



Weed Management Plan

2016





Arum Lily (*Zantedeschia aethiopica*)

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Please formally acknowledge the City of Joondalup if you choose to use any of the content contained within the *Weed Management Plan*.

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Acronyms

Acronym/Abbreviation	Definition
CBP	Commercial Business Precinct
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAFWA	Department of Agriculture and Food WA
DEC	Department of Environment and Conservation
DFES	Department of Fire and Emergency Services
DPaW	Department of Parks and Wildlife
DSEWPC	Department of Sustainability, Environment, Water, Population and Communities
n.d.	No date
NIASA	Nursery Industry Accreditation Scheme Australia
NRM	Natural Resource Management
PAW	Pedestrian Access Way
PPOSCF	Parks and Public Open Spaces Classification Framework
QMS	Quality Management System
SAR	Specified Area Rates
WA	Western Australia
WALGA	Western Australian Local Government Association

1.0 Introduction

The City of Joondalup ('the City') is situated along the Swan Coastal Plain, with its southern boundary located just 15 kilometres from the Central Business District of Perth. The City covers an area of 96.5 kilometres which encompasses a diverse range of natural areas including 17 kilometres of coastal foreshore, a chain of wetlands and a variety of bushland ecosystems. The City also includes over 370 parks and reserves as well as a substantial number of urban landscaping areas.

The City is bounded by the City of Wanneroo to the east and north, the City of Stirling to the south, and the Indian Ocean to the west.

The City is located within the southwest Australian biodiversity hotspot, one of 35 biodiversity hotspots in the world, with over 2,900 endemic plant species occurring in this region.¹ There are a number of regionally, nationally and internationally significant natural areas located within or adjacent to the City including Yellagonga Regional Park, Marmion Marine Park and Neerabup National Park. There are seven Bush Forever sites within the City that contain species of high conservation value.

The *Weed Management Plan* has been developed in order to provide strategic ongoing weed management of the City's natural areas, parks and urban landscaping areas over the next five years and protect native vegetation and ecosystems in natural areas as well as the amenity, functionality and aesthetics of parks and urban landscaping areas. Weed management is conducted in the City to differing degrees, depending on the type of site. Weed management of natural areas is more extensive than weed management in parks and urban landscaping areas, due to the difference in biodiversity values. Section 4 of the Plan refers to weed management in natural areas, whilst section 5 of the Plan details weed management in parks and urban landscaping areas.

The *Weed Management Plan* details an integrated weed management approach which prevents, monitors and controls the spread of weeds in the City. The Plan describes the potential environmental impacts from weeds, weed control methods, the City's current weed management approach and proposes management strategies to be implemented over the life of the Plan in order to minimise potential impacts.

Weed management is conducted within the City by City staff, contractors and the valuable contributions from community members in 14 Friends Groups. Friends Group members voluntarily work to protect, preserve and enhance significant bushland areas in the community. The *Weed Management Plan* complements the voluntary work of Friends Group volunteers.

1.1 Strategic Context

The purpose of the *Weed Management Plan* aligns with the City of Joondalup Strategic Environmental Framework outlined in Figure 1. Details of the relevant local, State and Federal legislation policies, plans and strategies are outlined in Appendix 3.

¹ Conservation International (2014)



Geraldton Carnation Weed (*Euphorbia terracina*)

Figure 1: City of Joondalup Strategic Environmental Framework



2.0 Impact of Weeds

The City manages large areas of bushland, many of which are recognised as having local and regional significance; however the invasion of weeds threatens the diversity of these natural areas. Weeds are a key management issue for the City's natural areas and threaten the biodiversity values they contain.

The City also contains large areas of parks and urban landscaping areas. The invasion of weeds in these areas affects the amenity, functionality and aesthetics and impacts upon community use of the sites.

2.1 What are Weeds?

Weeds are plants that grow in natural ecosystems where they are not naturally occurring and proceed to modify natural processes, usually adversely, resulting in the decline of the communities they invade.² A weed usually requires some form of action to reduce its effects on the economy, the environment, human health and amenity.³ Weeds can establish themselves in terrestrial, aquatic or marine ecosystems.²

There are two types of invasive weeds: exotic plants that have been introduced and native species that have moved into new areas in response to changed land and water use and management practices.³

Weeds account for approximately 15% of all flora in Australia, with this figure increasing by approximately 10 species per year.⁴ Over 27,000 known weed species have been introduced to Australia and 10% of those are now considered to be established (have existed for a long time). Escaped garden plants are the main source of Australia's weeds, accounting for 66% of recognised weed species.⁵

Weeds typically produce large numbers of seeds and spread rapidly, invading natural areas, parks and urban landscaping areas. Weeds can be spread by:

- Dispersal of seeds by water, wind, birds, animals, human or vehicle movement
- Site activities
- Underground root systems
- Mulch, soil and plant stock
- Garden rubbish dumping
- Fire.⁴

Yearly growth patterns of weeds vary with some species growing in summer and seeding in autumn and others growing in winter and seeding in spring. The life cycle of weeds also varies, with weeds being classified as either:

- Annual: Weeds which germinate, grow, set seed and die in one season or year, such as Wild Oat, Veldt Grass, Paterson's Curse and Cape Weed.
- Biennial: Weeds which live for up to two years, usually growing and flowering in the first year and setting seed in the second, such as Bridal Creeper.
- Perennial: Weeds which live for three years or more, such as Geraldton Carnation Weed or Gazania.⁶

² DPaW (1999)

³ NRM Ministerial Council (2007)

⁴ Australian Government (2012b)

⁵ Groves, Boden and Lonsdale (2005)

⁶ CRC for Australian Weed Management (2005a)

2.2 Why Weed Management is Important

Weeds are one of the major threats to Australia's natural environment and biodiversity and can change the natural diversity and balance of ecological communities. Weeds have major environmental, economic, and social impacts in Australia.

Impacts on the natural environment from weeds include:

- Reducing the viability of native plant species by competing more vigorously for space, water and nutrients.⁷ This can result in a decrease in the abundance and health of native species, even to the point of extinction in that area.
- Reducing natural diversity by smothering native plants or preventing them from regenerating after clearing, fire or other disturbance.
- Altering nutrient recycling and soil quality by fixing nitrogen in the soil which can inhibit the germination of native species or releasing nutrients into the soil which may impact negatively on native seedling germination and growth.
- Introducing pests and disease from different areas which native species may not have previously had contact with and may be particularly susceptible to. Weeds can also be more resilient than native plants to certain pests and diseases.
- Creating high fuel loads for fires and increasing the risk of fire in bushland areas.⁸
- Negatively impacting on native fauna by replacing or reducing the native plants and altering plant communities that animals use for shelter, food and nesting.⁹

Weeds can have social impacts on communities by degrading parks, verges, median strips, public access ways and natural areas. Weeds can cause such areas to become degraded and less usable. Weeds impact these areas by lowering the amenity, functionality and aesthetics of sites and make these areas less usable by the community.

A number of weed species have also been linked to health conditions. For example, some common weeds can cause asthma and other respiratory problems, especially in children, cause skin irritation or are poisonous.⁷

2.3 The Effect of Climate Change on Weeds

Global climate change will impact on temperature, rainfall, wind strength, and intensity and frequency of extreme weather events. Predicting the exact scale and nature of climate change at a local level is challenging, and the effect on ecosystems is likely to be complex. The south-west of Western Australia is likely to experience changes in the frequency, duration and intensity of droughts, floods, storms, heatwaves and fire.¹⁰ These conditions create favourable environments for weeds as they are generally able to respond rapidly to disturbances enabling weed species to move into new areas or out-compete native species in their existing range.¹¹

Climate change has the potential to increase the presence of weeds by:

- Creating opportunities for weeds to establish through increased extreme events and resulting disturbance to natural areas.
- Providing weeds that are more readily able to adapt to future climates with a competitive advantage over native species.
- Altering distribution patterns of weed and native species.
- Increasing activity from sleeper weeds which may appear benign for many years, but have the potential to suddenly spread rapidly following certain natural events such as flood, fire, drought, climate change, or change in land or water management.¹²

⁷ Australian Government (2012a)

⁸ FESA (2011)

⁹ City of Joondalup (2012a)

¹⁰ Australian Government (n.d.)

¹¹ Australian Government (2012)

¹² Australian Government (2013)

3.0 Background on Weed Control

The City undertakes an integrated weed management approach to its weed control in natural areas, parks and urban landscaping areas including use of a variety of herbicides, a variety of herbicide application methods and hand weeding.

In determining the appropriate weed control method for a given situation the City takes the following into consideration:

- The target weed
- The season and timing i.e. before seeding
- Resistance of the weed to specific herbicides
- Site location and any special considerations i.e. near wetlands
- Weather conditions i.e. rain and wind
- Rotation of the type of herbicide used to reduce herbicide resistance
- Effectiveness of outcomes, labour intensity required and cost involved.

Weed control involves using a number of methods to reduce weed infestations to manageable levels or if possible to eradicate infestations. Potential weed control methods include:

- Physical weed control – the removal of weeds by physical or mechanical means, such as mowing, grazing, mulching, tilling, burning or by hand.
- Chemical weed control – the use of selective and non-selective herbicides to affect the growth of the weed and cause it to die.

- Thermal weed control – the application of hot water or steam to a weed plant causing it to die.
- Biological weed control – the introduction of a weeds natural enemy (could be an insect or pest, fungi or disease) to reduce its spread and growth.

There are many aspects that need to be taken into consideration when determining appropriate methods of weed control in natural areas, parks and urban landscaping areas. The types of weed control available to the City and their advantages and disadvantages are described in sections 3.1 to 3.4 and detailed in Appendix 6. Further discussion on the use of weed control in particular locations and circumstances is provided in section 4.6.2.

3.1 Physical Weed Control

There are several types of physical weed control methods, including:

- Mechanical or manual – for example hand removal, hand tools, harrows, tractor hoes, brushcutters and mowers.
- Smothering – using materials such as wood chips, newspaper or black plastic.
- Mulching – using organic matter.

Smothering and the use of mulch are not suitable for natural areas as it would also prevent the growth of native seedlings. Mechanical methods using large pieces of equipment or machinery would also create too much disturbance to the native vegetation and soil surface.

The physical removal of weeds through hand weeding can be appropriate in some circumstances. Advantages and disadvantages of hand weeding are provided in Table 1.

Table 1: Advantages and Disadvantages of Hand Weeding¹³

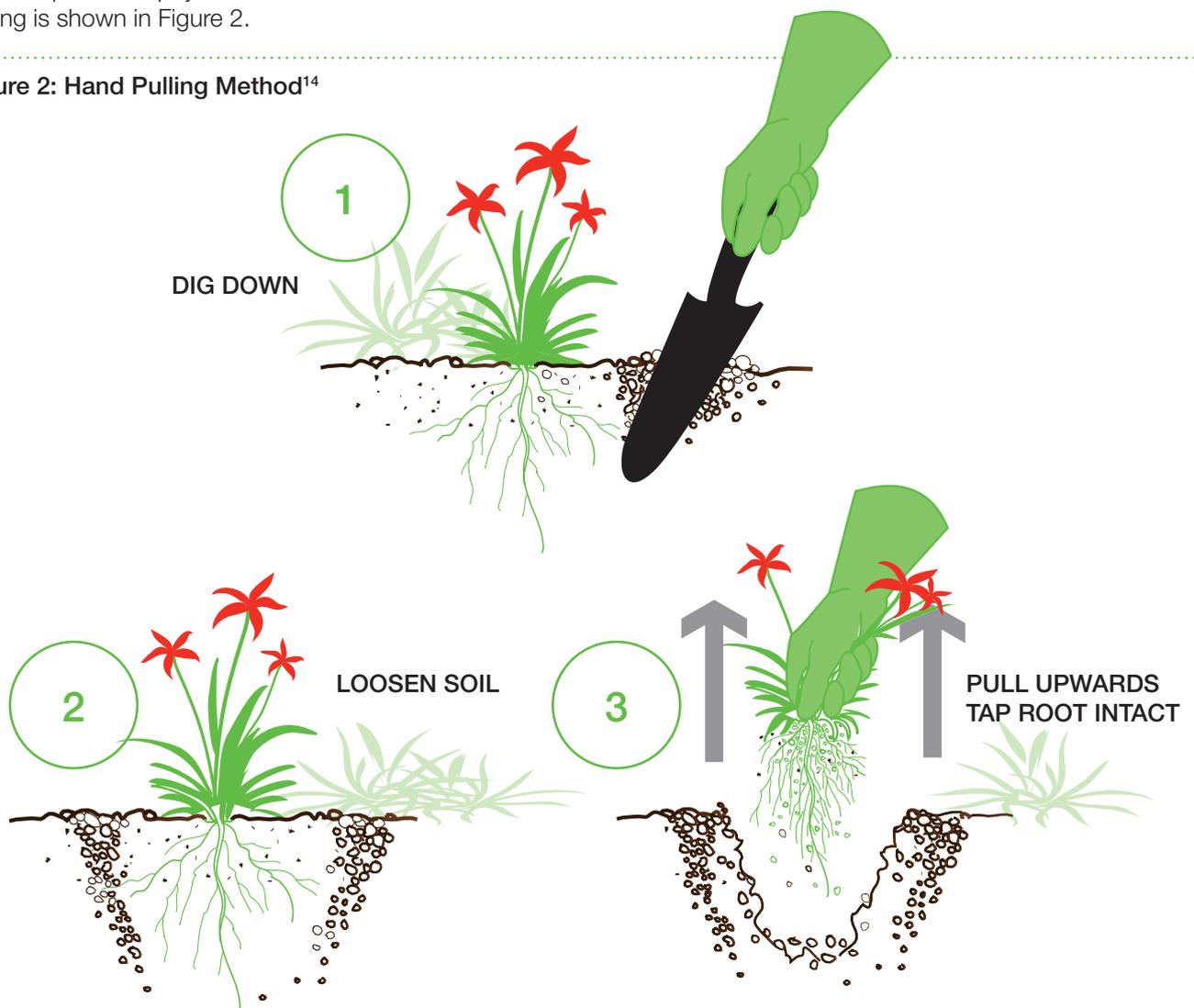
Hand Weeding	
Advantages	Disadvantages
<ul style="list-style-type: none"> • Young plants can be easy to pull out if soil is moist. • Allows for selective removal of weeds. • Can be effective for small infestations. • Avoids the use of herbicides. 	<ul style="list-style-type: none"> • Can be difficult to remove plants if soil is dry or plants are large. • Is time consuming and labour intensive. • Digging can cause soil disturbance and disturb the root systems of native vegetation. • Can result in trampling and destruction of understorey and shrubs (particularly if there are a large number of people conducting hand weeding). • Is not effective for large infestations. • Can make the area more vulnerable to erosion.

¹³ CRC for Weed Management (2004)

Whilst hand weeding has been found to be more time consuming and labour-intensive and less effective than herbicide use, it can form an important part of an integrated weed management approach. Hand weeding using hand tools can be used and may be suitable for many annual species and for relatively small infestations. Hand weeding is particularly useful for the control of herbicide resistant weeds or when herbicides are unable to be used. However it is mainly used for small infestations or as a follow-up to other methods. The City undertakes a small amount of hand weeding. A substantial amount of hand weeding is conducted by Friends Groups volunteers who contribute significantly to weed control in 17 natural areas within the City.

An example of the physical weed control method of hand pulling is shown in Figure 2.

Figure 2: Hand Pulling Method¹⁴



¹⁴ Department of Planning (n.d.)



Acacia Longifolia (Sydney Wattle)

3.2 Chemical Weed Control

Chemical weed control through the use of herbicides can be an effective and practical method of weed control applicable in a variety of situations.¹⁵ Herbicides are defined as 'a chemical substance used to destroy or inhibit the growth of plants, especially weeds'.¹⁶ Herbicides can be selective i.e. work on a specific range of plants or can be broad spectrum/non-selective and work on a wide variety of plants. There are also a number of ways in which herbicides can be applied depending on the situation to ensure specific weeds are targeted.¹⁷

Herbicides are an important and effective component of integrated weed management and are generally recognised as being the most effective weed control method having higher success rates than other forms of weed control. They are also generally the most economical means of weed control, requiring less labour, fuel and equipment than other methods.¹⁵ In some situations herbicides offer the only practical, cost-effective and selective method of managing certain weeds.¹⁸

However, herbicides are chemicals and do have the potential to damage the environment including other plants, fauna and people. The effect of applying herbicides on the environment varies depending on the target weed, chemical properties, rate, distribution and the soil environment. Herbicides vary in the length of time that they persist in the environment. The greater the solubility in water of a herbicide, the larger the distance that it can move through the soil. As well as impacting targeted plants, herbicides can impact on other aspects of the environment such as insects, bacteria, fungi, algae, non-targeted plants, soil and water. Figure 3 outlines some common processes that may occur following herbicide application.¹⁷

¹⁵ Department of Primary Industries (2011)

¹⁶ Houghton Mifflin Company (2009)

¹⁷ CRC for Australian Weed Management (2005a)

¹⁸ Australian Government (2012b)

Figure 3: Processes that may occur following Herbicide Application ¹⁷

What happens to a herbicide after application?

VOLATOLISATION

Some herbicides will readily 'evaporate'. They must be incorporated into the soil to reduce losses.



PHOTO-DECOMPOSITION

Ultraviolet light breaks down some herbicides.

TARGET PLANT

HERBICIDE

NON-TARGET PLANT

SOIL EROSION

Movement of soil can move herbicides too.



LEACHING

Water soluble herbicides can move down through the soil in water.

In water, soluble herbicides can move into the root zone and improve effectiveness.

PLANT UPTAKE

Some unaffected plants can take up and detoxify herbicides.

In water, soluble herbicides can move and kill non-target plants.

ANIMAL UPTAKE

Some worms, nematodes and insects consume herbicides from the soil.



MICROBIAL BREAKDOWN

Some bacteria, fungi and algae in the soil break down herbicides by using them as food.

ABSORPTION

Herbicides attach to surfaces in the soil, permanently, or are slowly released into soil water.



SOIL PARTICLE



In water, herbicides can move out of the root zone and reduce effectiveness.

In water, soluble herbicides can move causing environmental contamination.

Glyphosate is a broad-spectrum and non-selective herbicide effective on annual and perennial plants. Glyphosate currently has the highest global production volume of all herbicides. Glyphosate has been registered by the Australian Pesticides and Veterinary Medicines Authority (APVMA) for over 40 years and there are around 200 products containing glyphosate registered for use in Australia.

The City of Joondalup utilises herbicides in accordance with permits, regulations and label instructions applicable to the specific herbicide. The City endeavours to treat weeds prior to seed set in order to minimise spread.

In 2015 reports investigating the health effects of using glyphosate were released by IARC, an agency affiliated with the World Health Organisation (WHO), the reports classified glyphosate as 'probably carcinogenic to humans', following a hazard-based, assessment of publicly available scientific information. The IARC assessment looked at the intrinsic 'hazard' of the chemical glyphosate as a cancer-causing agent only. Other components of the toxicity of glyphosate are not taken into account.

Following the release of this report the Australian Pesticides and Veterinary Medicines Authority (APVMA) undertook several investigations to determine the risks for people using the formulated chemical product. As Australia's agricultural and veterinary chemical regulator, it is the role of the APVMA to consider all relevant scientific material when determining the likely impacts on human health and worker safety including long and short term exposure to users and residues in food before registering a product. The APVMA considered the full range of risks which include studies of cancer risks and how human exposure can be minimised through instructions for use and safety directions.

The APVMA, in collaboration with the Office of Chemical Safety in the Department of Health, examined the basis for the IARC classification including review of the full monograph related to glyphosate. The APVMA released the findings of its investigations in May 2016 which concluded that products containing glyphosate are safe to use as per the label instructions.

When herbicides, such as glyphosate, are used correctly they can be very effective and have limited negative impact on the environment.¹⁷ The correct application of herbicides involves knowing the target weed, understanding the site conditions, choosing the correct herbicide, choosing the correct application method, ensuring operators are trained and ensuring all regulations and label instructions are followed.

Certain weeds can become resistant to herbicides with repeated application, meaning that herbicides are no longer effective to control those species. There are currently 25 weed species in Australia with populations that are resistant to at least one herbicide group.¹⁹ Five are present in Western Australia and are also present within the City:

- Mediterranean Turnip (*Brassica tournefortii*)
- Patersons Curse (*Echium plantagineum*)
- Wimmera Ryegrass (*Lolium rigidum*)
- Wild Oat (*Avena fatua*)
- Wild Radish (*Raphanus raphanistrum*).²⁰

An integrated weed management approach will reduce the likelihood of weeds becoming resistant to a particular herbicide and will ensure a more effective response to those weeds that are resistant.

The advantages and disadvantages of chemical weed control are provided in Table 2.

Sensitive Facilities

The City considers the following as sensitive facilities:

- School or pre-school
- Kindergarten
- Childcare Centre
- Hospital
- Community Health Centre
- Nursing Home.

Herbicide use adjacent to sensitive facilities is subject to the City's assessment of authorised chemicals process. Additional consideration is given to the timing of herbicide application in the vicinity of sensitive facilities to minimise potential impacts.

Pesticide Use Notification

City residents wishing to be advised in advance of spraying activities, occurring within 100m of their residence, can apply to be added to the City's Notification Register. Residents listed on the Pesticide Notification Register will receive an automated notification at least 24 hours prior to spraying commencing. Further information on the *Pesticide Use Notification Plan* can be found on the City of Joondalup's website at joondalup.wa.gov.au

¹⁷ CRC for Australian Weed Management (2005a)

¹⁹ Department of Agriculture and Food (n.d.)

²⁰ WeedScience.org (2013)

Table 2: Advantages and Disadvantages of Chemical Weed Control

Chemical Weed Control	
Advantages	Disadvantages
<ul style="list-style-type: none"> • Is usually the most effective form of weed control. • Is cost effective for large infestations. • Can be selective (depending on choice of herbicide, timing, plant life cycles, operator skills). • Can prevent weeds seeding and spreading. • Is appropriate on small and large weed infestations. • Minimises direct soil disturbance. 	<ul style="list-style-type: none"> • Weeds can become resistant to particular herbicides. • Some herbicides may be soluble in water and therefore may not be appropriate in wetland or other sensitive areas. • Some herbicides are non-selective and can impact on other plants and animals. • Has potential for negative impacts on the broader environment, such as causing environmental contamination. • Herbicide residue can build up in the soil and affect the growth of native species. • Technical proficiency is required otherwise there may be operator/public hazards.

The City also displays 'caution' signage in areas where herbicides are being applied and until the herbicide has dried. This signage is placed at appropriate locations in all directions to allow the public sufficient warning. A marker dye is mixed with herbicides to indicate where spraying has been conducted in natural areas, other than on dual use paths. The purpose of marker dyes is for staff or contractors spraying herbicides to see which areas have been sprayed, rather than to alert the public about spraying. Caution signage is used to alert the public to avoid areas being sprayed.

Herbicide Use Procedures

When using herbicides the City:

- Uses herbicide products registered by the Australian Pesticides and Veterinary Medicines Authority.
- Follows all regulations and label instructions applicable to the specific herbicide.
- Complies with the Department of Agriculture and Food Western Australia's (DAFWA) Permit to Allow Minor Use of an Agvet Chemical Product for the Control of Environmental Weeds in Various Situations.

- Complies with the relevant Department of Health documents such as:
 - A guide to the use of pesticides in Western Australia.
 - A guide to the management of pesticides in local government pest control programs in Western Australia.
 - Quick contacts for the use of pesticides in WA.
 - *Health (Pesticides) Regulations 2011 – Signage Requirements*.
 - Guidelines for the safe use of pesticides in non-agricultural workplaces.
- Acts in accordance with its internal procedures which outline instructions for training, transport, handling, storage, resident notification, application, records, spills and use of new herbicides.
- Consults resources, such as the DPaW's Florabase website or *Southern Weeds and their Control* (DAFWA Bulletin 4744), in regards to best practice timing and methods of weed control for individual weed species.
- Undertakes assessment of authorised chemicals to determine whether or not more suitable alternatives are available and which also meet safety requirements and reduce potential environmental impacts. The City minimises the use of herbicides, where possible.

3.3 Thermal Weed Control

Thermal weed control involves applying hot water under pressure through a heated chamber on to the weed. The combination of heat and water pressure breaks down the cellular structure, causing discolouration and plant death within hours or over a few days.²¹ Thermal weed control has been suggested as a safer alternative to herbicide use.²² However research and trials into thermal weed control have generally found it to be less effective than chemical weed control, more expensive, uses large amounts of energy, is non-selective and is not practical in natural areas.

Thermal weed control generally kills the upper most portion of the weed and is therefore most suitable for annuals or young perennials. Perennial weeds with deeper roots will generally resprout as the thermal treatment does not affect the deeper root systems.^{21, 23, 24} As a result more repeat treatments are required when using thermal weed control. Thermal weed control has been found to be more expensive as the cost of the application is expensive and it takes longer so the labour costs are higher and more treatments are required.²⁴

Whilst thermal weed control is a non-chemical form of weed control, it also uses large amounts of energy to create the steam and therefore has environmental impacts in relation to greenhouse emissions. It can pose a safety risk to the operator through burns or scalds from the use of the hot steam.

Thermal weed control is not a viable option for the treatment of weeds in natural areas²⁵ because:

- It is non-selective and will therefore also kill non-target species including adjacent native species
- The very high temperatures kill beneficial soil microbes including fungi and bacteria and the soil can become inoculated allowing bad pathogens to replace good microbes
- Once treated, an area is left with rotting organic matter and moisture, which can promote seed germination in the soil increasing the number of weeds immediately following treatment
- The equipment also tends to be large and bulky and is generally unsuitable for accessing natural areas.

Thermal weed control has generally been investigated for use in urban environments, such as on footpaths or kerbs, where concerns about herbicide use are greater and off target impacts are less likely. However thermal weed control in urban environments is still less effective, more expensive and generally does not work as a stand-alone approach in the longer term. While a number of Local Governments have trialed the use of thermal weed control in urban areas with the aim of reducing herbicide use, many have now limited the use of thermal weed control (or stopped using it all together) as it is ineffective in the long term.²⁶

The advantages and disadvantages of thermal weed control are provided in Table 3.

Table 3: Advantages and Disadvantages of Thermal Weed Control

Thermal Weed Control	
Advantages	Disadvantages
<ul style="list-style-type: none"> • Does not involve the use of chemicals and may be appropriate in areas of chemical sensitivity. • Can be effective on annuals and some young perennials. 	<ul style="list-style-type: none"> • Is not suitable in natural areas. • Is more expensive, less effective and requires more repeat treatments. • Is non-selective and can harm adjacent plants. • The high temperatures can kill soil microbes and good bacteria. • May have some results in the short term but not in the long term. • Is carbon and energy intensive. • Equipment is large and bulky and is not suitable for accessing natural areas.

²¹ Department of Primary Industries (2011)

²² Collins (1999)

²³ Banks and Sandral (2007)

²⁴ Banks and Associates (2009)

²⁵ Natural Areas Consulting (2013)

²⁶ City of Nedlands (2013)



Rose Pelargonium (*Pelargonium capitatum*)

The City has undertaken two thermal weed control trials in urban areas and found that herbicides are more effective and less expensive (refer to section 4.7.1). Thermal weed control is not a part of the City's weed management approach due to its expense, lack of portability, long term ineffectiveness and potential for off-target damage.

A report on the effectiveness and cost of hydrothermal and herbicide trial treatments through their application at various locations throughout the City of Joondalup was reported to Council at its meeting held on 15 December 2009. It was noted that hydrothermal was the least effective and most expensive method of weed control and glyphosate and pendimethalin were endorsed for weed control. It was also requested that the City continue to investigate alternatives to herbicide use.²⁷

3.4 Biological Weed Control

Biological control involves using a weed's naturally occurring enemies (usually insects or disease), to help reduce the impact of the weed and achieve sustainable weed control. These natural enemies of weeds are often referred to as biological control agents.²⁸

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) states that '*A biological control agent is generally only used when the cost of conventional control methods such as herbicides, mechanical control or fire is so great, both in dollar terms and impact on the environment, that there is little option than to pursue the biological control avenue*'.²⁹

To develop a new biological control agent requires a substantial investment, adherence to a strict approval process, extensive host specificity testing to ensure it does not pose a threat to non-target species and a risk analysis. It should be noted that not all weeds have biological control agents that would be considered safe for introduction in Australia. Biological control agents have the potential to become pests themselves.²⁹

Biological control is unlikely to eradicate a weed species, but it can reduce a weed population and slow down its invasive potential. Successful programs may take more than 10 years to be effective, and results may vary from area to area. Biological control may be practical and effective for inaccessible areas such as timbered, rocky and steep locations, areas of low-priority for control, or where chemical control may be too expensive or not effective.³⁰

Biological weed control is not a part of the City's weed management approach because it is better undertaken at a regional level rather than a local level, takes too long to have an impact, is often not effective and can be expensive.

²⁷ City of Joondalup (2014)

²⁸ Australian Government (2012c)

²⁹ CSIRO (2013)

³⁰ Department of Primary Industries (2011)

4.0 Natural Areas Weed Management

There are a variety of regionally, nationally and internationally significant natural areas located within the City including seven Bush Forever sites which contain species of high conservation value such as Yellagonga Regional Park. Natural areas of significance adjacent to the City include the Marmion Marine Park and Neerabup National Park. The City also manages 36 natural areas listed in the District Planning Scheme No. 2 Schedule 5 as places having significance for the purpose of protection of the landscape or environment.

The City is committed to conserving and enhancing its natural assets to ensure the long term protection of the environment for future generations.

The City manages over 500 hectares of natural areas in 108 reserves containing significant flora and fauna species and ecological communities.

Environmental threats have the potential to degrade natural areas and reduce biodiversity values. Weeds are one of the key environmental threats to biodiversity in natural areas in the City. The City contains over 200 identified weed species, including eight declared pest plants and five Weeds of National Significance. Effective weed management is required to ensure that measures are taken to prevent, monitor and control the spread of weeds within the City.

In order to protect native vegetation and ecosystems within the City, section 4 of the *Weed Management Plan* addresses natural areas weed management. Section 4 complements the voluntary work of Friends Group volunteers who contribute substantially to weed management in the City's natural areas.

4.1 Purpose

The purpose of section 4 of the Plan is to provide an integrated weed management approach to prevent, monitor and control the spread of weeds in the City's natural areas and conserve biodiversity values.

Section 4 of the *Weed Management Plan* includes the following:

- Description of the City's current weed management approach.
- Identification of weed control measures.
- Recommended integrated weed management strategies to prevent, monitor and control the spread of weeds.
- Development of education initiatives to engage the organisation, stakeholders and the community in order to raise the awareness of weeds and weed management.
- Development of reporting mechanisms to identify weed risks.
- Recommended partnerships with and support for Friends Groups to facilitate weed management and bushland restoration.

4.2 Limitations

Section 4 excludes weed management of the following areas managed by the City:

- Parks
- Verges (apart from natural area verges)
- Medians
- Streetscapes.

Section 4 also excludes land not managed by the City, including but not limited to:

- Private property
- Natural areas managed by other government agencies or landholders, including Woodvale Nature Reserve, Pinnaroo Valley Memorial Park and Ern Halliday Recreation Camp
- Yellagonga Regional Park (jointly managed by the City of Joondalup, Department of Parks and Wildlife (DPaW) and City of Wanneroo). The approach for weed control for this area is outlined in the *DPaW Weed Control and Revegetation Plan (2002)*
- The marine environment.

4.3 Study Area

The study area for section 4 includes natural areas managed by the City as illustrated in Figure 4.

A list of the sites included within section 4 of the *Weed Management Plan* is provided in Appendix 1 and Appendix 2.

Figure 4: City of Joondalup Natural Areas



4.4 Weed Management Site Prioritisation

The City’s current approach to weed management prioritisation of natural area sites and within sites is detailed in the following sections.

4.4.1 Prioritisation of sites

The City has over 200 identified weed species in natural areas, including over 70 priority weeds. The City currently conducts weed management in natural areas on a priority basis using four criteria (in descending order), as shown in Figure 5.

4.4.2 Site Selection

The City ranks management of natural areas according to the Local Biodiversity Program Natural Areas Initial Assessment ranking.³¹ As part of the Local Biodiversity Program, the City assessed all natural areas from 2004 onwards using the ecological criteria of the Natural Area Initial Assessment, resulting in a priority ranking of natural areas.

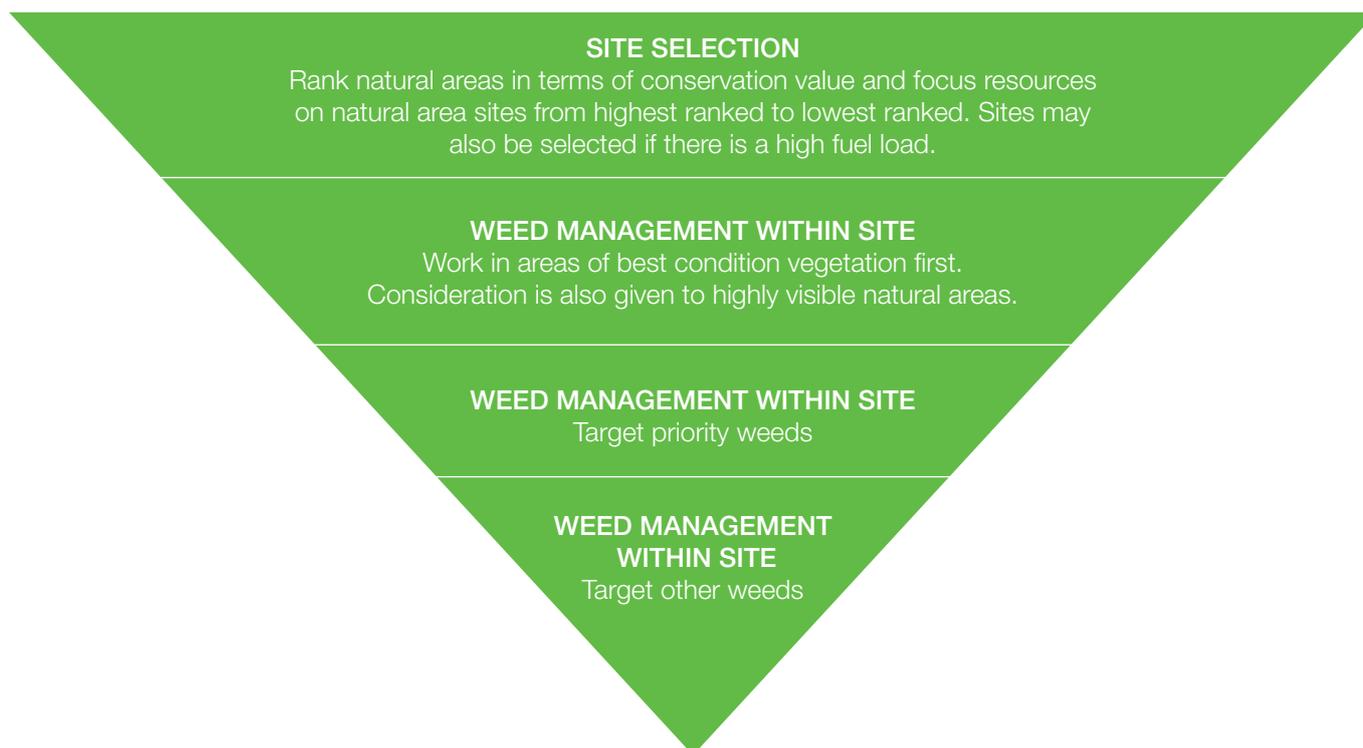
Natural Area Initial Assessments include a desktop assessment and field survey and document information such as:

- Vegetation complexes
- Threatened or significant flora or ecological communities
- Structural plant communities
- Weed species
- Vegetation condition assessment
- Ecological criteria rankings
- A viability estimate
- Fauna species observed.

