guidelines

Herbicides:

guidelines for use in and around water

herbicides and water

Herbicides can be a useful weed management tool in riparian and aquatic areas

The information presented here focuses on using herbicides for weed control. Generally, the use of herbicides near waterways should be minimised and therefore it is important to consider other techniques that can be alternatives to, or complementary with, herbicides. Other methods of control include mechanical removal, mulch or weed mat, shading, fire, flame guns, biological control agents, manual control, slashing, ring barking, and controlled grazing. Developing an integrated approach to weed management, combining all appropriate weed control options into an integrated weed management (IWM) plan, is the most desirable way to combat weeds. The IWM plan will be different for each site according to the characteristics of the riparian area and the weed(s) present.

Before deciding whether or not to include a herbicide in your control program you need **knowledge** about herbicides and an understanding of their **relevance** in a weed management program. When used correctly, herbicides can be very effective and have limited impact on the environment. Effective use of herbicides requires a thorough knowledge of:

- The **target weed** (weed identification, biology, susceptible growth stages).
- The **herbicide** (herbicide activity and application methodology).
- The **site conditions** (weather conditions, soil characteristics, water level, native plants and animals, livestock, nearby crops, ornamental plants, water off-takes).

The aim of this factsheet is to assist people responsible for riparian and aquatic weed management by providing information and specific recommendations. **Always seek site-specific advice if you are unsure of herbicide impacts**. It is important to determine the potential effects of herbicides on non-target organisms in the riparian area using a method of risk assessment (see pages 8-10).

Should herbicides be used to control weeds in and around water?

Land managers are often uncertain about using herbicides in aquatic and riparian situations due to a lack of information on what is legally permitted, effective and also environmentally responsible.

Before deciding to use a herbicide in these circumstances, the user:

- must check whether the use is restricted or prohibited by applicable regulations;
- should use the information in this factsheet to assess the risks of adverse herbicide effects; and
- should seek one or more expert options about the likely outcomes of herbicide use (see page 11).

Further information on using herbicides can be found in the Weeds CRC guidelines, *Herbicides: knowing when and how to use them*.

Is there a safe buffer distance?

Some herbicide users expect that a set distance to protect waterways can be advised for all herbicides. However, this is not possible given the variation in risk associated with different herbicides and different riparian environments.

Distances that reliably provided adequate protection in a worst case scenario would effectively prevent the use of many herbicides that are important for riparian weed management.

It is important to consider the risks of herbicide use in the context of all potential uses of water.
Photo: Victorian DPI

What is an aquatic area?

There is generally no difficulty in recognising an aquatic situation when controlling submerged weeds, floating weeds or weeds that emerge directly from water, although there is sometimes confusion when presence of water is intermittent.

What is a riparian area?

Riparian situations are more difficult to define and the term 'riparian' is not used on any herbicide labels.

Most formal definitions of 'riparian areas' are based on the area's proximity to water or frequency of flooding.

eg The Macquarie dictionary defines riparian as:

'*of, relating to, or situated or dwelling on the bank of a river or other body of water*'

Private landholders usually consider riparian zones to consist of whatever width has been fenced off from the body of water.

Although 'riparian' management and restoration is frequently promoted and inevitably involves dealing with weeds, it can be difficult to relate advice on these matters to the situations listed on herbicide labels.

Herbicide options for aquatic weed control

A few herbicides are registered for use in truly aquatic situations ie to control submerged, emergent or floating weeds. Very specific restrictions apply eg labels of glyphosate products registered for aquatic weed control state: "*Do not apply this product within 0.5 km up-stream of potable water intake in flowing water....*". Use must be exactly as described on the label and only for the weeds listed, unless a permit has been obtained (seek advice from state government departments as some limited exceptions may apply).

Despite being in accordance with label directions, it is still possible that herbicide treatment of aquatic weeds could cause environmental damage or could be prohibited by regulations that apply to a particular site. Later sections of this factsheet provide information on identifying and minimising potential adverse effects. Nevertheless aquatic weed control is a very sensitive area of work and expert advice should be sought (see page 11 for contacts).

Herbicide options for riparian weed control

The great majority of herbicides are **not** registered for use in strictly aquatic situations and their labels carry only a general instruction to avoid contamination of watercourses. Whether these products should be used on land adjoining waterbodies and how close to the water is not always clear.

Label instructions for a few products do have specific prohibitions or instructions that must be observed with respect to waterways. For example, atrazine product labels prohibit application within "*60 m of natural or impounded lakes or dams or within 20 m of any well, sink hole, intermittent or perennial stream or river*".

