i>Notopala sublineata</i>)	Murray Hardyhead (<i>Craterocephalus fluviatilis</i>)	Purple Spotted Gudgeon (<i>Mogurnda adspersa</i>)	Murray Cod (<i>Maccullochella peelii peelii</i>)	Southern Bell Frog (<i>Litoria reniformis</i>)
Classification	Vulnerable Species TSC Act	Endangered species TSC Act Vulnerable EPBC Act	Vulnerable Species TSC Act	Endangered species TSC Act	Endangered species TSC Act Vulnerable EPBC Act	Endangered population TSC Act	Vulnerable EPBC Act	Threatened species TSC Act Vulnerable EPBC Act
Habitat	Fast flowing open waters, with rapids and races.	Fast currents, deep water, snags.	Vegetated areas in small streams, lakes, billabongs, and other types of wetlands.	Along the banks attached to hard surfaces like rocks, logs, or in the mud.	Edges of slow flowing rivers, lakes and backwaters, amongst aquatic plants.	Slow-moving or still waters of rivers, creeks and billabongs, often amongst aquatic plants, rocks or snags.	Prefer slow flowing, turbid water in streams and rivers, favouring deeper water around boulders, undercut banks, overhanging vegetation and logs.	Lagoons, billabongs, swamps, amongst emergent vegetation.
Reproduction	Females shed 30,000 or more semi-buoyant eggs. The eggs develop in a few days to become feeding larvae that drift downstream	Females lay eggs which are large, adhesive and opaque, and are probably deposited on hard surfaces on or near the stream bottom.	Females produce anywhere from a few hundred to several thousand small transparent eggs, which are scattered over vegetation or rocks over the bottom.	They give birth to live young. Fertilisation is internal, with embryos retained in a pallia oviduct. The females carry their young until they are large enough to survive independently.	Eggs randomly dispersed amongst aquatic vegetation.	Females can spawn several times. The adhesive eggs are deposited in a cluster on a hard surface and hatch after 3-8 days.	Laying up to 40,000 eggs on a submerged log or other structure on the river bed. The eggs hatch 6-13 days later, with juveniles feeding freely within 3-4 weeks.	Laying eggs within a floating jelly raft that eventually breaks up and sinks, tadpoles hatching 2-4 days later.

One Endangered Ecological Community (EEC) was identified in the project area by DECC and NSW Fisheries.

The EEC identified as part of the project area is The Natural Drainage System of the Lower Murray River Catchment.

The following table lists potential impacts the program may have on the above mentioned species, populations, or communities and list management actions and mitigating circumstances to alleviate these risks.

Table 2. Impacts vs. Risk Mitigation.

Potential Impacts/Risks	Management Actions/Mitigating Circumstances
On site impact of herbicide contact with native vegetation (non-target species).	<p>Point 1: The herbicide will be applied from shallow bottom aluminium spray punt that allows close directed spray application. The product will be applied using a low-pressure spray pump fitted with a hand lance that incorporates a foam jet nozzle. The low pressure pump & foam jet nozzle minimises the fine droplets and produces a spray stream that allows for targeted specific application when spot sprayed.</p> <p>Point 2: Anecdotal evidence indicates that through the control of <i>Sagittaria graminea</i> other species such as <i>Schoenoplectus validus</i>, phragmites, and <i>Potamogeton sulcatus</i> are recolonising some of these previously infested areas.</p> <p>Point 3: The feasibility of replanting native species in previously infested areas is being investigated if natural recolonisation is not occurring.</p>
On site impact of herbicide contact with aquatic fauna species (adult fish, juvenile fish, eggs, tadpoles, etc).	<p>Point 4: Glyphosate with an aquatic label registration will be used in the control program and as such has a low aquatic toxicity. The concentration of glyphosate used for <i>Sagittaria graminea</i> control will be less than 0.002 mg/L when dispersed, which is less than 1% of the minimum level of protection for 99% of species in aquatic freshwater ecosystems, set by the Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000. This figure would probably further diminish as a result of any turbid water present which would cause inactivation of the active ingredient.</p> <p>Point 5: There is a low potential for glyphosate to build up in the tissues of aquatic invertebrates or other aquatic organisms (The Agrochemicals handbook 1991). Studies have shown that young fry are relatively insensitive to the effects of glyphosate poisoning at field concentrations. Study findings “indicate that formulated glyphosate (Weedmaster Duo) may not pose an acute threat to the long-term survival of Murray Cod populations at current application levels” (Raymond, Nugegoda, and Kibria 2006).</p> <p>Point 6: River levels and currents are higher during the irrigation season (refer to Appendix 2) and therefore dispersion of any herbicide will be greater during these times of increased flows, which will correspond with the control program period.</p> <p>Point 7: Water quality samples will be taken each control season to validate calculated herbicide levels present at the spray zone.</p>
Off site impact due to the current carrying the herbicide downstream to other sensitive areas (lagoons, wetlands, etc).	<p>Point 8: Turbid water deactivates glyphosate. Glyphosate is strongly adsorbed to suspended organic and mineral matter and is metabolised primarily by microorganisms. Therefore movement and mixing would result in further decrease in glyphosate concentration.</p> <p>Point 9: When applied according to the guidelines described in the Minor Use Permit 6175 issued by the APVMA, the concentration of glyphosate in the spray zone immediately after treatment was <0.22 mg/L ie. less than <99% level of protection (0.36 gm/L). Furthermore, glyphosate (>0.03 mg/L) could not be found downstream (50 m) of the spray zone (Appendix 4).</p>
Drought resulting in lower water levels and flows.	<p>Point 10: <i>Sagittaria graminea</i> only grows in water < 1 metre however most infestations occur in water < 0.5 metres depth in the Murray River. If the river levels dropped by over half a metre then it would enable a very effective, targeted control program. Aquatic plants exposed out of the water are more susceptible to herbicide intake and therefore a better result would be obtained. There would also be no water contamination risk as the plants would be exposed on the banks.</p>

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,

The following species have been selected on the basis that they are likely to occur in the project area, and/or are known to utilise habitat found within the Murray River and associated waterways.

The species which is listed in Part 1 of Schedule 1 of the NSW Threatened Species Conservation (TSC) Act is the Southern Bell Frog. It is also listed as a Vulnerable species under the federal legislation of the Environment Protection and Biodiversity Conservation (EPBC) Act.

Southern Bell Frog

The Southern Bell Frog inhabits the lagoons and billabongs that are frequently subject to inundation along the Murray River. Please refer to the following map for known recorded sites of the Southern Bell Frog.



In general, they are not active along the river during the months of January-April. Breeding sites have been mostly recorded in overflow areas such as oxbows, billabongs, and levee swamps and in still or slow moving water. The spray program for *Sagittaria graminea* is within the river channel and therefore these areas are not targeted.

Studies have shown that the surfactants used in herbicide application are harmful to frogs and tadpoles rather than the active ingredient glyphosate (DEC 2005). Glyphosate with an aquatic label registration will be used in the control program and as such has a low aquatic toxicity. The concentration of glyphosate used for *Sagittaria graminea* control will be less than 0.002 mg/L when dispersed, which is less than 1% of the minimum level of protection for 99% of species in aquatic freshwater ecosystems set by the Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000 (Point 4 Table 2). This figure would probably further diminish as a result of any turbid water present which would cause inactivation of the active ingredient. This is

also illustrated by the water quality test results taken on the river during the spray program in 2006-07. Please refer to Appendix 4 for further details.

The frogs use emergent vegetation such as typha, phragmites, and eleocharis as habitat and these species are being threatened by the invasive nature of *Sagittaria graminea*. Anecdotal evidence indicates that through the control of *Sagittaria graminea* other species such as *Schoenoplectus validus*, phragmites, and *Potamogeton sulcatus* are recolonising some of these areas (Point 2 Table 2).

The implementation of a control program on *Sagittaria graminea* will preserve habitat for the Southern Bell Frog, and we expect no adverse effect on the life cycle of the species such that a viable local population of the species will be placed at risk.

The species which are listed in Part 1 of Schedule 4 of the NSW Fisheries Management (FM) Act are Murray Hardyhead, Trout Cod, and the River Snail. Both Murray Hardyhead and Trout Cod are also listed as Vulnerable under the Commonwealth Environment Protection and Biodiversity Conservation (EPBC) Act

Murray Hardyhead

Murray Hardyhead live along the edges of slow-flowing lowland rivers and in lakes, billabongs and backwaters. They are often found amongst aquatic plants, in both fresh and quite saline waters (NSW Fisheries [NSW 1083]). Spawning occurs in the warmer months from about October to February, and their eggs are randomly dispersed amongst aquatic vegetation.

This control program will only use glyphosate with an aquatic registration which has a low aquatic toxicity, and no surfactant or adjuvant will be used as part of the program as per the minor use permit granted by the APVMA. Please refer to Point 4 & 5, Table 2.

A recovery action listed for Murray Hardyhead is the conservation of habitat and promoting the restoration and protection of aquatic and riparian (river bank) vegetation. *Sagittaria graminea* is threatening the plant species distribution and biodiversity along the edges of the Murray River and therefore a control program on this species will conserve the integrity of the aquatic and riparian vegetation by preventing the spread of *Sagittaria graminea*. Please refer to point 2 Table 2.