Priority rankings of sites based on Natural Area Initial Assessments utilise criteria such as:

- Biodiversity conservation value within a regional level (including designated conservation areas, containing significant flora, fauna or ecological communities or forming part of a regional ecological linkage)
- Biodiversity conservation value within a local level
- Representation of ecological communities and amount remaining locally
- Vegetation condition
- Area size of site
- Protection of wetland and coastal vegetation.³²

Figure 5: Criteria currently used to prioritise weed management actions for natural areas



³¹ WALGA (2014)

³² WALGA (2004)

The City reassesses its natural areas every five to seven years using the Natural Areas Initial Assessment tool. The City's natural areas are rated into categories of major conservation (highest ranking), high rated and then medium rated. Natural areas are listed by ratings in Appendix 2. The resources allocated to weed management in natural areas are guided by the ratings of individual sites. Generally the higher the rating of the site, the more resources are allocated to weed management.

Sites may also be prioritised for weed control if they have a high fuel load and are deemed to be a fire risk.

4.4.3 Weed Management within Sites

The City conducts weed management within individual natural areas according to the Bradley Method by focussing on areas of vegetation in best condition first, followed by areas of decreasing vegetation condition. The Bradley Method also encourages minimal disturbance to the environment and allowing for bushland generation in regards to the rate of clearing of weeds.^{33,34} This is implemented primarily to prioritise conservation of the highest biodiversity values. Vegetation condition in major conservation areas is assessed through flora surveys to inform Natural Areas Management Plans every five years. Vegetation condition in other sites is assessed visually by City staff during site inspections. Consideration is also given to highly visible natural areas.

4.4.4 Priority Weeds

The City prioritises weeds based on their invasiveness, ecological impacts, potential and current distribution and feasibility of control. Prioritisation of weeds enables more effective and targeted weed control.

The City classifies environmental weeds as priority weeds if they meet one or more of the following criteria:

- Weed species listed as a Weed of National Significance under the National Weeds Strategy (1997).
- The weed species is listed as a Declared Pest Plant according to the Department of Agriculture and Food (2011).
- The weed species is a High Priority Weed according to the Environmental Weed Strategy for WA (DPaW 1999).
- The weed species is listed as Very High Priority or High Priority weed according to the DPaW Weed Prioritisation Process for the Swan Region (2013).
- The weed species is listed as a pest plant under the City's *Pest Plant Local Law 2012*.
- The City has determined that the weed species: poses a major threat to vegetation or the structure of vegetation communities; is likely to lead to a significant outbreak of individual weed species; and/or contributes to a high fuel load (e.g. grasses).

A summary of priority weeds identified in the City according to criteria are listed in Table 4. A detailed list of priority weeds can be found in Appendix 5.

Table 4: Priority Weeds Identified in the City of Joondalup According to Criteria (2014)

Priority Weed Criteria	Number of Priority Weeds Identified within City of Joondalup
<i>National Weeds Strategy 1997</i>	Five weeds of National Significance
<i>Biosecurity and Agriculture Management Act 2007</i>	Eight declared pest plants
<i>Environmental Weed Strategy for Western Australia 1999</i>	22 high rated weeds
<i>DPaW Weed Prioritisation Process for Swan Region 2013</i>	Two very high and 18 high rated weeds
<i>City's Pest Plant Local Law 2012</i>	One pest plant

³³ Leschenault Catchment Council (n.d.)

³⁴ AABR (2013)

4.4.5 Integrated Weed Management Approach

Integrated weed management involves using a variety of different techniques to monitor, prevent and control weeds and keep weed densities at a manageable level. Using a variety of control methods, rather than just one, also ensures weeds are less able to adapt to the control methods used and less likely to become herbicide resistant.³⁵ An integrated approach is required for effective weed management, and therefore the management of weeds within the City includes:

- Weed monitoring
- Weed prevention
- Weed control (physical and chemical)
- Education and training
- Partnerships with external stakeholders.

4.5 Weed Monitoring

Ongoing monitoring of the City's natural areas is critical to ensuring the long term management of biodiversity within the City. Weed monitoring is important for identifying areas with weed populations, weed spread, discovering new weeds on a site, protecting significant native flora species and for measuring the effectiveness of weed control measures. Weed management can be modified according to weed monitoring results.

There are numerous different approaches to weed monitoring including weed mapping, taking of photographs, identification of weed species and their distribution (observational weed monitoring) and the use of high resolution multi-spectral imagery.

4.5.1 Weed Mapping

Weed mapping involves recording weed populations and distribution and is a form of weed monitoring.

Weed mapping is useful to:

- Identify and locate weed species to inform management plans and actions
- Record progress in weed management
- Provide a historical record to guide management actions
- Inform weed management at a Local Government level.³⁶

Current Management Approach

Weed mapping is conducted on a regular basis through City inspections of natural areas to establish the extent of weeds and to identify priority weed species. The outcomes from weed mapping inform the on ground weed management program. Inspections of the City's natural areas are conducted according to the Annual Maintenance Schedule which prioritises sites and the frequency of inspections, i.e. major conservation areas are scheduled for monthly inspections. During inspections, key priority weeds and maintenance issues are identified and marked on site maps as prioritised actions. These actions are then undertaken during the following maintenance visit to the site, if possible.

The City engages consultants to undertake flora, fauna and fungi surveys of the major conservation areas to inform the development of Natural Areas Management Plans. The surveys document components of biodiversity and make recommendations to minimise ecological impacts. Weed mapping is conducted as part of this survey with occurrences of priority weed species being recorded and mapped for individual natural areas. The flora and fauna surveys also identify vegetation condition and threatened and priority flora and fauna species on site. Information from flora and fauna surveys is utilised during City inspections of natural areas (through inspection maps) and used to inform maintenance visits.

Identification of weed species and their distribution is also undertaken approximately every five to seven years when the City undertakes its assessment of high priority and medium priority natural areas using the Natural Areas Initial Assessment tool and in accordance with the Natural Areas Assessment Schedule.

Recommended Weed Mapping Management Actions

Continue mapping of key priority weeds through regular inspections of natural areas in accordance with the Annual Maintenance Schedule to inform on ground weed management actions.

Through the development of Natural Areas Management Plans, continue undertaking flora, fauna and fungi surveys of the major conservation areas every five years to inform on ground weed management actions.

Continue to incorporate information from flora, fauna and fungi surveys into IntraMaps regarding vegetation condition and priority flora and fauna.

³⁵ CSIRO (2011)

³⁶ Australian Weeds Committee (n.d.)

Continue to assess high priority and medium priority natural areas every five to seven years using the Natural Areas Initial Assessment Tool, including identification of weed species and their distribution in accordance with the Natural Areas Assessment Schedule.

4.5.2 Photo Monitoring

Photo monitoring is a photographic record to assess changes occurring in vegetation over time at individual sites taken consistently from the same location. Photo monitoring can be used to assess the effectiveness of weed control on site and could focus on the management of a particular target weed or the recovery of native vegetation. Photo monitoring also requires recording information such as the date, time, location and GPS data.

Current Management Approach

Photo monitoring is not currently conducted within the City.

Recommended Management Approach

It is recommended to investigate the benefits of commencing photo monitoring in the City’s major conservation areas when measuring the natural areas key performance indicator annually to assess the effectiveness of ongoing weed control.

Recommended Photo Monitoring Management Action

Consider the use of photo monitoring in major conservation areas when measuring the natural areas key performance indicator annually to assess the effectiveness of ongoing weed control.

4.5.3 Observational Weed Monitoring

Observational weed monitoring can be conducted using permanent quadrats or transects to visually assess the percentage cover of weeds, as an indicator of vegetation health. Observational weed monitoring can guide weed control efforts and assess effectiveness of weed management actions.

Current Management Approach

The City measures the percentage cover of environmental weeds annually at the same time of year. Data is collected in ten of the City’s key natural areas through three transects on each site. The City’s density of environmental weeds has generally been decreasing over the past nine years due to increased weed management, as shown in Figure 6.

Observational weed monitoring using quadrats has previously been conducted at Warwick Open Space

and Craigie Open Space. Grasses in Warwick Open Space and *Lachenalia reflexa* in Craigie Open Space were monitored annually using quadrats to estimate weed density.

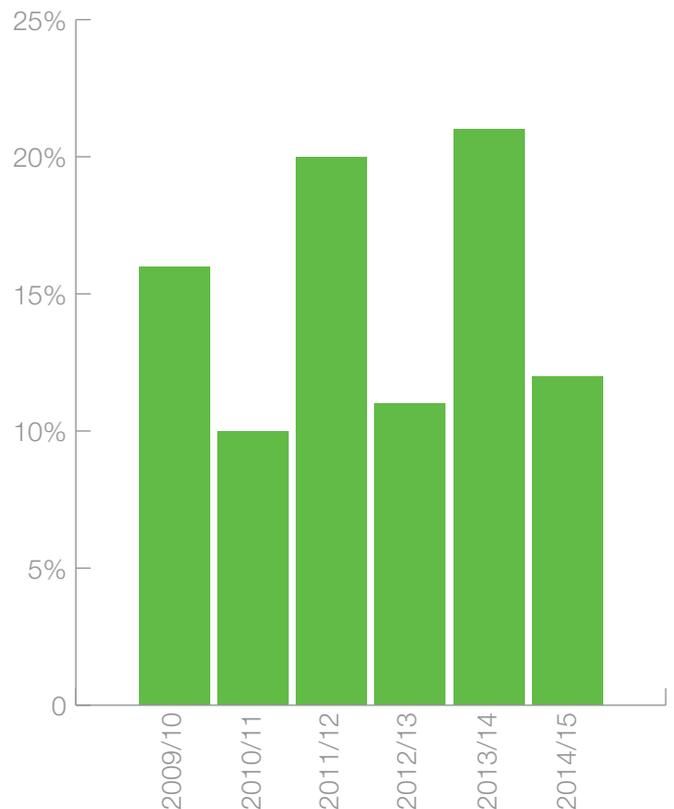
Recommended Management Approach

It is recommended that the City continues to measure the percentage cover of weeds annually in key natural areas, at the same time of year, as an indicator of vegetation health.

Recommended Observational Weed Monitoring Management Action

Continue to measure the percentage cover of weeds annually in key natural areas at the same time of year, as an indicator of vegetation health.

Figure 6: Indicator – Percentage Cover of Environmental Weeds



4.5.4 High Resolution Multi-spectral Imagery

High resolution multi-spectral imagery is aerial imagery that is composed of small pixels to allow for direct recognition of features of interest. The imagery includes a near-infrared spectral band that is sensitive to changes in chlorophyll and cell structure of vegetation and can be utilised to assess changes in the vigour and condition of trees and plants over time.³⁷ The imagery has the potential to provide information on the distribution and density of weeds in natural areas and the progress of weed management within natural areas.

The City currently acquires high resolution multi-spectral imagery of the City of Joondalup every two years, as recommended in the *Pathogen Management Plan*.

Current Management Approach

High resolution multi-spectral imagery using aerial photography was acquired for the whole of the City in 2012 and 2014 as datasets to analyse vegetation health and cover, as recommended in the *Pathogen Management Plan*. The *Pathogen Management Plan* also recommends that this data is acquired every two years. This information could also be analysed for weed distribution and density.

Recommended Management Approach

It is recommended that the City investigates analysing the high resolution multi-spectral imagery of parks and natural areas every two years for weed distribution and density to enable the ongoing monitoring of weed management within the City. High resolution multi-spectral imagery weed monitoring would be more precise, objective and extensive than the current annual weed monitoring methods using transects.³⁸ The estimated cost to analyse high resolution multi-spectral imagery for weed monitoring is \$12,000 every two years.

Recommended High Resolution Multi-spectral Imagery Management Action

Investigate the feasibility of analysing high resolution multi-spectral imagery of parks and natural areas every two years in order to monitor weed distribution and density.

4.6 Weed Prevention

Control of weed species can be both costly and labour intensive. Preventing weed establishment within natural areas is one of the most effective approaches to weed management.³⁹

Examples of ways that weeds can establish that can be addressed by the City include:

- Weeds seeds being attached to footwear, clothing or vehicles
- Introduction through landscaping materials;
- Movement via stormwater
- Garden rubbish dumping
- Post fire opportunities
- Fire prevention activities such as creating fire breaks and access ways.

The City can directly prevent the introduction of weeds through minimising access and disturbance, undertaking weed hygiene measures and minimising the impacts from fire prevention activities when operating in natural areas; see sections 4.6.1, 4.6.2 and 4.6.3.

The City can also indirectly prevent weed introduction and spread by educating the community on how they can prevent weeds by not dumping rubbish in natural areas, minimising disturbance of vegetation, undertaking weed hygiene measures and not planting species that have the potential to become bushland weeds.⁴⁰ Actions that community members can take to prevent weeds are described in more detail in section 7.1.

4.6.1 Minimising Access and Disturbance

Accessing natural areas for maintenance or management activities can cause disturbance, creating opportunities for weeds to invade or establish.

Accessing natural areas off paths or tracks, whether by vehicle or foot, can trample or disturb vegetation and soil and create bare surfaces. These bare surfaces create space and opportunities for weeds to establish or spread into. Accessing natural areas off paths or tracks is required for rubbish removal, weed control or revegetation activities.

Current Management Approach

City staff and contractors regularly access natural areas to undertake management activities such as weed control, removing rubbish, undertaking revegetation activities and regular inspections and monitoring. During these activities sites may be accessed by vehicles and/or foot and a variety of machinery and equipment may be used. Wherever possible, vehicle access on-site is avoided. When vehicles are on site they are kept on tracks and avoid disturbing vegetation where possible.

³⁷ City of Joondalup (2013)

³⁸ ArborCarbon (2014)

³⁹ State Weed Plan Steering Group (2001)

⁴⁰ DSEWPC (2012)a

Pedestrians also remain on tracks where possible. Care is taken when operating machinery or equipment to minimise the impact on vegetation and soil surfaces.

Recommended Management Approach

It is recommended that City staff and contractors continue to minimise disturbance to vegetation when accessing natural areas by vehicles, equipment and people remaining on tracks, where possible, during management and maintenance activities to reduce the establishment and spread of weeds.

Recommended Minimising Access and Disturbance Actions

Ensure City staff and contractors minimise disturbance to vegetation when accessing natural areas by vehicles, equipment and people remaining on tracks, where possible, during management and maintenance activities to reduce the establishment and spread of weeds.

4.6.2 Weed Hygiene

Weed hygiene is an important weed prevention measure to protect native vegetation from the introduction or spread of weed species through the movement of people, equipment, vehicles or landscaping materials. Weed material or weed seeds can become attached or lodged in footwear, vehicles and equipment and then transported into natural areas where they weren't found previously. Weed material or weed seeds can also be found in landscaping supplies such as plant stock, compost or mulch. Weed hygiene involves practices to ensure only clean and weed free vehicles, equipment, footwear, landscaping supplies and materials are entering natural areas. This is essential for preventing the introduction of weeds or further spreading weeds throughout natural areas.

Weed hygiene practices should be undertaken when:

- City staff or contractors are entering or leaving natural areas
- Landscaping supplies are being used in or adjacent to natural areas
- City staff or contractors are undertaking landscaping, maintenance or weeding activities in or adjacent to natural areas.

Current Management Approach

Staff and contractors conducting hand weeding in natural areas ensure that weeds are bagged and disposed of off-site to prevent weed spread.

City staff and contractors currently conduct weed hygiene practices of cleaning and brushing down soil and weed seeds from vehicles, machinery, equipment, tools, footwear, and clothing before they enter and leave key natural areas.

The supply of plant stock, mulch, soil and compost that contain weeds is a common way for weeds to establish within an area. The City undertakes revegetation along the coast and in bushland areas, as required. The majority of plant stock used for revegetation is grown at the City nursery and consists of plants, soil, Perlite and Vermiculite. The majority of the remaining plant stock that needs to be supplied is purchased from Nursery Industry Accreditation Scheme Australia (NIASA) accredited nurseries and the City currently purchases Australian Standard certified mulch and potting mix.

To provide guidance to City staff and contractors weed hygiene practices, the City has developed *Pathogen and Weed Hygiene Guidelines* and *Purchasing Guidelines for the Supply of Landscaping Materials*.

Recommended Management Approach

In order to reduce the risk of spreading weeds between vegetated areas, it is recommended that City staff and contractors clean and brush down soil and weed seeds from vehicles, machinery, equipment, tools, footwear, and clothing before they enter and leave key natural areas, in accordance with the City's *Pathogen and Weed Hygiene Guidelines*.

It is recommended that the City continues to purchase plant stock, mulch, soil and compost that comply with the City's *Purchasing Guidelines for the Supply of Landscaping Materials*, to eliminate the likelihood of introducing weed seeds.

Recommended Weed Hygiene Management Actions

Implement the *Pathogen and Weed Hygiene Guidelines*, to provide direction to staff and contractors working within the City's natural areas and parks in order to limit the spread of weeds within the City.

Implement the *Purchasing Guidelines for the Supply of Landscaping Materials* to provide information to City staff and contractors relating to the purchase of plant stock, soil, mulch compost and other materials for City parks and natural areas.

4.6.3 Fire Management and Response

Whilst fire is an important natural feature of the Australian landscape, human activity such as accidents and arson have resulted in increased incidences of fire within bushland reserves, which can have a negative effect on biodiversity and encourage growth of highly flammable and invasive weeds.^{41,42}

Natural areas may be disturbed and provide opportunities for weeds to invade or establish through the following fire related activities:

- Fire occurrences
- The construction or maintenance of firebreaks
- Emergency services responding to fire events including use of emergency vehicles and fire suppression activities.

Current Management Approach

The City monitors natural area fire occurrences through reports requested from DFES every five years. From these reports, natural areas with continued incidents of arson are identified. City Rangers increase patrols over a period of several months on problem sites in order to deter further arson incidents, where possible. The City does not currently have a prescribed burn management regime.

The construction and maintenance of firebreaks is an important and necessary fire prevention tool, however it also requires the clearing of native vegetation and allows opportunities for weeds to spread. The City complies with the *Bush Fires Act 1954* which requires firebreaks immediately inside and around all external boundaries of the land.⁴³ In addition to this the City constructs fire access ways within natural areas, where necessary, to ensure access for emergency vehicles and fire suppression activities in the event of a fire.

When a fire incident does occur; the response of DFES and the necessary fire suppression activities can also disturb vegetation and soil surfaces. In particular the use of high pressure hoses to suppress fire and the movement of vehicles can have a significant impact. Where possible care should be taken to minimise disturbance, however the City is mindful that the emergency situation takes precedence and that the City can not directly control the response of emergency services.

The City developed a *Fire Weed Management Guideline* to inform staff and contractors about weed management whilst developing and maintaining fire breaks and access ways.

Recommended Management Approach

The creation of fire breaks and access ways create large bare surfaces devoid of native vegetation and provide prime conditions for weed establishment as all competition for light, nutrients, moisture and space have been removed.⁴⁴ Where possible, to minimise impacts when constructing and maintaining firebreaks and fire access ways, the following should be considered:

- Undertake construction and maintenance activities on non-windy days to reduce weed seed dispersal
- Dispose of any weeds removed during construction and maintenance off-site
- Consider whether the placement of new fire access ways can take advantage of existing poorly degraded vegetation rather than clearing vegetation in good condition
- Ensure that adequate access ways are provided to minimise the need for vehicles to move off access ways into vegetated areas.

Recommended Fire Management and Response Actions

Continue to request natural area fire occurrence reports from DFES every five years to identify locations with continued incidents of arson. Where possible, increase City Rangers patrols in problem areas to deter arson and the resulting encouragement of weed growth.

Implement the *Fire Weed Management Guideline* to inform staff and contractors about weed hygiene when constructing and maintaining firebreaks and access ways.

Consider post fire revegetation in natural areas to prevent weed spread, on an as required basis.

4.7 Weed Control

While weed prevention is important for reducing new infestation of weeds from occurring or spreading in natural areas; weed control is necessary for reducing or eradicating weed infestations already occurring in natural areas. While weed control can be an expensive and time consuming exercise, failure to control weeds can have significant environmental impacts including displacing native plant species, harbouring pests and diseases and creating fuel loads for fire. Weeds also alter the structure and distribution of plant communities which has a negative impact on native flora and fauna. Weed control is necessary to protect and restore diverse natural ecosystems.⁴⁵ The City currently uses hand weeding and herbicide weed control methods in natural areas.

⁴¹ City of Joondalup (2012a)

⁴² City of Joondalup (2012b)

⁴³ DFES (2013)

⁴⁴ FESA (n.d)

⁴⁵ Brown and Brooks (2002)

Current Management Approach – Hand Weeding in Natural Areas

Hand weeding is used in natural areas as part of an integrated approach. This includes use of hand weeding for smaller infestations, for herbicide resistant weeds or as follow up to herbicide application. Widespread hand weeding is not used as it is labour intensive and, if applied inappropriately, can result in negative impacts to native vegetation by disturbance of the soil surface and may lead to erosion.

Current Management Approach – Herbicide Use in Natural Areas

Herbicides are used in the City as they are effective on large weed populations and can be economical compared to other weed control techniques. Methods of herbicide application used include blanket spray, spot spray, cut and paint, basal bark treatment and wick wiping. Appendix 6 provides further details on these different methods of herbicide application. The City implements herbicide use in natural areas in accordance with the Annual Maintenance Schedule.

To prevent herbicide resistance the City incorporates herbicide rotation into its Annual Maintenance Schedule. If herbicide resistant weeds are identified, the City either utilises alternative herbicides or undertakes hand weeding.

The City schedules its herbicide application according to rainfall and temperature in order to increase its effectiveness and minimise any adverse impacts. Hand weeding or maintenance is conducted when it rains, rather than using herbicides. Where possible, herbicide application is scheduled prior to seed production and within a few weeks of the first winter rainfall.

The City conducts flora surveys including vegetation condition assessments in key natural areas every five years. Information obtained from the flora surveys is utilised by the City to create vegetation condition maps which are used to guide weed control activities and prioritise works in best condition vegetation areas on sites.

The City partners with agencies or organisations to trial new forms of weed control, such as the Department of Parks and Wildlife.

City staff use herbicides in accordance with the City's Spraying Chemicals Work Instruction, an internal procedure in the ISO 9001 Quality Management System (QMS). The Spraying Chemicals Work Instruction is reviewed internally in accordance with the QMS.

City staff display caution signage when herbicides are being applied at appropriate locations until the herbicide

has dried, to allow the public sufficient warning. Caution signage is displayed in accordance with the Department of Health *Health (Pesticides) Regulations 2011* Signage Requirements.

Recommended Management Approach – Herbicide Use in Natural Areas

It is recommended that the City continues using an integrated weed management approach that includes physical and chemical weed control methods.

A formal register of herbicide resistant weeds, including locations and date identified, would enable ongoing monitoring and control of herbicide resistant weeds in the City. Research on herbicide rotation could be conducted to increase the effectiveness of herbicide use. The City could also investigate further opportunities to partner with agencies or organisations to trial new forms of weed control.

It is recommended that City staff continue to use vegetation condition maps from flora surveys conducted in key natural areas every five years to guide weed control activities and prioritise works in best condition vegetation areas on site. Maps are also to be provided to contractors.

The occurrence of aggressive weed species in areas previously free of the weed has the potential to impact on the structure of plant communities in a short period of time. The City should continue to monitor for new weed species and undertake control as a priority in order to eliminate the species and reduce the risk of spread.

It is proposed to continue to review the City's Spraying Chemicals Work Instruction, as part of the ISO 9001 Quality Management System.

It is recommended that the herbicide mixing volume rate by City staff and contractors be audited a minimum of twice per year, to ensure compliance with the applicable regulations and label instructions.

It is recommended that the City conduct regular auditing in accordance with the ISO 9001 Quality Management System regarding the use of caution signage by City staff and contractors when spraying herbicides, to ensure signage is left in place until herbicides are dry and compliance with the Department of Health *Health (Pesticides) Regulations 2011* Signage Requirements.

Recommended Weed Control Management Actions

Continue to implement weed control in natural areas in accordance with the Annual Maintenance Schedule.

Create a register of herbicide resistant weeds including locations and date identified to enable monitoring and control.

Conduct research or trials on herbicide rotation to increase the effectiveness of herbicides, as required.

Investigate opportunities to partner with agencies or organisations to trial new forms of weed control.

City staff are to continue to use vegetation condition maps from flora surveys conducted in key natural areas to guide their weed control activities and prioritise works in best condition vegetation areas on site. Maps are also to be provided to contractors.

Continue to monitor for new aggressive weed species and undertake control as a priority to eliminate the weed species and prevent spread.

Continue to review the City's Spraying Chemicals Work Instruction in accordance with the ISO 9001 Quality Management System.

Conduct audits a minimum of twice per year of City staff and contractors herbicide mixing volume rate, to ensure compliance with the applicable regulations and label instructions.

Conduct regular auditing in accordance with the ISO 9001 Quality Management System regarding the use of caution signage by City staff and contractors when spraying herbicides, to ensure signage is left in place until herbicides are dry and compliance with the Department of Health *Health (Pesticides) Regulations 2011* Signage Requirements.

4.7.1 Research and Trials

Weed control methods are improving over time as technologies and research become available. Weed control research and trials can assess the effectiveness of different weed control methods and inform the best weed management approach.

Table 5: Weed Control Trials undertaken in the City of Joondalup

Timeframe	Trial	Outcomes
2006 – 07	Use of certain herbicides to control One-leaf Cape Tulip (<i>Moraea flaccida</i>) in Iluka	The trial indicated a negative effect on native flora in soils with high pH values and the outcomes informed the future use of herbicides to control One-leaf Cape Tulip.
2007	Report on Weed Control using Hot Water/ Steam and Herbicides in the City of Joondalup (Urban areas only)	Found that herbicides are more cost effective and have better kill rates than thermal weed control methods. The cost advantages and speed of application indicate that herbicides are suitable for large scale operations. ⁴⁷
2009	Weed Control Trials comparing Hydrothermal and Herbicides in the City of Joondalup (Urban areas only)	Thermal control was found to be ineffective for long term weed control. ⁴⁸
2013 – 14	Effectiveness of hand weeding and herbicide methods in Central Park, Joondalup and Mullaloo Beach Foreshore ⁴⁹	The outcomes of the trial indicated that the use of herbicides combined with hand weeding was the most effective but also most expensive form of weed treatment, as compared to the use of herbicides only. The use of herbicides only was found to be the second most effective form of weed treatment but was less expensive.

⁴⁷ John Banks and Associates (2007)

⁴⁸ John Banks and Associates (2009)

⁴⁹ Natural Area Consulting (2013)

Current Management Approach

The City has undertaken a number of weed control trials, as shown in Table 5. The City has conducted trials on thermal control methods in urban areas. The unsuitability of using thermal control methods in natural areas is well documented and therefore has not been trialled by the City.⁴⁶

The City has also trialled Controlled Droplet Applicators (CDA) to apply herbicides within natural areas. The applicators provide a more targeted and efficient means of delivering herbicides and reduce the risk of spray drift. Conventional herbicide application technologies (back packs and hand held motorised spray guns) apply up to thirty times more volume than hand held CDA's. The use of the devices will continue with ongoing monitoring to measure the effectiveness.

Recommended Management Approach

The City should continue to investigate opportunities to trial new methods of weed control methods as they become available.

Recommended Weed Research and Trials Management Actions

As technology and research improves, investigate opportunities for the City to trial new weed control methods.

4.7.2 Weed Control in Specific Circumstances

Specialised weed management activities are required for weed control in specific circumstances including identification of new populations of weeds, weed control on verges and post-fire weed management.

New Weed Populations

Early identification of new weed populations in the City can enable their eradication or containment, particularly if they can be removed before they produce seed.³⁹ New weed populations could include weeds previously unidentified in the City or weeds previously unidentified on specific sites.

Weed Control on Verges

Weeds can spread into natural areas from adjacent verges. Effective weed control of verges adjacent to nearby areas minimises the risk of weed spread.

Weed Control Post-Fire

The City has fire occurrences in natural areas on a frequent basis. For example, there were seven fire occurrences in Lilburne Park, Duncraig in 2013. DFES is responsible for fire eradication, whilst the City is responsible for post fire weed management.

The disturbance of fire in bushland can create an opportunity for rapid growth of competitive weed species with minimal competition from native plants. Weed species may have established a long-term soil seed bank that is triggered to germination by fire. Weed species are quick to exploit the favourable conditions immediately after fires, germinating prolifically and spreading vigorously in the first few seasons.

After a fire there will be a reduction in groundcover and understorey vegetation, as well as a loss of fauna species dependent on that habitat. There is the potential for soil erosion until vegetation regenerates, particularly if significant rainfall occurs.⁵⁰

Equipment, machinery and vehicles involved in fire response and water flow across bare ground can inadvertently spread weed seeds into areas where the weed species were not previously established, decreasing the condition of the vegetation community. Weed species can compete with and reduce the ability of native plants to re-establish.⁵¹ Perennial Veldt Grass (*Ehrharta calycina*) is a species of weed that often establishes itself after fire.⁵¹

Current Management Approach

New Weed Populations

When new weed populations are identified in the City they are assessed and controlled as required. These populations are then monitored through regular site inspections.

Weed Control on Verges

The City conducts weed control on verges of key natural areas consisting of increased mowing of verges to reduce seed spread, spraying of weeds and spreading of certified mulch, where required.

Weed Control Post-Fire

In order to minimise weed occurrence in natural areas post fire, a *Fire Weed Management Guideline* has been developed. After a fire occurrence the City maps the fire scar information on IntraMaps to monitor fire frequency on individual sites. The City also obtains information from DFES regarding fire occurrence history for sites.

⁴⁶ Natural Areas Consulting (2013)

⁵⁰ Willoughby City Council (n.d.)

⁵¹ Brown and Brooks (2002)

The City allows for approximately three months of natural vegetation regeneration after fire before commencing weed control activities. This period of time prevents disturbance and allows native seedlings to resprout.

Regrowth of weeds are then managed prior to seeding with targeted herbicides. To ensure weed species do not reach an intense level of infestation timely post-fire management action (usually within 18 months) is necessary for containment. Weed control activities are ongoing in all City managed natural areas.

Recommended Management Approach

It is recommended that the City create a register of new weed populations including records of location, date and priority ranking to assist the City to track and monitor new weed populations.

The City should continue to undertake weed control on areas adjacent to the City's natural areas to prevent the spread of weeds into these natural areas.

Implementation of the *Fire Weed Management Guidelines* is recommended to ensure a consistent approach to weed management post fire occurrences, including the consideration of post fire revegetation in natural areas to prevent weed spread, on an as required basis.

Recommended Weed Control in Specific Location Actions

Create a register of new weed populations identified in the City to enable monitoring and weed management.

Continue to conduct weed control on verges adjacent to key natural areas including increasing mowing of verges to reduce weed seed spread, spraying of weeds and spreading of certified mulch, where required.

Implement the *Fire Weed Management Guidelines* to limit the infestation of weeds in the City's natural areas.

4.8 Partnerships

There are many organisations that also have roles and responsibilities in weed management including State government, other local governments, natural resource management agencies, research organisations and Friends Groups.

Local Friends Groups are an important partner of the City in managing natural areas and reducing weeds and contribute substantially to bushland conservation. The City's 14 Friends Groups voluntarily contributed 7,384 hours in 2013/14 towards bushland restoration in 17 natural areas. Friends Groups are involved in a variety of activities including weed control, for their chosen reserve,

with the aim of restoring the reserve's conservation values and the community's appreciation for the natural environment.

Current Management Approach

The City liaises with a variety of external stakeholders regarding weed management, such as Department of Parks and Wildlife, Department of Agriculture and Food WA, Water Corporation, other local governments (e.g. City of Wanneroo and City of Stirling), universities, schools and Friends Groups.

The City works with Friends Groups to protect, maintain and enhance natural areas and assist Friends Groups through the provision of special purpose grants that can be used for weed control activities and assisting with on-ground works, including weed control. The City has also developed the *City of Joondalup Natural Areas Friends Group Manual* to provide an appropriate framework and process for City support of Friends Groups and volunteers including recognising roles and responsibilities and ensuring environmental best-practice issues such as weed management are understood and implemented.⁵²

Recommended Management Approach

The City should continue to investigate opportunities to partner with stakeholders, research institutions and community groups to enable the City to build capacity and gain information relating to best practice approaches to weed management.

City staff should continue to regularly participate in research projects and take up opportunities for sharing information to ensure the City is implementing best practice approaches to the management of weeds.

The City will ensure that the *Weed Management Plan* is publically available to facilitate information sharing and enable a consistent approach to weed management for City staff and the community.

Recommended Partnerships Management Action

Continue to investigate opportunities to participate in research projects and take up opportunities for sharing information relating to best practice approaches to weed management.

Continue to partner with and support local Friends Groups to facilitate bushland restoration and weed management activities.

⁵² City of Joondalup (n.d.)d

5.0 Parks and Urban Landscaping Areas Weed Management



Fleabane (*Conyza spp.*)

The City manages over 370 parks and reserves and a substantial number of urban landscaping areas such as streetscapes, pedestrian access ways, sumps and swales.

5.1 Purpose

The purpose of section 5 of the Plan is to provide an integrated weed management approach to prevent, monitor and control the spread of weeds and conserve the amenity, aesthetics and functionality of the City's parks and urban landscaping areas.

Section 5 of the *Weed Management Plan* includes the following:

- Description of the City's current weed management approach.
- Identification of weed control measures.
- Recommended integrated weed management strategies to prevent, monitor and control the spread of weeds.

5.2 Limitations

Section 5 of the *Weed Management Plan* excludes weed management of natural areas managed by the City and land not managed by the City such as private property.