Weeds such as salvinia can quickly invade and degrade aquatic areas. A weed management plan needs to be designed and implemented to reduce the impact of such weeds on the native flora and fauna. Herbicide application can form part of the weed management plan.
Photo: NSW DPI

Read labels carefully. It is illegal to disregard label prohibitions and you must read all the label instructions (not just the rate).

Possible effects of herbicides on aquatic and riparian systems

The risk of herbicide contamination of water or effects on non-target organisms will be affected by:

- the amount of herbicide applied;
- the method of herbicide application;
- the mobility of the herbicide (in soil and water);
- the persistence of the herbicide; and
- the toxicity of the herbicide to flora and fauna.

Herbicides used in non-riparian situations

When herbicides are used in non-riparian situations they generally tend to remain at or close to the point of application until they break down to harmless substances.

Movement into aquatic systems is still possible via direct spray, vapour drift, surface runoff or percolation into groundwater. It is usually the case that this involves only a very small percentage of the herbicide originally applied.

However, some catchments may still have problems with herbicide contamination of waterways from non-riparian use, because even small proportions of the herbicide reaching waterways can be significant if the total amount being used in the catchment is large.

Herbicide use in aquatic or riparian areas

Application of herbicides in or next to watercourses is a different situation as:

- the distance that the herbicide needs to move by spray drift or runoff to reach water is much shorter; and
- small rises in water level may result in treated land being flooded.

Such **short-distance movement** is very difficult to predict. It is highly influenced by the weather conditions at application and the skill of the operator. Even though the amount of herbicide used in aquatic and riparian situations is usually very small compared to what is used over the catchment as a whole, the input from such herbicide use is still an important potential source of contamination.

Non-target organism effects

The most commonly occurring unwanted outcome from riparian herbicide use is damage to or death of **non-target plants** at the site of application. However, there is often concern about possible harmful effects on some of the other **non-target organisms** (NTOs) such as frogs, fish and other aquatic life. Harmful effects on populations of these animals are generally hard to detect or to relate to any particular herbicide application.

Risk of herbicide movement within water

An important reason to take special care on or near waterways is that the current may carry herbicide downstream so that it affects other landholders and water users. Irrigation of sensitive crops with herbicide-contaminated water could result in severe damage.

It is therefore important to consider the risks of herbicide use in the context of all potential uses of the water, rather than just the situation on the property where the herbicides are used. There are some additional regulations that limit herbicide use where water contamination is of particular concern, eg in drinking water catchments; advice should be sought to ensure that these regulations are complied with.

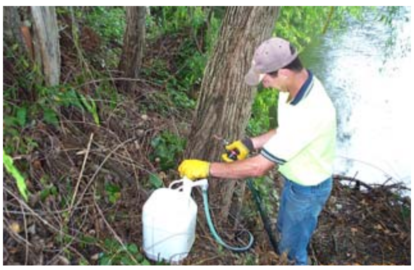
Amount of herbicide applied to riparian areas

It is preferable to treat weeds at a time when the lowest herbicide rate can be used. Some herbicide labels specify a range of concentrations for **spot spraying** a particular weed in different circumstances. Often there is a lower rate for seedlings or young plants than for mature plants.

Methods of herbicide application in riparian areas

Herbicides can be applied using various methods. This includes:

- spot spraying;
- boom spraying;
- aerial spraying;
- cut stump;
- stem injection;
- basal bark application;



Applying herbicide by stem injection to control willows on a riverbank.
Photo: Terry McCormack, North East CMA, Victoria.

- granules; and
- wick wiping.

Further information on these methods can be found in the Weeds CRC guidelines, *Herbicides: knowing when and how to use them*.

Choice of the most appropriate method increases the effectiveness of the herbicide and minimises the risks to the operator and environment (including NTOs).

Mobility of herbicides in riparian areas

Movement in soil

A large part of the herbicide applied may eventually reach the soil as a result of being:

- applied directly via spray;
- washed off treated weeds;
- released after treated vegetation decomposes (in the case of a few products).

Some herbicides strongly bind to soil particles and therefore are likely to remain close to the application site. In this instance toxicity in water or long persistence of the chemical may then be less of a concern because it is much less likely that the herbicide will reach the water by leaching.

Measuring herbicide mobility

One way to compare herbicide mobility is the **sorption coefficient** (K_{oc}). A high sorption coefficient shows that a herbicide has a strong tendency to bind to soil organic matter.