The implementation of a control program on *Sagittaria graminea* is expected to preserve habitat for the Murray Hardyhead, and we expect no adverse effect on the life cycle of the species such that a viable local population of the species will be placed at risk.

Trout Cod

Trout Cod are often found close to cover and in relatively fast currents, especially in fairly deep water close to the bank, and often congregate around snags (NSW Fisheries [DF101R]). They are believed to form pairs and spawn annually during late October to early November. The control program is

implemented in December to April and therefore will not impact on the eggs. The eggs are large, adhesive and opaque, and are probably deposited on hard surfaces on or near the stream bottom (NSW Department of Primary Industries April 2006).

The listed current issues and threats in the Trout Cod Recovery Plan are not adversely affected by the implementation of a control program on *Sagittaria graminea*. The control program will not; remove large woody debris, impact on river regulation or changes to natural flows, create barriers to fish movement, create cold-water pollution, involve illegal fishing, or introduce other fish species.

Furthermore, all activities associated with the implementation of a control program on *Sagittaria graminea* are not implemented in these areas of the river, ie. fast flowing deep water and the river bed, and will have no impact on the Trout Cod and we expect no adverse effect on the life cycle of Trout Cod such that a viable local population of the species will be placed at risk.

River Snails

River Snails once occurred in flowing rivers throughout the Murray-Darling system, where they were found along the banks attached to logs and rocks or crawling in the mud (NSW DPI [Primefact 182]). As a filter feeder the River Snail feeds on bacteria suspended in the water and also grazes on the bacterial 'biofilms' that occur on hard surfaces in free flowing waters. Artificially hard surfaces now provide habitat for the species with populations being recorded as surviving in irrigation pipelines throughout the Murray and Darling systems. The pipeline environment is thought to promote microbial production and organic accumulation, which is a highly nutritious food source for the species (NSW DPI July 2006).

Very little information on the biology and ecology of the River snail exists. They give birth to live young rather than the more usual method for freshwater gastropods of laying eggs that hatch in an external environment. Fertilisation is internal, with embryos retained in a pallia oviduct. The females carry their young until they are large enough to survive independently. It is possible that dispersal is via being attached to dislodged material such as leaves or wood.

The listed current issues and threats in the Draft Recovery Plan for the Endangered River Snail are not adversely affected by the implementation of a control program on *Sagittaria graminea*. The control program will not; impact on river regulation or changes to natural flows, remove large woody debris, involve removal from artificial habitats ie pipelines, affect sedimentation, or introduce carp. The control program will only use glyphosate with an aquatic label registration. Please refer to Point 4 & 5, Table 2.

The implementation of a control program on *Sagittaria graminea* will have no impact on the habitat for the River Snail, and we expect no adverse effect on the life cycle of the species such that a viable local population of the species will be placed at risk.

Also included in this factor of assessment will be species listed in Schedule 5 of the NSW FM Act , vulnerable species, that are identified as existing in the project area. They are Silver Perch and Southern Pygmy Perch.

Silver Perch

Silver Perch seem to prefer fast-flowing open waters, especially where there are rapids and races (NSW DPI [Primefact 8]). They are omnivorous, feeding on small aquatic insects, molluscs, earthworms, and green algae. Adults migrate upstream in spring and summer to spawn, and juveniles sometimes move upstream in response to rising water temperatures and levels. Females can shed 30,000 or more semi-buoyant eggs. The eggs develop in a few days to become feeding larvae that drift downstream.

Again the control program will only use glyphosate with an aquatic label registration. Please refer to Point 4 & 5, Table 2.

One of the factors listed that threaten Silver Perch is the degradation of instream habitats through the loss of riparian (riverbank) vegetation. *Sagittaria graminea* is threatening the plant species distribution and biodiversity along the edges of the Murray River and therefore a control program on this species will conserve the integrity of the aquatic and riparian vegetation. Please refer to Point 2 Table 2.

The implementation of a control program on *Sagittaria graminea* will preserve habitat for the Silver Perch, and we expect no adverse effect on the life cycle of the species such that a viable local population of the species will be placed at risk.

Southern Pygmy Perch

The Southern Pygmy Perch are a small fish, growing to 65-85 mm in length. They are found in vegetated areas in small streams, lakes, billabongs, and other types of wetlands. They are carnivorous, eating a range of aquatic crustaceans and insects, and reach sexual maturity in the first year when males are about 30mm and females are about 33mm long. Breeding occurs between September and January in response to rising water temperatures. Females produce anywhere from a few hundred to several thousand small transparent eggs, which are scattered over vegetation or rocks over the bottom (NSW Fisheries [NSWF 1094]).

The control program will only use glyphosate with an aquatic label registration. Please refer to Point 4 & 5, Table 2. This will ensure that the breeding and egg production cycles and the eggs are not harmed as a result of this control program.

Habitat degradation including the loss of aquatic and riparian vegetation is one of the reasons listed for the Southern Pygmy Perch being listed as threatened. Again, *Sagittaria graminea* is threatening the plant species distribution and biodiversity along the edges of the Murray River and therefore a control program on this species will conserve the integrity of the aquatic and riparian vegetation. Please refer to Point 2 Table 2.

The implementation of a control program on *Sagittaria graminea* will preserve habitat for the Southern Pygmy Perch, and we expect no adverse effect on the life cycle of the species such that a viable local population of the species will be placed at risk.

Also included in this factor of assessment will be a species listed as vulnerable under the Commonwealth EPBC Act, which is the Murray Cod.

The Murray Cod is the largest freshwater fish found in Australia. It occurs naturally in the waterways of the Murray-Darling Basin in a wide range of warm water habitats that range from clear rocky streams to slow flowing turbid rivers and billabongs. It is a long lived predator species that is highly territorial and aggressive (Department of Environment and Water Resources 2003). Murray Cod generally prefer slow flowing, turbid water in streams and rivers, favouring deeper water around boulders, undercut banks, overhanging vegetation and logs (NSW DPI 2006.a). Murray cod spawn in spring, laying their eggs on a submerged log or other structure on the river bed. The eggs hatch 6-13 days later, with juveniles feeding freely within 3-4 weeks. Each adult female will lay up to 40,000 eggs, with only a small proportion surviving to maturity (State of NSW 2005).

Studies by RMIT University Ecotoxicologists have shown that young fry are relatively insensitive to the effects of glyphosate poisoning at field concentrations. The study findings "indicate that formulated glyphosate (Weedmaster Duo) may not pose an acute threat to the long-term survival of Murray Cod populations at current application levels" (Goulburn-Murray Water and RMIT University, 2006).

Therefore all activities associated with the implementation of a control program on *Sagittaria graminea* are not implemented in these areas of the river, ie. the river bed, and will have no impact on the Murray Cod and we expect no adverse effect on the life cycle of Murray Cod such that a viable local population of the species will be placed at risk.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,

This factor of assessment refers only to the endangered population of the Purple Spotted Gudgeon (western population) as listed in Part 2 of Schedule 4 of the NSW FM Act.

Purple Spotted Gudgeon

Purple Spotted Gudgeons are found in slow-moving or still waters of rivers, creeks and billabongs, often amongst aquatic plants, rocks or snags. They feed mainly on insect larvae, but also consume worms, tadpoles, small fish and some plant matter. Males reach maturity at about 45mm and females at about 50mm in length. Females can spawn several times. The adhesive eggs

are deposited in a cluster on a hard surface and hatch after 3-8 days (NSW Fisheries [NSW 1089]).

One of the factors listing the western population of Purple Spotted Gudgeons as threatened is habitat degradation, particularly loss of aquatic plants. *Sagittaria graminea* is threatening the plant species distribution and biodiversity along the edges of the Murray River and therefore a control program on this species will conserve the integrity of the aquatic and riparian vegetation. Please refer to Point 2 Table 2. The control program will only use glyphosate with an aquatic label registration. Please refer to Point 4 & 5, Table 2. This will ensure that the breeding and egg production cycles and the eggs are not harmed as a result of this control program.

The implementation of a control program on *Sagittaria graminea* will preserve habitat for the Purple Spotted Gudgeon, and we expect no adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species will be placed at risk.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

The project area is in the aquatic ecological community in the natural drainage system of the lower Murray River catchment and is listed in Part 3 of Schedule 4 of the NSW FM Act as an endangered ecological community.

The Lower Murray Ecological Community

The lower Murray ecological community includes all native fish and aquatic invertebrates within all natural creeks, rivers, and associated lagoons, billabongs and lakes of the regulated portions of the Murray River below the Hume Weir (NSW Fisheries [NSWF 1120]). Artificial canals, water distribution and drainage works, farm dams and off-stream reservoirs are excluded from this definition.

The community is characterised by meandering channels and wide flood plains, and experience extremely variable water flows ranging from floods to droughts. Variability in environmental conditions has led to adaptations in the native aquatic flora and fauna. For example, many species rely on floods to trigger spawning and create suitable breeding habitats. In the lower Murray ecological community there is a wide range of habitats for fish and invertebrates, including pools, runs or riffles, backwaters and billabongs,

snags, and aquatic plants. The floodplains also provide a mosaic of habitat types, including permanent and temporary wetlands and terrestrial habitats.