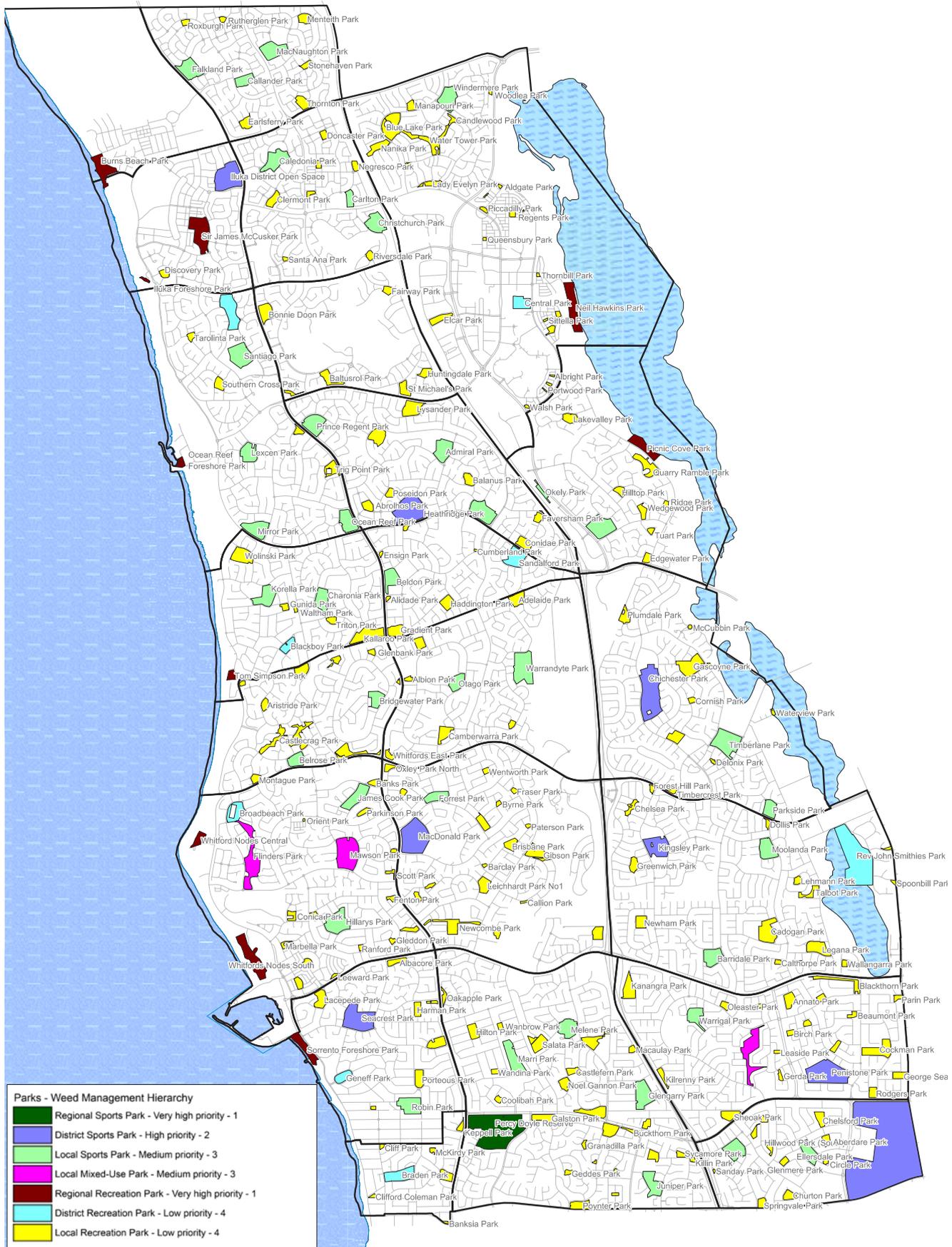
5.3 Study Area

The study area for section 5 includes parks and urban landscaping areas managed by the City. Urban landscaping areas managed by the City include the following:

- Streetscapes
- Pedestrian access ways (PAWs)
- Sumps and swales.

The parks managed by the City are shown in Figure 7 and detailed in Appendix 7. Urban landscaping areas are not shown or detailed due to the large number of such areas within the City.

Figure 7: Parks Managed by the City of Joondalup





Bridal Creeper

5.4 Service Agreements

The City manages several locations with service agreements, such as Specified Area Rates (SAR) service agreements for the provision of enhanced landscaping services.

Specified Area Rates Service Agreement

A SAR is an additional rate charge that is applied separately to designated areas within the City by agreement with the residents association. These rates cover additional maintenance costs for landscaping services (including weed management) over and above services usually provided by the City.

There are currently three areas within the City that have an applied SAR:

- Iluka
- Woodvale Waters Estate, Woodvale
- Harbour Rise Estate, Hillarys.

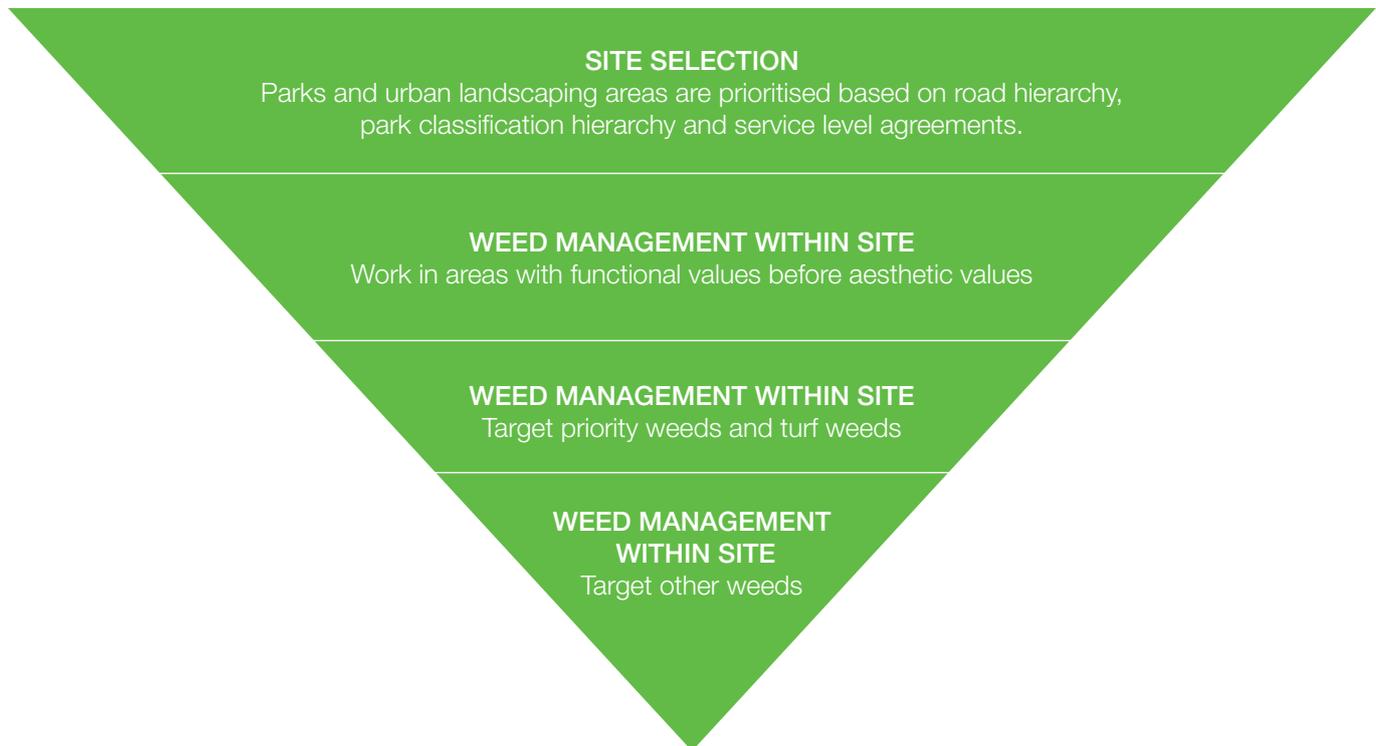
5.5 Weed Management Site Prioritisation

The City's current approach to weed management prioritisation of parks and urban landscaping area sites and within sites is detailed in the following sections.

5.5.1 Prioritisation of Sites

The City currently conducts seasonal weed management in parks and urban landscaping areas on a priority basis using four criteria (in descending order), as shown in Figure 8.

Figure 8: Criteria currently used to prioritise weed management actions for parks and urban landscaping areas



5.5.2 Site Selection

Parks and urban landscaping areas are categorised and prioritised based on the type, profile, amenity or functional requirements of a specific location. A consistent approach is applied to all areas that fall within the same category.

Listed below are the different types of parks and urban landscaping areas and details regarding their purpose, use and functional requirements.

Parks

Parks are areas of public open space that contain facilities for recreation and leisure. The current Parks and Public Open Space Classification Framework (PPOSCF) and the revised PPOSCF, adopted as a management guideline to assist in the planning and provision of park and public open space assets, is utilised to prioritise weed management in parks. Parks are classified using factors such as the site purpose, size and surrounding catchment.

Parks are given priority ratings from 1 to 4, as outlined below. Parks with priority ratings of 1 receive the highest level of weed management, whilst parks with priority ratings of 4 receive the lowest level of weed management. For example, Regional Sports Parks (Priority 1) are treated for weeds in accordance with the annual maintenance schedule and inspected at a higher frequency than Local Recreation Parks (Priority 4).

Sports Parks

Sports parks are designed for sporting activities. Sports parks are used with the main purpose of engaging in organised sporting activity, training, competitions or viewing as a spectator.

Sports parks that abut school ovals are given a higher priority for weed spraying to be undertaken during school holidays when fewer people are using the facilities in the vicinity.

Sports parks are split into four sub-categories and are prioritised in the following order:

- **Regional Sports Park** (Very high priority – 1): Regional Sports Parks are utilised for a wide range of sport, leisure and recreation purposes and contain related facilities. These parks have the capacity to service the needs of the City community and may also attract users from outside the City. An example of a Regional Sports Park is Percy Doyle Reserve in Duncraig.

- **District Sports Park** (High priority – 2): District Sports Parks are utilised for organised sporting activities and passive recreational activities such as walking and use of play equipment. District Sports Parks service the local area, as well as several surrounding suburbs. An example of a District Sports Park is Iluka District Open Space in Iluka.
- **Local Sports Park** (Medium priority – 3): Local Sports Parks are utilised for seasonal organised sporting activities as well as other passive recreational activities. Local Sports Parks are designed to cater for the needs of the community within the suburb. An example of a Local Sports Park is Caledonia Park in Currabine. Local Sports Parks adjacent to schools are classified as High priority (2) and use of herbicides for weed control is avoided during school hours.
- **Local Mixed-Use Parks** (Medium priority – 3): Local Mixed-Use Parks are developed parks used for both recreational activities and organised sporting activities. Local Mixed-Use Parks are designed to cater for the needs of the community within the suburb. An example of a Local Mixed-Use Park is Flinders Park in Hillarys.

Recreation Parks

Recreation Parks are predominately used for recreational activities such as picnics, play, walking and exercising animals. They contain turf suitable for low-wear applications and leisure-based infrastructure.

Recreation Parks are split into three sub-categories and ranked in the following order:

- **Regional Recreation Park** (Very high priority – 1): Regional Recreation Parks are used for recreation and leisure activities. They accommodate the needs of the wider City community and beyond and encourage short, medium and long stay usage. An example of a Regional Recreation Park is Tom Simpson Park in Mullaloo.
- **District Recreation Park** (Low priority – 4): District Recreation Parks are used for recreation and leisure activities. They accommodate the needs of the residents from the suburb and surrounding suburbs and encourage medium to short stay usage. An example of a District Recreation Park is Geneff Park in Sorrento.
- **Local Recreation Park** (Low priority – 4): Local Recreation Parks are used for short term activities such as play, walking and exercising animals (if permitted under the City's local laws). An example of a Local Recreation Park is Blue Lake Park in Joondalup.



Blue Lupin (*Lupinus cosentinii*)

Refer to Appendix 7 for a complete listing of City managed parks and their priority rankings, including areas that are covered by service agreements.

Urban Landscaping Areas

Urban landscaping areas are contained within roads or along road reserves and thoroughfares and provide attractive, green spaces to complement and enhance the urban environment. Also included in this category are areas that have functional requirements such as drainage sumps and swales.

Urban landscaping areas are broken down into the following categories and weed management is dependent on the priority rating:

- **Specified Area Rates Locations** (Very High Priority 1): SAR landscapes are subject to annual service agreements (between residents and the City). There are currently SARs in place for Iluka, Harbour Rise Estate, Hillarys and Woodvale Waters Estate in Woodvale. SAR locations are maintained in line with the individual negotiated Annual Service Reviews. Services in the reviews are in line with industry best practice and City protocols.
- **Commercial Business Precinct** (CBP) (Very High Priority 1): The CBP includes parks, verges, road reserves and pedestrian access ways in the Joondalup City Centre. The CBP is maintained to a higher standard of appearance and an increased frequency of all aspects of landscape maintenance within the area including weed management.
- **Streetscapes** (High Priority 2): The streetscape is the visual identity of a neighbourhood and includes footpaths, gardens, medians and landscaping along a street or road. Streetscapes are prioritised by the road hierarchy, as shown in Figure 9. The road hierarchy is prioritised in the following order: MRWA controlled roads (other than Mitchell Freeway); Distributor A; Distributor B; Local Distributor and Access Road.
- **Pedestrian Access Way** (Medium Priority 3): A pedestrian access way (PAW) is any path in the public domain that is available for use by pedestrians and vehicles that are not regulated by the *Road Traffic Act 1974* (e.g. bicycles, skateboards, rollerblades). Pedestrian access ways do not include pedestrian paths provided within road reserves, or on land zoned Parks and Recreation under the *Metropolitan Region Scheme*.
- **Sumps and Swales** (Low Priority 4): Infiltration basins (sumps) are depressions designed to capture and store stormwater prior to infiltration into the soil profile. Infiltration basins and trenches maintain site water balance and can replenish local groundwater. Swales are grassed or vegetated broad, shallow channels used to collect and convey stormwater flows, promote infiltration, reduce stormwater peak flow rates and discharge volumes, and remove sediment. The benefit of turf swales is that the area is also usable public open space and accessible to the public.

Figure 10: City of Joondalup Commercial Business Precinct



5.5.2 Weed Management within Sites

It is proposed that the City conduct weeds management within parks and urban landscaping areas by focussing on areas with functional values followed by areas with aesthetic values.

5.5.3 Priority Weeds

The City focuses on weed management of broadleaf weeds (most commonly found weeds), skeleton weed (declared pest plant) and caltrop (local pest plant) for parks and urban landscaping areas.

Broadleaf Weeds

The most common broadleaf weeds that are managed in parks and urban landscaping areas include:

- Fleabane (*Conyza* spp.)
- Dandelion (*Taraxacum officinale*)
- Medic Burr (*Medicago polymorpha*)
- Bindii (*Soliva sessilis*)
- Cudweed (*Gamochaeta calviceps*)
- White Clover (*Trifolium repens*)
- Flat Weed (*Hypochaeris radicata*)
- Common Cotula (*Cotula australis*)
- Blue Lupin (*Lupinus cosentinii*)

Skeleton Weed

Skeleton weed (*Chondrilla juncea*) is a declared pest plant in Western Australia under the *Biosecurity and Agriculture Management Act 2007*. The City is obligated to search for, and eradicate, all skeleton weed found on City managed land. All skeleton weed must be reported to the Department of Agriculture and Food WA and treated to prevent seed set within 48 hours.

Occurrences of skeleton weed are added to a City skeleton weed register and locations are inspected annually.

Caltrop

Under the *Biosecurity and Agriculture Management Act 2007* and the *Local Government Act 1995*, the Council of the City of Joondalup made the *Pest Plant Local Law 2012* to require the owner or occupier of private land within the City district to destroy, eradicate or otherwise control pest plants within a specified time. Caltrop (*Tribulus terrestris*) is designated as a pest plant.

The City maintains a Caltrop register to document confirmed locations of Caltrop on land managed by the City and public property. All Caltrop locations are inspected annually.

5.5.4 Integrated Weed Management Approach

Integrated weed management involves using a variety of different techniques to monitor, prevent and control weeds. Using a variety of control methods, rather than just one, also ensures weeds are less able to adapt to the control methods used and less likely to become herbicide resistant. An integrated approach is required for effective weed management, and therefore the management of weeds within the City parks and urban landscaping areas includes:

- Weed monitoring
- Weed prevention
- Weed control (physical and chemical)
- Training.

5.6 Weed Monitoring

Ongoing monitoring of the City's priority and high profile areas is beneficial to assist with the long term management of parks and urban landscaping areas within the City. Weed monitoring is important for identifying and effectively managing weed populations.

Observational weed monitoring is conducted for parks and urban landscaping areas.

5.6.1 Observational Weed Monitoring

Observational weed monitoring can guide weed control efforts and assess the effectiveness of weed management actions.

Current Management Approach

Weed inspections in parks and urban landscaping areas are regularly undertaken by staff during scheduled maintenance activities and site inspections. The frequency of inspections is determined by the site prioritisation, as detailed in Appendix 7.

When weed issues are identified during inspections, an evaluation is undertaken to determine the most effective and efficient method of control. This can be the immediate treatment of weeds or scheduling of specific weed management actions to effectively manage larger infestations.

SAR site audits are undertaken and reported quarterly including assessing the service agreement weed density key performance indicator for turf and garden beds.

Annual audits of Regional Sports Parks and Regional Recreation Parks, including turf and garden bed evaluations, are conducted by staff to establish the type of weed, level of infestation and recommended actions.

Recommended Management Approach

It is recommended that the City continue to annually audit Regional Sports Parks and Regional Recreation Parks to inform weed management actions.

Recommended Observational Weed Monitoring Management Action

Continue to undertake formal park audits of Regional Sports Parks and Regional Recreation Parks annually to inform weed management actions.

5.7 Weed Prevention

Prevention of weeds in parks and urban landscaping areas is the most effective method of weed control. Eradication of weeds usually requires more resources for weed management than those required for weed prevention.

Current Management Approach

The main weed prevention methods that are implemented by the City include mulching, turf management, renovation works, suppression of weed seed banks, best practice landscape design and management, minimising access and disturbance and undertaking weed hygiene measures.

Mulching

Pathogen and weed free mulch is applied to suppress weed growth in garden beds or non-turf areas.

Turf management practices

Fertiliser is applied, based on soil and leaf tissue analysis, to improve the quality of the turf and to promote healthy turf. Healthy turf reduces the likelihood of seasonal weeds.

Renovation works

Renovation works are undertaken to encourage improved density and coverage of turf, reducing the opportunity for weed growth. Weeds are more prevalent in sand and denuded areas.

Suppression of weed seed banks

Weed seed banks are suppressed through the use of chemical pre-emergents. These types of chemicals are applied to non-planted garden beds and hardstand areas.

Best practice landscape design and management

Landscape design and management can assist with reducing weed growth and ensuring effective weed management can be delivered through, for example, the use of stencilled concrete, hydro-zoning, eco-zoning and irrigation design.

Stencilled concrete has been installed rather than brick paving in some appropriate hardstand areas to assist with weed control and management. Stencilled concrete does not allow weeds to surface as easily as brick paving.

Hydro-zoning and eco-zoning have been applied in numerous City parks to conserve water whilst keeping the area's amenity and function. Hydro-zoning is the installation of irrigation to allow for different zones of a park or reserve to receive different amounts of water based on the type of use of the zones and turf requirements. Eco-zoning is the division of a park or reserve into zones of turf and natural areas to promote biodiversity and conserve water. Hydro-zoning and eco-zoning principles also assist with weed management through suppressing weeds and only watering targeted areas.

Examples of hydro-zoning and eco-zoning locations include:

- Emerald Park, Edgewater
- Marri Park, Duncraig
- Ellersdale Park, Warwick
- Kingsley Park, Kingsley
- Hillarys Park, Hillarys
- Mawson Park, Hillarys
- Warrandyte Park, Craigie.

Hygiene Measures

Hygiene is important to ensure weeds, pathogens and pests are not spread from or into parks and urban landscaping areas. City staff undertake hygiene measures on vehicles used for turf renovation activities between each site and at the end of each day. City contractors occasionally undertake turf renovation activities and are required by tenders and contracts to implement hygiene measures between sites and at the end of each day on vehicles used.

The majority of plant stock is supplied from Nursery Industry Accreditation Scheme Australia (NIASA) accredited nurseries and the City currently purchases Australian Standard certified mulch and potting mix. The City has developed *Purchasing Guidelines for the Supply of Landscaping Materials* that will be used to eliminate the likelihood of introducing weeds seeds from purchased materials.

Recommended Management Approach

It is recommended that the City continue to implement the following weed prevention methods:

- Use pathogen and weed free mulch to suppress weed growth in garden beds or non-turf areas.
- Undertake soil and leaf tissue analysis to determine fertiliser applications to improve the quality of turf and reduce the likelihood of weeds.
- Undertake turf renovation works to encourage improved density and coverage of turf and reduce the opportunity for weed growth.
- Use chemical pre-emergents to suppress weed seed banks in non planted garden beds and hardstand areas.
- Undertake best practice landscape design and management including hydro-zoning and eco-zoning principles.
- Undertake hygiene measures on City staff vehicles used for turf renovation activities between each site and at the end of each day.
- Continue to ensure relevant tenders and contracts require contractors conducting turf renovation activities to undertake hygiene measures between sites and at the end of each day on vehicles used.
- Investigate current industry best practice weed prevention measures for public open spaces.

Recommended Weed Prevention Management Actions

Continue to use pathogen and weed free mulch to suppress weed growth in garden beds or non-turf areas.

Continue to undertake soil and leaf tissue analysis to determine fertiliser applications to improve the quality of turf and reduce the likelihood of weeds.

Continue to undertake turf renovation works to encourage improved density and coverage of turf and reduce the opportunity for weed growth.

Continue the use of chemical pre-emergents to suppress weed seed banks in non planted garden beds and hardstand areas.

Continue to undertake best practice landscape design and management including hydro-zoning and eco-zoning principles.

Continue to undertake hygiene measures on City staff vehicles used for turf renovation activities between each site and at the end of each day.

Continue to ensure relevant tenders and contracts require contractors conducting turf renovation activities to undertake hygiene measures between sites and at the end of each day on vehicles used.

Continue to investigate current industry best practice weed prevention measures for public open spaces.

5.8 Weed Control

While weed prevention is important for reducing new infestation of weeds from occurring or spreading in parks and urban landscaping areas, weed control is necessary for reducing or eradicating weed infestations. While weed control can be expensive and resource intensive, failure to control weeds can have significant impacts including affecting the quality of playing surfaces or the aesthetics and amenity of parks and urban landscaping areas.

The City undertakes an integrated weed management approach to its weed control in parks and urban landscaping including the use of a variety of approved herbicides.

Weed control involves using a number of methods to reduce weed infestations to manageable levels or, if possible, to eradicate infestations. Weed control methods used in parks and urban landscaping areas include:

- Chemical weed control – the use of selective and non-selective herbicides to control or suppress weeds.
- Physical weed control – the removal of weeds by physical or mechanical means, such as mowing, mulching or by hand.

5.8.1 Chemical Weed Control

The majority of weed control in parks and urban landscaping areas is managed by the use of approved herbicides as they are effective on large weed populations and are economical compared to other weed control techniques.

The two main methods of chemical application in parks and urban landscaping areas are blanket and target spraying. Appendix 6 provides further details on the different methods of herbicide application.

Blanket spraying

Blanket spraying is generally undertaken by machinery with boom sprays and is the most effective and efficient method to apply chemicals to large open spaces such as sports ovals.

Broadleaf selective turf weeds are subject to seasonal control generally between July and September. This activity is only conducted on the City's sporting parks, regional parks, CBP and at service agreement locations (SARs).

Target Spraying

Target spraying can be undertaken using the following methods: backpack spray units or vehicle mounted tanks and hoses with applicable control attachments where required; wick or sponge wiping via a handheld applicator directly on to targeted plant/s or a cut and paint/basal bark treatment which involves painting pesticide directly onto a woody cut plant. Target spraying is generally used in small areas or where obstacles or site constraints restrict access of larger machinery.

Target spraying weeds with herbicide is conducted on an as required basis with frequency dependent on the service levels in place at the time for:

- Landscaped medians and verges
- Kerblines, footpaths and brick paved areas
- Joondalup CBP
- Parks infrastructure and tree surrounds.

Weed management within the City's parks and open spaces, verges, median strips and gardens is both seasonally and resource driven.

5.8.2 Physical Weed Control

Physical weed control is mainly undertaken in urban landscaping areas when required. This method is utilised when the weed species are significantly impacting on the presentation of the landscape and chemical application is not determined to be the most effective method of removal, as compared to herbicide use.

5.8.3 Site Specific Weed Control

Weed control is conducted according to specific site attributes such as parks, streetscapes, SARs, CBP, PAW's and sumps and swales.

Parks

Weed control is conducted in all sports parks and regional recreation parks through the following methods:

- Turf – broadleaf selective, target spraying i.e. around infrastructure
- Landscaped garden beds – hand weeding, target spraying, mulch application
- Hardstands and footpaths - target spraying, use of pre-emergent herbicides (where appropriate).

Weed control in landscaped garden beds, hardstands and footpaths in district and local recreation parks is assessed as per scheduled site inspections.

Streetscapes

Weed control is conducted from July to September according to the annual maintenance schedule and is subject to ongoing site inspections and reactive maintenance from October to June. Weed control in streetscapes is conducted through the following methods:

- Landscaped garden beds – hand weeding, target spraying, mulch application
- Turf – broadleaf selective, target spraying i.e. around infrastructure
- Kerblines - target spraying
- Medians – blanket spraying, use of pre-emergent herbicides (where appropriate)
- Hardstands and footpaths - target spraying, use of pre-emergent herbicides (where appropriate)
- Entry statements – hand weeding, target spraying, mulch application.

Specified Area Rates

SAR locations receive a higher frequency of weed control activities to ensure the area is maintained at the standard established in the service agreements.

Weed control is conducted in SARs through the following methods:

- Parks - broadleaf selective, target spraying i.e. surrounding infrastructure
- Landscaped garden beds – hand-weeding, target spraying, broadleaf selective, mulch application
- Streetscapes – hand weeding, target spraying, broadleaf selective, mulch application
- Turf – broadleaf selective, target spraying i.e. around infrastructure
- Medians – blanket spraying, use of pre-emergent herbicides
- Hardstands and footpaths - target spraying, use of pre-emergent herbicides.

Commercial Business Precinct

The Commercial Business Precinct (CBP) or Joondalup City Centre receives a higher frequency of weed control activities to maintain the area to a higher standard of appearance. The visual appearance of this area is particularly important given its role in supporting the City's economic activities.

Weed control is conducted in the CBP through the following methods:

- Parks - broadleaf selective, target spraying i.e. around infrastructure
- Landscaped garden beds – hand weeding, target spraying, broadleaf selective, mulch application
- Streetscapes - hand-weeding, target spraying, broadleaf selective, mulch application
- Turf – broadleaf selective, target spraying i.e. around infrastructure
- Kerblines - target spraying
- Medians – broadleaf spraying, use of pre-emergent herbicides
- Hardstands and footpaths - target spraying, use of pre-emergent herbicides.



Veldt Daisy (*Dimorphotheca ecklonis*)

Pedestrian Access Ways

Weed control on pedestrian access ways (PAWs) is conducted from July to September in accordance with the annual scheduled maintenance and is subject to ongoing site inspections and reactive maintenance from October to June.

Weed control is conducted in PAWs through the following methods:

- Fence lines – target spraying
- Hardstands and footpaths – target spraying, use of pre-emergent herbicides.

Sumps and Swales

The City has approximately 200 sumps with weed control being undertaken annually. Weed control in sumps consists of mowing weeds and use of herbicide applications. It is conducted prior to summer to reduce fuel load and lower the fire hazard risk.

Swales are mowed in accordance with the annual maintenance schedule.

Recommended Management Approach

It is recommended that the City continues to implement weed control in parks and urban landscaping areas in accordance with the annual maintenance schedule.

Recommended Weed Control Management Actions

Continue to undertake weed control in parks and urban landscaping areas in accordance with the annual maintenance schedule.

6.0 Weed Control in Wetlands

Wetlands can contain weeds on the perimeter or aquatic weeds within the water body. The City manages 17 wetlands contained within parks, including being responsible for weed control (see Table 6). Yellagonga Regional Park wetlands are managed separately through the *Yellagonga Integrated Catchment Management Plan 2015-2019*.

Alternative methods of weed control for weeds on the perimeter of wetlands, such as hand weeding, slashing and matting, to minimise the risk of chemicals entering the water bodies and risk to native fauna and flora, are preferable to using herbicides. Herbicides can enter water bodies through spray drift, dripping from treated plant foliage or landing on a hard surface (e.g. rock or gravel) and washing into the water.⁵³ However, some weed species are best controlled with the use of herbicides and can form part of an integrated weed management approach.

Aquatic weeds can be emergent (stems and leaves above waterline), free floating (not attached to the soil), floating leaf (rooted into soil with leaves on water surface) or submerged weeds (rooted into soil with the whole plant submerged under water). Aquatic weeds can be introduced through dumping of invasive garden pond plants or spread through mediums such as birds or boats. Weed control of aquatic weeds poses a risk to wildlife, fish and native plants in the wetland. Early control of aquatic weeds prevents weed spread. Some aquatic weeds can be controlled with the use of herbicides such as glyphosate and diquat.⁵⁴ Excessive growth of algae is a major aquatic weed issue in wetlands.

Algae

Algae range in size from microscopic (for example single cells) to large (for example seaweed) and are a diverse group of aquatic plants containing chlorophyll and other photosynthetic pigments. The majority of algae are found in water, although they can also be found on soil.⁵⁵

Algae are a natural part of aquatic environments and are not necessarily a problem, even when they are abundant. An algal bloom is a rapid excessive growth of algae, usually caused by high nutrient levels and favourable conditions.

Table 6: Wetlands in the City of Joondalup

Wetland	Suburb
Beaumaris Park	Ocean Reef
Blackboy Park	Mullaloo
Blue Lake Park	Joondalup
Broadbeach Park	Hillarys
Central Park	Joondalup
Conica Park	Hillarys
Craigie Open Space	Craigie
Flinders Park (North and South)	Hillarys
Lacepede Park	Sorrento
Mawson Park	Hillarys
McCubbin Park	Woodvale
Oahu Park	Hillarys
Sir James McCusker Park (North and South)	Iluka
Whitfords Nodes Park South	Hillarys
Wolinski Park	Mullaloo

⁵³ CRC for Australian Weed Management (2005b)

⁵⁴ Department of Agriculture and Food (2009)

⁵⁵ Water and Rivers Commission (1998)

When large amounts of algae die and decompose, the effect can be deoxygenation of the water leading to the death of aquatic plants and animals. However, an increase in intensity and frequency of algal blooms can upset the delicate natural balance of an aquatic ecosystem. Algal blooms can cause public health and ecological issues.⁵⁵

Algal blooms also have an effect on midges. Wetlands rich in nutrients (often from fertilisers or high-nutrient wastes) combined with environmental conditions, such as warmth or light, may lead to an increase in aquatic plant growth (eutrophication), causing large algal blooms to occur. This can create an accumulation of dead and dying algal material at the bottom of the water body, providing a food resource for midge larvae and leading to populations multiplying to high densities. Midges can cause a nuisance to people living nearby or using the area.⁵⁵

Current Management Approach

The City conducts wetland water quality monitoring three times a year in accordance with the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000) to monitor chemical and physical water conditions.

Weeds growing in or around wetlands are controlled either by physical removal or treatment with a herbicide formulated for use in or around wetlands.

The City treats algae through the use of enzyme based products or by scooping the algae out of the water.

Recommended Management Approach

Wetland Guidelines have been developed to minimise weed establishment and spread into and around wetlands. A *Wetland Management Plan* is currently being developed to provide guidance and minimise environmental impacts from weed control activities in or around wetlands.

Recommended Wetlands Weed Control Management Actions

Implement the Wetland Guidelines and finalise and implement the draft *Wetland Management Plan* to provide direction to staff and contractors conducting weed control activities in and around wetland areas and minimise environmental impacts, where possible.

Figure 11: Wetland in Lacepede Park, Sorrento



⁵⁵ Water and Rivers Commission (1998)

7.0 Education and Training

An important component of this Plan is to ensure that the local community, visitors to the City's natural areas and parks and those that manage the City's natural areas and parks have the necessary awareness, knowledge, motivation and behaviour to assist in protecting the City's natural areas and parks from the threat of weeds.

7.1 Community Education

Environmental objectives cannot be achieved through the actions of the City alone; the community can also affect the local environment in both positive and negative ways. Environmental outcomes require the support of an engaged community that is aware and participating in environmental activities.

Raising community awareness regarding weed prevention and control is important as sometimes individuals are not aware of the impact of weeds and the weed hygiene actions required to prevent weed spread.⁵⁶

The community can prevent weed introduction and spread by:

- Minimising their access and disturbance to natural areas by staying on tracks, not taking vehicles into natural areas, and not allowing dogs to run off-leash in natural areas
- Undertaking appropriate hygiene practices such as cleaning footwear when entering and leaving natural areas, removing any weed seeds attached to clothing and removing and disposing appropriately of dog excrement (may contain weed seed)
- Planting local, native species in their gardens where possible
- Opting for native species rather than invasive species in private gardens to reduce the spread of invasive species to natural areas
- Not dumping garden rubbish in natural areas or parks
- Joining a Friends Group to participate in bushland restoration and maintenance activities.

Schools are also an important avenue for raising awareness and interest in environmental issues and creating future community members that are aware of and actively participate in local environmental management. Many schools are located adjacent to bushland areas which creates learning opportunities for students.

Current Management Approach

The City implements an Annual Environmental Education Program to address key environmental issues and encourage greater environmental stewardship by the community. The City actively encourages participation within its community to raise awareness of key environmental issues within the City.

As part of the Environmental Education Program, the City has developed an Adopt a Bushland Program for students from years 4 to 7 to provide an interactive Bushland Management Program. This program has been trialled with Padbury Catholic Primary School at Hepburn Heights Conservation Area in 2014/15.

In order to educate the community about how they can prevent weed introduction and spread the City has developed a number of key brochures titled *Being WEEDwise: Garden Escapees in the City of Joondalup*⁵⁶, *Being WEEDwise: Environmental Weeds in the City of Joondalup*⁵⁷ and *Protecting our Natural Areas and Parks*.⁵⁸

A Signage Strategy has been developed as recommended in the City's *Walkability Plan 2013-2018* to guide the development and installation of new 'wayfinding' and interpretive signage within the City's natural areas. Signage in natural areas can be a useful educational tool to raise awareness of the ecological values of natural areas and encourage community members to prevent weed spread through actions such as sticking to paths, keeping dogs on leads and cleaning up after dogs. Natural areas wayfinding and interpretive signage will be installed in key conservation areas with the first signage to be installed in Hepburn Heights Conservation Area and Lilburne Park by December 2015.

Recommended Management Approach

It is proposed that the City implements an Adopt a Bushland Program to educate students about bushland management through an interactive bushland management program.

The City should also continue to deliver its Annual Environmental Education Program and distribute the '*Being WEEDwise*' and '*Protecting our Natural Areas and Parks*' brochures at City events and facilities.

The Signage Strategy includes content for natural areas suggesting that people utilise designated paths, walk dogs on leashes and clean up after dogs to prevent weed spread. Natural areas signage could incorporate this content.

⁵⁶ City of Joondalup n.d.(a)

⁵⁷ City of Joondalup n.d.(b)

⁵⁸ City of Joondalup n.d.(c)

Recommended Community Education Management Actions

Implement an Adopt a Bushland program for students to provide an interactive bushland management program.

Continue to distribute the 'Being WEEDwise' and 'Protecting our Natural Areas and Parks' brochures through the community.

Install natural areas wayfinding and interpretive signage in key conservation areas and include content suggesting that people utilise designated paths, walk dogs on leashes and clean up after dogs to reduce weed spread.

7.2 Training

Continue to ensure City staff have the necessary knowledge and experience to undertake weed management activities which is essential for effective weed management, best use of the City's resources, reducing any potential negative impacts as well as ensuring the safety of staff. Training is important for the continued development of staff knowledge and expertise.

The City's Friends Groups help to protect, preserve and enhance significant bushland areas within the City and will continue to benefit from training related to weed management.