Soils that contain large proportions of organic matter therefore have less tendency for herbicides to be leached from them. The safest situation is when a herbicide with a high K_{oc} is applied:

- to a soil high in organic matter; and

- at a location where transportation of soil appears unlikely in the time needed for herbicide decomposition.

Movement into waterways

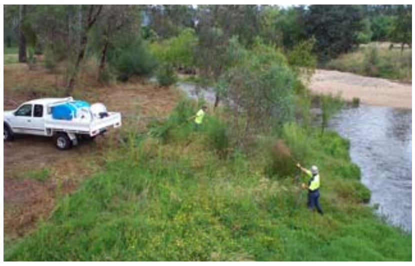
Although a herbicide may have a high K_{oc}, the soil that it binds to may still be moved into a watercourse by erosion.

Herbicide used in riparian situations also has the potential to reach the water without coming into direct contact with soil. There are a number of ways that herbicides can enter a body of water.

Herbicide may enter the water due to:

- spray drift or misdirection;
- herbicide dripping from treated plant foliage; or
- herbicide landing on rock, gravel, concrete structures, or other hard surfaces and later washing into the water.

Until more research has been completed it is safest to assume that much of the herbicide deposited on hard surfaces will wash into the water with the first rain.



The impact of a particular herbicide on nearby aquatic and riparian systems will depend on the amount applied, application method used, chemical mobility and persistence and its toxicity to NTOs and non-target plants.
Photo: Terry McCormack, North East CMA, Victoria.

Persistence of chemicals in soils	
Term	**Definition**
Soil half-life	Average time taken for half of the amount of herbicide originally applied to be broken down to other compounds. Soil half-life of a herbicide: less than 30 days = low persistence 30-100 days = moderately persistent more than 100 days = highly persistent If a herbicide has a half-life of 30 days half of it would be left after 30 days, a quarter left after 60 days, an eighth left after 90 days and so on.
Dissipation half-life	Rate at which the concentration at the site of application decreases. Dissipation half-lives tend to be shorter because they include leaching and volatilisation losses in addition to the actual breakdown of the herbicide.
Photodegradation	Process by which some herbicides (eg triclopyr and picloram) are broken down by sunlight. The intensity of sunlight the herbicide is exposed to affects the rate of photodegradation, so whether the herbicide has been applied beneath a tree or shrub canopy or in the open, and whether it has remained on leaf or soil surfaces, or been washed deeper into the soil can be important considerations. In water the presence of dissolved or suspended substances that absorb light can reduce the rate of photolysis.
Microbial degradation	Occurs when microorganisms in soil or water cause chemical breakdown of the herbicide. This process happens fastest in warm moist conditions and where high levels of organic matter support large numbers of microbes.
Chemical hydrolysis	Breakdown of herbicides by chemical reactions that do not depend on microorganisms. Frequently more than one process is responsible for the breakdown of a particular herbicide. Metsulfuron methyl for example is mainly broken down by chemical hydrolysis if the soil is acid, but in more alkaline soils this process is slow and microbial breakdown is the main decomposition process.

Persistence of herbicides in riparian areas

Highly persistent herbicides are those that remain chemically unchanged for a long period of time after application. Persistence is often expressed as the **soil half-life or dissipation half-life** (see Table left).

Highly persistent herbicides are generally a greater risk than ones with lower persistence. However they may be acceptable if high persistence is combined with low mobility and/or low toxicity.

One complication is that the initial breakdown may produce another compound that is toxic, and therefore the half-lives of both the herbicide and its breakdown products may have to be taken into account.

For example the substance nonylphenol ethoxylate, which is contained in some surfactants, degrades into intermediate compounds that are much more toxic to aquatic organisms than the original chemical. However, triclopyr ester, which is moderately toxic to fish (eg for rainbow trout the LD_{50} (see page 5) for this compound is 2.3 mg per litre), will rapidly break down to triclopyr acid, which is less toxic (LD_{50} value is 5.3). Further degradation of this less toxic

