Lake Kununurra and Lily Creek Lagoon

Vegetation Management Plan

PREPARED BY

Sterling Environmental

FOR

The Shire of Wyndham East Kimberley

Revision	Date	Description	Author	Checker	Approver
0	02-July-2025	Issued for Use		xx	xx
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Table of Contents

1. EXECUTIVE SUMMARY

The purpose of this plan is to identify management actions for aquatic and foreshore vegetation within the Study Area.

There are several plans and reports for the area of Lily Creek Lagoon and Lake Kununurra (1987, 1995 and 2006). Unfortunately, recommendations from these plans have been implemented sporadically and many of the issues identified as far back as 1987 remain.

The main issues that the vegetation management actions identified in this Plan are seeking to address include:

- Weed control (aquatic, riparian and terrestrial) including the management of cumbungi and other flourishing aquatic plants; and
- Protection and rehabilitation of riparian and foreshore vegetation.

In addition, this plan recommends some guiding principles that should be followed when managing vegetation within the Study Area:

Principle 1	Large scale clearing of weed species that are performing environmental functions will be avoided unless a long term weed removal and rehabilitation plan is developed for the area.
Principle 2	Rehabilitation and follow up control on weed removal areas will be provided for in vegetation management programs.
Principle 3	Clearing of cumbungi will be limited to areas determined for recreation and amenity or areas identified as having experienced large scale increases in cumbungi growth.
Principle 4	Removal of cumbungi will be areas no longer than 100m with areas of no less than 20m long left in between the removed 100m areas.
Principle 5	If cleared, banks will be replanted with small local native rushes and riparian areas with scattered trees.
Principle 6	The use of chemicals in and close to the water will be avoided.
Principle 7	Riparian vegetation and cumbungi around drainage outlets will be retained unless it can be shown to be contributing to upstream flooding.

Native vegetation is protected under the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004* and therefore any removal of native vegetation with the Study Area requires a permit from the Department of Water and Environmental Regulation (DWER).

2. DEFINITIONS

Acronym	Definition
Aquatic vegetation	Vegetation that is living or growing in water
Conservation area	An area set aside for conservation and preservation due to its high conservation value. In the context of the Study Area, vegetation exhibiting high conservation value is that which is in good to very good condition (see **Table 1**)
Foreshore	Land between the water's edge and cultivated land; land along the edge of a body of water
P1	Kununurra's public drinking water source area has been classified as a Priority One (P1) area. Land use activities within the PDWSA must be compatible with the WA *Planning Commission's Statement of Planning Policy 2.7 - Public Drinking Water Source Policy 2003* prepared under the *Town Planning and Development Act 1928*
Parkland	An area used as a park and for recreation. These areas have high amenity value and usually require the highest amount of maintenance
Riparian Zone	The riparian zone, commonly called the riverbank, is the interface between land and the water body. The riparian vegetation is the flora growing beside the water's edge
Weeds	for the purpose of this document weeds are a plant growing out of place. This may be either non-native (exotic) plants or native Australian plants that are not local (indigenous) to the area they are growing in. Plants that invade our natural ecosystems are sometimes known as '**environmental weeds**'. A plant may be considered a weed because it: • competes with or displaces native species; • affects natural processes e.g., fire intensity, stream flows; • appears unnatural; • restricts the recreational movement of people; or • causes injury to animals or humans. Many plant species may be useful in some situations but are troublesome weeds when growing where they are not wanted