Current Management Approach

City staff are trained in the correct application and safe use of herbicides. Contractors directly involved in the use of herbicides are licenced with the Department of Health under the *Health (Pesticides) Regulations 2011*.

City staff in the Natural Areas team are qualified with a Certificate in Conservation and Land Management or relevant experience. The City currently conducts regular plant identification training, including weed management. City staff also undertake relevant training to increase knowledge of weed identification, safety and effective methods of weed control.

Through ongoing meetings with Friends Groups, the Friends Groups Coordinator shares information about weed hygiene practices to protect the biodiversity of natural areas.

Recommended Management Approach

The City should continue to provide training to staff to ensure they have appropriate knowledge to undertake weed management activities effectively and safely.

Recommended Training Management Actions

Ensure City staff working within natural areas and parks continue to undertake relevant training to increase knowledge of weed identification, safety and research on effective methods of weed control.

Continue to conduct ongoing weed hygiene practices information sharing with City Friends Groups.



Common Vetch (*Vicia sativa*) Photo: Gary Tate

8.0 Implementation



Victorian (Coastal) Tea Tree (*Leptospermum laevigatum*)

Effective and coordinated implementation of the Weed Management Plan is critical to achieving the objectives of the Plan. Implementation of the Plan will be coordinated by establishing processes for annual reporting and review of the Plan.

8.1 Reporting

In accordance with the City's Project Management Framework the implementation progress of recommended management actions within the Plan will be reported against on an annual basis.

The Key Performance Indicators to be measured annually for the Plan are:

- Percentage cover of environmental weeds in key conservation reserves to be 20% or less
- Percentage cover of broadleaf weeds in SARs parks, CBP parks, Regional Sports Parks, District Sports Parks, Local Sports Parks and Regional Recreation Parks to be 10% or less.

The Key Performance Indicator relating to percentage cover of environmental weeds in ten key conservation reserves has been reported against in the City's *Annual Report* since 2004/05.

8.2 Management Plan Review

A major review of the *Weed Management Plan* will be undertaken in 2021/22 to ensure the City is managing weeds in accordance with best practice approaches.

8.3 Recommendations

Forty-four management actions have been recommended to coordinate and improve the City's weed management activities. A list of the recommended management actions is provided in the following table.

Recommended Management Actions

Area	Recommended Management Action	Relevant to Natural Areas	Relevant to Parks and Urban Landscaping Areas
Weed Mapping	Continue mapping of key priority weeds through regular inspections of natural areas in accordance with the Annual Maintenance Schedule, to inform on ground weed management actions.	✓	
	Through the development of Natural Areas Management Plans, continue undertaking flora, fauna and fungi surveys of the major conservation areas every five years to inform on ground weed management actions.	✓	
	Continue to incorporate information from flora, fauna and fungi surveys into IntraMaps regarding vegetation condition and priority flora and fauna.	✓	
	Continue to assess high priority and medium priority natural areas every five to seven years using the Natural Areas Initial Assessment Tool, including identification of weed species and their distribution in accordance with the Natural Areas Assessment Schedule.	✓	
Photo Monitoring	Consider the use of photo monitoring in major conservation areas when measuring the natural areas key performance indicator annually to assess the effectiveness of ongoing weed control.	✓	
Observational Weed Monitoring	Continue to measure the percentage cover of weeds annually in key natural areas, at the same time of year, as an indicator of vegetation health.	✓	
	Continue to undertake formal park audits of Regional Sports Parks and Regional Recreation Parks annually to inform weed management actions.		✓
High Resolution Multi-spectral Imagery Weed Monitoring	Investigate the feasibility of analysing high resolution multi-spectral imagery of parks and natural areas every two years in order to monitor weed distribution and density.	✓	✓

Area	Recommended Management Action	Relevant to Natural Areas	Relevant to Parks and Urban Landscaping Areas
Minimising Access and Disturbance	Ensure City staff and contractors minimise disturbance to vegetation when accessing natural areas by vehicles, equipment and people remaining on tracks, where possible, during management and maintenance activities to reduce the establishment and spread of weeds.	✓	
Weed Hygiene	Implement the <i>Pathogen and Weed Hygiene Guidelines</i> to provide direction to staff and contractors working within the City's natural areas and parks in order to limit the spread of weeds within the City.	✓	✓
	Implement the <i>Purchasing Guidelines for the Supply of Landscaping Materials</i> to provide information to City staff and contractors relating to the purchase of plant stock, soil, mulch compost and other materials for City parks and natural areas.	✓	✓
Fire Management and Response	Continue to request natural area fire occurrence reports from DFES every five years to identify locations with continued incidents of arson. Where possible, increase City Rangers patrols in problem areas to deter arson and the resulting encouragement of weed growth.	✓	
	Implement the <i>Fire Weed Management Guideline</i> to inform staff and contractors about weed hygiene when constructing and maintaining firebreaks and access ways.	✓	
	Consider post fire revegetation in natural areas to prevent weed spread, on an as required basis.	✓	
Weed Control	Continue to implement weed control in natural areas in accordance with the Annual Maintenance Schedule.	✓	
	Create a register of herbicide resistant weeds including locations and date identified to enable monitoring and control.	✓	
	Conduct research or trials on herbicide rotation to increase the effectiveness of herbicides, as required.	✓	
	Continue to investigate opportunities to partner with agencies or organisations to trial new forms of weed control.	✓	✓

Area	Recommended Management Action	Relevant to Natural Areas	Relevant to Parks and Urban Landscaping Areas
Weed Control	City staff are to continue to use vegetation condition maps from flora surveys conducted in key natural areas to guide their weed control activities and prioritise works in best condition vegetation areas on site. Maps are also to be provided to contractors.	✓	
	Continue to monitor for new aggressive weed species and undertake control as a priority to eliminate the weed species and prevent spread.	✓	✓
	Continue to review the City's Spraying Chemicals Work Instruction in accordance with the ISO 9001 Quality Management System.	✓	✓
	Conduct audits a minimum of twice per year of City staff and contractors herbicide mixing volume rate, to ensure compliance with the applicable regulations and label instructions.	✓	✓
	Conduct regular auditing in accordance with the ISO 9001 Quality Management System regarding the use of caution signage by City staff and contractors when spraying herbicides, to ensure signage is left in place until herbicides are dry and compliance with the Department of Health <i>Health (Pesticides) Regulations 2011</i> Signage Requirements.	✓	✓
	Continue to undertake weed control in parks and urban landscaping areas in accordance with the annual maintenance schedule.		✓
	Weed Research and Trials	As technology and research improves, investigate opportunities for the City to trial new weed control methods.	✓
Weed Control in Specific Locations	Create a register of new weed populations identified in the City to enable monitoring and weed management.	✓	
	Continue to conduct weed control on verges adjacent to key natural areas including increasing mowing of verges to reduce weed seed spread, spraying of weeds and spreading of certified mulch, where required.	✓	✓
	Implement the <i>Fire Weed Management Guidelines</i> to limit the infestation of weeds in the City's natural areas.	✓	

Area	Recommended Management Action	Relevant to Natural Areas	Relevant to Parks and Urban Landscaping Areas
Partnerships	Investigate opportunities to participate in research projects and take up opportunities for sharing information relating to best practice approaches to weed management.	✓	
	Continue to partner with and support local Friends Groups to facilitate bushland restoration and weed management activities.	✓	
Weed Prevention	Continue to use pathogen and weed free mulch to suppress weed growth in garden beds or non-turf areas.	✓	✓
	Continue to undertake soil and leaf tissue analysis to determine fertiliser applications to improve the quality of turf and reduce the likelihood of weeds.		✓
	Continue to undertake turf renovation works to encourage improved density and coverage of turf and reduce the opportunity for weed growth.		✓
	Continue the use of chemical pre-emergents to suppress weed seed banks in non planted garden beds and hardstand areas.		✓
	Continue to undertake best practice landscape design and management including hydro-zoning and eco-zoning principles.		✓
	Continue to undertake hygiene measures on vehicles used for turf renovation activities between each site and at the end of each day.		✓
	Continue to ensure relevant tenders and contracts require contractors conducting turf renovation activities to undertake hygiene measures between sites and at the end of each day on vehicles used.		✓
	Investigate current industry best practice weed prevention measures for public open spaces.		✓
Wetlands Weed Control	Implement the Wetland Guidelines and finalise and implement the draft <i>Wetland Management Plan</i> to provide direction to staff and contractors conducting weed control activities in and around wetland areas and minimise environmental impacts, where possible.	✓	

Area	Recommended Management Action	Relevant to Natural Areas	Relevant to Parks and Urban Landscaping Areas
Community Education	Implement an Adopt a Bushland program for students to provide an interactive bushland management program.	✓	
	Continue to distribute the ' <i>Being WEEDwise</i> ' and ' <i>Protecting our Natural Areas and Parks</i> ' brochures through the community.	✓	✓
	Install natural areas wayfinding and interpretive signage in key conservation areas and include content suggesting that people utilise designated paths, walk dogs on leashes and clean up after dogs to reduce weed spread.	✓	✓
Training	Ensure City staff working within natural areas and parks continue to undertake relevant training to increase knowledge of weed identification, safety and research on effective methods of weed control.	✓	✓
	Continue to conduct ongoing weed hygiene practices information sharing with City Friends Groups.	✓	

9.0 References

- ArborCarbon (2014) Using airborne MSI to manage weeds in urban bushland: City of Joondalup Natural Areas, Perth, Western Australia.
- Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, 2000, *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, Artarmon, New South Wales.
- Australian Association of Bush Regenerators (AABR), 2013, *The Bradley Method*, viewed 4 May 2015, <http://www.aabr.org.au/learn/what-i-bush-regeneration/general-principles/the-bradley-method/>.
- Australian Glyphosate Sustainability Working Group, n.d., *Sustainable Glyphosate Use on Roadsides, Railways, Public Utilities and Parks*.
- Australian Government, 2012a, *Impact of Weeds*, viewed 7 March 2014, <http://www.environment.gov.au/biodiversity/invasive/weeds/weeds/why/impact.html>.
- Australian Government, 2012b, *Weeds in Australia*, viewed 26 November 2012, <http://www.environment.gov.au/biodiversity/invasive/weeds/index.html>.
- Australian Government, 2012c, *Biological Control*, viewed 11 April 2014, <http://www.environment.gov.au/biodiversity/invasive/weeds/management/biological-control.html>.
- Australian Government, n.d., *Climate Change: Extreme climate events*, viewed 11 December 2013, <http://www.climatechange.gov.au/climate-change/grants/australian-climate-change-science-program/extreme-climate-events>.
- Australian Weeds Committee, n.d., *Weed Mapping*, viewed 22 August 2014, <http://www.weeds.org.au/mapping.htm>.
- Banks, J. And Sandral, G., 2007, *Report on Weed Control using hot water/ steam and herbicides in the City of Joondalup*. Prepared for the City of Joondalup, Perth, Western Australia.
- Banks and Associates, 2009, *Weed Control Trials comparing hydrothermal and Herbicides in the City of Joondalup*. Prepared for the City of Joondalup, Perth, Western Australia.
- Bettink, K. and Keighery, G., 2008, *Environmental Weed Census and Prioritisation, Swan NRM Region*, Swan Catchment Council and Department of Environment and Conservation, Perth, Western Australia.
- Brown and Brooks, 2002, *Bushland Weeds: A practical guide to their management*, Perth, Western Australia.
- City of Joondalup, n.d.(a), *Being WEEDwise – Environmental Weeds in the City of Joondalup*, Perth, Western Australia.
- City of Joondalup, n.d.(b), *Being WEEDwise – Garden Escapees in the City of Joondalup*, Perth, Western Australia.
- City of Joondalup, n.d.(c), *Protecting our Natural Areas and Parks*, Perth, Western Australia.
- City of Joondalup, n.d.(d), *Natural Areas – Friends Group Manual*, Perth, Western Australia.
- City of Joondalup, 2012a, *Draft City of Joondalup Environment Plan 2012-2015*, Perth, Western Australia.
- City of Joondalup, 2012b, *Lilburne Park Management Plan*, Perth, Western Australia.
- City of Joondalup, 2013, *Pathogen Management Plan 2013-2016*, Perth, Western Australia.
- City of Joondalup, 2014, *City of Joondalup – Minutes of Meeting of Council – 17.02.14*, viewed 16 February 2015, http://www.joondalup.wa.gov.au/files/councilmeetings/2014/CJ140217_MIN.pdf.
- City of Nedlands, 2013, *Weed control decision saves more than \$83,000*, Media Release November 2013, Perth, Western Australia.
- Collins, M, 1999, *Thermal Weed Control, A Technology with a Future? Twelfth Australian Weeds Conference, Hobart, Tasmania*.
- Conservation International, 2014, *Hotspots*, viewed 4 May 2015, <http://www.conservation.org/how/pages/hotspots.aspx>.
- Cooperative Research Centre (CRC) for Australian Weed Management, 2004, *Introductory Weed Management Manual*, Department of Environment and Heritage, Australia.
- Cooperative Research Centre (CRC) for Australian Weed Management, 2005a, *Herbicide Guidelines: Knowing when and how to use them*, Glen Osmond, South Australia.
- Cooperative Research Centre (CRC) for Australian Weed Management, 2005b, *Herbicide Guidelines: For use in and around water*, Glen Osmond, South Australia.
- Commonwealth, Science and Industry Research Organisation (CSIRO), 2011, *Biological Control of Weeds*, viewed 11 April 2014, <http://www.csiro.au/Outcomes/Food-and-Agriculture/WeedBiocontrol.aspx>.
- Commonwealth, Science and Industry Research Organisation (CSIRO), 2013, *Integrated Weed Management*, viewed 27 March 2014, <http://www.csiro.au/Outcomes/Food-and-Agriculture/IWM.aspx>.
- Demand Media Inc., 2013, *How Does Organic Weed Killer Work?*, viewed 27 August 2013, http://www.ehow.com/how-does_4709678_organic-weed-killer-work.html.
- Department of Agriculture and Food, n.d, *Weeds*, viewed 13 December 2013, http://www.agric.wa.gov.au/PC_93079.html.

- Department of Agriculture and Food, 2009, *Garden Note: Aquatic Weeds and Their Control*, viewed 8 January 2014, http://www.agric.wa.gov.au/objtwr/imported_assets/content/pw/weed/decp/gn_aquaticweeds_control.pdf.
- Department of Agriculture and Food, 2011, *Declared Plants in Western Australia*, Perth, Western Australia.
- Department of Parks and Wildlife (DPaW), 1999, *Environmental Weed Strategy for WA*, Perth, Western Australia.
- Department of Parks and Wildlife (DPaW), 2002, *Weed Control and Revegetation Plan*, Perth, Western Australia.
- Department of Fire and Emergency Services (DFES), 2013, *Bush Fires Act 1957*, Perth, Western Australia.
- Department of Parks and Wildlife (DPaW), 2013, *Weed Prioritisation Process for DPaW*, Perth, Western Australia.
- Department of Planning, n.d., *Weeds and Weed Management*, viewed 27 August 2013, http://www.planning.wa.gov.au/dop_pub_pdf/8_weeds_management.pdf.
- Department of Primary Industries (DPI), 2011, *Noxious and environmental weed control handbook – a guide to weed control in non-crop, aquatic and bushland situations*, 5th Edition, New South Wales.
- Department of Sustainability, Environment, Water, Population and Communities (DSEWPC)a, 2012, *Weed Prevention*, viewed 1 August 2013, <http://www.environment.gov.au/biodiversity/invasive/weeds/management/prevention.html>.
- Department of Sustainability, Environment, Water, Population and Communities (DSEWPC)b, 2012, *Why are weeds a problem?* viewed 13 February 2013, <http://www.environment.gov.au/biodiversity/invasive/weeds/weeds/why/index.html>.
- Dunne, C., 2005, *Managing Phytophthora Dieback in Bushland*, Dieback Working Group and the Threatened Species Network, Perth, Western Australia.
- Eurobodalla Shire Council, n.d., *Weed Control Methods*, viewed 8 August 2013, <http://www.esc.nsw.gov.au/site/Weeds/control%20methods.htm>.
- Fire and Emergency Services Authority (FESA) of Western Australia, n.d., *Firebreak Location, Construction and Maintenance Guidelines*, Perth, Western Australia.
- Fire and Emergency Services Authority (FESA) of Western Australia, 2011, *Biodiversity Conservation and Fire in Road and Rail Reserves: Management Guidelines*, Perth, Western Australia.
- Groves, R.H., Boden, R. & Lonsdale, W.M., 2005, *Jumping the Garden Fence: Invasive Garden Plants in Australia and their Environmental and Agricultural Impacts*, CSIRO report prepared for WWF-Australia, WWF-Australia, Sydney, New South Wales.
- Houghton Mifflin Company, 2009, *The American Heritage Dictionary of the English Language*, viewed 30 November 2012, <http://www.thefreedictionary.com/herbicide>.
- Johansson, E., n.d., *Alternative Weed Control Methods*, viewed on 27 August 2013, <http://www.kootenayweeds.com/pdf/AlternativeControl.pdf>.
- John Banks and Associates, 2007, *Report on Weed Control Using Hot Water/ Steam in the City of Joondalup*, Prepared for the City of Joondalup.
- John Banks and Associates, 2009, *Weed Control Trials Comparing Hydrothermal and Herbicides in the City of Joondalup*, Prepared for the City of Joondalup.
- Leschenault Catchment Council, n.d., *Bringing Back the Bush*, viewed 16 February 2015, <http://www.leschenaultcc.com/uploads/BBTB%20Bradley%20Method%20-%20A4%20web%20version.pdf>.
- Natural Area Consulting, 2013, *Draft City of Joondalup Weed Treatment Trial – Interim Report December 2013*, unpublished report.
- Natural Resource Management (NRM) Ministerial Council, 2007, *The Australian Weeds Strategy: A national strategy for weed management in Australia*, Canberra, Australian Capital Territory.
- New South Wales (NSW) Government, n.d., *Weeds*, viewed on 26 November 2012, <http://www.dpi.nsw.gov.au/agriculture/pests-weeds/weeds>.
- Nursery and Garden Industry, no date, *Way to Grow!*, viewed on 9 December 2013, <http://ngiq.asn.au/wp-content/uploads/FINAL-NIASA-Production-A4-Brochure-05.pdf>.
- Penn State, 2014, *Adjuvants for Enhancing Herbicide Performance*, viewed on 2 April 2014, <http://extension.psu.edu/pests/weeds/control/adjuvants-for-enhancing-herbicide-performance>.
- State Weed Plan Steering Group, 2001, *A Weed Plan for Western Australia*, Perth, Western Australia.
- The University of Queensland, 2011, *Weeds of Australia*, viewed on 26 November 2012, <http://keyserver.lucidcentral.org/weeds/data/03030800-0b07-490a-8d04-0605030c0f01/media/Html/Index.htm#A>.
- Water and Rivers Commission, 1998, *Water Facts: Algal Blooms*, Perth, Western Australia.
- Water and Rivers Commission, 2001, *Water notes: Herbicide Use in Wetlands*, Perth, Western Australia.
- WeedScience.org, 2013, *Herbicide Resistant Weeds in Australia*, viewed 27 August 2013, <http://weedscience.org/summary/Country.aspx>.
- Western Australian Herbarium, n.d., *Florabase*, viewed on 26 November 2012, <http://florabase.dec.wa.gov.au/>.
- Western Australian Local Government Association (WALGA), 2014, *Biodiversity Program*, viewed 25 April 2014, <http://pbp.walga.asn.au/Home.aspx>.
- Western Australian Local Government Association (WALGA), 2004, *Local Government Biodiversity Planning Guidelines for the Perth Metropolitan Region*, viewed 13 August 2014, <http://pbp.walga.asn.au/Publications/LocalGovernmentBiodiversityPlanningGuidelines.aspx>.
- Willoughby City Council, n.d., *Ecological Burning*, Willoughby, New South Wales.

10.0 Appendices

Appendix 1 – Natural Area Sites within Study Area (Alphabetically)

Appendix 2 – Prioritisation of City of Joondalup Natural Areas

Appendix 3 – Relevant Local, State and Federal Legislation, Policies, Plans and Strategies

Appendix 4 – Examples of City of Joondalup Priority Weeds

Appendix 5 – Weeds Identified in City of Joondalup and Weed Status

Appendix 6 – Weed Control Methods

Appendix 7 – Park Weed Management Prioritisation

Appendix 1

Natural Area Sites within Study Area (Alphabetically)

Natural Area	Suburb
Adelaide Park	Craigie
Alfreton Park	Duncraig
Barwon Park	Craigie
Beaumaris Park	Ocean Reef
Bethany Park	Iluka
Blue Lake Park	Joondalup
Bonnie Doon Park	Connolly
Bridgewater Park	Kallaroo
Brisbane Park	Padbury
Burns Beach Park	Burns Beach
Cadogan Park	Kingsley
Caledonia Park	Currambine
Callander Park	Kinross
Candlewood Park	Joondalup
Carnaby Reserve	Connolly
Castlecrag Park	Kallaroo
Cawarra Park	Craigie
Central Park	Joondalup
Chadlington Park	Padbury
Chichester Park	Woodvale
Christchurch Park	Currambine
Circle Park	Warwick
Clare Park	Sorrento
Clermont Park	Currambine
Conidae Park	Heathridge
Craigie Leisure Centre	Craigie
Craigie Open Space	Craigie
Cranston Park	Kinross
Culwalla Park	Kallaroo
Dardanus Park	Heathridge
Duncraig Library Bushland	Duncraig
Earlsferry Park	Kinross
Fairway Park	Connolly
Fernwood Park	Padbury
Finney Park	Marmion

Natural Area	Suburb
Garrong Park	Edgewater
Glenbar Park	Duncraig
Greenshank Park	Joondalup
Gunida Park	Mullaloo
Haddington Park	Beldon
Harman Park	Sorrento
Hawker Park	Warwick
Hepburn Heights Conservation Area	Padbury
Huntingdale Park	Connolly
Huxley Park	Burns Beach
Iluka Foreshore	Iluka
Kallaroo Park	Mullaloo
Kiernan Park	Kallaroo
Kilrenny Park	Greenwood
Korella Park	Mullaloo
Kuta Park	Iluka
Lacepede Park	Sorrento
Lady Evelyn Park	Joondalup
Lakeside Park	Joondalup
Lakevalley Park	Edgewater
Ledge Park	Sorrento
Lilburne Park	Duncraig
Littorina Park	Heathridge
Lookout Park	Edgewater
Lysander Park	Heathridge
MacNaughton Park	Kinross
Madana Park	Craigie
Manapouri Park	Joondalup
Mandalay Park	Craigie
Maritana Park	Kallaroo
Marmion Beach Foreshore	Marmion
Menteith Park	Kinross
Merrifield Park	Kallaroo
Nanika Park	Joondalup
Naturaliste Park	Iluka

Natural Area	Suburb
Negresco Park	Currabine
Neil Hawkins Park	Joondalup
Ocean Reef Foreshore	Ocean Reef
Okely Park	Edgewater
Pentland Park	Duncraig
Periwinkle Park	Mullaloo
Picnic Cove Park	Edgewater
Pine Valley Park	Connolly
Porteous Park	Sorrento
Quarry Park	Edgewater
Quarry Ramble Park	Edgewater
Riversdale Park	Currabine
Robin Park	Sorrento
Sandalford Park	Beldon
Shepherds Bush Reserve	Kingsley
Sir James McCusker Park	Iluka
Sorrento Beach Foreshore	Sorrento
St Michael's Park	Connolly
Stilt Park	Joondalup
Sweeney Park	Padbury
Timbercrest Park	Woodvale
Timberlane Park	Woodvale
Tom Simpson Park	Mullaloo
Trig Point Park	Ocean Reef
Trigonometric Park	Duncraig
Walsh Park	Joondalup
Warrandyte Park	Craigie
Warwick Open Space	Warwick
Water Tower Park	Joondalup
Whitfords Nodes North	Kallaroo
Whitfords Nodes South	Hillarys

Appendix 2

Prioritisation of City of Joondalup Natural Areas

Site	Suburb	Priority	Bush Forever Site	Listed in District Planning Scheme No. 2 Schedule 5	Friends Group
Warwick Open Space	Warwick	Conservation Area	✓		✓
Craigie Open Space	Craigie	Conservation Area	✓		
Hepburn Heights Conservation Area*	Padbury	Conservation Area	✓	✓	✓
Shepherd's Bush Park*	Kingsley	Conservation Area	✓	✓	
Lilburne Park	Duncraig	Conservation Area		✓	
Marmion Beach Foreshore	Marmion	Conservation Area			✓
Sorrento Beach Foreshore	Sorrento	Conservation Area			✓
Whitfords Nodes – Hillarys	Hillarys	Conservation Area	✓		
Whitfords Nodes – Kallaroo	Kallaroo	Conservation Area	✓		
Mullaloo Beach Foreshore	Mullaloo	Conservation Area	✓		✓
Ocean Reef Beach Foreshore	Ocean Reef	Conservation Area	✓		✓
Iluka Beach Foreshore^	Iluka	Conservation Area	✓		✓
Burns Beach Foreshore	Burns Beach	Conservation Area	✓		
Cranston Park	Kinross	High		✓	
Fairway Park	Connolly	High		✓	
Lakeside Park	Joondalup	High		✓	
Lakevalley Park	Edgewater	High		✓	
Saint Clair / Quarry Park	Edgewater	High			
St Michaels Park	Connolly	High		✓	
Lady Evelyn Park^	Joondalup	High			
Timberlane Park	Woodvale	High		✓	
Beaumaris Park	Ocean Reef	High		✓	
Bonnie Doon Park	Connolly	High		✓	
Cadogan Park	Kingsley	High		✓	✓
Central Park	Joondalup	High		✓	
Clermont Park	Currambine	High		✓	
Naturaliste Park	Iluka	High		✓	
Chadlington Park	Padbury	High			

Site	Suburb	Priority	Bush Forever Site	Listed in District Planning Scheme No. 2 Schedule 5	Friends Group
Neil Hawkins Park^*	Joondalup	High	✓	✓	✓
Cawarra Park	Craigie	High		✓	
Glenbar Park	Duncraig	High		✓	✓
Littorina Park^	Heathridge	High		✓	
Maritana/Bridgewater Park	Kallaroo	High		✓	✓
Periwinkle Park	Mullaloo	High		✓	✓
Porteous Park	Sorrento	High		✓	✓
Trigonometric Park	Duncraig	High		✓	✓
Blue Lake Park^	Joondalup	High		✓	
Burlos/Water Tower Park^	Joondalup	High		✓	
Carnaby Reserve	Connolly	High		✓	✓
Kallaroo Park	Mullaloo	High			
MacNaughton Park	Kinross	High			
Nanika Park^	Joondalup	High		✓	
Sandalford Park	Beldon	High		✓	
Sir James McCusker Park	Iluka	High		✓	
Huxley Park	Burns Beach	Medium			
Chichester Park	Woodvale	Medium			
Garrong Park	Edgewater	Medium			
Korella Park	Mullaloo	Medium			✓
Madana Park	Craigie	Medium			
Mandalay Park	Craigie	Medium			
Warrandyte Park	Craigie	Medium			
Alfreton Park	Duncraig	Medium		✓	
Duncraig Library Bushland	Duncraig	Medium			
Harman Park	Sorrento	Medium			✓
Lacepede Park	Sorrento	Medium			
Picnic Cove Park	Edgewater	Medium	✓		✓
Negresco Park^	Currambine	Medium			
Robin Park	Sorrento	Medium			

Site	Suburb	Priority	Bush Forever Site	Listed in District Planning Scheme No. 2 Schedule 5	Friends Group
Finney Park	Marmion	Medium			
Bethany Park	Iluka	Medium			
Caledonia Park	Currambine	Medium		✓	
Huntingdale Park	Connolly	Medium			
Kuta Park	Iluka	Medium			
Manapouri Park^	Joondalup	Medium			
Greenshank Park	Joondalup	Medium			
Pine Valley Park	Connolly	Medium		✓	
Adelaide Park	Craigie	Medium			
Callander Park	Kinross	Medium			
Castlecrag Park	Kallaroo	Medium			
Conidae Park	Heathridge	Medium			
Earlsferry Park	Kinross	Medium			
Lysander Park	Heathridge	Medium			
Menteith Park	Kinross	Medium			
Okely Park	Edgewater	Medium			
Brisbane Park	Padbury	Medium			
Candlewood Park^	Joondalup	Medium		✓	
Gunida Park	Mullaloo	Medium			
Ledge Park	Sorrento	Medium			
Quarry Ramble Park	Edgewater	Medium		✓	
Trig Point Park	Ocean Reef	Medium			

Note: Sites in Appendix 1 that are not listed in the above table are classified as low priority and no weed management activities are undertaken.

* = State Heritage Site

^ = Aboriginal Heritage Site

Appendix 3

Relevant Local, State and Federal Legislation, Policies, Plans and Strategies

Local Government

The purpose of the *Weed Management Plan* aligns with the environmental aims and objectives of a number of City of Joondalup Plans including:

Strategic Community Plan

The City of Joondalup *Strategic Community Plan 2012 – 2022* highlights the focus on preservation, rehabilitation and accessibility of the City's natural assets and the importance of engaging with the community, key stakeholders and relevant agencies.

Environment Plan

The City of Joondalup *Environment Plan 2014 – 2019* provides strategic direction in the delivery of environmental initiatives within the City.

Biodiversity Action Plan

The City of Joondalup *Biodiversity Action Plan 2009 – 2019* provides direction for the City's biodiversity management activities and details the development of individual Natural Areas Management Plans as an action.

City of Joondalup Pest Plant Local Law 2012

Under the *Agriculture and Related Resources Protection Act 1976* and the *Local Government Act 1995*, the Council of the City of Joondalup made the *Pest Plant Local Law 2012* to require the owner or occupier of private land within the City district to destroy, eradicate or otherwise control pest plants within a specified time. Caltrop (*Tribulus terrestris*) is designated as a pest plant. Caltrop has been identified within the City.

Local Biodiversity Program (formerly Perth Biodiversity Project)

The City of Joondalup is one of 32 local governments participating in the Western Australian Local Government Association's (WALGA's) Local Biodiversity Program. The aim of the Local Biodiversity Program is to support local governments to effectively integrate biodiversity conservation into land use planning to protect and manage local natural areas.

As part of the Local Biodiversity Program, the City assessed all natural areas from 2004 onwards using the ecological criteria of the Natural Area Initial Assessment process, resulting in a priority ranking of natural areas. The City assess major conservation, high priority and medium priority natural areas approximately every five to seven years using this assessment tool.

Natural Area Initial Assessments include a desktop assessment and field survey and document information such as:

- Vegetation complexes
- Threatened or significant flora or ecological communities
- Structural plant communities
- Weed species
- Vegetation condition assessment
- Ecological criteria rankings
- A viability estimate
- Fauna species observed.

State Government

Biosecurity and Agriculture Management Act 2007

The Act gives provision to prevent new animals and plant pests (vermin and weeds) and diseases from entering WA and manages the impact and spread of those pests already present in the State. The Act also gives provision to safely manage the use of agricultural chemicals. There are 67 species on the list of declared pest plants in WA.

The City contains eight known declared pest plants.

Minor Use of Chemicals Permit 2012 to 2017

The Department of Agriculture and Food Western Australia (WA) are the Permit Holder of a Permit to Allow Minor Use of an Agvet Chemical Product for the Control of Environmental Weeds in Various Situations (Permit number PER13333). This permit was issued by the Australian Government Australian Pesticides and Veterinary Medicines Authority and allows the use of stated products in a manner other than specified on the approved product label in WA.

Environmental Weed Strategy for Western Australia 1999

The Department of Conservation and Land Management (CALM) (now DPaW) developed an Environmental Weed Strategy for WA (1999). The Strategy prioritises 1,350 weed species using the criteria of invasiveness, distribution and environmental impacts to rate weeds as high, moderate, mild or low priority. High ratings were issued to 34 weed species.⁵⁹

The City contains 22 high, 63 moderate, 23 mild and 66 low rated weeds in the Environmental Weed Strategy for WA.

⁵⁹ DPaW (1999)

DPaW Weed Prioritisation Process 2013

The DPaW conducted a weed prioritisation process for weeds in each DPaW region, with the aim being to establish a species-led and an asset-protection-based approach to weed management, focussing on infestations of species which are considered to be high impact, rapidly invasive and still at a population size which is feasible to eradicate or contain to a manageable size. The weed prioritisation process is based on the Environmental Weed Census and Prioritisation, Swan Natural Resource Management Region project (Bettink and Keighery 2008) and the *Environmental Weed Strategy of Western Australia* (DPaW 1999). The assessment prioritises weeds using criteria of potential distribution, current distribution, ecological impact, invasiveness and feasibility of control to rate weeds as very high, high, medium, low, negligible, further assessment required or alert. The DPaW Swan Region weed prioritisation process rated 765 weed species.

The City contains two very high, 18 high, 21 medium, 73 low, 49 negligible, 15 further assessment required and 5 alert rated weeds in the DPaW Weed Prioritisation Process for the Swan Region.

State Weed Plan 2001

A *Weed Plan for WA* (2001), referred to as the 'State Weed Plan' was developed by the State Weed Plan Steering Group to help achieve coordinated, effective weed management throughout WA.

Federal Government

National Weeds Strategy 1997

The *National Weeds Strategy* provides a strategic framework for managing weeds at a national level. As part of the implementation of the *National Weeds Strategy*, 67 Weeds of National Significance are identified as nationally agreed priority plant species for control and management based on the criteria of invasiveness and impact characteristics, potential and current area of spread and economic, environmental and social impacts.

The City contains five known Weeds of National Significance.

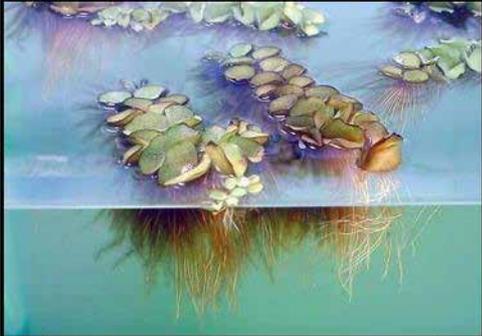
Appendix 4

Examples of City of Joondalup Priority Weeds

Table 7: Outlines the Pest Plants, Declared Plants and Weeds of National Significance within the City.