The aquatic community has been listed as endangered due to degradation of the riparian zone through clearing of native vegetation. As stated before, *Sagittaria graminea* is threatening the plant species distribution and biodiversity along the edges of the Murray River and therefore a control program on this species will conserve the integrity of the aquatic and riparian vegetation. Please refer to Point 2 Table 2.

Two identified recovery actions for endangered aquatic community are to conserve and where possible restore habitats through the protection of aquatic and riparian vegetation, and to develop and implement a control program for introduced species. The *Sagittaria graminea* program will achieve both of these objectives through encouraging native species to recolonise and through the control of an introduced species.

The percentage cover of *Sagittaria graminea* along both banks of the Murray from Echuca downstream to the Torrumbarry Weir only comprised 1.3% of vegetative cover at the end of the 2006-07 control program. At the beginning of the control program in 2002 the cover along the riparian zone consisted of 20.6% *Sagittaria graminea*, making the plant one of the more dominant plant species along the Murray River in this area. The impact on native vegetation as a result of the program also appears to be having a positive effect due to specialised herbicide application which has minimal off-target damage and is leading to the re-colonisation of native species where introduced species were dominant before the control program.

The introduced species *Sagittaria graminea* has the potential to infest up to 50% or more of the banks of the Murray River below Echuca due to its invasive qualities, however due to the control program implemented in 2002-03 the spread has been controlled and effectively reduced to more than fifteen times smaller than the original infestation size. Options to re-plant native species in control areas are also being investigated.

The aquatic community has been listed as endangered due to agricultural practises including the use of pesticides which have affected water quality. The control program will only use the herbicide glyphosate with an aquatic label registration. Please refer to Point 4, Table 2. Therefore the program will not affect water quality, and water sample testing will be carried out annually to ensure that herbicide levels applied are not higher in concentration in the water body than calculated.

Therefore in the case of the lower Murray ecological community the action proposed will not have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, and will only enhance the community. Also in the case of the lower Murray ecological community the action proposed will not substantially and adversely modify the composition of the ecological community such that its

local occurrence is likely to be placed at risk of extinction, but will protect and preserve the ecological community.

(d) in relation to the habitat of a threatened species, population or ecological community;

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

The habitat of the lower Murray ecological community will be protected and enhanced as a result of the implementation of the control program on *Sagittaria graminea*. It is most important that the *Sagittaria graminea* be removed from the ecological community as it does not provide natural habitat for any species, being an introduced pest plant species. Any threatened species or species population that may be utilising *Sagittaria graminea* as habitat is likely to relocate across to the adjoining habitat provided by the native plant species present along the lower Murray River as the *Sagittaria graminea* plants slowly die due to the application of glyphosate. Habitat will not become fragmented or isolated as a result of this action as the river provides an effective conduit for species to travel from site to site. Currently the *Sagittaria graminea* only comprises a small percentage of the plant cover along the river bank, approximately 1.3% of vegetative cover.

Riparian vegetation is degraded by the complete removal or modification of native plants. A major cause of degradation is the introduction of, or the invasion by, non-native species (NSW DPI [Primefact 12]). *Sagittaria graminea* falls distinctly into this category of being an invasive, non-native plant.

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),

Critical habitat refers only to those areas of land listed in the Register of Critical Habitat kept by the Director General of Department of Environment and Climate Change and in the Register of Critical Habitat kept by the Director General of Department of Primary Industries. The registers have been checked and the project area does not involve works being carried out in areas of critical habitat.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,

This project is consistent with the Recovery Plan for Silver Perch, the Draft Recovery plan for the endangered river snail (*Notopala sublineata*), Trout Cod

(*Maccullochella macquariensis*) Recovery Plan, and the Southern Bell Frog (*Litoria raniformis*) Recovery Plan.

A recovery action listed for silver perch in its recovery plan is to encourage protection and rehabilitation of river reaches known to support important silver perch populations. The reach of river between Mildura and Torrumbarry is known to be the most significant population of silver perch in the Murray river and the project area is directly above, and partially downstream into this reach of the river. The plan proposes to “encourage community groups, relevant natural resource management agencies, local councils and landholders to protect and rehabilitate riparian vegetation and instream habitats along key river stretches where remnant silver perch populations are known to occur” (NSW DPI 2006). The project is consistent with this action and will protect and enhance the riparian vegetation.

The draft recovery plan for the endangered river snail has an objective of encouraging the rehabilitation of river reaches known to support, or with the potential to support river snail populations. The management action listed is to provide technical support to community groups, natural resource management agencies, local councils and landholders to protect and rehabilitate riparian vegetation and instream habitats along key river stretches where remnant river snail populations are known or may potentially occur (NSW DPI July 2006). Again this project is consistent with this management action and will protect and rehabilitate the riparian vegetation.

Habitat protection and restoration is a key component in the recovery actions for the trout cod recovery plan. Several actions listed are consistent with the objectives of this project. They include; ensuring that the risk of trout cod habitat is minimised, and actively promoting trout cod habitat protection and/or rehabilitation within broader natural resource management programs in NSW. The plan states to “encourage the adoption of land use ‘best practise’ to assist in minimising adverse impacts on stream flows, habitat connectivity, riparian vegetation and water quality” (NSW DPI April 2006). The project adopts industry ‘best practise’ techniques for the control of *Sagittaria graminea* and aims to protect and enhance trout cod habitat.

The third recovery action listed in the southern bell frog recovery plan is habitat management and monitoring. Management will be aimed at maintaining or enhancing shelter, foraging and breeding habitat (DEC 2005). This may include but is not limited to the exclusion of stock from wetlands, wetland regeneration and weed removal, alteration to flooding and drainage regimes, removal of introduced fish from water bodies, signage and fencing of roadside habitats and measures to minimise chemicals from entering waterbodies. The *Sagittaria graminea* control program will actively implement measures to minimise chemical from entering the water while at the same time implementing weed removal and assisting the regeneration of riparian vegetation. Damage to native flora along the edge of the river will be minimised by using a closely directed spot spraying technique, and it is anticipated that no off-target damage will occur. Please refer to Points 1 & 2, Table 2.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Herbicide application and/or weed control is not listed as a key threatening process as listed in Schedule 3 of the TSC Act and Schedule 6 of the FM Act. Consideration must also be given if the action may exacerbate a key threatening process.

The key threatening process that is considered to be linked most closely to this control program is the Degradation of Native Riparian Vegetation along New South Wales Water Courses as found in Schedule 6 of the NSW FM Act.

Riparian vegetation is degraded by the complete removal or modification of native plants. A major cause of degradation is the introduction of, or the invasion by, non-native species (NSW DPI [Primefact 12]). *Sagittaria graminea* falls distinctly into this category of being an invasive, non-native plant. Therefore the control of this pest species is believed to be protecting and enhancing the integrity of native riparian vegetation found within the project area. In fact the Primefact note lists general guidelines for the management of riparian areas to minimise the impacts of degradation on native aquatic species and ecosystems. Riparian areas should be managed to maintain the health of existing native vegetation, encourage recruitment of juvenile trees and shrubs, and incorporate weed control (NSW DPI [Primefact 12]).

Furthermore, an EPBC referral was completed and submitted to the Department of Environment and Heritage for the pilot project conducted between Echuca and Torrumbarry Weir, 2005-2007. The spray activities were not considered as a “controlled action”, therefore approval was not deemed necessary under the EPBC Act.

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Appendix 2: Water flows in Murray and National Channel at Torrumbarry Weir and at Yarrawonga Weir.