3. ACRONYMS AND ABBREVIATIONS

Acronym	Definition
APVMA	Australian Pesticides and Veterinary Medicines Authority
DBCA	Department of Biodiversity, Conservation and Attractions
DEC	Department of Environment and Conservation (now DWER)
DFES	Department of Fire and Emergency Services
DoFA	Department of Food and Agriculture (now DPIRD)
DoW	Department of Water (now DWER)
DOT	Department of Transport
DPI	Department for Planning and Infrastructure (now DPLH)
DPIRD	Department of Primary Industries and Regional Development
DPLH	Department of Planning, Lands and Heritage
DWER	Department of Water and Environmental Regulation
KAI	Kimberley Agricultural Investment
LMU	Land Management Unit
M1	Main Irrigation Channel
MG	Miriuwung Gajerrong Corporation
MNES	Matters of National Environmental Significance
NAP	National Action Plan for Salinity and Water Quality
NT	Northern Territory
NVCP	Native Vegetation Clearing Permit
OIC	Ord Irrigation Cooperative
OLW	Ord Land and Water
PDWSA	Public Drinking Water Source Area
SEEKS	Save Endangered East Kimberley Species
SWEK	Shire of Wyndham East Kimberley
TAFE	Technical and Further Education
TEC	Threatened Ecological Community
UCL	Unallocated Crown Land
VMU	Vegetation Management Unit
WRC	Water and Rivers Commission

4. INTRODUCTION

4.1 Background

This Plan was prepared for the Shire of Wyndham East Kimberley (SWEK) in January 2008 as part of SWEK's commitment to the National Action Plan for Salinity and Water Quality (NAP) funded project.

The draft report was prepared independently by Chris Spurr and Kimberley TAFE with the final document being prepared by Katya Tripp from SWEK. The report was edited independently by Rachel Nelson.

Community consultation was initially based on the 2006 version of the Lake Kununurra Foreshore Plan (the Foreshore Plan).

In addition to this, the following community members made comment:

- Dick Pasfield - Coordinator for Ord Land and Water (OLW)
- Colleen Dupe - Kimberley Seeds
- Louise Williams - Kimberley Community Weed Project Officer

The following departments and organisations were consulted throughout the process and have all provided input and advice into the final document:

- Department of Water (now part of DWER (Department of Water and Environmental Regulation));
- Department of Environment and Conservation (also now part of DWER);
- Water Corporation;
- Department for Planning and Infrastructure (now DPLH (Department of Planning, Lands and Heritage)); and
- SWEK.

Following extensive stakeholder consultation, the Foreshore Plan was updated in 2024.

4.2 Purpose

Weeds, ad hoc development, and increased visitor use and access place pressure on the Study Area (as defined in Section 4.3 below) and require ongoing management. The development of this Plan arose in response to conflict between the management of these pressures, and community and agency concern over slashing boundaries, weed removal without rehabilitation, and unauthorised cumbungi (*Typha domingensis*) removal.

The purpose of this Plan is to identify management actions for aquatic and foreshore vegetation that meets community expectations for the Study Area, as identified in the Foreshore Plan, and retains the ecosystem values associated with the water body. This also includes clearly identifying the responsibilities, policies, actions, and regulations that are in place to ensure effective vegetation management within the Study Area. The Plan is therefore to provide for the management of vegetation in and around the Lake Kununurra town foreshore and Lily Creek Lagoon that is compliant with all relevant regulatory and planning bodies.

This Plan is intended to be updated as future developments occur and new strategies and techniques arise, or as the floristic structure of an area changes.

4.3 Overview of Study Area

Lily Creek Lagoon and Lake Kununurra are permanent water bodies formed by the damming of the Ord River. Built in 1963 to supply water to the Ord River Irrigation Area, water levels of Lake Kununurra are regulated and managed primarily for this purpose by the Water Corporation.

Biophysical conditions within the water bodies include high water temperatures, an intense sunlight regime, high water clarity, relatively high concentrations of total nitrogen and phosphorus, and fertile sediments. These conditions are ideal for growth of aquatic plants and the lake, including Lily Creek Lagoon, becomes eutrophic at various times in the year (Watkins *et al,* 1997).

This Plan focuses on the vegetation surrounding and within these water bodies. The Study Area extends from upstream of the Diversion Dam to the upper reaches of Lily Creek Lagoon bordered by the Victoria Highway, and to the eastern most edge of Hamilton Inlet (see Figure 1).