Latin Name	Common Name	Declared Pest Plant in Perth	Weeds of National Significance	Image
<i>Argemone ochroleuca</i>	Mexican Poppy	Yes – C3	-	 <p><i>Argemone ochroleuca</i> Photos: R. Knox & Anon.</p> <p>Photos: R. Knox and Anon. (WA Herbarium n.d.)</p>
<i>Asparagus asparagoides</i>	Bridal Creeper	Yes – C3	Yes	
<i>Chondrilla juncea</i>	Skeleton Weed	Yes – C2	-	

Latin Name	Common Name	Declared Pest Plant in Perth	Weeds of National Significance	Image
<i>Chrysanthemoides monilifera</i> subsp. <i>monilifera</i>	Boneseed	Yes- C1	Yes	 <p data-bbox="948 770 1433 792"><i>Chrysanthemoides monilifera</i> subsp. <i>monilifera</i> Photos: H. Cherry & R. Knox</p> <p data-bbox="948 815 1433 882">Photos: H. Cherry and R. Knox (WA Herbarium n.d.)</p>
<i>Cirsium arvense</i>	Perennial Thistle, Canada Thistle	Yes- C1	-	 <p data-bbox="948 1249 1433 1317">Photo: C.G. Wilson (Aust Government 2012)</p>
<i>Cynara cardunculus</i>	Artichoke Thistle, Cardoon	Yes – C3		 <p data-bbox="948 1662 1433 1684"><i>Cynara cardunculus</i> Photos: AGWEST</p> <p data-bbox="948 1706 1433 1742">Photos: AGWEST (WA Herbarium n.d.)</p>
<i>Lantana camara</i>	Lantana	Yes – C3	Yes	 <p data-bbox="948 2119 1449 2186">Photo: A. Johnson (NSW Government n.d.)</p>

Latin Name	Common Name	Declared Pest Plant in Perth	Weeds of National Significance	Image
<i>Salvinia molesta</i>	Salvinia	-	Yes	 <p><i>Salvinia molesta</i> Photo: AGWEST</p> <p>Photo: AGWEST (WA Herbarium n.d.)</p>
<i>Silybum marianum</i>	Variegated Thistle	Yes – C3	-	 <p><i>Silybum marianum</i> Photos: R. Knox & J. Dodd</p> <p>Photos: R. Knox and J. Dodd (WA Herbarium n.d.)</p>
<i>Tamarix aphylla</i>	Athel Tree, Tamarisk, Tamarix	Yes – C3	Yes	 <p><i>Tamarix aphylla</i> Photos: K.C. Richardson</p> <p>Photos: K.C. Richardson (WA Herbarium n.d.)</p>

Latin Name	Common Name	Declared Pest Plant in Perth	Weeds of National Significance	Image
<i>Tribulus terrestris</i>	Caltrop*	-	-	
<i>Zantedeschia aethiopica</i>	Arum Lily	Yes – C3		

Notes:

* = Pest plant under *Local Government Act 1995*

The following summarises the effect of the declaration categories for plants under the *Biosecurity and Agriculture Management Act 2007*:

- C1: Exclusion – Pests are assigned to this category if they are not established in Western Australia and control measures are to be taken, including border checks, in order to prevent them entering and establishing in the State.
- C2: Eradication - Pests are assigned to this category if they are present in Western Australia in low enough numbers or in sufficiently limited areas that their eradication is still feasible.
- C3: Management - Pests are assigned to this category if they are established in Western Australia but it is feasible, or desirable, to manage them in order to limit their damage. Control measures can prevent a C3 pest from increasing in population size or density or moving from an area in which it is established into an area which currently is free of that pest.

Appendix 5

Weeds Identified in City of Joondalup and Weed Status

Latin Name	Common Name	Pest Plant under Local Govt Act 1995	DPaW Weed Assessment Swan Region (2012)	WA Enviro Weed Strategy Rating	Declared Plant (in Perth)	Weed of National Significance	Priority Weed in CoJ
<i>Acacia baileyana</i>	Cootamundra Wattle		Medium (D,E,F)	Low			
<i>Acacia dealbata</i>			Medium (D,E,F)	Mild			
<i>Acacia iteaphylla</i>	Flinders Range Wattle		High (G,H,I)	Low			Yes
<i>Acacia longifolia</i>	Sydney Wattle			Not listed			
<i>Acacia longifolia subsp. sophorae</i>			High (G,H,I)	Not listed			Yes
<i>Acacia microbotrya</i>	Manna Wattle		Negligible (A,B)	Not listed			
<i>Acacia podalyriifolia</i>	Queensland Silver Wattle		Medium (D,E,F)	Low			
<i>Acacia xanthina</i>	White-stemmed Wattle			Not listed			
<i>Acetosa vesicaria</i>	Ruby Dock		High (H,I)	High			Yes
<i>Agave americana</i>	Century Plant		Low (B,C,D)	Low			
<i>Agonis flexuosa</i>	Weeping Peppermint			Not listed			Yes
<i>Aira caryophyllea</i>	Silvery Hairgrass		Negligible (B)	Moderate			
<i>Aira cupaniana</i>	Silvery Hairgrass		Negligible (B)	TBA			
<i>Alyssum linifolium</i>	Flax-leaf Alyssum			Low			
<i>Ammophila arenaria</i>	Marram Grass		Low (B,C,D)	Low			
<i>Aptenia cordifolia</i>	Gartenflora			Not listed			
<i>Arctotheca calendula</i>	Cape Weed		Low (D,E)	Moderate			Yes
<i>Arctotis stoechadifolia</i>	White Arctotis		Further assessment required	Low			
<i>Arenaria leptoclados</i>			Further assessment required	Not listed			
<i>Argemone mexicana</i>	Mexican Poppy		Further assessment required	Not listed			Yes
<i>Argemone ochroleuca</i>	Mexican Poppy		Negligible (A,B)	Mild	Yes - C3		Yes
<i>Argyranthemum frutescens</i>	Marguerite		Negligible (A,B)	Low			

Latin Name	Common Name	Pest Plant under Local Govt Act 1995	DPaW Weed Assessment Swan Region (2012)	WA Enviro Weed Strategy Rating	Declared Plant (in Perth)	Weed of National Significance	Priority Weed in CoJ
<i>Asparagus asparagoides</i>	Bridal Creeper		Low (D)	High	Yes - C3	Yes	Yes
<i>Asphodelus fistulosus</i>	Onion Weed		Low (D)	Mild			
<i>Avena barbata</i>	Bearded Oat		Low (D, E)	Moderate			Yes
<i>Avena fatua</i>	Wild Oat		Low (D)	Moderate			Yes
<i>Babiana nana</i>	Baboon Flower		High (H,I)	Mild			Yes
<i>Banksia nivea</i>	Honeypot Dryandra			Not listed			
<i>Banksia prionotes (Wheatbelt Form)</i>	Acorn Banksia			Not listed			
<i>Brassica tournefortii</i>	Mediterranean Turnip		Low (D)	High			Yes
<i>Briza maxima</i>	Blowfly Grass		Low (B,C)	Moderate			
<i>Briza minor</i>	Shivery Grass		Low (B,C)	Moderate			
<i>Bromus diandrus</i>	Brome Grass		Low (D)	High			Yes
<i>Bromus hordeaceus</i>	Soft Brome		Low (D)	Low			
<i>Bromus madritensis</i>	Madrid Brome		Low (D)	Low			
<i>Bromus rubens</i>	Red Brome Grass		Low (D)	Moderate			
<i>Cakile maritima</i>	Sea Rocket		Low (D)	Moderate			
<i>Callitris preissii</i>	Rottnest Island Pine		Negligible (A,B)	Not listed			
<i>Calothamnus rupestris</i>	Mouse Ears			Not listed			
<i>Carpobrotus edulis</i>	Hottentot Fig (Pig Face)		Medium (D,E,F)	Moderate			
<i>Casuarina equisetifolia</i>	Sheoak		Further assessment required	Low			
<i>Cenchrus echinatus</i>	Mossman River Grass, Burrgrass		Low (C)	Low			
<i>Cenchrus setaceus</i>	Fountain Grass		Further assessment required	Mild			
<i>Centaurea melitensis</i>	Maltese Cockspur		Medium (D,E,F)	Moderate			Yes
<i>Centaureum erythraea</i>	Common Centaury		Low (D)	Moderate			
<i>Centranthus macrosiphon</i>	Spanish Valerian		High (H,I)	Low			Yes
<i>Centranthus ruber</i>	Red Valerian		Low (B,C,D)	Low			

Latin Name	Common Name	Pest Plant under Local Govt Act 1995	DPaW Weed Assessment Swan Region (2012)	WA Enviro Weed Strategy Rating	Declared Plant (in Perth)	Weed of National Significance	Priority Weed in CoJ
<i>Cerastium glomeratum</i>	Mouse Ear Chickweed		Low (D)	Low			
<i>Ceratonia siliqua</i>	Carob Tree			Not listed			
<i>Chamaecytisus palmensis</i>	Tagasaste		Low (C)	Mild			
<i>Chamelaucium uncinatum</i>	Geraldton Wax		Low (B,C,D)	Not listed			
<i>Chondrilla juncea</i>	Skeleton Weed		ALERT - DECLARED agric weed	Low	Yes - C2		Yes
<i>Chrysanthemoides monillifera subsp. monillifera</i>	Boneseed		Very High (H,I)	TBA		Yes	Yes
<i>Cicendia filiformis</i>	Slender Cicendia		Negligible (B)	Low			
<i>Cirsium arvense</i>	Perennial Thistle, Canada Thistle			Low			Yes
<i>Citrullus lanatus</i>	Pie Melon		Negligible (A)	Low			
<i>Conospermum triplinervium</i>	Tree Smokebush			Not listed			
<i>Conyza albida</i>	Fleabane			Low			
<i>Conyza bonariensis</i>	Flaxleaf Fleabane		Negligible (A)	Low			
<i>Conyza sumatrensis</i>	Tall Fleabane		Low (D)	Low			
<i>Coprosma repens</i>	Mirror Plant		ALERT spp for swan - likely to turn up	Low			Yes
<i>Cortaderia selloana</i>	Pampas Grass		Low (D,E)	High			Yes
<i>Cotula australis</i>	Common Cotula						
<i>Cotula turbinata</i>	Funnel Weed		Negligible (A,B)	Low			
<i>Crassula glomerata</i>			Further assessment required	Moderate			
<i>Cucumis myriocarpus</i>	Paddy Melon		Negligible (B)	TBA			
<i>Cuscuta epithymum</i>	Lesser Dodder		Negligible (B)	Moderate			
<i>Cynara cardunculus</i>	Artichoke Thistle, Cardoon		Alert - no herb records for Swan Region	Low	Yes - C3		Yes
<i>Cynodon dactylon</i>	Couch		Low (D,E)	Moderate			Yes
<i>Cyperus eragrostis</i>	Umbrella Grass		Negligible (B)	Moderate			
<i>Cyperus rotundus</i>	Nut Grass		Negligible (A)	Moderate			

Latin Name	Common Name	Pest Plant under Local Govt Act 1995	DPaW Weed Assessment Swan Region (2012)	WA Enviro Weed Strategy Rating	Declared Plant (in Perth)	Weed of National Significance	Priority Weed in CoJ
<i>Digitaria sanguinalis</i>	Crab Grass		Further assessment required	Low			
<i>Dimorphotheca ecklonis</i>	Veldt Daisy		Low (B,C,D)	Low			
<i>Diplolaena dampieri</i>	Southern Diplolaena		ALERT - Native to south of Perth, not to north. Need to be wary of inappropriate planting as a native	Not listed			Yes
<i>Disa bracteata</i>	South African Orchid		Negligible (B)	Moderate			
<i>Dischisma arenarium</i>			Negligible (B)	TBA			
<i>Dischisma capitatum</i>	Woolly-headed Dischisma		Negligible (B)	TBA			
<i>Dittrichia graveolens</i>	Stinkwort		Medium (D,E,F)	Mild			
<i>Dysphania ambrosioides</i>	Mexican Tea		Further assessment required	Low			
<i>Echium plantagineum</i>	Paterson's Curse		Low (B,C,D)	TBA			Yes
<i>Ehrharta calycina</i>	Perennial Veldt Grass		Low (D,E)	High			Yes
<i>Ehrharta longiflora</i>	Annual Veldt Grass		Low (D)	Moderate			
<i>Eleusine indica</i>	Crowsfoot		Negligible (A,B)	Low			
<i>Emex australis</i>	Doublegee		Low (C)	Low			
<i>Emex spinosa</i>	Lesser Jack			Low			
<i>Eragrostis curvula</i>	African Lovegrass		Low (D)	High			Yes
<i>Erodium botrys</i>	Long Storksbill		Negligible (B)	Low			
<i>Erodium cicutarium</i>	Common Storksbill		Negligible (B)	Moderate			
<i>Erodium cygnorum</i>	Blue Heronsbill			Not listed			
<i>Erodium moschatum</i>	Musky Crowfoot		Negligible (A,B)	Low			
<i>Eucalyptus caesia</i>	Caesia			Not listed			
<i>Eucalyptus platypus</i>	Moort			Not listed			
<i>Euphorbia cyathophora</i>	Painted Spurge		Negligible (A,B)	Not listed			

Latin Name	Common Name	Pest Plant under Local Govt Act 1995	DPaW Weed Assessment Swan Region (2012)	WA Enviro Weed Strategy Rating	Declared Plant (in Perth)	Weed of National Significance	Priority Weed in CoJ
<i>Euphorbia paralias</i>	Sea Spurge		Negligible (B)	Moderate			
<i>Euphorbia peplus</i>	Petty Spurge		Negligible (B)	Moderate			Yes
<i>Euphorbia terracina</i>	Geraldton Carnation Weed		Medium (D,E,F,G)	High			Yes
<i>Ferraria crispa</i>	Black Flag		Medium (D,E,F)	TBA			Yes
<i>Ficus carica</i>	Fig		Low (D)	Moderate			Yes
<i>Foeniculum vulgare</i>	Fennel		Negligible (A)	TBA			
<i>Freesia alba x leichtlinii</i>			Low (D,E)	TBA			Yes
<i>Freesia sp.</i>	Freesia			High			Yes
<i>Fumaria capreolata</i>	Whiteflower Fumitory		Low (D)	Mild			
<i>Galenia pubescens var. pubescens</i>	Coastal Galenia		Further assessment required	Low			
<i>Galium murale</i>	Small Goosegrass		Negligible (B)	Moderate			
<i>Gamochaeta calviceps</i>	Cudweed		Negligible (A,B)	Low			
<i>Gamochaeta coarctata</i>			Negligible (A,B)	Not listed			
<i>Gazania linearis</i>	Gazania		High (H,I)	Low			Yes
<i>Genista monspessulana</i>	Cape Broom		Low (D)	Not listed			Yes
<i>Gladiolus angustus</i>	Long Tubed Painted Lady		Low (C)	Mild			Yes
<i>Gladiolus caryophyllaceus</i>	Wild Pink Gladiolus		Medium (D,E,F)	Moderate			
<i>Gladiolus undulatus</i>	Wavy Gladiolus		Medium (D,E,F,G)	Moderate			Yes
<i>Gomphocarpus fruticosus</i>	Narrowleaf Cottonbush		Low (D,E)	Moderate			
<i>Grevillea leucopteris</i>	White Plume Grevillea			Not listed			
<i>Grevillea robusta</i>	Silky Oak			Low			
<i>Hedypnois rhagadioloides subsp. Cretica</i>				Mild			
<i>Heliophila pusilla</i>			Negligible (B)	Moderate			
<i>Hesperantha falcata</i>			Low (D)	Moderate			Yes
<i>Hordeum leporinum</i>	Barley Grass		Negligible (B)	Moderate			Yes

Latin Name	Common Name	Pest Plant under Local Govt Act 1995	DPaW Weed Assessment Swan Region (2012)	WA Enviro Weed Strategy Rating	Declared Plant (in Perth)	Weed of National Significance	Priority Weed in CoJ
<i>Hydrocotyle verticillata</i>	Shield Pennywort			Low			Yes
<i>Hyparrhenia hirta</i>	Tambookie Grass		High (G,H,I)	High			Yes
<i>Hypochaeris glabra</i>	Smooth Catsear		Low (D)	Moderate			Yes
<i>Hypochaeris radicata</i>	Flat Weed		Low (D)	Not listed			Yes
<i>Ipomoea indica</i>	Morning Glory		Low (B,C,D)	Mild			
<i>Isolepis marginata</i>	Course Club-rush		Negligible (B)	Not listed			
<i>Ixia maculata</i>	Yellow Ixia		High (H,I)	Low			Yes
<i>Lachenalia bulbifera</i>			Low (B,C,D)	Low			Yes
<i>Lachenalia reflexa</i>	Yellow Soldier, Cape Cowslip		High (H,I)	High			Yes
<i>Lactuca serriola</i>	Prickly Lettuce		Medium (D,E,F)	Moderate			Yes
<i>Lagurus ovatus</i>	Hare's Tail Grass		Low (D)	High			Yes
<i>Lantana camara</i>	Lantana		Low (B,C,D)	Moderate	Yes - C3	Yes	Yes
<i>Lathyrus tingitanus</i>	Tangier Pea		Low (B,C,D)	Low			
<i>Lavandula stoechas</i>	Italian Lavender		Low (B,C,D)	Low			
<i>Leptospermum laevigatum</i>	Victorian (Coastal) Tea Tree		High (H,I)	High			Yes
<i>Lobularia maritima</i>	Sweet Alyssum		Low (B,C,D)	Low			
<i>Lolium perenne</i>	Perennial Rye Grass			Low			
<i>Lolium rigidum</i>	Wimmera Ryegrass			Moderate			
<i>Lupinus angustifolius</i>	Narrowleaf Lupin		High (G,H,I)	Mild			Yes
<i>Lupinus cosentinii</i>	Blue Lupin		High (G,H,I)	High			Yes
<i>Lysimachia arvensis</i>	Pimpernel			Moderate			
<i>Malva parviflora</i>	Marshmallow		Negligible (B)	Low			
<i>Matthiola incana</i>	Common Stocks		Negligible (A,B)	Low			
<i>Medicago spp</i>	Burr Medic		Negligible (B)	Mild			
<i>Melaleuca lanceolata</i>	Rottnest Teatree			Not listed			Yes
<i>Melaleuca nesophila</i>	Mindiyed		Further assessment required	Not listed			
<i>Melia azedarach</i>	White Cedar		Negligible (A,B)	Not listed			
<i>Melilotus indicus</i>	Yellow Sweet Clover		Medium (D,E,F)	TBA			

Latin Name	Common Name	Pest Plant under Local Govt Act 1995	DPaW Weed Assessment Swan Region (2012)	WA Enviro Weed Strategy Rating	Declared Plant (in Perth)	Weed of National Significance	Priority Weed in CoJ
<i>Melinis repens</i>	Ruby Grass		Low (B,C,D)	Mild			
<i>Mesembryanthemum crystallinum</i>	Ice Plant		Very High (H,I)	Moderate			Yes
<i>Monoculus monstrosus</i>			Low (B,C)	Not listed			
<i>Moraea flaccida</i>	One-leaf Cape Tulip		Low (D,E)	High			Yes
<i>Moraea miniata</i>	Two-leaf Cape Tulip		Low (D,E)	Moderate			Yes
<i>Oenothera drummondii</i>	Beach Evening Primrose		Medium (D,E,F)	Moderate			
<i>Oenothera glazioviana</i>	Evening Primrose		Low (C)	Low			
<i>Oenothera stricta</i>	Common Evening Primrose		Low (C)	Low			
<i>Olea europea</i>	Olive		High (H,I)	Moderate			Yes
<i>Onopordum acaulon</i>	Stemless Thistle			Low			
<i>Ornithogalum arabicum</i>	Lesser Cape Lily		Alert - not on DEC estate Difficult to control. Unknown impacts	Low			Yes
<i>Ornithopus pinnatus</i>	Slender Serradella		Low (B,C)	Low			
<i>Oxalis</i>	Oxalis			Not listed			
<i>Oxalis incarnata</i>	Oxalis incarnata		Negligible (A,B)	Low			
<i>Oxalis pes-caprae</i>	Soursob		Low (C)	Mild			Yes
<i>Oxalis purpurea</i>	Largeflower Wood Sorrel		Low (C)	Low			
<i>Papaver rhoeas</i>	Field Poppy			Low			
<i>Paspalum dilatatum</i>	Dallis Grass		Low (B,C)	Moderate			Yes
<i>Passiflora foetida</i>	Stinking Passion Flower			High			Yes
<i>Pelargonium capitatum</i>	Rose Pelargonium		Low (D,E)	High			Yes
<i>Pennisetum clandestinum</i>	Kikuyu		Low (C)	Moderate			Yes
<i>Pentameris airoides</i>	False Hairgrass		Negligible (B)	Moderate			
<i>Pentameris airoides subsp. Airoides</i>				Not listed			

Latin Name	Common Name	Pest Plant under Local Govt Act 1995	DPaW Weed Assessment Swan Region (2012)	WA Enviro Weed Strategy Rating	Declared Plant (in Perth)	Weed of National Significance	Priority Weed in CoJ
<i>Pentameris pallida</i>	Pentameris pallida		Low (B,C,D)	Low			Yes
<i>Petrorhagia dubia</i>	Hairy Pink		Low (D)	Mild			
<i>Petrorhagia velutina</i>	Velvet Pink			Mild			
<i>Phyllopodium cordatum</i>			Further assessment required	Mild			
<i>Phytolacca octandra</i>	Red Ink Weed		Low (B,C,D)	Mild			
<i>Plantago lanceolata</i>	Rainbow Plantain		Low (B,C,D)	Low			
<i>Poa annua</i>	Winter Grass		Low (B,C)	Mild			
<i>Polycarpon tetraphyllum</i>	Fourleaf Allseed		Low (D)	Low			
<i>Polygala myrtifolia</i>	Butterfly Bush		Medium (D,E,F,G)	Not listed			Yes
<i>Polypogon monspeliensis</i>	Annual Beardgrass		Low (B,C)	Moderate			
<i>Poinsettia</i>	Poinsettia			Not listed			
<i>Raphanus raphanistrum</i>	Wild Radish		Negligible (B)	Mild			
<i>Retama raetam</i>	White Broom		High (H,I)	TBA			Yes
<i>Ricinus communis</i>	Castor Oil Plant		Medium (D,E,F)	Low			
<i>Romulea flava</i>			Negligible (B)	Moderate			
<i>Romulea rosea</i>	Guildford Grass			High			Yes
<i>Romulea rosea var. australis</i>	Guildford Grass		Negligible (B)	TBA			
<i>Salvinia molesta</i>	Salvinia		Medium (D,E,F,G)	High		Yes	Yes
<i>Scaevola paludosa</i>				Not listed			
<i>Schinus terebinthifolius</i>	Brazilian Pepper		Medium (D,E,F)	Moderate			Yes
<i>Senecio mikanioides</i>	Cape Ivy			TBA			
<i>Senecio vulgaris</i>	Common Groundsel		Low (B,C,D)	Low			
<i>Silene gallica</i>	French Catchfly		Negligible (B)	Low			
<i>Silene gallica var. gallica</i>			Negligible (B)	Low			
<i>Silybum marianum</i>	Variegated Thistle		Low (C)	Low	Yes - C3		Yes
<i>Solanum linnaeanum</i>	Apple of Sodom		Medium (D,E,F)	Moderate			Yes

Latin Name	Common Name	Pest Plant under Local Govt Act 1995	DPaW Weed Assessment Swan Region (2012)	WA Enviro Weed Strategy Rating	Declared Plant (in Perth)	Weed of National Significance	Priority Weed in CoJ
<i>Solanum nigrum</i>	Black Berry Nightshade		Low (B,C)	Moderate			
<i>Soliva sessilis</i>	Bindii		Negligible (A)	TBA			
<i>Sonchus asper</i>	Rough Sowthistle		Negligible (B)	Moderate			
<i>Sonchus oleraceus</i>	Common Sowthistle		Negligible (B)	Moderate			
<i>Sporobolus africanus</i>	Parramatta Grass		Low (B,C,D)	TBA			
<i>Stellaria media</i>	Chickweed		Negligible (B)	Low			
<i>Stenotaphrum secundatum</i>	Buffalo Grass		Low (C)	Moderate			Yes
<i>Tagetes minuta</i>	Stinking Roger			TBA			
<i>Tamarix aphylla</i>	Athel Tree, Tamarisk, Tamarix		High (G,H,I)	Moderate	Yes - C3	Yes	Yes
<i>Taraxacum officinale</i>	Dandelion			Low			
<i>Tetragonia decumbens</i>	Sea Spinach		Low (D)	Moderate			
<i>Thinopyrum junceiforme</i>	Sea Wheatgrass			Not listed			
<i>Trachyantra divaricata</i>	False Onion Weed		Low (D)	Mild			
<i>Tribulus terrestris</i>	Caltrop	Yes	Medium (D,E,F)	Not listed			Yes
<i>Tribolium uniolae</i>	Tribolium		High (G,H,I)	Moderate			Yes
<i>Trifolium arvense</i>	Hare's Foot Clover		Further assessment required	Moderate			
<i>Trifolium arvense var. arvense</i>			Further assessment required	Not listed			
<i>Trifolium campestre</i>	Hop Clover			Moderate			
<i>Trifolium dubium</i>	Suckling Clover		Further assessment required	Moderate			
<i>Trifolium repens</i>	White Clover			Mild			
<i>Trifolium subterraneum</i>	Subterranean Clover		Further assessment required	Moderate			
<i>Trifolium tomentosum</i>	Woolly Clover			Low			
<i>Triticum aestivum</i>	Wheat			Low			
<i>Tropaeolum majus</i>	Nasturtium		Negligible (A,B)	Low			
<i>Typha orientalis</i>	Non-local Bulrush		Low (D,E)	High			Yes

Latin Name	Common Name	Pest Plant under Local Govt Act 1995	DPaW Weed Assessment Swan Region (2012)	WA Enviro Weed Strategy Rating	Declared Plant (in Perth)	Weed of National Significance	Priority Weed in CoJ
<i>Urospermum picroides</i>	False Hawkbit		Low (D)	Moderate			
<i>Ursinia anthemoides</i>	Ursinia		Negligible (B)	Moderate			
<i>Ursinia anthemoides subsp. anthemoides</i>				Moderate			
<i>Vicia sativa</i>	Common Vetch		Negligible (B)	Moderate			
<i>Vulpia fasciculata</i>			Medium (D,E,F)	Moderate			
<i>Vulpia myuros</i>	Rat's Tail Fescue			Moderate			Yes
<i>Wahlenbergia capensis</i>	Cape Bluebell		Low (B,C)	Moderate			
<i>Watsonia meriana var. bulbifera</i>	Watsonia		High (H,I)	High			Yes
<i>Watsonia meriana var. meriana</i>	Watsonia		High (H,I)	Not listed			
<i>Zantedeschia aethiopica</i>	Arum Lily		Medium (D,E,F,G)	High	Yes - C3		Yes



Veldt Daisy (*Dimorphotheca ecklonis*)

Appendix 6

Weed Control Methods Used by the City of Joondalup

Weed Control Method	Suitable for Species	Notes	Advantages	Disadvantages
Hand removal or digging	Many annual species and for relatively small infestations	Need to remove the entire plant.	<ul style="list-style-type: none"> Young plants can be easy to pull out if soil is moist Allows for selective removal of weeds 	<ul style="list-style-type: none"> Can be difficult to remove plants if soil is dry or plants are large Time consuming and labour intensive Digging can cause soil disturbance and disturb the root systems of native vegetation
Spot spray	Small populations of weeds	Application of diluted herbicide with hand-held spray guns.	<ul style="list-style-type: none"> Targeted weed application Quick and cheap method to control low populations of weeds spread over large areas 	<ul style="list-style-type: none"> Time consuming in large areas
Cut and paint	Woody weeds (low numbers)	The plant is cut off close to ground level with a horizontal cut and undiluted herbicide (according to Permit or label) is applied immediately to the cut surface. ⁶⁰	<ul style="list-style-type: none"> Targeted weed application 	<ul style="list-style-type: none"> Time consuming for large populations Weed has to be felled prior to treatment Can cause root suckers
Basal bark treatment	Woody weeds and root suckers (low numbers)	Diluted herbicide (rates according to Permit or label) is painted or sprayed on to the bark at the base, from ground level to 30cm high. ⁶⁰	<ul style="list-style-type: none"> Targeted weed application No risk of regrowth 	<ul style="list-style-type: none"> Time consuming for large populations

⁶⁰Eurobodalla Shire Council (n.d.)

Weed Control Method	Suitable for Species	Notes	Advantages	Disadvantages
Wick wiping	Tail weeds	Herbicides can be wiped on to individual plants with a weed wiper, rope wick applicator or sponge roller.	<ul style="list-style-type: none"> Targeted weed application 	<ul style="list-style-type: none"> Only controls weeds which grow above surrounding vegetation. Time consuming Rope wicks can be ineffective due to dripping and clogging with dirt Multiple treatments may be required
Mowing	Annual species	Mowing down aboveground biomass. To be done before seed set.	<ul style="list-style-type: none"> Delays production of seed Will eventually deplete the soil seed store 	<ul style="list-style-type: none"> Not a permanent method of control Can result in spreading of seed, if plants have already seeded⁶¹ Should be combined with another weed control method
Mulching using loose particles of organic matter	All	Most effective if weeds are cleared before applying. Certified weed and pathogen free mulch should be used. Planting species in mulch suppresses weed growth. ⁶²	<ul style="list-style-type: none"> Provides organic matter as it breaks down Helps retain water 	<ul style="list-style-type: none"> Some weeds may still grow Difficult to apply around non-target species
Slashing or brushcutting	Annual species	Slashing or brushcutting aboveground biomass. To be done before seed set.	<ul style="list-style-type: none"> Delays production of seed Will eventually deplete the soil seed store 	<ul style="list-style-type: none"> Not a permanent method of control Can result in spreading of seed, if plants have already seeded⁶³ Should be combined with another weed control method

⁶¹ Eurobodalla Shire Council (n.d.)

⁶² Johansson (n.d.)

⁶³ Eurobodalla Shire Council (n.d.)

Weed Control Methods Not Used by the City of Joondalup

Weed Control Method	Suitable for Species	Notes	Advantages	Disadvantages
Smothering using materials such as black plastic, fibre, carpet, cardboard, newspaper, wood chips or jute matting	All	Most effective if weeds are cleared before applying. Suppresses or kills weeds by creating a barrier between the weeds and sunlight.	<ul style="list-style-type: none"> Prevent germination of weed seeds. 	<ul style="list-style-type: none"> Expensive Materials can be difficult to apply around established plants Possible issues with water and nutrient penetration Clean up of degraded materials can be time consuming
Scrape and paint	Large vines and scrambling plants with a woody stem	Scrape 20cm to 100cm of the stem with a knife, for a third of the diameter of the stem (or scrape on two sides if stem is over 1cm in diameter), to expose the sapwood just below the bark. Apply undiluted herbicide (rates according to Permit or label) immediately to the scraped section.	<ul style="list-style-type: none"> Effective method of weed control 	<ul style="list-style-type: none"> Time consuming for large populations
Stem injection	Woody weeds (low numbers)	Purpose-built stem injection devices can be used, or a hammer and chisel or cordless drill. An angled cut or hole is made into the sapwood just below and bark and undiluted herbicide (rates according to Permit or label) is applied into the cut immediately. Avoid drilling further than the sapwood into the heartwood as it doesn't take up the herbicide.	<ul style="list-style-type: none"> Targeted weed application 	<ul style="list-style-type: none"> Time consuming for large populations
Granules	Various	Granules or pellets (root absorbed herbicide) are applied to the surface of moist soil or into the top soil.	<ul style="list-style-type: none"> No spray drift Controlled release can reduce the need for repeat applications 	<ul style="list-style-type: none"> Rain or moisture is required Herbicides are expensive Even spread can be difficult Limited choice of herbicides Potential for herbicide to be washed off site May effect non-targeted species

Weed Control Method	Suitable for Species	Notes	Advantages	Disadvantages
Drowning of emergent species by cutting the species beneath the water level in winter ⁶⁴	Emergent species (e.g. Bulrush and Kikuyu)	Suited to wetlands. Need to cut species below water level.	<ul style="list-style-type: none"> Effective on a significant number of emergent species targeted 	<ul style="list-style-type: none"> Time consuming Water levels may change
Solarisation, or heating, of weeds to high temperatures under plastic	Low-growing and semi-aquatic weeds	Weeds are smothered with plastic sheeting until seeds or plants have been cooked. ⁶⁵ Works best when weeds are growing in full sun. ⁶⁶	<ul style="list-style-type: none"> Best used for small infestations 	<ul style="list-style-type: none"> May not kill seed stored in the soil Plastic may need to be weighted down and left in place for months Time consuming Vegetation needs to be cleared from the area
Flame weeding	Young weeds and grasses, some annual and perennial weeds	Direct propane flame at weeds. A thin blast of heat (1000°C) causes the water within the cell stalk to boil.	<ul style="list-style-type: none"> Leaves no chemical residue No soil disturbance More effective than infrared radiation 	<ul style="list-style-type: none"> Safety and fire hazards May require a series of flamings (2-3 weeks apart) Gas usage
Infrared radiation	Shallow rooted weeds	Uses gas burners and has no visible flame on the combustion surface.	<ul style="list-style-type: none"> Cover a more closely defined area than flame weeders 	<ul style="list-style-type: none"> Need time to heat up Gas usage Unsure of effectiveness against deep rooted weeds⁶⁷
Steam	Young weeds	Jets of steam are applied to weeds through standard spray nozzles enclosed under a steel housing.	<ul style="list-style-type: none"> More effective than flame weeders 	<ul style="list-style-type: none"> Requires significant energy and water Difficult to get the steam to condense on the plant to make use of the latent heat May not reduce subsequent weed seedling emergence⁶⁷
Boiling water	Annuals and perennials	Boil water and pour stream on to the crown of the weed.	<ul style="list-style-type: none"> Works well in concrete, paved and rock areas⁶⁸ 	<ul style="list-style-type: none"> Safety hazards May effect non-targeted species Time consuming Water usage May need to be repeated

⁶⁴ Water and Rivers Commission (2001)

⁶⁵ Department of Planning (n.d.)

⁶⁶ Eurobodalla Shire Council (n.d.)

⁶⁷ Bond, Turner and Grundy (2003)

⁶⁸ Johansson (n.d.)

Weed Control Method	Suitable for Species	Notes	Advantages	Disadvantages
Acidic	Annuals, biennials and some perennials	Contain approx 15-20% acidic ingredients such as lemon, lime or vinegar, sprayed directly on the leaves, causing them to die. ⁶⁹	<ul style="list-style-type: none"> Leaves no soil residue 	<ul style="list-style-type: none"> May effect non-targeted species Foliage must be sprayed so it is completely wet Health risks
Fatty acids	Annual weeds, grasses and broadleaf weeds	Coconut fatty acid is often an ingredient. Dissolves membranes of plants leaves, causing the leaves to die.	<ul style="list-style-type: none"> Will not move through soil to harm nearby plants Fast acting Leave no residue in the soil⁷⁰ 	<ul style="list-style-type: none"> May effect non-targeted species Repeat applications may be required on larger weeds

⁶⁹ Demand Media Inc. (2013)

⁷⁰ Johansson (n.d.)