Definitions of how chemical toxicity to organisms is expressed	
Term	**Definition**
LD_{50} (expressed as mg of chemical per kg of body weight)	Acute (short-term) toxicity of herbicides or other chemicals is often assessed by administering a range of doses to different groups of animals. Deaths of animals over the following few days are recorded and used to calculate **median lethal dose** or **LD_{50}** which is the dose that killed 50% of the test organisms within the specified time. To compensate for the fact that it takes a higher dose to kill a larger animal, the LD_{50} is usually expressed as mg of chemical per kg of body weight. Different LD_{50} figures may be produced by different routes of uptake (oral, inhalation, injection). The figures most commonly quoted are for oral uptake by rats.
LC_{50} (expressed as mg of chemical per litre of water)	Oral administration is not appropriate for aquatic organisms as they absorb herbicide directly from the water across their gills or skin. The amount of chemical absorbed by their bodies is more influenced by the chemical concentration in the water. To assess acute toxicity of a herbicide to aquatic organisms the number of deaths is recorded in tanks containing a range of herbicide concentrations. Results are expressed as **median lethal concentration** or **LC_{50}** which is the concentration that would cause 50% of the organisms to die during the test period.
EC_{50} (expressed as mg of chemical per litre of water)	Sometimes instead of death of the test organism toxicity is measured by the appearance of some clear harmful effect such as loss of swimming ability or cessation of feeding. The result is then expressed as **median effective concentration** or **EC_{50}** which is the concentration that would cause the effect to appear in 50% of the organisms during the test period.
Take note:	A high LD_{50} or LC_{50} indicates that large amounts of the herbicide are required to cause death of the organisms tested; higher numbers equal less toxic. Many herbicides have such low toxicity that their LC_{50} is just quoted as being greater than the highest concentration tested.

breakdown product occurs more slowly, particularly in low light conditions.

Herbicide degradation can sometimes be a complex process, with different breakdown routes dominating at different stages.

The importance of the different processes (**photodegradation**, **microbial degradation** and **chemical hydrolysis**) will depend on the herbicide used and the environmental conditions (see Table page 4). Precise prediction of how long a herbicide will persist is therefore difficult.

Toxicity of herbicides in riparian areas

Aquatic organisms are often highly sensitive to toxic substances absorbed directly from the water. The effects may be difficult to detect because death of smaller organisms goes unnoticed or because the effects are more subtle, eg reduced breeding success.

Toxicity of herbicides and other chemicals are commonly indicated using the terms: **LC_{50}**, **LD_{50}** or **EC_{50}** (see Table above for definitions).

Short-term test drawbacks

The relatively short-term tests used to define lethal concentrations have some important drawbacks. However, until more information has been gathered on effects of long-term exposure to low levels of herbicides, the standards set to protect aquatic systems are in many cases based on maintaining a concentration that is only a small fraction of the LD_{50} for sensitive organisms (ANZECC & ARMCANZ, 2000).

Accumulation of chemicals in organisms

Environmental impact of some types of chemicals relates not to short-term toxic effects but to their capacity to accumulate in organisms to a harmful concentration in the longer term (see Table below).

ANZECC & ARMCANZ (2000) have only indicated that one of their listed herbicides (trifluralin) is a chemical for which possible bioaccumulation should be considered.

Herbicide formulations (including surfactants and penetrants)

Herbicides are sold as formulations that contain the active compound plus additional substances such as fillers, wetting agents, solvents or stabilisers. Toxicity tests are often done using only the active compound. However some of the additives in commercial formulations may have harmful effects

A standardised terminology has been suggested for describing toxicity (other forms of words are also used)	
LC_{50} for aquatic organism (mg per litre)	**Description**
less than 0.1	very highly toxic
0.1-1.0	highly toxic
>1.0-10	moderately toxic
>10-100	slightly toxic
>100	not acutely toxic

Definitions relating to accumulation of chemicals in organisms	
Term	**Definition**
Bioaccumulation	Process where tissues of organisms accumulate a chemical from the water because uptake is greater than elimination and breakdown.
Bioconcentration	Occurs when the bioaccumulation results in higher concentrations of the chemical in the organism than in the water. The ratio of concentration in an aquatic organism divided by the concentration in the water is called the bioconcentration factor.
Biomagnification	An increase in concentration of a chemical occurs along the food chain, ie from one organism to its predator. The organochlorin pesticide DDT is a well known example that is found in higher concentrations in birds than in the fish they feed on.
Octanol water partition coefficient (K_{ow} or K_p)	An important physical property of chemicals that indicates the potential of organic chemicals to bioaccumulate. $\mathbf{K_{ow}}$ is the ratio of the concentration of a chemical in n-octanol (a surrogate for animal fat) to the concentration in water. Chemicals with $\log_{10} K_{ow}$ values below three are not considered to bioaccumulate, while highly fat soluble, lipophilic chemicals are most likely to bioaccumulate. However, a K_{ow} greater than three only indicates a potential for bioaccumulation to occur, the risk that it will actually happen is affected by factors such as mobility and persistence in soil and water and the rate at which the chemical is metabolised by animals. Fluazifop is an example of a herbicide with high K_{ow} (4.5) but with the risk of bioaccumulation in aquatic organisms reduced by low mobility and short persistence in soil (**see section on persistence page 4**).

on aquatic life themselves or may modify the toxicity of the herbicide.