Abbreviations: ML/D -

Megalitres of Water per day

Date	Murray Flow ML/D	Nat Chnl Flow ML/D	Torrumbarry Total Flow ML/D	Yarrawonga Weir Flow ML/D
1-Jul-05	7021	0	7021	6000
2-Jul-05	6983	0	6983	4980
3-Jul-05	6655	0	6655	4980
4-Jul-05	6174	0	6174	6000
5-Jul-05	5752	0	5752	6480
6-Jul-05	5270	0	5270	7490
7-Jul-05	4984	0	4984	7500
8-Jul-05	5017	0	5017	7490
9-Jul-05	5417	0	5417	7490
10-Jul-05	5825	0	5825	6970
11-Jul-05	6208	0	6208	6000
12-Jul-05	6412	0	6412	6000
13-Jul-05	6585	0	6585	6000
14-Jul-05	6378	0	6378	6000
15-Jul-05	6070	0	6070	6000
16-Jul-05	5752	0	5752	6000
17-Jul-05	5715	0	5715	6000
18-Jul-05	5528	0	5528	6000
19-Jul-05	5528	0	5528	6000
20-Jul-05	5306	0	5306	6000
21-Jul-05	5233	0	5233	6970
22-Jul-05	5380	0	5380	6970
23-Jul-05	5566	0	5566	6970
24-Jul-05	5715	0	5715	5930
25-Jul-05	5930	0	5930	5930
26-Jul-05	6035	0	6035	5930
27-Jul-05	6174	0	6174	5930
28-Jul-05	5930	0	5930	6000
29-Jul-05	5640	0	5640	6000
30-Jul-05	5123	0	5123	6970
31-Jul-05	4984	0	4984	8020
1-Aug-05	4686	500	5186	8990
2-Aug-05	4344	500	4844	10100
3-Aug-05	4583	1000	5583	10000
4-Aug-05	4515	1500	6015	10100
5-Aug-05	4753	1500	6253	10100
6-Aug-05	5160	1500	6660	11800
7-Aug-05	5528	1500	7028	11800
8-Aug-05	5752	1500	7252	11800
9-Aug-05	5566	1500	7066	11900
10-Aug-05	5603	1500	7103	11900
11-Aug-05	5895	2000	7895	13000
12-Aug-05	5930	2000	7930	13000
13-Aug-05	6208	2000	8208	13000
14-Aug-05	6276	2000	8276	13000
15-Aug-05	6344	3000	9344	13000

16-Aug-05	6983	3000	9983	13000
17-Aug-05	7328	3000	10328	11900
18-Aug-05	7483	2000	9483	11000
19-Aug-05	7891	2000	9891	11000
20-Aug-05	8074	1500	9574	11000
21-Aug-05	8404	1500	9904	11900
22-Aug-05	8515	1500	10015	11800
23-Aug-05	8626	1500	10126	13000
24-Aug-05	8663	1500	10163	15000
25-Aug-05	9299	1500	10799	15100
26-Aug-05	10538	1000	11538	15100
27-Aug-05	11300	800	12100	15100
28-Aug-05	11215	800	12015	15100
29-Aug-05	10749	650	11399	14400
30-Aug-05	10203	900	11103	13200
31-Aug-05	10120	900	11020	13200
1-Sep-05	9912	800	10712	14000
2-Sep-05	10078	600	10678	14000
3-Sep-05	10287	600	10887	14000
4-Sep-05	10370	600	10970	26000
5-Sep-05	13106	600	13706	31000
6-Sep-05	17307	600	17907	27000
7-Sep-05	19310	1100	20410	25000
8-Sep-05	20085	1100	21185	21000
9-Sep-05	19413	1100	20513	21000
10-Sep-05	17714	1100	18814	19000
11-Sep-05	14769	1100	15869	16000
12-Sep-05	12736	1100	13836	14500
13-Sep-05	11386	1100	12486	15500
14-Sep-05	10791	2200	12991	21500
15-Sep-05	9954	2200	12154	21500
16-Sep-05	10454	2200	12654	21500
17-Sep-05	11045	2200	13245	21500
18-Sep-05	11215	2200	13415	22531
19-Sep-05	10960	2200	13160	20803
20-Sep-05	10538	2200	12738	14700
21-Sep-05	10162	2800	12962	12400
22-Sep-05	9541	2800	12341	11000
23-Sep-05	9419	2800	12219	10000
24-Sep-05	9379	2800	12179	9280
25-Sep-05	9258	2800	12058	8360
26-Sep-05	9339	2800	12139	8500
27-Sep-05	9058	2800	11858	8500
28-Sep-05	8779	3100	11879	9500
29-Sep-05	9582	3100	12682	10600
30-Sep-05	9460	3100	12560	12800
1-Oct-05	9058	3100	12158	14500

2-Oct-05	8478	3100	11578	16300
3-Oct-05	7927	3100	11027	17000
4-Oct-05	7522	3100	10622	17000
5-Oct-05	7251	3100	10351	15300
6-Oct-05	7406	1700	9106	13000
7-Oct-05	7290	1700	8990	11700
8-Oct-05	7328	1700	9028	10500
9-Oct-05	7376	1700	9076	10600
10-Oct-05	7406	1700	9106	8990
11-Oct-05	7483	1700	9183	8990
12-Oct-05	7445	1700	9145	8990
13-Oct-05	7251	2000	9251	8990
14-Oct-05	6690	2000	8690	11000
15-Oct-05	6480	2000	8480	15000
16-Oct-05	6000	2000	8000	16000
17-Oct-05	5715	2000	7715	17000
18-Oct-05	5566	2500	8066	17000
19-Oct-05	4984	3100	8084	17000
20-Oct-05	5491	2600	8091	17000
21-Oct-05	6655	2100	8755	17100
22-Oct-05	7213	2100	9313	18000
23-Oct-05	7561	2100	9661	20000
24-Oct-05	7891	2100	9991	22000
25-Oct-05	8515	2100	10615	22000
26-Oct-05	9138	2100	11238	21000
27-Oct-05	10078	2100	12178	21000
28-Oct-05	11172	2100	13272	19500
29-Oct-05	11557	1200	12757	18000
30-Oct-05	11557	1200	12757	17500
31-Oct-05	12461	1500	13961	18500
1-Nov-05	12553	1500	14053	19500
2-Nov-05	12553	500	13053	23000
3-Nov-05	12006	1000	13006	24500
4-Nov-05	11300	1000	12300	24500
5-Nov-05	11130	1000	12130	23000
6-Nov-05	11130	1000	12130	21500
7-Nov-05	11172	2000	13172	20000
8-Nov-05	12644	2000	14644	18000
9-Nov-05	12829	2000	14829	20000
10-Nov-05	13013	800	13813	24200
11-Nov-05	12829	800	13629	27100
12-Nov-05	13245	800	14045	28200
13-Nov-05	14140	800	14940	28200
14-Nov-05	15160	1000	16160	24200
15-Nov-05	15013	1000	16013	22000
16-Nov-05	14965	1800	16765	20000
17-Nov-05	14430	2200	16630	18900
18-Nov-05	13572	2500	16072	18000
19-Nov-05	12187	2500	14687	17500
20-Nov-05	11735	2500	14235	17000
21-Nov-05	11471	2500	13971	16500
22-Nov-05	11386	3500	14886	16000
23-Nov-05	11557	3500	15057	15500
24-Nov-05	11514	3500	15014	15000
25-Nov-05	11471	3500	14971	15000

26-Nov-05	11130	3200	14330	15000
27-Nov-05	11386	2480	13866	15000
28-Nov-05	11130	2480	13610	15000
29-Nov-05	10749	2480	13229	15000
30-Nov-05	10580	2480	13060	15000
1-Dec-05	10328	2480	12808	15000
2-Dec-05	9954	2590	12544	15000
3-Dec-05	9788	2450	12238	14700
4-Dec-05	9788	2450	12238	14100
5-Dec-05	9419	2450	11869	16000
6-Dec-05	9058	2450	11508	16000
7-Dec-05	8938	2200	11138	15000
8-Dec-05	9178	2200	11378	14500
9-Dec-05	9138	2200	11338	14000
10-Dec-05	9018	2200	11218	13500
11-Dec-05	8978	2200	11178	13100
12-Dec-05	8779	2200	10979	12700
13-Dec-05	8404	1700	10104	12500
14-Dec-05	8147	2100	10247	12300
15-Dec-05	7600	2100	9700	12000
16-Dec-05	7376	2100	9476	11800
17-Dec-05	7174	2100	9274	11500
18-Dec-05	6983	2100	9083	11300
19-Dec-05	6906	2100	9006	11100
20-Dec-05	6868	2100	8968	10700
21-Dec-05	6242	2100	8342	10700
22-Dec-05	5528	2100	7628	10200
23-Dec-05	5306	3500	8806	10000
24-Dec-05	5715	3500	9215	10000
25-Dec-05	5566	3500	9066	10000
26-Dec-05	5417	3500	8917	10000
27-Dec-05	5306	3500	8806	10000
28-Dec-05	5196	3500	8696	10000
29-Dec-05	5017	3500	8517	10100
30-Dec-05	4852	3500	8352	10000
31-Dec-05	4753	3500	8253	10000
1-Jan-06	4481	3500	7981	10000
2-Jan-06	4380	3500	7880	10000
3-Jan-06	4235	3500	7735	10000
4-Jan-06	4091	3500	7591	10000
5-Jan-06	3898	3200	7098	10000
6-Jan-06	4583	3200	7783	10000
7-Jan-06	4652	3200	7852	10000
8-Jan-06	4819	3200	8019	10000
9-Jan-06	4941	3200	8141	10000
10-Jan-06	5123	3200	8323	10200
11-Jan-06	5306	3200	8506	10200
12-Jan-06	5566	2800	8366	10200
13-Jan-06	6105	3000	9105	10200
14-Jan-06	5086	3000	8086	10200
15-Jan-06	5160	3000	8160	10200
16-Jan-06	5380	3000	8380	10200
17-Jan-06	5528	3000	8528	10200
18-Jan-06	5417	3000	8417	10200
19-Jan-06	5491	3000	8491	10200