Sea Rocket (*Cakile maritima*)

Appendix 7

Park Weed Management Prioritisation

Location	Suburb	School Oval Priority (Y/N)	Weed Management Priority
Regional Sports Park			
Percy Doyle Reserve	Duncraig	N	Very high priority - 1
District Sports Park			
Chichester Park	Woodvale	Y	High priority - 2
Heathridge Park	Heathridge	N	High priority - 2
Iluka District Open Space	Iluka	N	High priority - 2
Kingsley Park	Kingsley	Y	High priority - 2
MacDonald Park	Padbury	N	High priority - 2
Penistone Park	Greenwood	N	High priority - 2
Seacrest Park	Sorrento	N	High priority - 2
Warwick Open Space	Warwick	N	High priority - 2
Local Sports Park			
Admiral Park	Heathridge	N	Medium priority - 3
Barridale Park	Kingsley	N	Medium priority - 3
Beldon Park	Beldon	Y	High priority - 2
Belrose Park	Kallaroo	N	Medium priority - 3
Bramston Park	Burns Beach	N	Medium priority - 3
Bridgewater Park	Kallaroo	N	Medium priority - 3
Caledonia Park	Currambine	Y	High priority - 2
Callander Park	Kinross	Y	High priority - 2
Carlton Park	Currambine	Y	High priority - 2
Charonia Park	Mullaloo	N	Medium priority - 3
Christchurch Park	Currambine	N	Medium priority - 3
Ellersdale Park	Warwick	N	Medium priority - 3
Emerald Park	Edgewater	N	Medium priority - 3
Falkland Park	Kinross	N	Medium priority - 3
Forrest Park	Padbury	N	Medium priority - 3
Glengarry Park	Duncraig	N	Medium priority - 3
Hawker Park	Warwick	N	Medium priority - 3
Hillarys Park	Hillarys	N	Medium priority - 3
James Cook Park	Hillarys	N	Medium priority - 3
Juniper Park	Duncraig	N	Medium priority - 3
Kinross College Oval	Kinross	Y	High priority - 2
Korella Park	Mullaloo	Y	High priority - 2
Lexcen Park	Ocean Reef	N	Medium- priority - 3
Littorina Park	Heathridge	Y	High priority - 2
MacNaughton Park	Kinross	N	Medium priority - 3

Location	Suburb	School Oval Priority (Y/N)	Weed Management Priority
Marri Park	Duncraig	N	Medium priority - 3
Melene Park	Duncraig	N	Medium priority - 3
Mirror Park	Ocean Reef	N	Medium priority - 3
Moolanda Park	Kingsley	N	Medium priority - 3
Ocean Reef Park	Ocean Reef	N	Medium priority - 3
Okely Park	Edgewater	N	Medium priority - 3
Otago Park	Craigie	N	Medium priority - 3
Parkside Park	Woodvale	Y	High priority - 2
Prince Regent Park	Heathridge	N	Medium priority - 3
Robin Park	Sorrento	N	Medium priority - 3
Santiago Park	Ocean Reef	Y	High priority - 2
Timberlane Park	Woodvale	N	Medium priority - 3
Warrandyte Park	Craigie	N	Medium priority - 3
Warrigal Park	Greenwood	N	Medium priority - 3
Windermere Park	Joondalup	N	Medium priority - 3
Local Mixed-Use Park			
Blackall Park and Calectasia Park	Greenwood	N	Medium priority - 3
Flinders Park	Hillarys	N	Medium priority - 3
Mawson Park	Hillarys	N	Medium priority - 3
Regional Recreation Park			
Burns Beach Park	Burns Beach	N/A	Very high priority - 1
Neil Hawkins Park	Joondalup	N/A	Very high priority - 1
Picnic Cove Park	Edgewater	N/A	Very high priority - 1
Tom Simpson Park	Mullaloo	N/A	Very high priority - 1
Sorrento Foreshore	Sorrento	N/A	Very high priority - 1
Whitfords Nodes Central	Hillarys	N/A	Very high priority - 1
Whitfords Nodes South	Hillarys	N/A	Very high priority - 1
Ocean Reef Foreshore Park	Ocean Reef	N/A	Very high priority - 1
Iluka Foreshore Park	Iluka	N/A	Very high priority - 1
District Recreation Park			
Beaumaris Park	Ocean Reef	N/A	Low priority - 4
Blackboy Park	Mullaloo	N/A	Low priority - 4
Braden Park	Marmion	N/A	Low priority - 4
Broadbeach Park	Hillarys	N/A	Low priority - 4
Geneff Park	Sorrento	N/A	Low priority - 4
Rev John Smithies Park	Kingsley	N/A	Low priority - 4
Sandalford Park	Beldon	N/A	Low priority - 4

Location	Suburb	School Oval Priority (Y/N)	Weed Management Priority
Local Recreation Park			
Aberdare Park	Warwick	N/A	Low priority - 4
Abrolhos Park	Heathridge	N/A	Low priority - 4
Adelaide Park	Craigie	N/A	Low priority - 4
Albacore Park	Sorrento	N/A	Low priority - 4
Albion Park	Craigie	N/A	Low priority - 4
Alder Park	Duncraig	N/A	Low priority - 4
Alfreton Park	Duncraig	N/A	Low priority - 4
Alidade Park	Beldon	N/A	Low priority - 4
Anemone Park	Mullaloo	N/A	Low priority - 4
Annato Park	Greenwood	N/A	Low priority - 4
Aristride Park	Kallaroo	N/A	Low priority - 4
Balanus Park	Heathridge	N/A	Low priority - 4
Baltusrol Park	Connolly	N/A	Low priority - 4
Banks Park	Hillarys	N/A	Low priority - 4
Banksia Park	Marmion	N/A	Low priority - 4
Barclay Park	Padbury	N/A	Low priority - 4
Barwon Park	Craigie	N/A	Low priority - 4
Beachside Park	Burns Beach	N/A	Low priority - 4
Beaumont Park	Edgewater	N/A	Low priority - 4
Birch Park	Greenwood	N/A	Low priority - 4
Blackthorn Park	Greenwood	N/A	Low priority - 4
Blue Lake Park	Joondalup	N/A	Low priority - 4
Bonnie Doon Park	Connolly	N/A	Low priority - 4
Bracken Park	Duncraig	N/A	Low priority - 4
Brazier Park	Padbury	N/A	Low priority - 4
Brisbane Park	Padbury	N/A	Low priority - 4
Buckthorn Park	Duncraig	N/A	Low priority - 4
Byrne Park	Padbury	N/A	Low priority - 4
Cadogan Park	Kingsley	N/A	Low priority - 4
Callion Park	Padbury	N/A	Low priority - 4
Calthorpe Park	Kingsley	N/A	Low priority - 4
Camberwarra Park	Craigie	N/A	Low priority - 4
Candlewood Park	Joondalup	N/A	Low priority - 4
Captain Park	Heathridge	N/A	Low priority - 4
Carr Park	Warwick	N/A	Low priority - 4
Castlecrag Park	Kallaroo	N/A	Low priority - 4
Castlefern Park	Duncraig	N/A	Low priority - 4
Chadstone Park	Craigie	N/A	Low priority - 4
Chelsea Park	Kingsley	N/A	Low priority - 4
Chelsford Park	Warwick	N/A	Low priority - 4

Location	Suburb	School Oval Priority (Y/N)	Weed Management Priority
Churton Park	Warwick	N/A	Low priority - 4
Cinque Ports Park	Connolly	N/A	Low priority - 4
Circle Park	Warwick	N/A	Low priority - 4
Clare Park	Sorrento	N/A	Low priority - 4
Clermont Park	Currambine	N/A	Low priority - 4
Cliff Park	Marmion	N/A	Low priority - 4
Clifford Coleman Park	Marmion	N/A	Low priority - 4
Conica Park	Hillarys	N/A	Low priority - 4
Conidae Park	Heathridge	N/A	Low priority - 4
Coolibah Park	Duncraig	N/A	Low priority - 4
Cornish Park	Woodvale	N/A	Low priority - 4
Culwalla Park	Kallaroo	N/A	Low priority - 4
Cumberland Park	Beldon	N/A	Low priority - 4
Cunningham Park	Padbury	N/A	Low priority - 4
Dampier Park	Kallaroo	N/A	Low priority - 4
De Crillon Park	Currambine	N/A	Low priority - 4
Delonix Park	Woodvale	N/A	Low priority - 4
Dollis Park	Kingsley	N/A	Low priority - 4
Doncaster Park	Currambine	N/A	Low priority - 4
Earlsferry Park	Kinross	N/A	Low priority - 4
Edgewater Park	Edgewater	N/A	Low priority - 4
Elcar Park	Joondalup	N/A	Low priority - 4
Ensign Park	Beldon	N/A	Low priority - 4
Fairmont Park	Currambine	N/A	Low priority - 4
Fairway Park	Connolly	N/A	Low priority - 4
Faversham Park	Heathridge	N/A	Low priority - 4
Fenton Park	Hillarys	N/A	Low priority - 4
Fernwood Park	Padbury	N/A	Low priority - 4
Filbert Park	Greenwood	N/A	Low priority - 4
Finney Park	Marmion	N/A	Low priority - 4
Forest Hill Park	Kingsley	N/A	Low priority - 4
Fraser Park	Padbury	N/A	Low priority - 4
Galston Park	Duncraig	N/A	Low priority - 4
Geddes Park	Duncraig	N/A	Low priority - 4
George Sears Park	Greenwood	N/A	Low priority - 4
Gerda Park	Greenwood	N/A	Low priority - 4
Gibson Park	Padbury	N/A	Low priority - 4
Gleddon Park	Hillarys	N/A	Low priority - 4
Glenbank Park	Kallaroo	N/A	Low priority - 4
Glenmere Park	Warwick	N/A	Low priority - 4
Gradient Park	Beldon	N/A	Low priority - 4

Location	Suburb	School Oval Priority (Y/N)	Weed Management Priority
Granadilla Park	Duncraig	N/A	Low priority - 4
Greenlaw Park	Duncraig	N/A	Low priority - 4
Greenwich Park	Kingsley	N/A	Low priority - 4
Gunida Park	Mullaloo	N/A	Low priority - 4
Haddington Park	Beldon	N/A	Low priority - 4
Harman Park	Sorrento	N/A	Low priority - 4
Hartley Park	Greenwood	N/A	Low priority - 4
Herreshoff Park	Ocean Reef	N/A	Low priority - 4
Hilltop Park	Edgewater	N/A	Low priority - 4
Hillwood Park (North)	Warwick	N/A	Low priority - 4
Hillwood Park (South)	Warwick	N/A	Low priority - 4
Hilton Park	Duncraig	N/A	Low priority - 4
Huntingdale Park	Connolly	N/A	Low priority - 4
Illawong Park	Kingsley	N/A	Low priority - 4
Kallaroo Park	Mullaloo	N/A	Low priority - 4
Kanangra Park	Greenwood	N/A	Low priority - 4
Katrine Park	Joondalup	N/A	Low priority - 4
Kelvin Park	Duncraig	N/A	Low priority - 4
Keppell Park	Marmion	N/A	Low priority - 4
Kiernan Park	Kallaroo	N/A	Low priority - 4
Killin Park	Duncraig	N/A	Low priority - 4
Kilrenny Park	Greenwood	N/A	Low priority - 4
Kimberley Park	Hillarys	N/A	Low priority - 4
Kingfisher Park	Kingsley	N/A	Low priority - 4
Lacepede Park	Sorrento	N/A	Low priority - 4
Lady Evelyn Park	Joondalup	N/A	Low priority - 4
Lakevalley Park	Edgewater	N/A	Low priority - 4
Lanark Park	Duncraig	N/A	Low priority - 4
Larkspur Park	Heathridge	N/A	Low priority - 4
Leaside Park	Greenwood	N/A	Low priority 4
Legana Park	Kingsley	N/A	Low priority - 4
Lehmann Park	Kingsley	N/A	Low priority - 4
Leichhardt Park	Padbury	N/A	Low priority - 4
Lysander Park	Heathridge	N/A	Low priority - 4
Macaulay Park	Duncraig	N/A	Low priority - 4
Manapouri Park	Joondalup	N/A	Low priority - 4
Maquire Park	Hillarys	N/A	Low priority - 4
McKinlay Park	Padbury	N/A	Low priority - 4
McKirdy Park	Marmion	N/A	Low priority - 4
Menteith Park	Kinross	N/A	Low priority - 4
Merrifield Park	Kallaroo	N/A	Low priority - 4

Location	Suburb	School Oval Priority (Y/N)	Weed Management Priority
Montague Park	Kallaroo	N/A	Low priority - 4
Monument Park	Beldon	N/A	Low priority - 4
Nanika Park	Joondalup	N/A	Low priority - 4
Negresco Park	Currambine	N/A	Low priority - 4
Newcombe Park	Padbury	N/A	Low priority - 4
Newham Park	Kingsley	N/A	Low priority - 4
Ninnis Park	Hillarys	N/A	Low priority - 4
Noal Gannon Park	Duncraig	N/A	Low priority - 4
Oakapple Park	Duncraig	N/A	Low priority - 4
Oleaster Park	Greenwood	N/A	Low priority - 4
Orient Park	Hillarys	N/A	Low priority - 4
Oxley Park (Central & North)	Padbury	N/A	Low priority - 4
Parin Park	Greenwood	N/A	Low priority - 4
Parkinson Park	Hillarys	N/A	Low priority - 4
Paterson Park	Padbury	N/A	Low priority - 4
Paveta Park	Greenwood	N/A	Low priority - 4
Plumdale Park	Woodvale	N/A	Low priority - 4
Porteous Park	Sorrento	N/A	Low priority - 4
Portree Park	Duncraig	N/A	Low priority - 4
Poseidon Park	Heathridge	N/A	Low priority - 4
Poynter Park	Duncraig	N/A	Low priority - 4
Quarry Ramble Park	Edgewater	N/A	Low priority - 4
Ranford Park	Hillarys	N/A	Low priority - 4
Grand Ocean Entrance	Burns Beach	N/A	Low priority - 4
Ridge Park	Edgewater	N/A	Low priority - 4
Riversdale Park	Currambine	N/A	Low priority - 4
Rodgers Park	Greenwood	N/A	Low priority - 4
Roxburgh Park	Kinross	N/A	Low priority - 4
Rutherglen Park	Kinross	N/A	Low priority - 4
Salata Park	Duncraig	N/A	Low priority - 4
Sanday Park	Warwick	N/A	Low priority - 4
Santa Ana Park	Currambine	N/A	Low priority - 4
Scott Park	Hillarys	N/A	Low priority - 4
Sherington Park	Greenwood	N/A	Low priority - 4
Simpson Park	Padbury	N/A	Low priority - 4
Southern Cross Park	Ocean Reef	N/A	Low priority - 4
Southport Park	Burns Beach	N/A	Low priority - 4
Spoonbill Park	Kingsley	N/A	Low priority - 4
Springvale Park	Warwick	N/A	Low priority - 4
St Michael's Park	Connolly	N/A	Low priority - 4
Stanford Park	Kallaroo	N/A	Low priority - 4

Location	Suburb	School Oval Priority (Y/N)	Weed Management Priority
Stonehaven Park	Kinross	N/A	Low priority - 4
Sweeney Park	Padbury	N/A	Low priority - 4
Sycamore Park	Duncraig	N/A	Low priority - 4
Talbot Park	Kingsley	N/A	Low priority - 4
Tarolinta Park	Ocean Reef	N/A	Low priority - 4
Telopia Park	Duncraig	N/A	Low priority - 4
Thornton Park	Kinross	N/A	Low priority - 4
Timbercrest Park	Woodvale	N/A	Low priority - 4
Tom Walker Park	Sorrento	N/A	Low priority - 4
Trappers Park	Woodvale	N/A	Low priority - 4
Trig Point Park	Ocean Reef	N/A	Low priority - 4
Triton Park	Mullaloo	N/A	Low priority - 4
Tuart Park	Edgewater	N/A	Low priority - 4
Wallangarra Park	Kingsley	N/A	Low priority - 4
Walsh Park	Joondalup	N/A	Low priority - 4
Waltham Park	Mullaloo	N/A	Low priority - 4
Wanbrow Park	Duncraig	N/A	Low priority - 4
Wandina Park	Duncraig	N/A	Low priority - 4
Water Tower Park	Joondalup	N/A	Low priority - 4
Waterview Park	Woodvale	N/A	Low priority - 4
Wedgewood Park	Edgewater	N/A	Low priority - 4
Wentworth Park	Padbury	N/A	Low priority - 4
Whitfords East Park	Craigie	N/A	Low priority - 4
Whitfords West Park	Kallaroo	N/A	Low priority - 4
Windmill Park	Burns Beach	N/A	Low priority - 4
Woodlea Park	Joondalup	N/A	Low priority - 4

Specified Area Rates (SAR) Park	Suburb	Priority	Park Classification
Harbour View Park	Hillarys	Very high priority - 1	Local Recreation Park
Leeward Park	Hillarys	Very high priority - 1	Local Recreation Park
Marbella Park	Hillarys	Very high priority - 1	Local Recreation Park
Oahu Park	Hillarys	Very high priority - 1	Local Recreation Park
Atma Park	Iluka	Very high priority - 1	Local Recreation Park
Discovery Park	Iluka	Very high priority - 1	Local Recreation Park
Pattaya Park	Iluka	Very high priority - 1	Local Recreation Park
Sir James McCusker Park	Iluka	Very high priority - 1	Regional Recreation Park
Beenyup Park	Woodvale	Very high priority - 1	Local Recreation Park
McCubbin Park	Woodvale	Very high priority - 1	Local Recreation Park
Commercial Business Precinct (CBP) Park	Suburb	Priority	Park Classification
Central Park	Joondalup	Very high priority - 1	District Recreation Park
Albright Park	Joondalup	Very high priority - 1	Local Recreation Park
Aldgate Park	Joondalup	Very high priority - 1	Local Recreation Park
Charing Cross Park	Joondalup	Very high priority - 1	Local Recreation Park
Embankment Park	Joondalup	Very high priority - 1	Local Recreation Park
Greenshank Park	Joondalup	Very high priority - 1	Local Recreation Park
Piccadilly Park	Joondalup	Very high priority - 1	Local Recreation Park
Portwood Park	Joondalup	Very high priority - 1	Local Recreation Park
Queensbury Park	Joondalup	Very high priority - 1	Local Recreation Park
Regents Park	Joondalup	Very high priority - 1	Local Recreation Park
Sittella Park	Joondalup	Very high priority - 1	Local Recreation Park
Stilt Park	Joondalup	Very high priority - 1	Local Recreation Park
Thornbill Park	Joondalup	Very high priority - 1	Local Recreation Park
Wesley Park	Joondalup	Very high priority - 1	Local Recreation Park
Identified Parks with Weed Management Issues	Suburb	Priority	Park Classification
Cockman Park	Greenwood	Medium priority - 3	Local Recreation Park
Gascoyne Park	Woodvale	Medium priority - 3	Local Recreation Park
Sheoak Park	Greenwood	Medium priority - 3	Local Recreation Park
Wolinski Park	Mullaloo	Medium priority - 3	Local Recreation Park



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Australian Government
**Australian Pesticides and
Veterinary Medicines Authority**



MARCH 2017

**Final regulatory position: Consideration
of the evidence for a formal
reconsideration of glyphosate**

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FOREWARD

The Australian Pesticides and Veterinary Medicines Authority (APVMA) is an independent statutory authority with responsibility for the regulation of agricultural and veterinary chemicals in Australia. Its statutory powers are provided in the Agvet Codes scheduled to the Agricultural and Veterinary Chemicals Code Act 1994.

The APVMA has legislated powers to reconsider the approval of an active constituent, registration of a chemical product or approval of a label at any time after it has been registered. The reconsideration process is outlined in sections 29 to 34 of Part 2, Division 4 of the Agvet Codes.

A reconsideration may be initiated when new research or evidence raises concerns about the use or safety of a particular chemical, a product containing that chemical, or its label. The scope of each reconsideration can cover a range of areas including human health (toxicology, public health, occupational health and safety), the environment (environmental fate and ecotoxicology), residues and trade, chemistry, efficacy or target crop/animal safety. However, the scope of each reconsideration is determined on a case-by-case reflecting the specific issues raised by the new research or evidence.

The reconsideration process (illustrated in Figure 1) includes a call for information from a variety of sources, a review of that information and, following public consultation, a decision about the future use of the chemical or product. The information and technical data required by the APVMA to review the safety of both new and existing chemical products must be generated according to scientific principles. The APVMA conducts science and evidence-based risk analysis with respect to the matters of concern, analysing all the relevant information and data available.

When the APVMA receives or is made aware of a significant new piece of information that questions the safety (to target animals, humans or the environment) or efficacy of a registered chemical, the APVMA assesses the new information to determine whether a formal reconsideration of that chemical and/or products containing that chemical should be initiated.

In undertaking this process, the APVMA works in close cooperation with external experts including the Department of Health, Food Standards Australia New Zealand (FSANZ), the Department of the Environment and Energy and the state departments of agriculture, as well as other expert advisers as appropriate.

This document sets out the nomination assessment process for glyphosate that was initiated following the classification of glyphosate as 'probably carcinogenic to humans' by the International Agency for Research on Cancer (IARC) in March 2015.

This document, the proposed regulatory decision document including a detailed description of the assessment, and the technical reports relating to glyphosate are available from the APVMA website at www.apvma.gov.au. The technical reports are:

- Review of IARC Monograph 112 (Glyphosate): Tier 1
- Review of IARC Monograph 112 (Glyphosate): Tier 2

6 FINAL REGULATORY POSITION: CONSIDERATION OF THE EVIDENCE FOR A FORMAL RECONSIDERATION OF GLYPHOSATE

<p>1. Nomination</p>	<p>Nomination. Any person or group (including the APVMA and its partner agencies) may nominate an active constituent, product or label for reconsideration. The APVMA assesses the supporting scientific information and determines whether a reconsideration is warranted. Not all nominations will proceed to a formal reconsideration - there are other regulatory pathways available that may more efficiently address concerns.</p> <p>The APVMA nominated glyphosate for reconsideration following the classification of glyphosate as ‘probably carcinogenic to humans’ by the International Agency for Research on Cancer in 2015.</p>	
<p>2. Prioritisation</p>	<p>Prioritisation. The APVMA (with input from its advisory agencies) determines the priority of the reconsideration.</p>	
<p>3. Scoping and work plan</p>	<p>Scope. A scope document is prepared that outlines the areas of concern to be reconsidered. From 1 July 2015 the APVMA is legislatively required to publish a work plan for all reconsiderations to provide predictability about the timeframe for the reconsideration.</p>	
<p>4. Notice of reconsideration</p>	<p>Notice of reconsideration. To begin the reconsideration, the APVMA gives each holder a written Notice of Reconsideration that invites the holder to make a written submission to the APVMA. The holder is legally obliged to submit any available data relevant to the scope of the reconsideration. The APVMA supplements the submitted data with data available in the public domain (eg peer-reviewed scientific journal articles or international assessment reports).</p>	
<p>5. Assessment</p>	<p>Toxicology Assessment. The toxicology assessment characterises all of the adverse health effects that a compound may cause and establishes health-based guidance values (also known as public health standards) for exposure to the chemical. The toxicology assessment recommends first aid directions, poisons scheduling and any necessary warnings for product labels.</p>	<p>Environment risk assessment. The environmental risk assessment may include an evaluation of environmental fate and ecotoxicology.</p>
	<p>Human exposure assessment. The Toxicology assessment findings are used in the Occupational Health and Safety (human exposure) assessment. This assessment recommends safety directions, re-entry periods and restraints for all the uses supported by the assessment.</p>	<p>Residues and dietary exposure risk assessment (includes trade). The available residues data are used in the residues and dietary exposure risk assessment. This assessment recommends withholding periods, MRLs and restraints for all use patterns supported by this assessment. It also considers the potential trade risks arising from all the supported uses of products.</p>
	<p>Efficacy: If included in the scope of the review efficacy assessments are conducted by the APVMA.</p>	

6. Draft regulatory measure	<p>Interim Regulatory Action. At any time during a reconsideration, the APVMA may take regulatory action to mitigate any risks identified in relation to the use of a chemical. The aim of any such action is to protect human health, the environment and/or trade while a final decision is being reached through the reconsideration process.</p> <p>Proposed Regulatory Decision. The APVMA considers all the assessments and develops draft recommendations for the reconsideration which summarise the results of the assessment, identified risks, risk mitigation measures, proposed review findings and draft regulatory decisions. The PRD and the component assessment reports are released for public consultation.</p>
7. Consultation	<p>Consultation. Further data or information may be submitted to the APVMA from a range of stakeholders including holders, users of the chemicals, peak industry bodies, interest groups, non-government organisations, state and territory governments or the public.</p> <p>Usually a 3-month public consultation period is conducted following publication of the PRD. Any further data or information submitted during consultation will be taken into consideration before making the final regulatory decision.</p>
8. Regulatory decision	<p>Regulatory decision. After the public consultation period has closed, the APVMA assesses all the comments received and amends the assessment, review findings and the proposed regulatory measures as necessary. We then make the final regulatory decision.</p> <p>There are three possible regulatory outcomes from a reconsideration:</p> <ul style="list-style-type: none"> • affirm the approvals and/or registrations • vary the relevant particulars or conditions and affirm the approval or registration, or • suspend or cancel the approval or registration. <p>The APVMA will affirm the approval or registration only if satisfied that it meets all statutory safety, efficacy, trade and labelling criteria and also complies with all requirements in the regulations</p> <p>If the active constituent, product or label does not meet the criteria as described above, the APVMA will examine whether the relevant particulars or conditions of the approval or registration can be varied so that the criteria can be met. This may include varying the instructions for use on the label.</p> <p>If product registrations or label approvals are cancelled the APVMA will examine whether a phase out period for dealing with or using cancelled products or products bearing cancelled labels is appropriate. Additional instructions may be applied during phase out. If a phase out period is not appropriate then recall action may be required.</p>
END OF RECONSIDERATION (regulatory decision)	
9. Implementation	<p>Implementation. Once the decision is made to affirm, cancel or vary conditions of registrations or approvals the APVMA will send written Notices to the holders of registrations and approvals and publish Notices of affirmation, variation of conditions, and cancellation of actives, products or label approvals.</p> <p>These Notices will include brief statements of the reasons for the actions, relevant particulars for any affirmed approvals or registrations and any appropriate instructions of use or phase-out periods for cancellations. The APVMA will publish details of any applicable phase out periods if any approvals of actives, registration of products or label approvals are cancelled. The maximum legislated phase out period is 12-months.</p>

Figure 1: The chemical reconsideration process

EXECUTIVE SUMMARY

Introduction

Glyphosate is a broad-spectrum, non-selective, post-emergent, systemic herbicide that kills or suppresses all plant types (except those genetically modified to be resistant to glyphosate) and is commonly used to control annual and perennial broadleaf and grassy weeds in various agricultural and non-agricultural settings. Glyphosate acts by disrupting the shikimic acid pathway, which is unique to plants, to prevent protein biosynthesis and kill the plant.

The first product containing glyphosate was registered for use in Australia in the 1970s, under the trade name 'Roundup®'. Products containing glyphosate that are registered for use in Australia are formulated as solutions, granules, aerosols and gels and are generally applied using ground or aerial equipment.

Concerns have previously been raised about human exposure to glyphosate, following an assessment by the International Agency for Research on Cancer (IARC) that re-classified glyphosate as 'probably carcinogenic to humans'.

The APVMA chose to consider glyphosate for reconsideration following the publication of the IARC Monograph 112 in July 2015. Once a chemical has been nominated for reconsideration, the APVMA examines the new information to determine whether there are sufficient scientific grounds to warrant placing the chemical under formal reconsideration. This regulatory position report represents the outcome of that scientific nomination assessment process.

Assessment of the carcinogenic potential of glyphosate: a weight-of-evidence approach

The nomination assessment process involved a scientific weight-of-evidence evaluation of information in the IARC monograph, risk assessments undertaken independently by regulatory agencies in other countries and expert international bodies, in addition to Adverse Experience Reports (AERs) submitted to the APVMA. A weight-of-evidence assessment involves an examination of the quality, biological relevance and consistency of studies, assessment reports and scientific conclusions according to the scientific method.

The APVMA commissioned a review of the IARC monograph by the Office of Chemical Safety (OCS) within the Department of Health. This review was conducted in two phases: Tier 1 involved conducting a preliminary scoping review of the IARC monograph to ascertain the relevance of the carcinogenicity classification of glyphosate and any implications that this may have for glyphosate approvals and registrations in Australia; Tier 2 involved conducting a detailed assessment of those studies that were identified during the Tier 1 assessment as requiring further evaluation.

The APVMA also reviewed a number of very recent international assessments of glyphosate including those undertaken by the Joint Food and Agriculture Organisation of the United Nations/World Health Organisation (FAO/WHO) Meeting on Pesticide Residues, the European Food Safety Authority (EFSA), the European Chemicals Agency (ECHA), Health Canada and the New Zealand Environmental Protection Authority (NZ EPA).

For a detailed description of the methodology used and the outcomes of this assessment, please refer to the proposed regulatory position document on the APVMA's website at www.apvma.gov.au/node/13891.

Consideration of public submissions

The proposed regulatory position report and the Tier 1 and Tier 2 OCS reports were published for public consultation from 30 September 2016 until 30 December 2016. In total, 197 submissions were received during the consultation period. Submissions were received from representatives of growers that use glyphosate (2), representatives of non-governmental organisations (NGOs) (8), a private business (1) and members of the public (186).

The majority of submissions received were beyond the scientific scope of the APVMA's assessment of the nomination for reconsideration of glyphosate. One submission raised concerns about the toxicity of N-nitrosoglyphosate (NNG; synonym N-nitroso-N-phosphonomethylglycine) that is often present as an impurity of glyphosate technical.

No new scientific evidence relating to the possible carcinogenicity of glyphosate that has not already been considered by the APVMA was received during the consultation period.

Final regulatory position

Based on this nomination assessment, the APVMA concludes that the scientific weight-of-evidence indicates that:

- exposure to glyphosate does not pose a carcinogenic or genotoxic risk to humans
- there is no scientific basis for revising the APVMA's satisfaction that glyphosate or products containing glyphosate:
 - would not be an undue hazard to the safety of people exposed to it during its handling or people using anything containing its residues
 - would not be likely to have an effect that is harmful to human beings
 - would not be likely to have an unintended effect that is harmful to animals, plants or things or to the environment
 - would be effective according to criteria determined by the APVMA by legislative instrument, and
 - would not unduly prejudice trade or commerce between Australia and places outside Australia.
- there are no scientific grounds for placing glyphosate and products containing glyphosate under formal reconsideration
- the APVMA will continue to maintain a close focus on any new assessment reports or studies that indicate that this position should be revised.

1 INTRODUCTION

Glyphosate [*N*-(phosphonomethyl)glycine] is an aminophosphonic analogue of glycine, which is a naturally occurring amino acid. Glyphosate is a broad-spectrum, non-selective, post-emergent, systemic herbicide that kills or suppresses all plant types, except those that have been genetically modified to be resistant to glyphosate, and can be used as a plant-growth regulator/desiccator at lower dose rates. Herbicide products that contain glyphosate are commonly used to control annual and perennial broadleaf and grassy weeds in various agricultural and non-agricultural settings. Glyphosate binds strongly to soil particles and is readily metabolised by soil microorganisms, thus when applied post-emergence, glyphosate demonstrates no pre-emergence or residual activity.

The water solubility of technical-grade glyphosate acid can be increased by formulating it primarily as its isopropylamine salt, or less commonly as monoammonium, potassium, trimesium, monoethanolamine or dimethylammonium salts, or various combinations of those salts. Furthermore, commercial formulated products contain various non-ionic surfactants to facilitate uptake by plants. Some commercial formulations also contain other active constituents in an attempt to mitigate herbicide resistance.

Glyphosate is taken up by the leaves and other green parts of the plant and translocated to the entire plant systemically. As a result, glyphosate is capable of total destruction of the plant. Glyphosate binds to and blocks the enzyme 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS), thereby disrupting the shikimic acid pathway and preventing the plant from synthesising the essential aromatic amino acids required for protein biosynthesis (phenylalanine, tyrosine and tryptophan), killing the plant. As this pathway is unique to plants and therefore is not present in mammals, glyphosate demonstrates low vertebrate toxicity.

The first product containing glyphosate was registered for use in Australia in the 1970s, under the trade name 'Roundup'. Products containing glyphosate that are registered for use in Australia are formulated as solutions, granules, aerosols and gels and can be applied using ground or aerial equipment, as well as some specialised application methods (eg aerosol).

1.1 Current regulatory status of glyphosate in Australia

As of February 2016 there were 80 active constituent approvals for glyphosate and 471 registered products containing glyphosate. Of the 471 registered products, 130 are for home garden use and 370 are for commercial/agricultural use. In these registered products, glyphosate is present at varying concentrations and are formulated in various salt forms, including ammonium, dimethylammonium, isopropylamine, mono-ammonium, monoethanolamine and potassium salts. Some registered products contain additional active constituents, including amitrole, ammonium thiocyanate, butafenacil, carfentrazone-ethyl, diflufenican, imazapyr and oxyfluorfen.

Glyphosate is approved for use in Australia to control various annual and perennial broadleaf, grassy and woody weeds, trees and brush and is used in a variety of different situations, such as:

- croplands for the control of emerged weeds prior to crop and fallow establishment, minimum tillage farming, direct drilling into seedbed, for pre-harvest desiccation
- non-cultivated land (eg industrial, commercial, domestic and public service areas) and rights of way
- forests, orchards, vines and plantations
- home garden use on rockeries, garden beds, driveways, fence lines, firebreaks, around buildings and prior to planting new lawns and gardens
- aquatic areas (restricted to dry drains and channels, dry margins or dams, lakes and streams)
- aquatic weed control and control of weeds on margins of dams, lakes and streams or in channels, drains or irrigation (selected products only).

Glyphosate is applied by ground boom, knapsack/handgun, gas/splatter gun, wiper equipment, controlled droplet application equipment, aerial spraying, aerosol spray, ready to use spray bottle and ready to use gel dispenser.

The Poisons Standard (SUSMP)

The Poisons Standard, or the Standard for the Uniform Scheduling of Medicines and Poisons (SUSMP) controls how medicines and poisons are made available to the public and classifies them into Schedules according to the level of regulatory control that is required in order to maintain public health and safety. Scheduling of medicines and poisons in Australia is a legislative requirement administered by the [Therapeutic Goods Administration](#) (TGA). However, the scheduling controls are implemented through State and Territory legislation, thus the implementation of any restrictions imposed by the TGA may differ between States and Territories.

Glyphosate is classified as a Schedule 5 (caution) substance, which is defined as a substance with a 'low potential for causing harm, the extent of which can be reduced through the use of appropriate packaging with strong warnings and safety directions on the label'.

1.2 Health-based guidance values for glyphosate

Health-based guidance values are established by regulatory authorities (and international bodies such as the Joint FAO/WHO Meeting on Pesticide Residues; JMPR) for the purpose of determining whether human exposure (via the diet or occupationally) to a particular chemical is safe. Health-based guidance values provide quantitative information to risk managers to enable them to make informed, scientific decisions related to protecting human health.

Acceptable Daily Intake (ADI)

The ADI is the amount of a chemical that can be ingested daily over a lifetime without any appreciable risk to health. The ADI is based on the lowest NOAEL (No Observed Adverse Effect Level) for the most sensitive adverse effect relevant to humans.

The ADI for glyphosate in Australia is 0.3 mg/kg bw/day based on the NOAEL of 30 mg/kg bw/day (the highest tested dose) in a 3-generation reproduction dietary study in rats and using a 100-fold safety factor to account for extrapolation from animals to humans as well as variation in sensitivity within the human population.

Acute Reference Dose (ARfD)

The ARfD is an estimate of the amount of a substance in food and drinking water, expressed on a milligram per kilogram bodyweight basis, which can be ingested in a period of 24 hours or less without appreciable health risk to the consumer. In 1998, JMPR concluded that an ARfD must be determined for all pesticides, unless the toxicological profile indicated that the pesticide was unlikely to present an acute hazard. As the toxicology assessments of glyphosate indicate that there is no likelihood of glyphosate presenting an acute hazard to human health, an ARfD has not been established for glyphosate in Australia or overseas.