A well known case concerns the surfactants in some glyphosate products. Toxicity results showed that these compounds were harmful to frogs (much more so than the glyphosate itself). The surfactants were replaced by less toxic ones in all glyphosate products registered for use in aquatic situations (National Registration Authority 1996).

Unnecessary use of surfactants should be avoided when using herbicides in and around water. If they are required the amount should never be increased above the label recommendation for that particular use.

Toxicity of herbicides is also relevant to the health and safety of herbicide users and also to safe transport and storage of herbicides. These matters all fall outside the scope of this factsheet and information on these matters can be obtained by contacting the relevant State or Territory Workcover Authority.

Risk assessment of riparian herbicide use

A risk assessment should be conducted before deciding to use a herbicide to control a weed in a riparian area. This will assist in determining if the herbicide will pose an unacceptable level of risk to non-target organisms (both plants and animals) in the riparian zone. (see risk assessment procedure pages 8 and 9).

Possible harm to things outside the riparian zone, eg susceptible crops, should also be taken into account.

The risk assessment procedure suggested in this factsheet is intended to identify unacceptably high risks to both terrestrial and aquatic NTOs based on answering fairly simple questions that generally do not necessarily require precise data.

Trigger values

An alternative approach to protect the aquatic environment is to calculate the likely herbicide concentration that would occur in the water and decide whether a predetermined trigger value would be exceeded (see Table next page for an example calculation).

The Australian and New Zealand Guidelines for Freshwater and Marine Water Quality (**ANZECC guidelines**) provide information on how to develop suitable trigger values and also list default values for a few herbicides. When it is intended to apply herbicides close to water on a large scale this approach is preferable.

Moderate reliability default trigger values to protect aquatic ecosystems are however only available for ten herbicides, with low reliability (indicative interim) values for a further ten (see Table page 7). The ANZECC guidelines provide information on how each trigger value was obtained and make it clear that there is a lack of good information on toxicity levels.

Trigger values are adjusted to the quality of the aquatic system concerned, as discussed in the ANZECC guidelines. Apart from aquatic ecosystem protection other herbicide concentrations apply if water is for irrigation use of for livestock or human drinking. Human drinking water

Default herbicide trigger values (mg per litre) for slightly to moderately disturbed freshwater ecosystems			
Moderate reliability		**Low reliability** (indicative interim values)	
2,4-D	0.280	acrolein	0.00001
atrazine	0.013	amitrole	0.022
diquat	0.0014	bromacil	0.180
glyphosate	0.370	diuron	0.0002
molinate	0.0034	hexazinone	0.075
tebuthiuron	0.0022	imazethapyr	0.240
thiobencarb	0.0028	ioxynil	0.0004
thiram	0.00001	MCPA	0.0014
trifluralin	0.0026	metolachlor	0.00002
simazine	0.0032	metsulfuron	0.008

Source: Australian and New Zealand Guidelines for Fresh and Marine Water Quality, ANZECC & ARMCANZ, (2000)

guidelines are available from the National Health and Medical Research Council.

Predicting herbicide concentrations in the water is extremely difficult for most riparian situations due to the effects of factors such as pre- and post-application weather conditions, operator skill, local soil types, varying weed density and unknown waterbody volume or rate of water flow.

The risk assessment procedure on pages 8 and 9 is much simpler and has the advantage of dealing with both terrestrial and freshwater effects. It also includes effects that might occur only near the site of application and not necessarily the whole of the waterbody.

Recording the risk assessment process as suggested provides a record of how decisions were reached and where additional information is most needed. If the only effective and low risk herbicide treatment that can be identified by the process is prohibited by regulations then an application for a permit could be considered, or non-chemical control measures developed.

Indirect impacts

In addition to the process in the checklist, indirect impacts should also be considered. These impacts arise from the death of the target weed, rather than from toxicity of the herbicide to non-target organisms.

Indirect impacts are more likely if the weeds are a large component of the riparian or aquatic vegetation. Indirect impacts can include:

- erosion of bare banks;
- increases in water temperature after shade is removed; and
- fouling of water by rotting aquatic weeds.

Often the best ways to **minimise indirect effects** are to:

- remove weeds gradually in conjunction with restoration; and
- carefully choose herbicides to minimise indirect impacts, eg choose a selective product that allows grass cover to persist after spraying of woody weeds as this can reduce post-treatment erosion problems.