The Study Area is comprised of numerous parcels of Crown land including Reserve 41812, Unallocated Crown Land (UCL) and a number of smaller reserves adjacent to the Lake and Lagoon foreshore, freehold land, the proposed Packsaddle Conservation Area, and leases to community and private organisations.

4.4 Significance of the wetland

Lake Kununurra and Lily Creek Lagoon are listed under the Convention on Wetlands of International Importance (Ramsar Convention) as components of the listing 'Lakes Argyle and Kununurra', Western Australia site no. 32 and are therefore afforded protection under both State and Commonwealth legislation. The Lake supports habitat for waterbirds, freshwater fish, and the freshwater crocodile and is an important dry season refuge. Twenty-one species of fish are known to occur in Lake Kununurra (Hall, 2000).

Lake Kununurra and Lily Creek Lagoon are used extensively for a variety of industry purposes and recreational activities and the area considered by this Plan is central to the character of Kununurra. The water body and its environs are highly valued by the community (both residents and visitors alike).

Over the years, in absence of an overarching strategic plan, developments have occurred within the Study Area. These include several caravan parks, a golf course, boating and yachting facilities, areas for swimming and water-skiing, and an amphitheatre (Lake Kununurra Foreshore Committee, 2006).

Water from Lake Kununurra is used to irrigate farms via Stage 1 of the Ord Irrigation Scheme and the M2 Supply Channel Project has expanded irrigation infrastructure to support agriculture on approximately 50,000 hectares of black soil plains, including the Weaber, Keep River, and Knox Creek Plains (KDC, 2025). This expansion was facilitated by the construction of the M2 supply channel, with development commencing around 2010. Farming activities, particularly on the Goomig farmlands, began in 2015 (DPIRD, 2018).

The project is being developed by Kimberley Agricultural Investment (KAI), which entered into lease agreements with the Western Australian Government in 2017. Further expansion, referred to as Stage

3, is underway, focusing on an additional 6,000 hectares of red loamy soils at the Cockatoo Sands near Kununurra (KDC, 2025).

Water for these developments continues to be sourced from Lake Kununurra, as in Stage 1, and is distributed through the newly established M2 channel infrastructure. This expansion has significantly increased the irrigated agricultural area in the region, supporting a variety of crops and contributing to the local economy.

The water from Lake Kununurra and Lily Creek Lagoon also recharges the bores from which Kununurra's potable water is supplied. The Study Area includes the well-head protection zone around the bores and a larger P1 classification area designed to ensure the town's water supply is not compromised.

The water body and its environs are important to the local Aboriginal people and a number of significant Aboriginal Heritage Sites are located within the Study Area.

The foreshore and waterway directly supports a thriving tourism industry. People who visit Kununurra often utilised commercial tourism opportunities during their stay. These tourism enterprises, such as caravan parks, tour boat operators and the annual Ord Valley Muster's Kimberley Moon Experience, Directly contribute to the local economy and provide local employment.

The foreshore and waterbodies are used extensively by residents and visitors for both passive and active recreational pursuits. These include:

- Walking;
- Bird watching;
- Dog exercising;
- Picnicking;
- Swimming;
- Sightseeing;
- Boating;
- Water-skiing;
- Local events;
- Sailing;
- Fishing; and
- Canoeing/ kayaking.

Balancing these activities and values while maintaining the ecological and amenity values upon which these activities rely is a challenge.

4.5 Legislation and policies

The Study Area covers a wide range of land tenures, and many agencies have Acts, Regulations and policies that will guide any vegetation use and management. These include:

- *Land Administration Act 1997;*

- *Country Area Water Supply Act 1947;*
- *Rights in Water and Irrigation Act 1914* (RIWI Act)*;*
- *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act);
- *Aboriginal Heritage Act 1972;*
- *Environmental Protection Act 1986* (EP Act)*;*
- *Environmental Protection (Clearing of Native Vegetation Regulations 2004);*
- *Biodiversity Conservation Act 2016;*
- *Biosecurity and Agriculture Management Act 2007*;
- *Conservation and Land Management Act 1984* (CALM Act);
- *Planning and Development Act 2005;* and
- Statement of Planning Policies.