Maximum Residue Limits (MRL) and National Residue Survey (NRS)

The maximum amount of a chemical that is legally permitted in a food is known as the MRL. The MRL is based on good agricultural and chemical use practices to ensure that an agricultural or veterinary chemical has been used according to the directions on the approved label. The MRL is set well below the level that would result in the health-based guidance values being exceeded if the chemical is used according to the approved label instructions. Thus, while exceedance of the MRL may indicate a misuse of the chemical, it does not normally indicate that there is a public health or safety concern. The APVMA sets MRLs for agricultural and veterinary chemicals in agricultural produce. The states and territories are responsible for enforcing MRLs.

The *Agricultural and Veterinary Chemicals Code Instrument No. 4 2012* ([MRL Standard](#)) lists MRLs for chemicals that may arise from the approved use of products containing that chemical, and outlines the definitions of those residues. The glyphosate residue definition for enforcement is the sum of glyphosate, *N*-acetyl-glyphosate and aminomethyphosphonic acid (AMPA) metabolite, expressed as glyphosate. For dietary risk assessment, the glyphosate residue definition is the sum of glyphosate, *N*-acetyl-glyphosate, aminomethyphosphonic acid (AMPA) and *N*-acetyl-aminomethyphosphonic acid (*N*-acetyl-AMPA), expressed as glyphosate.

As a part of the Department of Agriculture and Water Resources strategy to minimise chemical residues in agricultural product, the NRS facilitates testing of animal and plant products for pesticide and veterinary medicine residues, and environmental contaminants. In the 2013–14 NRS report, glyphosate residues greater than half of the MRL were not detected in any samples of barley, canola, chickpea, faba bean, field pea, lentil, lupin, maize, sorghum, triticale, wheat, wheat durum or macadamias. In 1/28 samples of oats, glyphosate residues above the MRL were detected (NRS 2014b), while in 1/37 almond samples, glyphosate residues lower than the MRL were detected (NRS 2014a). In the 2014–15 report, glyphosate residues above the MRL were reported in 1/42 oat samples and residues below the MRL (above half of the MRL) were reported in 4/42 oat samples (NRS 2015).

No residues greater than half of the MRL were detected in any samples of barley, chickpea, faba bean, canola, cowpea, field pea, lentil, maize, lupin, maize, mung bean, sorghum or wheat. In the 2015–16 NRS report, glyphosate residues greater than half of the MRL were not detected in any samples of barley, canola, chickpea, cowpea, faba bean, field pea, lentil, linseed, lupin, maize, mung bean, sorghum, soybean, sunflower, triticale, wheat, wheat bran, wheat bran durum, wheat durum, wheat flour, wheat semolina, almonds or macadamias. In 2/35 samples of oats, glyphosate residues above half of the MRL were detected and in 1/35 samples of oats, glyphosate residues above the MRL were detected (NRS 2016).

Australian Total Diet Study (ATDS)

The ATDS is coordinated by FSANZ to monitor Australia's food supply and ensure that food regulatory measures are protecting consumer health and safety. The ATDS assesses dietary exposure to pesticide residues, contaminants and other substances and is conducted approximately every two years.

The 23rd ATDS examined dietary exposure to 214 agricultural and veterinary chemicals, nine contaminants, 12 mycotoxins and 11 nutrients in 92 commonly consumed foods and beverages in 2008 (FSANZ 2011a). Glyphosate residues were detected in 2/12 samples of multigrain bread (mean concentration 0.016 mg/kg) (FSANZ 2011b). Based on these results, FSANZ estimated the mean consumer dietary exposure to glyphosate as 0.12, 0.81, 0.87, 0.97 and 1.4 µg/day in children aged 9 months, 2–5 years, 6–12 years and 13–16 years and adults aged 17 years and above, respectively (FSANZ 2011b). These estimated exposures are well below the ADI of 0.3 mg/kg indicating that there are no safety concerns for Australian and New Zealand consumers.

Drinking water standards

The [Australian Drinking Water Guidelines](#) (the Guidelines) are a joint publication of the National Health and Medical Research Council (NHMRC) and the Agricultural and Resource Management Council of Australia and New Zealand. The Guidelines are not legally enforceable but provide a standard for water authorities and state health authorities to ensure the quality and safety of Australia's drinking water.

The health-related guideline value (expressed as mg/L) is the concentration or measure of a water quality characteristic that, based on present knowledge, does not result in any significant risk to the health of the consumer over a lifetime of consumption (NHMRC 2011). Health values are derived so as to limit intake from water alone to approximately 10% of the ADI, on the assumption that (based on current knowledge) there will be no significant risk to health for an adult having a daily water consumption of 2 litres over a lifetime. The current health-related guideline value for glyphosate in drinking water is 1 mg/L – excursions above this value would need to occur over a significant period of time to be of a health concern (NHMRC 2011). Glyphosate is generally not reported in the analysis of Australian waters and is unlikely to be found at levels that may cause health concerns.

1.3 Legislative basis for a reconsideration of glyphosate

The basis for a reconsideration of the registration and approvals for a chemical is whether the APVMA is satisfied that the safety, efficacy and trade criteria listed in sections 5A, 5B and 5C of the Agvet Code for continued registration and approval are being met. These requirements are that the use of the product, in accordance with instructions approved, or to be approved, by the APVMA for the product or contained in an established standard:

- would not be an undue hazard to the safety of people exposed to it during its handling or people using anything containing its residues
- would not be likely to have an effect that is harmful to human beings
- would not be likely to have an unintended effect that is harmful to animals, plants or things or to the environment
- would be effective according to criteria determined by the APVMA by legislative instrument, and
- would not unduly prejudice trade or commerce between Australia and places outside Australia.

The APVMA may also consider whether labels for containers for chemical products containing glyphosate meet the labelling criteria as defined in section 5D of the Agvet Code which requires that labels have adequate instructions relating to:

- the circumstances in which the product should be used
- how the product should be used
- the times when the product should be used
- the frequency of the use of the product
- the re-entry period after use of the product
- the withholding period after the use of the product
- disposal of the product and its container
- safe handling of the product and first aid in the event of an accident
- any matters prescribed by the regulations.

2 SUBMISSIONS RECEIVED DURING THE CONSULTATION PERIOD

2.1 List of submissions

Following the publication of the APVMA's proposed regulatory position on glyphosate in September 2016, 197 submissions were received from representatives of growers that use glyphosate (2), representatives of NGOs (8), a private business (1) and members of the public (186) (Table 1). Of the 186 submissions received from members of the public, 172 were generated from an online petition campaign (submissions 23 to 194 in Table 1).

Table 1: List of submissions to the glyphosate proposed regulatory position report

Order of receipt	Submitter	Issue	Response
1	Seed breeding business, Victoria	Supports the proposed decision. Note importance of glyphosate for controlling weeds that pose a threat to the environment.	The APVMA acknowledges the submission.
2	Chemical sensitivities NGO, SA	Disagrees with proposed decision. Note other countries (Brazil, Portugal) moving towards banning glyphosate. Expressed concern about impacts on soil and to life on earth.	Outside of the scope (carcinogenicity) of the nomination assessment.
3	Private citizen, Victoria	Disagrees with proposed decision due to concerns about glyphosate residues on genetically modified (GM) crops	Outside of the scope (carcinogenicity) of the nomination assessment. The APVMA is not responsible for residue testing in foods.
4	Private citizen, Victoria	Disagrees with proposed decision, requests that the APVMA utilise the precautionary principle and withdraw approval until sufficient independent scientific information is available.	The APVMA utilises the scientific weight-of-evidence risk management approach outlined in the proposed regulatory position document and is confident that sufficient robust scientific information has been assessed.
5	Private citizen, Queensland	Disagrees with proposed decision, concerned that information on the APVMA's website regarding the regulatory status of glyphosate overseas is misleading.	The APVMA will edit the information provided on the webpage to improve clarity.

Order of receipt	Submitter	Issue	Response
6	Agricultural chemical and biotechnology representative, ACT	Supports the proposed decision. Notes that it is crucial that regulatory processes are based on accurate scientific data and independent assessment. Notes that numerous regulatory agencies have reviewed the data relied on by the IARC and have overwhelmingly concluded that glyphosate poses no unreasonable risks to humans or the environment when used according to approved label directions. Notes the substantial resources utilised by the APVMA to reaffirm the existing scientifically and technically robust regulatory position.	The APVMA acknowledges the submission.
7	Cotton grower representative, NSW	Supports the proposed decision. Note importance of glyphosate for weed management in Australian cotton farming systems. Supportive of the methodology utilised by the APVMA. Supportive of the APVMA maintaining close focus on any new scientific evidence that indicates the proposed regulatory position should be revised.	The APVMA acknowledges the submission.
8	Environmental NGO, Victoria	Disagrees with proposed decision. Request full reconsideration of toxicity (including endocrine disruption, genotoxicity, neurotoxicity, liver and kidney damage, ecotoxicity, effects on gut microbiome etc) of glyphosate and glyphosate-based products. Request that the APVMA assess the use of nanomaterials in glyphosate formulations. Request that APVMA commission new data and revise current health standards for glyphosate. Requested extension for public consultation period.	Outside of the scope (carcinogenicity) of the nomination assessment. The APVMA is not aware of any evidence that nanomaterials are used in glyphosate formulations. The APVMA does not commission research. The recent JMPR assessment determined that current health standards were appropriate. Whilst the APVMA acknowledges that the public consultation period concluded during the holiday period, we have no reason to believe that additional scientific information that has not already been assessed would be submitted if the consultation period was extended.
9	Private citizen	Disagrees with proposed decision due to concerns about the effects of glyphosate on human and animal health (reference study about piglet malformations; detections in urine and blood, no reference; toxic at low levels of exposure, no reference), and the environment (reference news article about a NSW DPI study about AMPA; reference permaculture news article about impacts of GMO-crops on biodiversity).	Outside of the scope (carcinogenicity) of the nomination assessment.

Order of receipt	Submitter	Issue	Response
10	Chemical pollutants NGO, NSW	Disagrees with proposed decision. Note glyphosate residue testing in foods by US FDA to begin; EU and Canada implemented risk management measures.	The APVMA is not responsible for residue testing in foods. As described in the proposed regulatory position report, current residue testing of food indicates that Australian consumers are not exposed to unsafe level of glyphosate.
11	GMO-free NGO, Victoria	Disagrees with proposed decision. Does not support the APVMA's evaluation methodology; request use precautionary principle. Request full reconsideration of toxicity of glyphosate and glyphosate-based products, commission research in conjunction with FSANZ to reassess residues in food, offer IARC opportunity to comment on APVMA's assessment, consider the impact of nanomaterials in formulated products, review current exposure levels to glyphosate products, and revise current health standards for glyphosate. Collaborate with FSANZ to determine residues on food.	The APVMA utilises the scientific weight-of-evidence risk management approach outlined in the proposed regulatory position document and is confident that sufficient robust scientific information has been assessed. The scope of the APVMA's assessment was limited to carcinogenicity of glyphosate, as per the IARC categorisation. The APVMA is not aware of any evidence that nanomaterials are used in glyphosate formulations. The APVMA does not commission research. The recent JMPR assessment determined that current health standards were appropriate. The APVMA is not responsible for residue testing in foods.
12	Public and Environmental Health NGO, Tasmania	Disagrees with proposed decision. Request full reconsideration of toxicity (substitution by glyphosate for glycine in vivo, chelating effects of essential metals causing deficiencies in vivo, effects on gut microbes, inhibition of cytochrome P450 enzymes, endocrine disruption, immune modulator, oxidative stress inducers, genotoxicity, antimicrobial resistance) of glyphosate and glyphosate-based products. Request that all industry data be re-analysed. Request re-assess NOEL and ADI (include data for Australian native flora and fauna). Request that any materials used to increase or amplify effects of glyphosate (nanoparticles and POEA) be reviewed. Request full review of carcinogenicity.	Outside of the scope (carcinogenicity) of the nomination assessment. The APVMA routinely analyses data provided by industry and has already done so for the nomination assessment of glyphosate. The recent JMPR assessment determined that current health standards were appropriate. The APVMA is not aware of any evidence that nanomaterials are used in glyphosate formulations. The APVMA assesses the toxicity of complete product formulations (including additional surfactants such as POEA) during the registration process. No new scientific data has been submitted to support the request for the APVMA to conduct a formal reconsideration of the carcinogenicity of glyphosate.
13	Private citizen, Tasmania	Disagrees with proposed decision due to concerns about the effects of glyphosate and adjuvants (particularly POEA) used in formulated products on human health (birth and reproductive defects, endocrine disruption, cancers, genotoxicity, neurotoxicity, respiratory problems, nausea, fever, allergies and skin problems).	Outside of the scope (carcinogenicity) of the nomination assessment. The APVMA assesses the toxicity of complete product formulations (including additional surfactants such as POEA) during the registration process.

18 FINAL REGULATORY POSITION: CONSIDERATION OF THE EVIDENCE FOR A FORMAL RECONSIDERATION OF GLYPHOSATE

Order of receipt	Submitter	Issue	Response
14	Private citizen, Tasmania	Disagrees with proposed decision. Note farming and living in rural areas is associated with poor health. Concerned about the environmental impact of glyphosate.	Outside of the scope (carcinogenicity) of the nomination assessment.
15	Pesticide NGO, WA	Disagrees with proposed decision due to concerns about the effects of glyphosate on human and animal health, and the environment. Concerned that APVMA has ignored the findings of the IARC. Concerned about herbicide resistance; effects of chemical combinations and residues on environment, wildlife and public health; off-label usage; correct use of PPE; independence of APVMA; influence of government policy on APVMA's decisions; carcinogenicity, neurological diseases and autoimmune diseases; soil and foliage testing for glyphosate residues; safety of children in public areas).	Outside of the scope (carcinogenicity) of the nomination assessment. The APVMA has conducted a thorough scientific evaluation of the information relied on by the IARC and has determined that there is not sufficient evidence to warrant placing glyphosate under formal reconsideration. Any concerns about off-label usage should be referred to State and Territory authorities. The APVMA makes regulatory decisions based on the available scientific information and does not have regard to government policy.
16	Environmental NGO, WA	Disagrees with proposed decision due to concerns about the effects of glyphosate on human health (cancer, endocrine disruption, kidney disease etc) and the environment, herbicide resistance under-reporting to the APVMA's AER program, and alleged off-label use.	Outside of the scope (carcinogenicity) of the nomination assessment. Any concerns about off-label usage should be referred to State and Territory authorities.
17	Private citizen, UK	Disagrees with proposed decision due to concerns about the effects of glyphosate on human health (obesity, statistics for disease rates in various populations, not referenced) and the environment (biodiversity in Great Barrier Reef). Provided information about an unpublished observational study of the biodiversity in a small nature reserve exposed to ultra-low dose Roundup. Note that RoundUp is 'banned' in France, Switzerland and Germany.	Outside of the scope (carcinogenicity) of the nomination assessment. The APVMA makes regulatory decisions independently based on the available scientific information. Note that claims that RoundUp is banned in some European countries is not correct.
18	Private citizen, Victoria	Disagrees with proposed decision. Concerned that the APVMA's assessment was incorrectly scoped (based on incorrect interpretation of the APVMA's legislation) and narrowly focussed (IARC also categorised other organophosphates as probably carcinogenic).	Outside of the scope (carcinogenicity) of the nomination assessment. The IARC also categorised malathion and diazinon as 'probably carcinogenic to humans'. These chemicals are currently under reconsideration by the APVMA, so were not addressed here.

Order of receipt	Submitter	Issue	Response
19	Private citizen, Victoria	Petition with signatures (62) attached. Request review all glyphosate formulations for all toxicity (including endocrine disruption and long-term effects on eg immune system).	Outside of the scope (carcinogenicity) of the nomination assessment.
20	Private citizen, WA	Disagrees with proposed decision due to concerns about the effects of glyphosate on human health (endocrine disruption). Notes attendance at the Monsanto Tribunal in the Hague in 2016. Provided report by Food Democracy Now about detections of glyphosate residues in food in the US.	Outside of the scope (carcinogenicity) of the nomination assessment. Current residue testing of food indicates that Australian consumers are not exposed to unsafe level of glyphosate.
21	Private citizen	Disagrees with proposed decision due to concerns about the effects of glyphosate and impurities (NNG) in formulated products on human health.	The Australian standard for glyphosate permits a maximum of 1 mg/kg NNG to be present in glyphosate technical. The toxicity of toxicologically significant impurities is included in the chemistry and toxicology assessments of the active constituent during the registration process.
22	Private citizen, Queensland	Disagrees with proposed decision due to concerns about the effects of glyphosate on human health (Parkinson's disease, foetal abnormalities; glyphosate detected in breast milk and urine), and residues in food (beer and honey). Concerned about off-label use and spray drift.	Outside of the scope (carcinogenicity) of the nomination assessment. Glyphosate has not been detected by validated methods at concentrations that would indicate acceptable health standards have been exceeded. Any concerns about off-label usage and spray drift should be referred to State and Territory authorities.
23	Sustainable agriculture NGO, Victoria	Disagrees with proposed decision due to concerns about the effects of glyphosate on human health (gut health imbalance, birth defects, autism) and the environment (soil ecosystems, GM crops). Concerned that other constituents in formulations contribute to toxicity. Glyphosate reported to be detected in vaccines.	Outside of the scope (carcinogenicity) of the nomination assessment The APVMA assesses the toxicity of complete product formulations (including additional constituents) in whole animal studies during the registration process. The study reporting glyphosate detections in vaccines has been widely criticised for using inappropriate and unreliable methodology.
24	Private citizen, WA	Petition with signatures (12) attached. Request review of toxicity (including endocrine disruption) and effects of long term exposure (particularly for illnesses related to immune system disruption and damage).	Outside of the scope (carcinogenicity) of the nomination assessment.

20 FINAL REGULATORY POSITION: CONSIDERATION OF THE EVIDENCE FOR A FORMAL RECONSIDERATION OF GLYPHOSATE

Order of receipt	Submitter	Issue	Response
25	Private citizen, Victoria	Disagrees with proposed decision due to concerns about the impacts of GM maize on human health.	Outside of the scope (carcinogenicity) of the nomination assessment The responsibility for regulating GM crops lies with the Office of the Gene Technology Regulator.
26-197	Private citizens, campaign submissions	Disagree with proposed decision.	Many of these submissions were outside the scope of the APVMA's assessment of the carcinogenic potential of glyphosate. No new scientific information that has not already been considered by the APVMA was provided.

2.2 Assessment of submissions received during the consultation period

The majority of submissions received were beyond the scope of the APVMA's assessment of the nomination for reconsideration of glyphosate.

One submission raised concerns about the toxicity of NNG that is often present as an impurity of glyphosate technical. The United States EPA concluded that less than 1.0 ppm NNG in glyphosate technical was not toxicologically significant (USEPA 1993). The Australian [standard](#) for glyphosate permits a maximum of 1 mg/kg NNG to be present in glyphosate technical. The toxicity of toxicologically significant impurities is included in the chemistry and toxicology assessments of the active constituent during the registration process.

No new scientific evidence relating to the possible carcinogenicity of glyphosate that has not already been considered by the APVMA was received during the consultation period.

3 INTERNATIONAL REGULATORY STATUS

For a more detailed description of the international regulatory status of glyphosate, refer to the proposed regulatory decision document on the website.

3.1 United States

The registration of glyphosate is currently being reviewed as a part of the US Environmental Protection Agency's (US EPA's) standard re-evaluation process. The [*Glyphosate Issue Paper: Evaluation of Carcinogenic Potential*](#) was published by the US EPA in September 2016.

Glyphosate-based formulations are currently registered in the US to control weeds in various fruit, vegetable and other food crops, glyphosate-resistant transgenic crops, ornamental plantings, lawns and turf, greenhouses, aquatic areas, forest plantings and roadside rights of way. Products registered in the US that contain glyphosate are formulated as liquids, solids and ready-to-use formulations, and can be applied using ground and aerial equipment as well as small hand-held sprayers.

3.2 Canada

In 2010 Health Canada's Pest Management Regulatory Agency (PMRA) commenced a re-evaluation of glyphosate in collaboration with the US EPA's re-evaluation of glyphosate. In April 2015, the PMRA published its Proposed Re-evaluation Decision (PRVD2015-01) for glyphosate. In that document, the PMRA proposed continued registration of products containing glyphosate for sale and use in Canada. However, as a condition of the proposed continued registration, new risk reduction measures were proposed for end-use products, aimed at protecting both human health and the environment. These included a restricted-entry period of 12 hours for agricultural uses, directions to apply when potential for drift into areas of human activity is minimised, environmental hazard statements, spray buffer zones, precautionary statements and use restrictions to reduce runoff to aquatic areas.

3.3 Europe and the United Kingdom

Glyphosate is registered for use throughout the European Union (EU) and the UK and in August 2014 was subjected to a re-assessment by the Rapporteur Member State (RMS), Germany, as mandated by the European Commission (EC) and coordinated by the European Food Safety Authority (EFSA). For more details about this assessment, please refer to the APVMA's proposed regulatory decision on glyphosate on the website.

The initial registration of glyphosate was scheduled to expire on 31 December 2015 (EC 2015). The EFSA recommended that a renewal of the registration of glyphosate be granted, and to accommodate a thorough peer review by the competent authorities of the EU Member States, the registration of glyphosate was provisionally extended until 30 June 2016. All but one of the Member States experts agreed that glyphosate is unlikely to be genotoxic or pose a carcinogenic risk to humans.

The EU Standing Committee on Plants, Animals, Food and Feed (hereafter referred to as the Standing Committee) held a series of meetings to discuss the re-registration for glyphosate in the EU; however, the EU Environment Committee Members of the European Parliament (MEPs) were unable to reach a qualified majority regarding a decision.

Subsequently, on 29 June 2016, the EC extended the approval of glyphosate in the EU to allow the European Chemicals Agency (ECHA) to complete an assessment of glyphosate (expected by 31 December 2017). On 11 July 2016, Member State experts voted as a qualified majority in favour of two recommendations proposed by the EC as conditions to the registration extension, at a meeting of the Standing Committee. These restrictions included:

- an EU-wide ban on polyethoxylated tallowamines (POEAs) contained in some glyphosate-based formulations
- restricted use of glyphosate-based formulations in public parks, playgrounds and home gardens and for pre-harvest application.

Glyphosate is currently authorised throughout the EU and UK, predominantly for uses in agriculture (cereals, vineyards, olives, citrus, nuts etc), but also to manage weed growth on non-cultivated areas (eg railway tracks, verges), public amenities, forestry and aquatic environments, and in home gardens. Glyphosate is authorised for weed control use after harvest or sowing, before a new crop is planted. Glyphosate is also authorised for pre-harvest weed control use and desiccation (to promote the maturation of crops) in crops such as oilseed rape and cereals. It is not currently clear which uses will be affected as a result of the recently announced use restrictions described above.

3.4 New Zealand

Glyphosate has been registered in New Zealand since 1976 and is used in various settings, including orchards, vineyards, pastures, vegetable patches, along roadways and in parks, sporting fields and home gardens.

4 EVALUTATION METHODOLOGY: THE WEIGHT OF SCIENTIFIC EVIDENCE

Consistent with the scientific method, a weight-of-evidence approach should be used to determine whether a chemical is carcinogenic. To conduct an initial quality assessment of each individual study, the study design should be assessed, taking into account international (eg Organisation for Economic Co-operation and Development; OECD) or national test guidelines where appropriate. In a weight-of-evidence assessment, any observation should be reproducible: the strength of any finding will be increased if it can be replicated under the same conditions in more than one laboratory. Plausible patterns in the hierarchy of the results will also strengthen the finding—ie where a finding *in vitro* is reproduced *in vivo*.

In toxicological science, there are a number of criteria that are used to determine whether an effect, such as cancer, is treatment-related and adverse:

- *Dose-response relationship*—the number of animals or subjects showing the effect and/or the severity of the effect should increase with dose. There should be a progression to a more severe state of toxicity as the dose and duration of dosing increases.
- *Consistency of the effect*—the effect should be observed consistently across studies of similar exposure duration and sexes (in unusual cases an effect may be sex-specific). Additionally, an effect should be corroborated by related toxicological endpoints—for example, increases in malignant neoplasms should be preceded by cellular changes that should be observed at lower doses or following shorter exposure durations.
- *Statistical significance*—differences between treated groups and the concurrent control group should be statistically significant. However, statistical significance on its own does not imply biological significance and the absence of statistical significance also does not necessarily mean the absence of an effect (for example a rare type of tumour may be highly biologically relevant).
- *Biological plausibility*—an observed effect needs to be mechanistically plausible based on the characteristics of the chemical and principles of biology/physiology.
- *Natural variation and incidental findings*—the normal range of natural variation of a parameter in the test species needs to be understood through the use of age and sex-matched historical control data. All laboratory animal strains used in rodent bioassays have a background incidence of age- and sex-related neoplasms at different tissue sites. It is critical that this normal range of biological variation is documented and understood.

When assessing toxicological data associated with chemical residues in food, the APVMA has regard to the principles and methods outlined by the International Programme on Chemical Safety (IPCS) (IPCS 2009) including guidance on the interpretation of toxicological data by JMPR¹ and OECD². For the evaluation of carcinogenicity via dietary or other exposure routes, the IPCS has published a mode-of-action (MOA) framework for chemical carcinogenesis (Meek et al 2013). In this framework, treatment-related cancer must first be demonstrated in laboratory animals before proceeding to examine genotoxicity data, human epidemiological and mechanistic data in order to determine the mechanism for how cancer arises and the human relevance of adverse effects observed in laboratory animals.

The APVMA considered aspects of study design and reporting that may either increase or decrease confidence in the data. The presence of a dose-response relationship, consistency and reproducibility were considered to increase confidence in the data, while any unexplained inconsistencies and significant deviations from international test guidelines were considered to reduce confidence in the data. Thus, those studies that demonstrated a dose-response relationship, adhered to international test guidelines (where appropriate) and were consistent and reproducible within and/or between laboratories were given more weight in the assessment.

For epidemiological data, the APVMA considered prospective cohort studies to be more powerful than retrospective case-control studies, which are more prone to recall bias and confounding by exposure to other chemicals and environmental situations. It is well known that study participants' memory may not be reliable: participants are often asked to provide information about use patterns that occurred many years previously, participants may be providing information relating to a family members' usage (not their own) and it is possible that a participant with cancer may have spent more time thinking about possible causes and exposure scenarios than participants without cancer. It is also very difficult to separate usage of one pesticide from another: those who routinely use glyphosate-based formulations are likely to have been using many other types of agricultural and/or industrial chemicals, or be exposed to other occupational scenarios that may confound the data.

For more detailed information about the methodology used by the APVMA to conduct the nomination assessment of glyphosate, refer to the [proposed regulatory position](#) document on the website.

¹ www.who.int/foodsafety/publications/jmpr_guidance_document_1.pdf?ua=1

² www.oecd-ilibrary.org/docserver/download/9750321e.pdf?expires=1472172141&id=id&accname=quest&checksum=28F68D5204F38A1B96055A611D12C4DF

5 SUMMARY OF ASSESSMENTS AND CONCLUSIONS

For a detailed description of the APVMA's assessment outcomes, refer to the [proposed regulatory position](#) document on the website. Please note that the US EPA's assessment of the carcinogenicity of glyphosate was not available during the APVMA's assessment.

5.1 The IARC glyphosate monograph

The IARC is a specialist cancer agency of the WHO and, as such, follows the general governing rules of the United Nations. However, IARC has its own Governing Council and Scientific Council. Currently, 25 countries are IARC members, including Australia.

The IARC appoints a working group to evaluate carcinogenic risks to humans, which is guided by the [Preamble](#) (IARC 2006). The Monographs produced by the working groups assess the strength of available evidence that an agent could alter the age-specific incidence of cancer in humans.

The IARC Monographs evaluate cancer hazards (as opposed to cancer risks evaluated by regulatory bodies) and the Preamble cautions that cancer hazards may be identified even when the risks are very low at current exposure levels (IARC 2006). A cancer hazard is defined in the Preamble as 'an agent that is capable of causing cancer under some circumstances' while a cancer risk is defined as 'an estimate of the carcinogenic effects expected from exposure to a cancer hazard'.

When assessing an agent for a Monograph, the working group reviews epidemiological studies, cancer bioassays in experimental animals, as well as exposure, mechanistic and other relevant data. In each case, the working group only considers data that has been determined by them to be relevant to the evaluation. Only reports that have been published or accepted for publication in the openly available scientific literature and data from government agency reports that are publicly available are reviewed (IARC 2006). Unlike regulatory authorities, IARC does not consider the often large number of unpublished studies submitted for regulatory assessment.

The outcome of the working group's assessment is a categorisation of an agent that reflects the strength-of-evidence from studies in humans and experimental animals and other relevant data.

Assessment of glyphosate by IARC

In March 2015, IARC evaluated the potential carcinogenicity of five organophosphate pesticides and classified glyphosate (as well as malathion and diazinon) as 'probably carcinogenic to humans', Group 2A. The complete [monograph](#) was published in July 2015. Note that where the working group cited an unpublished study, it relied on the published summary report as the complete, original study report was not available.

The working group concluded that there was 'limited evidence of carcinogenicity' in humans, with a positive association observed between exposure to glyphosate and non-Hodgkin's lymphoma (NHL) (IARC 2015). The IARC preamble explains that 'limited evidence of carcinogenicity' in humans is concluded when the working group has determined that a credible causal link between the agent and cancer may have been identified 'but chance, bias or confounding could not be ruled out with reasonable confidence' (IARC 2006). The working group also concluded that there was 'sufficient evidence of carcinogenicity' in experimental animals (IARC 2015). The IARC Preamble describes that sufficient evidence of carcinogenicity is concluded when a causal relationship between the agent and an increased incidence of malignant neoplasms or an appropriate combination of benign and malignant neoplasms has been established in either two or more species of animals, or two or more independent studies in one species. Sufficient evidence is also considered to be established when an increased incidence of tumours is observed in both sexes of a single species in a well conducted study (preferably conducted according to good laboratory practice; GLP). Alternatively, sufficient evidence of carcinogenicity may be considered established in a single study in one species and sex when malignant tumours occur to an 'unusual degree with regard to incidence, site, type of tumour or age at onset, or when there are strong findings of tumours at multiple sites' (IARC 2006).

The studies relied on by the working group for human carcinogenicity comprised reports of the Agricultural Health Study (AHS), which concluded that exposure to glyphosate was not associated with all cancers combined or any cancer at a specific anatomical site (De Roos et al. 2005), and various case-control studies conducted in the US, Canada and Sweden. The working group concluded that these studies presented increased risks for the development of NHL associated with exposure to glyphosate (IARC 2015).

The studies relied on by the working group for animal carcinogenicity comprised two dietary studies in male and female mice, five dietary studies in male and female rats, as well as one drinking-water study of a glyphosate-based formulation in male and female rats.

The working group concluded that there was strong evidence that glyphosate and glyphosate-based formulations are genotoxic and, along with the main metabolite, AMPA can act to induce oxidative stress.

5.2 Assessment of the IARC monograph

The assessment of the IARC Monograph was undertaken by the Department of Health (OCS). The APVMA requested that OCS conduct a preliminary scoping review of the IARC Monograph to ascertain the relevance of the carcinogenicity classification of glyphosate and any implications that this may have to the registration of glyphosate and glyphosate-based formulations in Australia. In particular, the APVMA requested that OCS identify any relevant data not previously evaluated by Australia. This constituted Tier 1 of the OCS assessment ([supporting document 1](#)).

Tier 2 of the OCS scoping assessment involved a detailed review of any studies that had been reviewed by IARC as part of its assessment of glyphosate and were identified by OCS as requiring further review during the Tier 1 assessment ([supporting document 2](#)).

Previous OCS epidemiological review in 2005

An association between reported glyphosate use and an increased risk of NHL was reviewed by the OCS in 2005 (unpublished). Thus, the OCS did not assess the epidemiological studies described in the IARC monograph published prior to 2005 and recommended that the APVMA rely on international assessments for any additional epidemiological information relating to glyphosate exposure. The OCS' unpublished 2005 assessment of epidemiological information relating to glyphosate exposure is summarised in the proposed regulatory position document.

Tier 1 assessment of the IARC glyphosate monograph

The OCS examined the reference list from the IARC Monograph 112, which included 264 published papers. Publicly available papers were sourced and designated as either:

- relevant for the carcinogenicity classification for humans and requiring further analysis (19; Tier 2, Part 1)
- relevance for the carcinogenicity classification for humans unclear and to be determined internationally (71; the APVMA will rely on international assessment of these studies)
- not relevant to the classification and excluded (174).

The OCS noted that parallel reviews of the IARC Monograph were being planned or were in progress by independent expert international bodies (eg JMPR). Therefore, the OCS recommended that rather than undertaking a full review in isolation, the APVMA make use of this international assessment. This approach is consistent with the APVMA's policy on the use of international assessments (see www.apvma.gov.au/node/14181).

Tier 2 assessment of the IARC glyphosate monograph

The Tier 2 assessment involved:

- Evaluation of 19 studies relevant to the carcinogenicity classification of glyphosate
 - 12 genotoxicity studies
 - five oxidative stress studies
 - one epidemiology study
 - one classification review report

The Tier 2 assessment did not include a detailed review of the epidemiological studies or studies that evaluated the possible carcinogenicity of glyphosate-based formulations, as a number of international reviews of the IARC Monograph will be undertaken concurrently with the OCS assessment. A total of 47 studies that were not reviewed by the EU Renewal Assessment Report (RAR) and 19 studies that were reviewed by the EU RAR were not reviewed by the OCS in the Tier 2 assessment of glyphosate because their relevance to the carcinogenicity classification for humans was unclear. The APVMA will rely on international assessments of these studies.

Animal carcinogenicity studies

The OCS evaluated one published study that reviewed animal carcinogenicity studies to support regulatory requirements (Greim et al. 2015). The review paper included nine rat and five mouse studies in a weight-of-evidence assessment of the carcinogenicity of glyphosate that included a review of absorption, distribution, metabolism and excretion (ADME), acute toxicity, genotoxicity, epidemiology and animal chronic toxicity studies.

The authors refer to an article that qualitatively analysed the outcomes from seven cohort studies and 14 case-control studies that examined an association between glyphosate and cancers. No consistent pattern of positive statistical associations between total cancer or site-specific cancer in adults or children exposed to glyphosate was evident (Mink et al. 2012). All studies cited by Mink et al. (2012) were referenced in the IARC Monograph and five (Nordstrom et al. 1998; Hardell & Eriksson 1999; McDuffie et al. 2001; Hardell et al. 2002; De Roos et al. 2005) were included in a previous assessment of glyphosate by the OCS in 2005, which concluded that glyphosate is not mutagenic or carcinogenic and it is unlikely that exposure to glyphosate is associated with an increased risk of NHL.

Greim et al. (2015) evaluated five chronic toxicity/carcinogenicity studies (conducted over a minimum duration of 18 months) in mice, four of which were considered reliable and were performed according to GLP following OECD testing guidelines (OECD TGs). In four of those studies, spontaneous tumours were observed at all doses. However, as no dose-response was observed, these were not considered to be treatment-related.

Greim et al. (2015) evaluated nine chronic toxicity/carcinogenicity (24 to 29 months) studies in rats submitted by industry. Some of the studies reported spontaneous and/or age-related neoplasms that did not exhibit a dose-response relationship and were therefore not considered treatment-related. In some cases, the tumours observed were known to be common age-related tumours in the particular strain of rat used. In addition, some studies reported the development of benign tumours that did not exhibit a dose-response relationship and did not progress to malignant neoplasms. Other studies reported no increase in tumour incidence following glyphosate exposure.