Example: estimating water concentration and comparison with a trigger value	
Location	Control of weeds in a 10-15 m wide strip around a pond edge.
Chemical product	Glyphosate product (360 g per litre).
Amount of product required	Estimated that the chemical application will require 400 litres of spray at 10 ml of product per litre = 4 000 ml (4 litres) of product, therefore, 4 x 360 = 1440 g of glyphosate will be applied.
Volume of water	Pond is 70 m long x 40 m wide with a depth of 2 m. Volume of water is 70 x 40 x 2 = 5 600 m^3 or 5 600 000 litres.
Approx. amount of herbicide entering pond	It is estimated that in the worst case scenario that 1/3 of the herbicide might enter the water, therefore, 1/3 x 1440 = 480 g or 480 000 mg.
Calculated trigger value for glyphosate	Glyphosate concentration in the pond can therefore be calculated, $\frac{480\ 000 \text{ mg}}{5\ 600\ 000 \text{ litres}}$ = 0.086 mg per litre.
Predetermined trigger value for glyphosate	0.37 mg per litre (*see Table above for default trigger value*).
Outcome	The estimated glyphosate concentration in the pond after treatment of the weeds around it is calculated as 0.086 mg per litre. This is acceptable as the trigger value for protection of slightly to moderately disturbed aquatic ecosystems is 0.37 mg per litre. It is still important to minimise the amount of spray entering the water, especially as the concentration in the shallows would temporarily be higher than the calculated value due to incomplete mixing with the rest of the pond.

Steps required to complete a risk assessment for each non-target organism (NTO)		
Step 1. List all of the non-target organisms present at the site.		
Step 2. List all of the herbicide options known to be effective for the target weed.		
For each NTO and each herbicide option, complete Steps 3 to 6 using the questionnaire on page 9 as a data recording sheet.		
Step 3. Assess the toxicity of each herbicide option to each NTO.		
Step 4. Assess the likelihood of each herbicide option coming into contact with each NTO.		
Step 5. Assess the likelihood of each NTO coming into contact with each herbicide via movement or leaching.		
Step 6. Completed risk assessment for NTO and herbicide option.		
Step 1	List the non-target organisms present at the site.	1. 2. 3. 4. 5.
Step 2	List the herbicide options for the target weed.	1. 2.
Steps 3 - 6 **(see recording sheet on following page for risk assessment questions).**	Risk assessment of each herbicide option to each NTO eg if there are two (2) herbicide options and five (5) NTOs, then ten (10) assessment sheets (2 x 5 = 10) will need to be completed.	1. 2. 3. 4. 5. 6. 7. 8. 9. 10.

Notes for steps 1 and 2 of risk assessment	
Step 1. **List of non-target organisms (NTOs) present at the site**	Non-target organisms (NTOs) to be assessed should include both aquatic flora and fauna and also terrestrial species found in the riparian zone. Weeds that are not the target of the treatment and unwanted pasture species should not be included as NTOs. Often data on susceptibility of individual species will be absent and similar organisms will have to be assessed as a group, eg all fish considered together. Do not group organisms though when there are known differences amongst them in susceptibility, eg 'native plants' is too broad a group.
Step 2. **Effective herbicides and application methods for the weeds**	Assess only the herbicides and application methods that are known to be effective for the weed(s) present and practical for the site. If herbicides with more than one active ingredient are to be used then assess each active ingredient separately, beginning with the one thought to be of most concern.
NTO vs herbicide option	To save time begin the process with the NTO that seems likely to be most sensitive.