20-Jan-06	5566	3000	8566	10200
21-Jan-06	5790	3000	8790	10200
22-Jan-06	5640	3000	8640	10200
23-Jan-06	5491	4000	9491	10200
24-Jan-06	5640	4000	9640	10200
25-Jan-06	5603	4000	9603	10200
26-Jan-06	5930	4000	9930	10200
27-Jan-06	5640	4000	9640	10200
28-Jan-06	5491	4000	9491	10200
29-Jan-06	5454	4000	9454	10200
30-Jan-06	5491	3600	9091	10200
31-Jan-06	5640	3600	9240	10200
1-Feb-06	5752	3600	9352	10200
2-Feb-06	5752	3600	9352	10200
3-Feb-06	5790	3600	9390	10200
4-Feb-06	5965	3600	9565	10200
5-Feb-06	6070	3600	9670	10200
6-Feb-06	6105	3600	9705	10200
7-Feb-06	6171	3600	9771	10200
8-Feb-06	6276	3600	9876	10200
9-Feb-06	6378	3600	9978	10200
10-Feb-06	6208	3600	9808	10200
11-Feb-06	6140	3600	9740	10000
12-Feb-06	6174	3600	9774	10000
13-Feb-06	6070	3600	9670	10000
14-Feb-06	6140	3600	9740	10000
15-Feb-06	6105	3600	9705	10000
16-Feb-06	5965	3600	9565	10000
17-Feb-06	6000	3600	9600	10000
18-Feb-06	6035	3600	9635	10000
19-Feb-06	6000	3600	9600	10100
20-Feb-06	6105	3600	9705	10000
21-Feb-06	6105	3600	9705	10000
22-Feb-06	6070	3600	9670	10000
23-Feb-06	6035	3600	9635	10000
24-Feb-06	6000	3600	9600	10000
25-Feb-06	6000	3600	9600	10000
26-Feb-06	6174	3600	9774	10000
27-Feb-06	6140	3600	9740	10000
28-Feb-06	5640	3000	8640	10000
1-Mar-06	5930	3000	8930	10000
2-Mar-06	5860	3346	9206	10000
3-Mar-06	5715	3346	9061	10000
4-Mar-06	5790	3346	9136	10000
5-Mar-06	5752	3346	9098	10000
6-Mar-06	5566	3346	8912	10000
7-Mar-06	5306	3346	8652	10000
8-Mar-06	5196	3346	8542	10000
9-Mar-06	4951	3600	8551	10000
10-Mar-06	4549	3600	8149	10000
11-Mar-06	4481	3600	8081	10000
12-Mar-06	4617	3600	8217	10000
13-Mar-06	4720	3600	8320	10000
14-Mar-06	4819	3600	8419	10000
15-Mar-06	4951	3600	8551	10000

16-Mar-06	5196	4100	9296	9720
17-Mar-06	5528	4100	9628	9720
18-Mar-06	5528	4100	9628	9790
19-Mar-06	5603	4100	9703	9790
20-Mar-06	5417	4100	9517	9790
21-Mar-06	5233	3900	9133	10 000
22-Mar-06	6515	3900	10415	10 000
23-Mar-06	7673	3900	11573	10 000
24-Mar-06	6620	3900	10520	10 000
25-Mar-06	4652	3900	8552	10 000
26-Mar-06	4344	3900	8244	10 000
27-Mar-06	4414	3900	8314	9790
28-Mar-06	4344	3900	8244	9790
29-Mar-06	4271	3900	8171	10000
30-Mar-06	4307	3900	8207	10000
31-Mar-06	4163	3900	8063	10000
1-Apr-06	4020	3900	7920	10000
2-Apr-06	3979	3900	7879	10 000
3-Apr-06	4127	3900	8027	10 000
4-Apr-06	4056	3900	7956	10 000
5-Apr-06	4056	3900	7956	10 000
6-Apr-06	4235	3900	8135	10 000
7-Apr-06	4448	3900	8348	10 000
8-Apr-06	4235	3900	8135	10 000
9-Apr-06	4448	3900	8348	10 000
10-Apr-06	4583	3900	8483	10 000
11-Apr-06	4549	3900	8449	10 000
12-Apr-06	4583	3900	8483	10 000
13-Apr-06	5050	3900	8950	10 000
14-Apr-06	5050	3900	8950	10 000
15-Apr-06	5160	3000	8160	10 000
16-Apr-06	5895	3000	8895	10 000
17-Apr-06	5965	3000	8965	10 000
18-Apr-06	6105	3000	9105	10 000
19-Apr-06	6174	3000	9174	10 000
20-Apr-06	6174	3000	9174	10 000
21-Apr-06	6310	3000	9310	10 000
22-Apr-06	6412	3000	9412	9720
23-Apr-06	6446	3000	9446	9720
24-Apr-06	6276	3000	9276	9720
25-Apr-06	6515	3000	9515	9720
26-Apr-06	6550	3000	9550	9790
27-Apr-06	6446	2400	8846	9790
28-Apr-06	6795	1300	8095	9790
29-Apr-06	7328	300	7628	9790
30-Apr-06	7673	0	7673	9790
1-May-06	7745	0	7745	9570
2-May-06	7891	0	7891	9420
3-May-06	7927	0	7927	9420
4-May-06	7927	0	7927	9130
5-May-06	8074	0	8074	9130
6-May-06	8074	0	8074	8920
7-May-06	8037	0	8037	8640
8-May-06	7927	0	7927	8500
9-May-06	7673	0	7673	8150

10-May-06	7483	0	7483	7950
11-May-06	7367	0	7367	7750
12-May-06	7174	0	7174	7490
13-May-06	7021	0	7021	7160
14-May-06	7367	0	7367	6720
15-May-06	7406	0	7406	6300
16-May-06	7290	0	7290	5930
17-May-06	7097	0	7097	5480
18-May-06	6725	0	6725	4980
19-May-06	6276	0	6276	4980
20-May-06	5895	0	5895	4010
21-May-06	5678	0	5678	3490
22-May-06	5603	0	5603	3020
23-May-06	5270	0	5270	2710
24-May-06	4918	0	4918	2510
25-May-06	4414	0	4414	2510
26-May-06	3778	0	3778	2280
27-May-06	3280	0	3280	2190
28-May-06	3019	0	3019	2100
29-May-06	2728	0	2728	2020
30-May-06	2692	0	2692	1770
31-May-06	2378	0	2378	1810
1-Jun-06	2412	0	2412	1810
2-Jun-06	2243	0	2243	1810
3-Jun-06	2043	0	2043	1810
4-Jun-06	2043	0	2043	1810
5-Jun-06	2043	0	2043	1810
6-Jun-06	1977	0	1977	1810
7-Jun-06	1945	0	1945	1810
8-Jun-06	2010	0	2010	1810
9-Jun-06	1977	0	1977	1810
10-Jun-06	1912	0	1912	1810
11-Jun-06	2043	0	2043	1810
12-Jun-06	1912	0	1912	1810
13-Jun-06	1912	0	1912	1810
14-Jun-06	1912	0	1912	1810
15-Jun-06	1977	0	1977	1810
16-Jun-06	1912	0	1912	1810
17-Jun-06	1945	0	1945	1810
18-Jun-06	2076	0	2076	1810
19-Jun-06	2010	0	2010	1810
20-Jun-06	1912	0	1912	1810
21-Jun-06	1945	0	1945	1810
22-Jun-06	1977	0	1977	1810
23-Jun-06	2310	0	2310	1810
24-Jun-06	2277	0	2277	1810
25-Jun-06	2210	0	2210	1810
26-Jun-06	2143	0	2143	1810
27-Jun-06	2143	0	2143	1850
28-Jun-06	2243	0	2243	2020
29-Jun-06	2243	0	2243	2100
30-Jun-06	2143	0	2143	2190
1-Jul-06	2043	0	2043	2190
2-Jul-06	2243	0	2243	2190
3-Jul-06	2176	0	2176	2190

4-Jul-06	2310	0	2310	2970
5-Jul-06	2412	0	2412	3490
6-Jul-06	2378	0	2378	4510
7-Jul-06	2515	0	2515	5480
8-Jul-06	2656	0	2656	6480
9-Jul-06	3056	0	3056	6970
10-Jul-06	3659	0	3659	6970
11-Jul-06	4515	0	4515	6970
12-Jul-06	5196	0	5196	6970
13-Jul-06	5640	0	5640	6970
14-Jul-06	5860	0	5860	6970
15-Jul-06	6344	0	6344	6970
16-Jul-06	6070	0	6070	8020
17-Jul-06	6035	0	6035	9060
18-Jul-06	5930	0	5930	9060
19-Jul-06	5965	0	5965	8990
20-Jul-06	6175	0	6175	8990
21-Jul-06	6550	0	6550	8990
22-Jul-06	6868	0	6868	8990
23-Jul-06	7021	0	7021	8990
24-Jul-06	7136	0	7136	8990
25-Jul-06	7290	0	7290	9500
26-Jul-06	7367	0	7367	10000
27-Jul-06	7445	0	7445	10000
28-Jul-06	7445	0	7445	10000
29-Jul-06	7522	0	7522	10000
30-Jul-06	7600	0	7600	10000
31-Jul-06	7745	0	7745	10000
1-Aug-06	7927	0	7927	10000
2-Aug-06	8001	0	8001	10000
3-Aug-06	8037	0	8037	10000
4-Aug-06	8110	0	8110	10000
5-Aug-06	8147	0	8147	9790
6-Aug-06	8147	0	8147	9790
7-Aug-06	8220	0	8220	9790
8-Aug-06	8220	0	8220	9790
9-Aug-06	8257	0	8257	9790
10-Aug-06	8220	500	8720	7990
11-Aug-06	7290	1400	8690	9790
12-Aug-06	6655	1500	8155	9790
13-Aug-06	6725	2000	8725	9790
14-Aug-06	6620	2000	8620	9790
15-Aug-06	6344	2000	8344	9790
16-Aug-06	6310	2000	8310	9790
17-Aug-06	6140	2300	8440	9790
18-Aug-06	5965	2600	8565	9790
19-Aug-06	5454	3000	8454	9790
20-Aug-06	5233	3000	8233	9790
21-Aug-06	5233	3000	8233	9790
22-Aug-06	5233	3000	8233	9790
23-Aug-06	5270	3000	8270	9790
24-Aug-06	5343	3000	8343	9790
25-Aug-06	5270	3000	8270	9790
26-Aug-06	5160	3000	8160	9790
27-Aug-06	5160	3000	8160	9790