Greim et al. (2015) combined the results from the animal studies with results from human carcinogenicity epidemiology conclusions reported by Mink et al. (2012)³ and concluded that glyphosate is not carcinogenic. They noted that while some studies reported an increase in a specific neoplasm at high dose, the pooled data did not identify any consistent pattern of neoplasm development or dose-response relationship. Thus, the authors concluded that the observed effects were not consistent or reproducible and were not treatment related. The OCS agreed with the conclusion that the evidence indicates that glyphosate is not carcinogenic in animals.

³ Mink et al (2012) concluded that there was no consistent evidence of an association between exposure to glyphosate and cancer in humans.

Genotoxicity

The OCS appraised 11 studies and one review paper that assessed the genotoxicity of glyphosate. Of these studies, six assessed genotoxicity via the comet assay (or single cell gel electrophoresis; SCGE) *in vitro*, using lymphocytes (Mladinic et al. 2009a; Mladinic et al. 2009b; Alvarez-Moya et al. 2014), HepG2 cells (liver carcinoma cells) (Gasnier et al. 2009), Hep-2 cells (epithelial carcinoma cells derived from a cervical cancer) (Manas et al. 2009), GM38 cells (diploid fibroblast cells) or HT1080 cells (fibrocarcinoma cells) (Monroy et al. 2005). All of these studies were considered by the EFSA RAR (2015). DNA damage observed using sister chromatid exchange (SCE) or the comet assay is regarded as an indirect measure of genotoxicity and positive results using these endpoints may reflect induction of cytotoxicity, rather than genotoxicity, as DNA damage does not directly measure heritable events or effects that are closely associated with heritable events (Kier & Kirkland 2013).

Chromosomal effects, such as induction of chromosomal aberrations or micronuclei in cultured mammalian cells are considered direct measures of genotoxicity. Five studies assessed genotoxicity of glyphosate using the *in vivo* micronucleus assay in various strains of mice, while one utilised the *in vitro* micronucleus assay in human lymphocytes.

Three studies assessed genotoxicity using chromosome aberration studies in bone marrow cells obtained from Swiss albino mice (Prasad et al. 2009), SD mice (Li & Long 1988) and human lymphocytes (Manas et al. 2009).

In addition to the chromosome aberration assay, two studies utilised a variety of other methods to assess genotoxicity, including prokaryotic genotoxicity tests (*Salmonella*/histidine plate incorporation reversion assay, *E. coli* WP2 reverse mutation assay, *B. subtilis* Rec-assay) and *in vitro* mammalian genotoxicity tests (Chinese hamster ovary hypoxanthine-guanine phosphoribosyl transferase or CHO-HGPRT gene mutation assay, unscheduled DNA synthesis) (Li & Long (1988); Rank et al. (1993)).

Overall, the OCS concluded that the weight-of-evidence indicates that glyphosate is not genotoxic in mammals at concentrations relevant to human exposure.

Oxidative stress

Overall, seven studies assessed the potential for glyphosate to induce oxidative stress. Oxidative stress is an imbalance between the production of reactive oxygen species (ROS) and their elimination. ROS are important for cell signalling and cycling and are normally physiologically-controlled to prevent cell damage.

Three studies assessed ROS production in response to *in vitro* treatment of human HepG2 cells with glyphosate (Chaufan et al. 2014), keratinocytes (HaCaT) (Elie-Caille et al. 2010) and erythrocytes (Kwiatkowska et al. 2014). Chaufan et al. (2014) also investigated the enzymatic (catalase, CAT; glutathione-S-transferase, GST; superoxide dismutase, SOD) and non-enzymatic antioxidant activity (glutathione equivalents, GSH) in human HepG2 cells *in vitro* following exposure to either glyphosate, AMPA or a glyphosate-based formulation. Overall, the OCS concluded that there was limited evidence for an increase in ROS production following exposure to glyphosate, its metabolites or impurities, or a glyphosate-based formulation in *in vitro* cell culture studies using high concentrations of the test substances; however, the weight-of-evidence indicates that exposure to glyphosate at concentrations relevant to human exposure is unlikely to result in increased ROS production in humans.

Caspases participate in the programmed cell death pathway. Some apoptotic cells display caspase 3/7 activity, in contrast to necrotic cells. Two studies investigated caspase activity *in vivo* in male Wistar rats, following ip administration of glyphosate (alone or in combination with other pesticides) (Astiz et al. 2009) and *in vitro* in human HepG2 cells (Chaufan et al. 2014). Calpains have also been implicated in apoptosis. In addition to investigating caspase activity, Astiz et al. (2009) also investigated calpain activity *in vivo* in male Wistar rats following exposure to glyphosate alone and in combination with dimethoate and/or zineb.

Bolognesi et al. (1997) investigated oxidative stress in Swiss CD-1 male mice (n=3 per dose) following administration of either 300 mg/kg glyphosate technical or 900 mg/kg of Roundup® (~270 mg/kg glyphosate) via ip injection.

Oxidative potential and impact on DNA was measured in human lymphocytes using Ferric-inducing ability of plasma (FRAP), thiobarbituric acid reactive substances (TBARS) and the human 8-oxoguanine DNA N-glycosylase 1 (hOGG1) modified comet assay (Mladinic et al. 2009a).

Three studies assessed various aspects of cell morphology and structural integrity *in vitro* in various human cell lines: HepG2 cells (Chaufan et al. 2014), keratinocyte HaCaT cells (Elie-Caille et al. 2010) and erythrocytes (Kwiatkowska et al. 2014).

Overall, the OCS concluded that no definitive conclusions could be drawn on the ability of glyphosate products and their associated impurities to induce oxidative stress, as there is limited reliable information available regarding the involvement of an oxidative stress mechanism for inducing cytotoxicity.

5.3 Joint FAO/WHO Meeting on Pesticide Residues (JMPR)

The JMPR is an expert scientific body that was established in 1963 and meets annually to scientifically evaluate pesticide residues in food. There are two expert panels that meet in parallel (hence the term 'Joint Meeting'), the Toxicology Panel (the WHO's Core Assessment Group on pesticides), and the Residues Panel (Organised by the Food and Agricultural Organisation of the United Nations). The Toxicology Panel of the JMPR is responsible for evaluating the adverse effects of pesticides on human health (including carcinogenicity) and establishing health-based guidance values which in turn are important for establishing MRLs used in international trade. The Residues Panel are responsible for evaluating the dietary risks from residues present on food commodities and for setting MRLs. The JMPR is also at the forefront of developing new risk assessment methodologies for pesticides and setting international scientific policy on the interpretation of toxicological studies. Participation in the JMPR is not representational but based on expertise in toxicology and pesticide risk assessment.

The process used by JMPR to assess potential risks associated with pesticide residues in food is described in detail in the [International Programme on Chemical Safety \(IPCS\) Environmental Health Criteria 240: Principles and Methods for the Risk Assessment of Chemicals in Food](#), which is a joint publication of the FAO and WHO.

Glyphosate has been assessed by JMPR in 2003, 2006 and most recently, in 2011. Following the IARC decision in March 2015 to reclassify glyphosate as 'probably carcinogenic to humans' and noting that new data may have been generated since the JMPR's most previous assessment of glyphosate in 2011, the WHO established an ad hoc expert taskforce to evaluate the available data relating to glyphosate and report its findings to JMPR. The task force completed its assessment of the IARC monograph in September 2015 and recommended that JMPR conduct a full re-evaluation of glyphosate, as the IARC assessment included a number of peer reviewed scientific publications that had not been available during the JMPR's 2011 assessment (WHO 2015).

The evaluation of glyphosate was discussed at an extraordinary meeting of the JMPR at WHO headquarters in Geneva, Switzerland on 9 to 13 May 2016. The Meeting [summary report](#) was published online in May 2016.

The Meeting considered prospective epidemiological cohort studies to be a more powerful study design than case-control studies, as case-control studies are usually retrospective and are therefore more prone to recall and selection biases (JMPR 2016). The one large, prospective cohort study (the AHS cohort) found no evidence of a positive association between glyphosate exposure and NHL incidence. Various case-control studies reported varying results, with some reporting elevated risks (both significant and non-significant) and others not observing an association. The Meeting concluded that there was some evidence of a positive association between glyphosate exposure and the risk of NHL; however, the AHS—a large, high-quality prospective cohort study found no evidence of an association at any exposure level (JMPR 2016).

The Meeting identified nine carcinogenicity studies in mice, two of which were considered to be of insufficient quality for inclusion in the assessment (JMPR 2016). Equivocal evidence of lymphoma induction was apparent in 3/7 studies in male mice and 1/7 studies in female mice at high doses (5000–40 000 ppm or 814–4348 mg/kg bw/day). In contrast, higher doses (up to 50 000 ppm or 7470 mg/kg bw/day) in the remaining three studies did not cause an effect. In 4/7 studies, there was a trend for a marginal increase in induction of kidney adenomas in male mice at the highest dose tested; however, again, higher doses failed to illicit a response.

The Meeting identified 10 appropriate combined chronic toxicity and carcinogenicity studies in rats (JMPR 2016). An increased incidence of various tumours (interstitial cell tumours of the testes, pancreatic islet cell adenoma, thyroid C-cell tumours, skin keratoma) was observed in 1/10 or (in one case) 2/10 studies. However, in all cases, higher doses used in other studies did not illicit a response. The Meeting also reported a lack of dose-response relationship for some tumour types. There was no evidence for spleen or kidney lymphoma induction in any of the studies. Thus, the Meeting concluded that there was no reliable evidence for treatment-related tumours in rats at doses of up to 32 000 ppm (or 1750 mg/kg bw/day).

The Meeting concluded that glyphosate is not carcinogenic in rats, but was unable to exclude the possibility that glyphosate is carcinogenic in mice at very high doses (JMPR 2016).

The overall weight-of-evidence suggested that oral doses of up to 2000 mg/kg bw/day glyphosate (either alone or in a formulated product) are not associated with genotoxic effects in the majority of studies in mammals. In cell culture models and organisms that are phylogenetically different to humans, DNA damage and chromosomal effects have been observed following exposure to glyphosate. However, these effects have not been replicated in oral *in vivo* mammalian model studies. Thus, the Meeting concluded that glyphosate is unlikely to be genotoxic at anticipated dietary exposures (JMPR 2016).

The Meeting's overall conclusion relating to the carcinogenic potential of glyphosate was that, the absence of carcinogenic potential in rodents at human-relevant doses and the absence of genotoxicity in mammals following oral exposure, along with the epidemiological evidence from occupational exposure indicated that glyphosate is unlikely to pose a carcinogenic risk to humans via exposure from the diet (JMPR 2016).

The Meeting further concluded that the glyphosate metabolite, AMPA, is unlikely to be genotoxic following oral exposure in mammals and there was no evidence for embryo or fetal toxicity. Similarly, two other metabolites, *N*-Acetyl-glyphosate and *N*-Acetyl-AMPA are unlikely to be genotoxic in mammals (JMPR 2016).

5.4 European Food Safety Authority (EFSA)

Glyphosate is registered for use throughout Europe and the UK and in 2010 was subjected to a re-assessment by the RMS, Germany, as mandated by the EC and coordinated by EFSA. The German Federal Institute for Risk Assessment (BfR) concluded that glyphosate was 'unlikely to pose a carcinogenic hazard to humans and the evidence does not support classification with regard to its carcinogenic potential' (EFSA 2015).

In July 2015, the BfR was commissioned to review the IARC monograph on the re-classification of glyphosate. The BfR concluded that no consistent positive association between glyphosate exposure and the development of cancer was demonstrated and the most statistically highly-powered study detected no effect. The BfR further noted that it was not possible to differentiate between the effects of glyphosate and the co-formulants from the epidemiology studies discussed in the IACR monograph (Germany 2015).

The BfR assessed the studies relied on by the IARC working group and concluded that the weight-of-evidence suggests that there is no carcinogenic risk related to the use of glyphosate and that no hazard classification for carcinogenicity is warranted according to the CLP criteria (Germany 2015).

The BfR concluded that a weight-of-evidence assessment approach indicates that neither glyphosate nor AMPA induce mutations *in vivo* and no hazard classification for mutagenicity was warranted according to CLP criteria (Germany 2015). It further concluded that the mechanistic and other studies do not provide evidence for a carcinogenic mechanism.

The BfR agreed with the IARC working group that there is some indication of induction of oxidative stress, based on *in vitro* studies using human cells and *in vivo* mammalian studies, particularly in blood plasma, liver, brain and kidney of rats; however, it was not indicative of genotoxic or carcinogenic activity in humans.

5.5 The European Chemicals Agency (ECHA)

The ECHA is responsible for managing the harmonised classification (CLH) process for active constituent chemicals within plant protection products in the EU. The CLH is based solely on the hazardous properties (i.e. toxicity) of the chemical and does not take into account exposure; thus, the CLH procedure conducted by ECHA is not a risk assessment. In that respect, the CLH procedure undertaken by ECHA is similar to the scope of the IARC assessment process.

As a part of the procedure for the renewal of the glyphosate registration in the EU, Germany submitted a proposal for CLH to ECHA. The ECHA concluded that, while epidemiological data is of limited value for detecting the carcinogenic potential of a pesticide, the data do not provide convincing evidence for an association between glyphosate exposure in humans and any cancer type and no hazard classification for carcinogenicity is warranted for glyphosate according to the CLP criteria (ECHA 2016). The ECHA held a 45 day [public consultation of the CLH proposal](#) for glyphosate between 2 June and 18 July 2016; comments are available on the ECHA's [website](#). The Committee for Risk Assessment (RAC) held the first [preparatory discussion](#) on the harmonised classification and labelling of glyphosate in December 2016. A second meeting is scheduled for March 2017 and the deadline for the RAC to adopt its opinion is the end of November 2017. Once it has been finalised, ECHA will submit the RAC's scientific opinion to the European Commission.

5.6 Health Canada

In 2010, Health Canada's PMRA commenced a re-evaluation of glyphosate in collaboration with the US EPA's re-evaluation of glyphosate. In April 2015, the PMRA published its Proposed Re-evaluation Decision (PRVD2015-01) for glyphosate.

The PMRA concluded that the available *in vitro* and *in vivo* tests demonstrated that glyphosate is not genotoxic in rats or mice and that glyphosate is not carcinogenic in rats. While there was some evidence for a marginal increase in the incidence of ovarian tumours in mice, no dose-response was evident, the increased incidence was only observed at the highest tested doses and historical control data were not available. Thus, the PMRA concluded that these results were of low concern for human health risk assessment.

Overall, the PMRA concluded that the weight-of-evidence obtained from both acute and chronic animal toxicity studies, genotoxicity assays and epidemiology studies indicates that glyphosate is unlikely to pose a human cancer risk.

5.7 New Zealand Environmental Protection Authority

The New Zealand Environmental Protection Authority commissioned a review of the evidence relating to the carcinogenicity of glyphosate.

The review concluded that a possible dose-response relationship in humans could not be evaluated, as the epidemiological evidence did not indicate whether any internal exposure was measured or, if there was, the extent of that exposure (Temple 2016).

The New Zealand review concluded that the total database of long-term carcinogenicity bioassays were consistently negative and the positive findings reported by the IARC working group are not considered supportive of carcinogenicity by other reputable scientific bodies, thus the overall weight-of-evidence does not indicate that glyphosate is carcinogenic (Temple 2016).

The overall conclusion of the review was that, based on a weight-of-evidence approach that considered the quality and reliability of the available data, glyphosate is unlikely to be genotoxic or carcinogenic to humans and does not require classification as either a carcinogen or a mutagen (Temple 2016).

5.8 Adverse Experience Reporting Program (AERP)

The AERP is a post-registration program that assesses reports of adverse experiences associated with the use of agricultural and veterinary products, when the product has been used according to the approved label instructions.

Between 1996 and 2013, a total of four AERs relating to the use of glyphosate and human safety were submitted to the AERP. All were classified as 'possible' or 'probable' by the AERP. Of the four AERs, one related to skin irritation while the remaining three were reports of eye irritation.

5.9 Consideration of public submissions

During the public consultation period (30 September 2016 until 30 December 2016), 197 submissions were received from representatives of growers that use glyphosate (2), representatives of NGOs (8), a private business (1) and members of the public (186).

No new scientific evidence relating to the possible carcinogenicity of glyphosate that has not already been considered by the APVMA was received during the consultation period.

6 ASSESSMENT OUTCOMES

In the Tier 1 assessment, the OCS examined the reference list from the IARC Monograph 112 for glyphosate, which included 264 publisher papers. Following analysis of the study abstracts, 174 references were excluded from requiring further review, mostly because the study utilised non-conventional species or methodology for evaluating human toxicity (eg fish). A total of 19 references were considered relevant to the carcinogenicity classification of glyphosate, requiring further in-depth revision. The remaining 71 references were considered to require further review to determine their relevance to the carcinogenicity classification. The APVMA will rely on international assessments of these papers.

The OCS concluded that, based on the results of the critical appraisal and the limited number of studies reviewed by the OCS in the Tier 2 assessment, there did not appear to be any additional information to indicate that glyphosate poses a carcinogenic risk to humans, on the basis of the following:

- a carcinogenic mechanism of action via genotoxicity or oxidative stress is not evident
- the level of cytotoxicity associated with *in vitro* genotoxicity testing of glyphosate was significant, limiting the ability of *in vitro* tests to determine the genotoxicity potential of glyphosate.

The OCS noted that there is some evidence that *in vitro*, glyphosate-based formulated products are more toxic to cells than glyphosate; however, this effect has not been confirmed *in vivo*. Furthermore, many of the studies exhibited significant methodological limitations, reducing the usefulness of the data.

No definitive conclusions could be drawn on the ability of glyphosate-based formulations to induce oxidative stress as there is limited information regarding the involvement of an oxidative stress mechanism for inducing cytotoxicity.

The OCS concluded that glyphosate was unlikely to pose a carcinogenic or genotoxic risk to humans.

The APVMA evaluated a number of recent assessments of glyphosate conducted by international organisations and regulatory agencies (JMPR, EFSA, ECHA, Health Canada and the NZ Environmental Protection Authority), which considered the publicly available data that was considered in the IARC monograph, as well as other published and unpublished data using a weight-of-evidence approach.

The APVMA agreed with the international assessments of the available epidemiological data that, while epidemiological data is of limited value for detecting carcinogenic potential of a pesticide, the weight-of-evidence does not provide convincing evidence for an association between glyphosate exposure in humans and any cancer type, as there was no consistent pattern of statistical associations that would suggest a causal relationship between glyphosate exposure and the development of cancer in adults or children (total or site-specific).

The APVMA agreed with the international assessments that the weight-of-evidence in experimental animals indicates that glyphosate does not pose a carcinogenic risk at realistic exposure levels, as no consistent dose-response relationship was evident in mice or rats and many of the reported tumours are common age-related tumours in rats and mice.

The APVMA agreed with the international assessments that glyphosate is not likely to be genotoxic, as well-designed *in vitro* tests consistently reported negative results. While some *in vitro* studies reported positive results for, these were generally observed following very high intraperitoneal doses and most likely a secondary effect of cytotoxicity.

Between 1996 and 2013, a total of four 'possible' or probable' AERs relating to the use of glyphosate and human safety (skin or eye irritation) were submitted to the AERP. The APVMA is confident that the current safety and use directions included on approved labels for products containing glyphosate are sufficient to mitigate these known adverse effects.

No new scientific evidence relating to the possible carcinogenicity of glyphosate that has not already been considered by the APVMA was received during the public consultation period following the publication of the proposed regulatory decision.

7 REGULATORY POSITION

On the basis of the evaluation of the scientific information and assessments, the APVMA concludes that the scientific weight-of-evidence indicates that:

- exposure to glyphosate does not pose a carcinogenic risk to humans
- there is no scientific basis for revising the APVMA's satisfaction that glyphosate or products containing glyphosate:
 - would not be an undue hazard to the safety of people exposed to it during its handling or people using anything containing its residues
 - would not be likely to have an effect that is harmful to human beings
 - would not be likely to have an unintended effect that is harmful to animals, plants or things or to the environment
 - would be effective according to criteria determined by the APVMA by legislative instrument, and
 - would not unduly prejudice trade or commerce between Australia and places outside Australia.
- there are no scientific grounds for placing glyphosate and products containing glyphosate under formal reconsideration
- the APVMA will continue to maintain a close focus on any new assessment reports or studies that indicate that any of the above conclusions may need revising.

ABBREVIATIONS

ACT	Australian Capital Territory
ADI	Acceptable daily intake (for humans)
ADME	Absorption, distribution, metabolism and excretion
AER	Adverse Experience Report
AERP	Adverse Experience Reporting Program
Agvet Code	Agricultural and Veterinary Chemicals Code, Schedule to the Agricultural and Veterinary Chemicals Code Act 1994
AHS	Agricultural Health Survey
AMPA	Aminomethylphosphonic acid
APVMA	Australian Pesticides and Veterinary Medicines Authority
ARfD	Acute reference dose
ATDS	Australian Total Diet Survey
BfR	Federal Institute for Risk Assessment
CAT	Catalase
CHO-HGPRT	Chinese Hamster Ovary-Hypoxanthine-Guanine Phosphoribosyl Transferase
CLH	Harmonised classification
CLP criteria	Classification, Labelling and Packaging of Substances and Mixtures
DNA	Deoxyribonucleic acid
EC	European Commission
ECHA	European Chemicals Agency
EFSA	European Food Safety Authority
EP	European Parliament
EPSPS	Enzyme 5-enolpyruvylshikimate-3-phosphate synthase
EU	European Union
FAO	Food and Agriculture Organisation
FRAP	Ferric-inducing ability of plasma
FSANZ	Food Standards Australia New Zealand

40 FINAL REGULATORY POSITION: CONSIDERATION OF THE EVIDENCE FOR A FORMAL RECONSIDERATION OF GLYPHOSATE

GLP	Good laboratory practice
GMO	Genetically modified organism
GSH	Glutathione
GST	Glutathione-S-transferase
hOGG1	Human 8-oxoguanine DNA N-glycosylase 1
IARC	International Agency for Research on Cancer
IPCS	International Programme on Chemical Safety
JMPR	Joint FAO/WHO Meeting on Pesticide Residues
kg	Kilogram
L	Litre
MEPs	Members of the European Parliament
mg/kg bw/day	Milligrams per kilogram of bodyweight per day
mg/L	Milligrams per litre
MOA	mode-of-action
MRL	Maximum residue limit
NGO	Non-governmental organisation
NHL	Non-Hodgkin's lymphoma
NHMRC	National Health and Medical Research Centre
NNG	N-nitrosoglyphosate (synonym N-nitroso-N-phosphonomethylglycine)
NOAEL	No observed adverse effect level
NRS	National Residue Survey
NSW	New South Wales
OCS	Office of Chemical Safety
OECD	The Organisation for Economic Co-operation and Development
OECD TGs	OECD Testing guidelines
PMRA	Pest Management Regulatory Agency
POEA	Polyethoxylated tallow amine (or polyoxyethylated tallow amine and various synonyms)

RAC	Committee for Risk Assessment (ECHA)
RAR	Renewal assessment rapport
RMS	Rapporteur member state
ROS	Reactive oxygen species
SCE	Sister chromatic exchange
SCGE	single cell gel electrophoresis
SOD	Superoxide dismutase
SUSMP	Standard for the Uniform Scheduling of Medicines and Poisons
TBARS	Thiobarbituric acid reactive substances
TGA	Therapeutic Goods Administration
UK	United Kingdom
US	United States
US EPA	US Environmental Protection Agency
US FDA	US Food and Drug Administration
WA	Western Australia
WHO	World Health Organization

GLOSSARY

Acceptable daily intake	A level of intake of a chemical that can be ingested daily over an entire lifetime without any appreciable risk to health
Acute reference dose	The estimated amount of a substance in food or drinking-water, (expressed on a body weight basis), that can be ingested or absorbed over 24 hours or less, without appreciable health risk
Maximum residue limit	The highest concentration of a chemical residue that is legally permitted in a food
No observed adverse effect level	Greatest concentration or amount of a substance, found by experiment or observation, which causes no detectable adverse alteration of morphology, functional capacity, growth, development, or lifespan of the target organism under defined conditions of exposure

REFERENCES

- Alvarez-Moya, C, Silva, MR, Ramirez, CV, Gallardo, DG, Sanchez, RL, Aguirre, AC & Velasco, AF 2014, 'Comparison of the in vivo and in vitro genotoxicity of glyphosate isopropylamine salt in three different organisms', *Genetics and Molecular Biology*, vol. 37, pp. 105–10.
- Astiz, M, de Alaniz, MJ & Marra, CA 2009, 'Effect of pesticides on cell survival in liver and brain rat tissues', *Ecotoxicology and Environmental Safety*, vol. 72, pp. 2025–32.
- Bolognesi, C, Bonatti, S, Degan, P, Gallerani, E, Peluso, M, Rabboni, R, Roggieri, P & Abbondandolo, A 1997, 'Genotoxic Activity of Glyphosate and Its Technical Formulation Roundup', *Journal of Agricultural and Food Chemistry*, vol. 45, pp. 1957–62.
- Chaufan, G, Coalova, I & Rios de Molina Mdel, C 2014, 'Glyphosate commercial formulation causes cytotoxicity, oxidative effects, and apoptosis on human cells: differences with its active ingredient', *International Journal of Toxicology*, vol. 33, pp. 29–38.
- De Roos, AJ, Blair, A, Rusiecki, JA, Hoppin, JA, Svec, M, Dosemeci, M, Sandler, DP & Alavanja, MC 2005, 'Cancer incidence among glyphosate-exposed pesticide applicators in the Agricultural Health Study', *Environmental Health Perspectives*, vol. 113, pp. 49–54.
- EC 2015, 'Commission Implementing Regulation (EU) 2015/1885 of 20 October 2015 amending Implementing Regulation (EU) No 540/2009 as regards the extension of the approval periods of the active substances, 2,4-D, acibenzolar-s-methyl, amitrole, bentazone, cyhalofop butyl, diquat, esfenvalerate, famoxadone, flumioxazine, DPX KE 459 (flupyrsulfuron-methyl), glyphosate, iprovalicarb, isoproturon, lambda-cyhalothrin, metalaxyl-M, metsulfuron methyl, picolinafen, prosulfuron, pymetrozine, pyraflufen-ethyl, thiabendazole, thifensulfuron-methyl and triasulfuron', *Official Journal of the European Union*, vol. L276, pp. 48–51.
- ECHA 2016, *CLH Report: Proposal for Harmonised Classification and Labelling: Substance name: N-(phosphonomethyl)glycine; Glyphosate (ISO)*, Based on Regulation (EC) No 1272/2008 (CLP Regulation), Annex VI, Part 2, ECHA, Helsinki, available at <http://echa.europa.eu/documents/10162/9fb5d873-2034-42d9-9e53-e09e479e2612>.
- EFSA 2015, 'Conclusion on the peer review of the pesticide risk assessment of the active substance glyphosate', *European Food Safety Authority Journal*, vol. 13, pp. 107.
- Elie-Caille, C, Heu, C, Guyon, C & Nicod, L 2010, 'Morphological damages of a glyphosate-treated human keratinocyte cell line revealed by a micro- to nanoscale microscopic investigation', *Cell Biology and Toxicology*, vol. 26, pp. 331–9.
- FSANZ 2011a, *The 23rd Australian Total Diet Survey*, Food Standards Australia New Zealand, Canberra, available at www.foodstandards.gov.au/publications/documents/FSANZ%2023rd%20ATDS_v8_.pdf.
- FSANZ 2011b, *The 23rd Australian Total Diet Survey - Appendices*, The 23rd Australian Total Diet Survey, Food Standards Australia New Zealand, Canberra, available at www.foodstandards.gov.au/publications/pages/23rdaustraliantotald5367.aspx.
- Gasnier, C, Dumont, C, Benachour, N, Clair, E, Chagnon, MC & Seralini, GE 2009, 'Glyphosate-based herbicides are toxic and endocrine disruptors in human cell lines', *Toxicology*, vol. 262, pp. 184–91.
- Germany 2015, *Final addendum to the renewal assessment report: risk assessment provided by the rapporteur Member State Germany and co-rapporteur Member State Slovakia for the active substance glyphosate according to the procedure for the renewal of the inclusion of a second group of active substances in Annex I to Council Directive 91/414/EEC laid down in Commission Regulation (EU) No. 1141/2010*, EFSA, Geneva, Switzerland, available at www.efsa.europa.eu.
- Greim, H, Saltmiras, D, Mostert, V & Strupp, C 2015, 'Evaluation of carcinogenic potential of the herbicide glyphosate, drawing on tumor incidence data from fourteen chronic/carcinogenicity rodent studies', *Critical Reviews in Toxicology*, vol. 45, pp. 185–208.
- Hardell, L & Eriksson, M 1999, 'A case-control study of non-Hodgkin lymphoma and exposure to pesticides', *Cancer*, vol. 85, pp. 1353–60.

Hardell, L, Eriksson, M & Nordstrom, M 2002, 'Exposure to pesticides as risk factor for non-Hodgkin's lymphoma and hairy cell leukemia: pooled analysis of two Swedish case-control studies', *Leukemia & Lymphoma*, vol. 43, pp. 1043–9.

IARC 2006, *Preamble: IARC monographs on the evaluation of carcinogenic risks to humans*, International Agency for Research on Cancer, Lyon, France, available at <http://monographs.iarc.fr/ENG/Preamble/CurrentPreamble.pdf>.

IARC 2015, *IARC monographs on the evaluation of carcinogenic risks to humans: Glyphosate*, International Agency for Research on Cancer, Lyon, France, available at <http://monographs.iarc.fr/ENG/Monographs/vol112/mono112-09.pdf>.

IPCS 2009, *Environmental health criteria 240: Principles and methods for the risk assessment of chemicals in food*, International Programme on Chemical Safety, Geneva, Switzerland, available at www.who.int/ipcs/publications/ehc/methodology_alphabetical/en/.

JMPR 2016, Report of the special session of the Joint Meeting of the FAO Panel of Experts on Pesticide Residues in Food and the Environment and the WHO Core Assessment Group on Pesticide Residues. FAO Plant Production and Protection Paper 227, Geneva, Switzerland, Joint FAO/WHO Meeting on Pesticide Residues.

Kier, LD & Kirkland, DJ 2013, 'Review of genotoxicity studies of glyphosate and glyphosate-based formulations', *Critical Reviews in Toxicology*, vol. 43, pp. 283–315.

Kwiatkowska, M, Huras, B & Bukowska, B 2014, 'The effect of metabolites and impurities of glyphosate on human erythrocytes (in vitro)', *Pesticide Biochemistry and Physiology*, vol. 109, pp. 34–43.

Li, AP & Long, TJ 1988, 'An evaluation of the genotoxic potential of glyphosate', *Fundamental and Applied Toxicology: Official Journal of the Society of Toxicology*, vol. 10, pp. 537–46.

Manas, F, Peralta, L, Raviolo, J, Ovando, HG, Weyers, A, Ugnia, L, Cid, MG, Larripa, I & Gorla, N 2009, 'Genotoxicity of glyphosate assessed by the comet assay and cytogenetic tests', *Environmental Toxicology and Pharmacology*, vol. 28, pp. 37–41.

McDuffie, HH, Pahwa, P, McLaughlin, JR, Spinelli, JJ, Fincham, S, Dosman, JA, Robson, D, Skinnider, LF & Choi, NW 2001, 'Non-Hodgkin's lymphoma and specific pesticide exposures in men: cross-Canada study of pesticides and health', *Cancer Epidemiology, Biomarkers & Prevention*, vol. 10, pp. 1155–63.

Mink, PJ, Mandel, JS, Scurman, BK & Lundin, JI 2012, 'Epidemiologic studies of glyphosate and cancer: a review', *Regulatory Toxicology and Pharmacology*, vol. 63, pp. 440–52.

Mladinic, M, Berend, S, Vrdoljak, AL, Kopjar, N, Radic, B & Zeljezic, D 2009a, 'Evaluation of genome damage and its relation to oxidative stress induced by glyphosate in human lymphocytes in vitro', *Environmental and Molecular Mutagenesis*, vol. 50, pp. 800–7.

Mladinic, M, Perkovic, P & Zeljezic, D 2009b, 'Characterization of chromatin instabilities induced by glyphosate, terbuthylazine and carbofuran using cytome FISH assay', *Toxicology Letters*, vol. 189, pp. 130–7.

Monroy, CM, Cortes, AC, Sicard, DM & de Restrepo, HG 2005, '[Cytotoxicity and genotoxicity of human cells exposed in vitro to glyphosate]', *Biomedica: revista del Instituto Nacional de Salud*, vol. 25, pp. 335–45.

Nordstrom, M, Hardell, L, Magnuson, A, Hagberg, H & Rask-Andersen, A 1998, 'Occupational exposures, animal exposure and smoking as risk factors for hairy cell leukaemia evaluated in a case-control study', *British Journal of Cancer*, vol. 77, pp. 2048–52.

NRS 2014a, *Almond Annual Report 2013-2014*, National Residue Survey, Canberra, available at www.agriculture.gov.au/SiteCollectionDocuments/agriculture-food/nrs/2013-14-results/almond.pdf.

NRS 2014b, *Oat Annual Report 2013-2014*, National Residues Survey, Canberra, available at www.agriculture.gov.au/SiteCollectionDocuments/agriculture-food/nrs/2013-14-results/oat.pdf.

NRS 2015, *Oat residue testing annual datasets 2014-15*, National Residues Survey, Canberra, available at www.agriculture.gov.au/SiteCollectionDocuments/agriculture-food/nrs/oat-residue-testing-datasets-2014-15.pdf.

NRS 2016, *Oat residue testing annual datasets 2015-16*, National Residues Survey, Canberra, available at www.agriculture.gov.au/SiteCollectionDocuments/agriculture-food/nrs/oat-residue-testing-datasets-2015-16.pdf.

Prasad, S, Srivastava, S, Singh, M & Shukla, Y 2009, 'Clastogenic effects of glyphosate in bone marrow cells of swiss albino mice', *Journal of Toxicology*, vol. 2009, pp. 308985.

Rank, J, Jensen, AG, Skov, B, Pedersen, LH & Jensen, K 1993, 'Genotoxicity testing of the herbicide Roundup and its active ingredient glyphosate isopropylamine using the mouse bone marrow micronucleus test, Salmonella mutagenicity test, and Allium anaphase-telophase test', *Mutation Research*, vol. 300, pp. 29-36.

Temple, W 2016, *Review of the evidence relating to glyphosate and carcinogenicity*, New Zealand Environmental Protection Authority, Wellington, available at www.epa.govt.nz/Publications/EPA_glyphosate_review.pdf.

USEPA 1993, *Reregistration eligibility decision (RED): Glyphosate*, United States Environmental Protection Agency, Washington, D.C., available at https://www3.epa.gov/pesticides/chem_search/reg_actions/reregistration/red_PC-417300_1-Sep-93.pdf.

WHO 2015, *Main findings and recommendations of the WHO Core Assessment Group on Pesticides Expert Task Force on diazinon, glyphosate and malathion*, World Health Organization, Geneva, Switzerland, available at www.who.int/foodsafety/areas_work/chemical-risks/main_findings_and_recommendations.pdf.