Information required to determine risk assessment for each non-target organism (NTO)		
Non-target organism: ______________________	Herbicide: ______________________	
Tick the appropriate answer to EACH of the steps (3-6) below. Read the accompanying notes provided to best assess the risk to this NTO. If you are unsure how the herbicide will affect the NTO, seek further advice before proceeding with the risk assessment.		
Step 3	**Is the herbicide toxic to the NTO?**	
	☐ **YES** - there is known or suspected herbicide toxicity to the NTO. If you answered 'YES' in Step 3, there is a potential risk to this NTO. To determine the risk, complete Steps 4 to 6.	◯ **NO** - the herbicide is not toxic or has a very low toxicity to the NTO. If you ticked 'NO' in Step 3, the risk is low for the NTO and you now need to repeat the assessment for the other NTOs. If all relevant NTOs have a low risk, use this control method following appropriate guidelines.
Step 4	**Will the NTO come into direct contact with the herbicide during application?**	
	☐ **YES** - the herbicide is likely to come into direct contact with the NTO.	◯ **NO** - the herbicide is unlikely to come into direct contact with NTO.
Step 5	**Is the herbicide mobile and likely to leach or move into contact with NTO?**	
	☐ **YES** - leaching or movement is likely to expose the NTO to toxic levels of herbicide.	◯ **NO** - it is unlikely that leaching will lead to herbicide contact with NTO.
Step 6	If you have ticked 'YES' in Step 3 and also a 'YES' in <u>either</u> Step 4 or Step 5, the risk to this NTO is UNACCEPTABLE. Another herbicide or non-herbicide control option should be used.	If you have ticked 'YES' in Step 3 and also 'NO' in <u>both</u> Step 4 and Step 5, then the risk to the NTO is low. Repeat assessment for ALL NTOs before proceeding with herbicide application.
Outcome	☐ **Unacceptable risk to this NTO**	◯ **Low risk to this NTO**

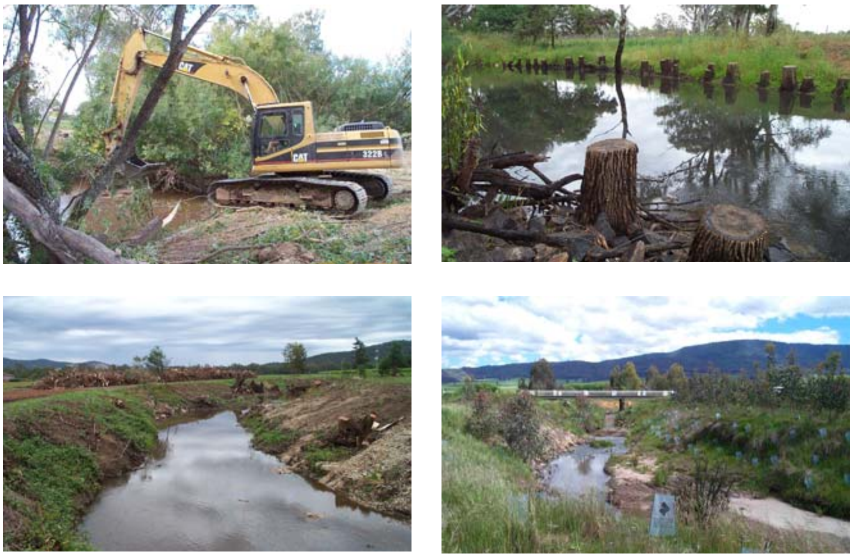
Notes for Steps 3 to 6 of Risk Assessment	
Step 3. Toxicity **Known or suspected significant toxicity to the NTO**	If no NTO susceptibility information is available, seek further advice.
Herbicide has no or very low toxicity to the NTO	Low toxicity to plants could include cases where some visible injury is expected but not death.
Step 4. Contact **Herbicide may come into contact with the NTO in amounts sufficient to be toxic**	Whether herbicide used on riparian weeds will reach aquatic NTOs by these routes should be assessed by someone experienced in herbicide application and who has seen the site. Method of application can have a large effect.
Unlikely to come into contact with NTO except in very small quantities	If a herbicide is highly toxic to the NTO and would be used in large amounts extreme care is needed before coming to this conclusion.
Step 5. Mobility and leaching **Leaching could expose NTO to substantial amounts of herbicide**	Includes when a toxic breakdown product of the herbicide may leach.
Unlikely to leach into contact with NTO, or only in very small amounts	Before reaching this conclusion remember to allow for the distance that tree roots may extend.
Step 6. Risk assessment outcome **Risk is very low for this NTO**	The assessment is site-specific so the risk may not be acceptable for this NTO/herbicide combination in other places.
Unacceptable risk to this NTO. Seek another herbicide or application method.	If the NTO (eg, susceptible plant) is confined to part of the site separate assessments can be done for the parts with these plants and for the rest of the site.
Risk is low for ALL relevant NTOs. Use control method, following guidelines.	If results for several NTOs are borderline decisions seek further advice before proceeding.

Best practice for riparian and aquatic herbicide use

The risk of waterway contamination or unwanted effects resulting from registered herbicide use in riparian or aquatic situations can be reduced by following a simple checklist (see Table below).

These general practices presented in the checklist are in addition to and not a replacement for, label directions and the pertinent codes of practice relating to chemical application.

Always seek site-specific advice if you are unsure of herbicide impacts on both the target weed and any non-target species (flora and fauna).