28-Aug-06	5160	3000	8160	9790
29-Aug-06	5160	3000	8160	9790
30-Aug-06	5086	3000	8086	9790
31-Aug-06	5050	3000	8050	9790
1-Sep-06	5017	3000	8017	9790
2-Sep-06	4753	3300	8053	9790
3-Sep-06	4344	3300	7644	9790
4-Sep-06	4235	3300	7535	9790
5-Sep-06	4199	3300	7499	9790
6-Sep-06	4414	3300	7714	9790
7-Sep-06	4583	3300	7883	9790
8-Sep-06	4652	3600	8252	9790
9-Sep-06	6000	3600	9600	9790
10-Sep-06	6655	3600	10255	9790
11-Sep-06	6830	3600	10430	9790
12-Sep-06	6906	3600	10506	9790
13-Sep-06	6944	2000	8944	9790
14-Sep-06	6310	2000	8310	9790
15-Sep-06	6105	2000	8105	9790
16-Sep-06	6105	2000	8105	9790
17-Sep-06	5930	2000	7930	9790
18-Sep-06	5825	2000	7825	9790
19-Sep-06	5790	2500	8290	9790
20-Sep-06	5123	2500	7623	9790
21-Sep-06	5086	2500	7586	9790
22-Sep-06	5017	2500	7517	9790
23-Sep-06	4885	2932	7817	9790
24-Sep-06	4583	2932	7515	9790
25-Sep-06	4617	2932	7549	9790
26-Sep-06	4583	2932	7515	9790
27-Sep-06	4414	2932	7346	9790
28-Sep-06	4414	2932	7346	9790
29-Sep-06	4414	2932	7346	9790
30-Sep-06	4448	2932	7380	9790
1-Oct-06	4380	2932	7312	9790
2-Oct-06	4414	2932	7346	9790
3-Oct-06	4344	2932	7276	9790
4-Oct-06	4344	2932	7276	9790
5-Oct-06	4127	2932	7059	9790
6-Oct-06	4199	2932	7131	9790
7-Oct-06	4163	2932	7095	9790
8-Oct-06	4056	2932	6988	9790
9-Oct-06	3939	2932	6871	9790
10-Oct-06	3979	2932	6911	9790
11-Oct-06	4091	2932	7023	9790
12-Oct-06	4163	2932	7095	9790
13-Oct-06	4307	2932	7239	9790
14-Oct-06	4271	2932	7203	9790
15-Oct-06	4199	2932	7131	9790
16-Oct-06	4199	2932	7131	9790
17-Oct-06	4271	3600	7871	9790
18-Oct-06	4617	3600	8217	9790
19-Oct-06	4753	3600	8353	9790
20-Oct-06	4753	3600	8353	9790
21-Oct-06	4786	3600	8386	9790

22-Oct-06	4918	3600	8518	9790
23-Oct-06	4918	3600	8518	9790
24-Oct-06	5017	3600	8617	9790
25-Oct-06	4951	3060	8011	9790
26-Oct-06	5086	2950	8036	9790
27-Oct-06	5270	2950	8220	9790
28-Oct-06	5491	2950	8441	9790
29-Oct-06	5454	2950	8404	9790
30-Oct-06	5343	2950	8293	9790
31-Oct-06	5491	2950	8441	9790
1-Nov-06	5603	2950	8553	9790
2-Nov-06	5528	2950	8478	10300
3-Nov-06	5678	2950	8628	10300
4-Nov-06	5715	2950	8665	10300
5-Nov-06	5603	2950	8553	10300
6-Nov-06	5603	2950	8553	10300
7-Nov-06	5640	2950	8590	10300
8-Nov-06	5965	2950	8915	10300
9-Nov-06	6035	2950	8985	10300
10-Nov-06	6070	2950	9020	10300
11-Nov-06	6035	2950	8985	10300
12-Nov-06	6035	2950	8985	10300
13-Nov-06	6105	2950	9055	10300
14-Nov-06	6310	2950	9260	9850
15-Nov-06	6344	2950	9294	9850
16-Nov-06	6310	2950	9260	9850
17-Nov-06	6242	2950	9192	10200
18-Nov-06	6310	2950	9260	10200
19-Nov-06	6276	2950	9226	10200
20-Nov-06	6140	2950	9090	10200
21-Nov-06	6070	2950	9020	10200
22-Nov-06	6035	2950	8985	10200
23-Nov-06	6174	2000	8174	10000
24-Nov-06	5825	2000	7825	10000
25-Nov-06	5678	2000	7678	10000
26-Nov-06	5603	2000	7603	10000
27-Nov-06	5454	2000	7454	10000
28-Nov-06	5491	2000	7491	10000
29-Nov-06	5417	2000	7417	10000
30-Nov-06	5343	2000	7343	10000
1-Dec-06	5491	2000	7491	9596
2-Dec-06	5491	2300	7791	9600
3-Dec-06	5343	2300	7643	9600
4-Dec-06	5270	2300	7570	9600
5-Dec-06	5233	2300	7533	9600
6-Dec-06	5306	2300	7606	9600
7-Dec-06	5123	2300	7423	9600
8-Dec-06	5017	2300	7317	9600
9-Dec-06	5160	2300	7460	9600
10-Dec-06	5017	2600	7617	9600
11-Dec-06	4720	2600	7320	9600
12-Dec-06	4549	2600	7149	9600
13-Dec-06	4515	2600	7115	9600
14-Dec-06	4686	2600	7286	9600
15-Dec-06	4753	2600	7353	9440

16-Dec-06	4617	2600	7217	9440
17-Dec-06	4583	2600	7183	9440
18-Dec-06	4583	2600	7183	9040
19-Dec-06	4686	2600	7286	8800
20-Dec-06	4515	2600	7115	8800
21-Dec-06	4549	2600	7149	8800
22-Dec-06	4448	2600	7048	8800
23-Dec-06	4819	2600	7419	8800
24-Dec-06	4448	2600	7048	8800
25-Dec-06	4481	2600	7081	8490
26-Dec-06	4481	2600	7081	8490
27-Dec-06	4481	2600	7081	8490
28-Dec-06	4448	2600	7048	8490
29-Dec-06	4380	2600	6980	8490
30-Dec-06	4481	2600	7081	8490
31-Dec-06	4583	2600	7183	8490
1-Jan-07	4583	2600	7183	8490
2-Jan-07	4583	2800	7383	8490
3-Jan-07	4414	2600	7014	8490
4-Jan-07	5086	2600	7686	8170
5-Jan-07	5232	2600	7832	7930
6-Jan-07	5306	2600	7906	7930
7-Jan-07	5417	2600	8017	7930
8-Jan-07	5160	2600	7760	7930
9-Jan-07	4984	2600	7584	7700
10-Jan-07	4951	2600	7551	7700
11-Jan-07	4918	2600	7518	7700
12-Jan-07	4852	2600	7452	7780
13-Jan-07	4686	2600	7286	7700
14-Jan-07	4549	2600	7149	7700
15-Jan-07	4481	2600	7081	7700
16-Jan-07	4549	2600	7149	7700
17-Jan-07	4686	2600	7286	7700
18-Jan-07	4720	2600	7320	7700
19-Jan-07	4852	2100	6952	7700
20-Jan-07	5528	2100	7628	7700
21-Jan-07	5930	2100	8030	7700
22-Jan-07	5860	2100	7960	7310
23-Jan-07	5860	600	6460	7000
24-Jan-07	5380	600	5980	7000
25-Jan-07	5306	600	5906	7000
26-Jan-07	5050	600	5650	7000
27-Jan-07	4852	1000	5852	7540
28-Jan-07	4127	1000	5127	7700
29-Jan-07	4056	1400	5456	7700
30-Jan-07	3551	2000	5551	8410
31-Jan-07	3659	2000	5659	8410
1-Feb-07	4163	2000	6163	8410
2-Feb-07	4481	2000	6481	8410
3-Feb-07	4549	1800	6349	8410
4-Feb-07	4951	1800	6751	8410
5-Feb-07	5050	1800	6850	8570
6-Feb-07	5160	1800	6960	8570
7-Feb-07	5086	1800	6886	8330
8-Feb-07	5123	1200	6323	8330