An integrated approach to weed management will produce the best results. In this riparian area, the willow management plan involved mechanical removal, herbicide application and revegetation of the banks.
Photos: Terry McCormack, North East CMA, Victoria.

	A checklist to assist in reducing the risks of herbicide contamination and unwanted herbicide effects in riparian and aquatic situations
☐	If possible suppress targeted aquatic weeds by restricting light and nutrients.
☐	Assess the risk to non-target organisms based on herbicide mobility, persistence and toxicity.
☐	Provide contractors with a map showing the location of waterways and associated soaks and drains.
☐	Avoid treating dense beds of submerged weeds in a single application as this may cause deoxygenation when they rot.
☐	Weeds overhanging a waterway or growing within the channel must be treated as an aquatic situation.
☐	Spray when heavy rain is not expected for some time (a minimum of several days).
☐	Choose the application method that minimises the amount of herbicide used and its dispersal.
☐	If spraying towards a waterway clearly mark the edge beforehand.
☐	Ensure that equipment is properly maintained, adjusted and not leaking.
☐	Around waterways carry herbicide only in secure containers.
☐	Only add surfactants to herbicides registered for aquatic use if they are specified on the label.
☐	Mix chemicals and rinse equipment well away from the waterway.
☐	Direct herbicide spray away from the waterway if at all possible.
☐	Apply the minimum amount of spray required to achieve the degree of wetting specified on the label.
☐	Move upstream when spraying to maximise dilution.

Further information

People to contact	Websites	Publications
Weeds Officers - at your local council, rural lands board, or state department of agriculture, primary industries, environment or natural resources. They have excellent local knowledge, a wide network of contacts and access to appropriate literature.	**www.weeds.crc.org.au** CRC for Australian Weed Management	Guidelines for herbicide use in and around water in Victoria, Weeds CRC Technical Series, *Nigel Ainsworth* (in publication). **www.weeds.crc.org.au**
	www.apvma.gov.au Australian Pesticides and Veterinary Medicines Authority	Herbicides: knowing when and how to use them. gl02, *Weeds CRC Guidelines series*, (2005). **www.weeds.crc.org.au**
Agronomists or **horticulturalists** employed by state government departments or rural supply retailers for information on using herbicides in production situations.	**www.avcare.org.au** Avcare is the National Association for Crop Production and Animal Health. It represents manufacturers, formulators and distributors of crop protection, animal health and biotechnology products.	Introductory weed management manual. *CRC for Australian Weed Management,* (2004). **www.weeds.crc.org.au**
Landcare, **Bushcare** or **Catchment Management** staff will have information on using herbicides in natural environments.	**www.msds.com.au** Search for product material safety data sheets (**MSDS**).	Bush invaders of south-east Australia - a guide to the identification and control of environmental weeds in south-east Australia. *A.Muyt* (2001). **www.weedinfo.com.au**
Staff of **herbicide manufacturers** can provide detailed information on product characteristics and use.	**www.pestgenie.com.au** Search for **product label** and material safety data sheet (**MSDS**).	Environmental Weeds: a field guide to SE Australia. *Kate Blood* (2001). **www.weedinfo.com.au**
	www.pesticideinfo.org Pesticide Action Network: a USA data base providing current toxicity information for pesticides	Bushland weeds. A practical guide to their management. *Kate Brown and Kris Brooks,* (2003). **www.weedinfo.com.au**
References used in publication *Australian and New Zealand Guidelines for Fresh and Marine Water Quality,* ANZECC & ARMCANZ, 2000. **www.deh.gov.au/water/quality/nwqms /volume1.html**	**www.weedinfo.com.au** Weed information website providing information on weed identification, weed management and control of environmental and agricultural weeds.	Rivercare: Guidelines for safe and effective herbicide use near water, *Tasmanian Department of Primary Industries, Water and Environment,* (2002). **www.dpiwe.tas.gov.au**
NRA Special Review of Glyphosate, National Registration Authority, Canberra, 1996. **www.apvma.gov.au/chemrev/ glyphosate.shtml**	**www.landcareaustralia.com.au** Landcare Australia for general information on weed management.	A process for rehabilitating Australian Streams. *CDROM, Land and Water Australia*, (2001).
	www7.health.gov.au/nhmrc/publication s/synopses/eh19syn.htm National Health and Medical Research Council (human drinking water guidelines).	Noxious weeds and environmental control handbook 2004-2005. **www.agric.nsw.gov.au/reader/weeds-general/nox-weeds-splash.htm**

For further information visit the Weeds CRC's website: www.weeds.crc.org.au

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