9-Feb-07	4885	1200	6085	8330
10-Feb-07	4984	1200	6184	8010
11-Feb-07	5123	1200	6323	8010
12-Feb-07	5017	1200	6217	8010
13-Feb-07	4984	1200	6184	8010
14-Feb-07	5017	1200	6217	7700
15-Feb-07	4948	1200	6148	7700
16-Feb-07	4951	1200	6151	7700
17-Feb-07	4951	1500	6451	6930
18-Feb-07	5086	1500	6586	6640
19-Feb-07	5050	1500	6550	6640
20-Feb-07	4819	1500	6319	6640
21-Feb-07	4819	1500	6319	6100
22-Feb-07	4652	1500	6152	6100
23-Feb-07	4686	1500	6186	6100
24-Feb-07	4753	1500	6253	6100
25-Feb-07	4617	1500	6117	6100
26-Feb-07	4686	1500	6186	6100
27-Feb-07	4753	1500	6253	5770
28-Feb-07	4753	1500	6253	5520
1-Mar-07	4652	1500	6152	5520
2-Mar-07	4583	1500	6083	5520
3-Mar-07	4617	1500	6117	5520
4-Mar-07	4414	1500	5914	5520
5-Mar-07	4199	1500	5699	5170
6-Mar-07	3778	1260	5038	4890
7-Mar-07	3551	1260	4811	4890
8-Mar-07	3381	1260	4641	4890
9-Mar-07	3205	1400	4605	4890
10-Mar-07	3483	1400	4883	4890
11-Mar-07	2800	1400	4200	4840
12-Mar-07	2728	1400	4128	4890
13-Mar-07	2550	1400	3950	4890
14-Mar-07	2583	1400	3983	4890
15-Mar-07	2692	1400	4092	4890
16-Mar-07	2873	1400	4273	4890
17-Mar-07	2910	1400	4310	4890
18-Mar-07	2621	1400	4021	4890
19-Mar-07	2692	1400	4092	4620
20-Mar-07	2910	1400	4310	4620
21-Mar-07	2515	1400	3915	4620
22-Mar-07	2515	1400	3915	4620
23-Mar-07	2515	1400	3915	4620
24-Mar-07	2310	1400	3710	4620
25-Mar-07	2446	1400	3846	4310
26-Mar-07	2210	2000	4210	4200
27-Mar-07	2446	2000	4446	4620
28-Mar-07	2515	2000	4515	4780
29-Mar-07	2515	2000	4515	4780
30-Mar-07	2446	1800	4246	4780
31-Mar-07	2764	1800	4564	4780
1-Apr-07	2764	1460	4224	4780
2-Apr-07	2873	1460	4333	4780
3-Apr-07	2837	1460	4297	4730
4-Apr-07	2692	1460	4152	4620

5-Apr-07	2800	1600	4400	4620
6-Apr-07	2837	1600	4437	4620
7-Apr-07	2946	1600	4546	4620
8-Apr-07	2946	1600	4546	4310
9-Apr-07	2910	1600	4510	4310
10-Apr-07	2946	1600	4546	4310
11-Apr-07	2764	1600	4364	4470
12-Apr-07	2621	1600	4221	4310
13-Apr-07	2515	1600	4115	4310
14-Apr-07	2515	1600	4115	4310
15-Apr-07	2585	1600	4185	4310
16-Apr-07	2692	1600	4292	4310
17-Apr-07	2550	1600	4150	4310
18-Apr-07	2692	1600	4292	4310
19-Apr-07	2873	1600	4473	4020
20-Apr-07	2837	1100	3937	4020
21-Apr-07	3056	1100	4156	3440
22-Apr-07	3056	1100	4156	3540
23-Apr-07	3056	1100	4156	3490
24-Apr-07	2983	870	3853	3200
25-Apr-07	2764	870	3634	3200
26-Apr-07	2550	870	3420	2880
27-Apr-07	2446	870	3316	2270
28-Apr-07	2764	1000	3764	2270
29-Apr-07	2800	750	3550	2270
30-Apr-07	3093	750	3843	2270
1-May-07	3314	750	4064	2270
2-May-07	2983	0	2983	2270
3-May-07	2873	0	2873	2270
8-Jan-00	2910	0	2910	2270
5-May-07	2728	0	2728	2000
6-May-07	2585	0	2585	2000
7-May-07	2515	0	2515	2000
8-May-07	2446	0	2446	1800
9-May-07	2243	0	2243	1800
10-May-07	2210	0	2210	1800
11-May-07	2070	0	2070	1800
12-May-07	2076	0	2076	1800
13-May-07	1977	0	1977	1800
14-May-07	2010	200	2210	1800
15-May-07	1717	200	1917	1800
16-May-07	1560	200	1760	1740
17-May-07	1685	200	1885	1800
18-May-07	1749	200	1949	1800
19-May-07	1782	200	1982	1800
20-May-07	1749	200	1949	1740
21-May-07	1749	200	1949	1800
22-May-07	1654	200	1854	1800
23-May-07	1654	200	1854	1800
24-May-07	1622	200	1822	1800
25-May-07	1685	200	1885	1510
26-May-07	1528	200	1728	1510
27-May-07	1496	200	1696	1510
28-May-07	1591	200	1791	1510
29-May-07	1591	200	1791	1510

30-May-07	1815	200	2015	1510
31-May-07	1717	200	1917	1800
1-Jun-07	1717	200	1917	2400
2-Jun-07	1591	200	1791	2970
3-Jun-07	1717	200	1917	2430
4-Jun-07	1464	500	1964	4520
5-Jun-07	2076	0	2076	5520
6-Jun-07	2310	0	2310	5960
7-Jun-07	2873	0	2873	6230
8-Jun-07	3620	0	3620	6230
9-Jun-07	4448	0	4448	5830
10-Jun-07	5160	0	5160	5000
11-Jun-07	5752	0	5752	4470
12-Jun-07	6070	0	6070	3750
13-Jun-07	6140	0	6140	3390
14-Jun-07	5752	0	5752	3390
15-Jun-07	5380	0	5380	3390
16-Jun-07	4786	0	4786	3390
17-Jun-07	4235	0	4235	3020
18-Jun-07	3818	0	3818	2610
19-Jun-07	3738	0	3738	2320
20-Jun-07	3347	0	3347	2230
21-Jun-07	3381	0	3381	2610
22-Jun-07	3056	0	3056	2610
23-Jun-07	2837	0	2837	2610
24-Jun-07	2621	0	2621	2610
25-Jun-07	2446	0	2446	2320
26-Jun-07	2550	0	2550	2000
27-Jun-07	2481	0	2481	1950
28-Jun-07	2837	0	2837	2000
29-Jun-07	2412	0	2412	2490
30-Jun-07	2550	0	2550	3020

From the past two years of river flow data:

Average flow ML/D for Torrumbarry= 7474

Average flow ML/D for Yarrawonga= 8955

Average flow for Torrumbarry between December and April for the last two years = 9,150 ML/D

Average flow for Yarrawonga between December and April for the last two years = 10,564 ML/D

Appendix 3: Sagittaria information note



Arrowhead

Sagittaria graminea



Arrowhead is an aquatic plant which is becoming an increasingly serious problem in irrigation areas. It spreads rapidly, blocks channels and greatly reduces the effectiveness of the water distribution system.

At present there are major infestations in G-MW's four eastern Irrigation Areas and there have been reports of minor infestations in the Pyramid-Boort and Torrumberry Irrigation Areas.

HABITAT AND DESCRIPTION

Arrowhead is an emergent, erect plant, up to one metre high when mature. It grows in a number of forms.

The most recognisable form has lance-shaped or arrow-shaped leaves (hence the name) which are a distinctive green colour.

The next most prominent form has long, narrow, straplike leaves. These are often more yellow in colour and can grow adjacent to or separate from the lance-shaped plants.

The least prominent form grows under water. Its leaves are also straplike but much shorter, and grow in a rosette arrangement, up to 50 cm long and almost flat against the soil.

Arrowhead is found along river and creek banks, lagoons, irrigation channels and drains, dams etc generally in water depths less than one metre.

RAPID SPREAD

Arrowhead spreads rapidly, due to its many methods of reproduction.

Not only does arrowhead reproduce by the germination of seeds, it also has several methods of vegetative reproduction available to it. The plant has underground rhizomes (horizontal stems which put out both roots and shoots) which when detached from the plant can establish a new plant. It also has bulbs which remain viable in the soil for many years.

RESEARCH

Research into the plant's biology and control methods is currently being undertaken by Goulburn-Murray Water. This approach will help to identify important aspects of arrowhead's germination, growth and spread, as well as assessing the effectiveness of current and potential methods of control. The information gathered will help in developing a more





effective control strategy, involving several aspects of physical, environmental, herbicidal and possibly biological control of arrowhead.

Information to assist in the identification of arrowhead can be found at G-MW.

Korang 5451 0116
 Rochester 5484 0406
 Tatura 5824 3137

Goulburn-Murray Water is on the web: www.g-mwater.com.au

Flower Position

Flowers positioned below the top of the plant...

Flowers

In whorls of 4-6. Feathery about 2-4 cm long.

Stems

Stems are triangular in cross section.



Underwater form



Lance shaped Form



Narrow leaf form



Appendix 4: Collection of water samples for residue analysis of glyphosate following spray application to arrowhead in 2006-07 control program.

Objective

Outline the method for determining the concentration of glyphosate in water before and after application of glyphosate to the aquatic weed *Sagittaria graminea* (Arrowhead) in the Murray River.

Background

The NSW EPA provided input into G-MW's Management Plan for control of arrowhead on the Murray River between Echuca and Torrumbarry Weir (Docs #1295288). In the report G-MW stated that monitoring would be carried out by taking water samples at surface and 1 metre depths, upstream 50 metres, spraying zone and 50 metres downstream and analysed for glyphosate (to be conducted at one site per season). These results would verify residue calculations detailed in the Management Plan and give the NSW EPA an indication of glyphosate concentration in water following herbicide treatment.

Equipment

- 28 tamper proof sampling bottles and corresponding labels were supplied by Eco Wise Environmental Victoria Pty Ltd.
- Insulated boxes for transport of samples
- Sampling pole including bottle cage
- Surgical gloves

Method

Sample Collection

On 18 January 2007, samples were collected at the surface and 1 meter depths, 50 m upstream, in the spray zone and 50 m down stream before and after treatment e.g. 2 sites x 3 positions x 2 depths x before/after treatment = 24 samples + 1 control (bottled water) + 1 treatment with glyphosate added to at 1.0 mg glyphosate acid /L.

Pre-spray treatment sampling

A punt (that was not used for herbicide application) was used to transport sampling equipment and personnel taking the samples. A 3 metre sampling pole with the sample bottle inserted into the dipping cage was lowered to the designated depth. The stopper cap was removed at the appropriate depth (via a string line) and sample bottle allowed to fill. The sample bottle was raised to the surface once bubbles were no longer obvious at the surface.

The samples from the surface water were taken 0.25-0.3 m into the infestation. Arrowhead only grows in water 0.5 m depth, therefore samples were taken in the infestation just above the sediment layer, taking care not to disturb or stir up the silt as silt may bind glyphosate.

Samples upstream after treatment

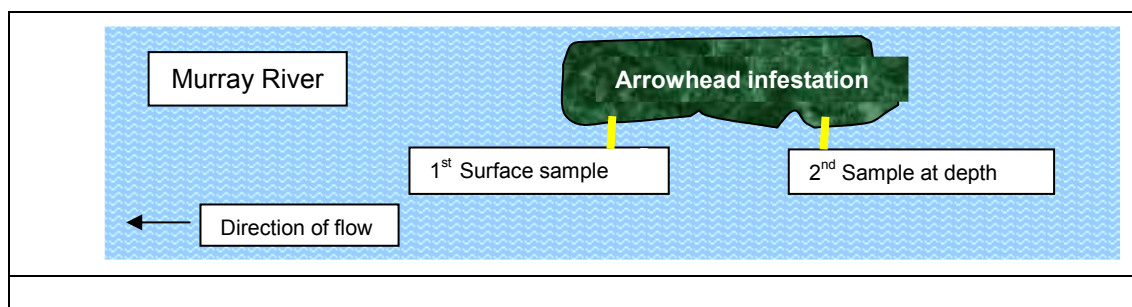
These samples were collected after the spray zone and the downstream sites.

Samples in spray zone after treatment

At least fifteen minutes elapsed between spray application and sampling in the spray zone to enable the glyphosate to dry onto the vegetation.

Samples down stream after treatment

The velocity of water at both sites was measured. Time for water from the treatment zone to move downstream 50 m was calculated and sample were taken to coincide with the glyphosate front.



Storage and transport of samples

Immediately after sampling tamper proof caps sealed the bottles. Samples bottles were placed on ice in an insulated container (Eski). At the completion of sampling, the insulated containers were topped up with ice and taken to TNT Transport, Shepparton. Samples were dispatched to Eco Wise Environmental Victoria Pty Ltd.

Chain of custody

Documentation outlining passage of samples was established. Phone contact with Eco Wise Environmental Victoria Pty Ltd was made at the estimated time of arrival of the samples at the analytical laboratory to confirm their arrival.

Herbicide application

Weedmaster Duo (glyphosate with an aquatic registration) was applied according to the method outline in Minor Use Permit 6875 issued by the APVMA. Two infestations were treated on 18 January 2007. The size and volume of glyphosate applied to the infestation is detailed in Table 1. Photos of each site are detailed in Figure 1.

The herbicide was applied from shallow bottom aluminium spray punt that allows close directed spray application. A low-pressure spray pump with a hand lance and foam jet nozzle that produced a spray stream allows for targeted spot application.

Table 1. Location, dimensions, volume of herbicide and water flow characteristics of glyphosate testing

Site Details	Site 1		Site 2	
GPS Reference	0284367 6008856		0284237 6008567	
Dimensions of infestation (length x width) (m)	7 x 2.5		35 x 2	
Spray time (s)	15		62	
Volume (l) of tankmix	1.3		4.2	
Volume (l) of Weedmaster Duo	0.13		0.42	
Mass (g) of glyphosate active ingredient	35		151	
Time of application	11:02		10:55	
Time of sampling	Before	After	Before	After
- spray zone	9:45	11:25	10:20	11:40
- 50 m upstream	9:55	11:30	10:20	11:45
- 50 m downstream	9:35	11:15	10:10	11:35
Velocity of water flow (ms ⁻¹)	0.06 m/s		Na	
Estimated time to move 50 m	13.9 min		Na	
Site 2 was located on inside of bend with no apparent flow between markers – six speed boats with skiers and 2 house boats caused some wave action.				

Results

Table 2 summarises the details of water samples collected from the River Murray near Echuca, and the associated glyphosate concentrations. All samples had glyphosate residue levels below the recommended ANZECC guidelines for the 95% protection of aquatic life of 1.2 mg/L. The only samples that had elevated levels of glyphosate residues were Samples 15, 21 and 22, which were collected from the spray zone. The levels within the spray zone were higher at Site 2 than at Site 1, which is likely to reflect the lack of water movement at this site.

Table 2: Concentration of glyphosate in water samples taken on 18 January 2007 before and after application to *Sagittaria graminea* in the Murray River, near Echuca.

Site No	Sample No.	Site location	Depth		Date	Time	Glyphosate (mg/L)
1	1	Down stream (50 m)	surface	Pre treatment	18 Jan	9:35	<0.03
1	2	Down stream (50 m)	depth	Pre treatment	18 Jan	9:35	<0.03
1	3	Spray zone	surface	Pre treatment	18 Jan	9:45	<0.03
1	4	Spray zone	depth	Pre treatment	18 Jan	9:45	<0.03
1	5	Upstream (50 m)	surface	Pre treatment	18 Jan	9:55	<0.03
1	6	Upstream (50 m)	depth	Pre treatment	18 Jan	9:55	<0.03
				Application	18 Jan	11:02	
1	13	Down stream (50 m)	surface	Post treatment	18 Jan	11:15	<0.03
1	14	Down stream (50 m)	depth	Post treatment	18 Jan	11:15	<0.03
1	15	Spray zone	surface	Post treatment	18 Jan	11:25	0.042
1	16	Spray zone	depth	Post treatment	18 Jan	11:25	<0.03
1	17	Upstream (50 m)	surface	Post treatment	18 Jan	11:30	<0.03
1	18	Upstream (50 m)	depth	Post treatment	18 Jan	11:30	<0.03
2	7	Down stream (50 m)	surface	Pre treatment	18 Jan	10:10	<0.03
2	8	Down stream (50 m)	depth	Pre treatment	18 Jan	10:10	<0.03
2	9	Spray zone	surface	Pre treatment	18 Jan	10:20	<0.03
2	10	Spray zone	depth	Pre treatment	18 Jan	10:20	<0.03
2	11	Upstream (50 m)	surface	Pre treatment	18 Jan	10:20	<0.03
2	12	Upstream (50 m)	depth	Pre treatment	18 Jan	10:20	<0.03
				Application	18 Jan	10:55	
2	19	Down stream (50 m)	surface	Post treatment	18 Jan	11:35	<0.03
2	20	Down stream (50 m)	depth	Post treatment	18 Jan	11:35	<0.03
2	21	Spray zone	surface	Post treatment	18 Jan	11:40	0.18
2	22	Spray zone	depth	Post treatment	18 Jan	11:40	0.22
2	23	Upstream (50 m)	surface	Post treatment	18 Jan	11:45	<0.03
2	24	Upstream (50 m)	depth	Post treatment	18 Jan	11:45	<0.03
	25	0.36 mg/L solution					0.41
	26	Distilled water					<0.03



Site 1 – Typical size infestation



Site 2 – large infestation



Taking surface sample



Securing Sample