These instruments relate to actions such as clearing of native vegetation, taking of water, flora and/or fauna, disturbance to bed and banks, protection of heritage and aboriginal sites and developments. Consultation with relevant agencies and departments should occur before any new actions or activities take place within the Study Area.

4.6 Related documents

in addition to statutory obligations, this Plan is guided by the following documents. Each of these documents were prepared with a high level of community consultation and each should be considered in future management of the Study Area:

- Ord Land and Water Management Plan (2000);
- Lake Kununurra Foreshore Plan (2024);
- Kimberley Natural Resource Management Plan (2005);
- Rangelands Natural Resource Management Strategy (2006); and
- Ord Surface Water Allocation Plan (2013).

Consideration of and consistency with these above documents contributes to ensuring that this Plan fulfils community expectations.

5. VISION AND OBJECTIVES

Vision

To manage Lily Creek Lagoon and Lake Kununurra in a manner that satisfies conservation requirements whilst maintaining aesthetic and recreational values.

Objectives

- To maintain the ecological values of Lily Creek Lagoon and Lake Kununurra whilst still enabling the management and maintenance of public open space for recreation purposes.
- To integrate the town development with that of the Lake foreshore and provide appropriate recreational and tourism facilities while avoiding degradation of the Lake's and Lagoon's ecological values.
- To outline a cooperative and coordinated approach to the management of vegetation in and around Lake Kununurra and Lily Creek Lagoon that meets legislative requirements as well as community expectations.
- To conserve the natural, scenic, and wildlife resources.
- To protect the foreshore from fire, erosion, and general misuse.

6. MANAGEMENT RESPONSIBILITIES AND ARRANGEMENTS

(extract from the Lake Kununurra Foreshore Plan, 2025)

The foreshore reserves and associated areas included in the Plan are owned or managed by a variety of agencies including SWEK, the DWER, Water Corporation, DPLH, the Miriuwung Gajerrong Corporation (MG) and the Department of Biodiversity, Conservation and Attractions (DBCA). Additionally, a number of private landholdings exist within the Study Area, including three caravan parks with access leases to the foreshore, and the land containing the Pump House Restaurant, which is held in freehold title by the Water Corporation.

6.1 DBCA

DBCA's overarching role is to achieve improved environmental outcomes. Key responsibilities include roles in conserving biodiversity and protecting, managing, regulating, and assessing many aspects of the use of the State's natural resources. Other responsibilities include the management of contaminated sites and coordination of pollution incident responses.

Key responsibilities in regard to Lake Kununurra and its foreshore are:

- Contributing to the environmental impact assessment process for proposed developments;
- DBCA is responsible for reporting on listed Ramsar wetlands, mapping wetland areas and management of wetlands on conservation estate under the CALM Act. DBCA provides advice to decision makers and is involved in wetlands research and monitoring; and
- Protecting native flora and fauna.

6.2 Kununurra Visitor Centre

The Kununurra Visitor Centre is involved in decision making ideas to bolster the tourism opportunities on the Foreshore. The Visitor Centre also play a vital role in promotion of the Foreshore to visitors and locals around tourism opportunities.

6.3 Water Corporation

The Water Corporation is responsible for the management of water levels in the lake for water supply for irrigation and environmental flows. The Water Corporation maintains the infrastructure associated with the lake which are the Lake Argyle Dam, Diversion Dam, Spillway, and the M1 irrigation channel intake.

In addition to management of the water supply and infrastructure for irrigation, the Water Corporation manages the Kununurra Public Drinking Water Source Area (PDWSA) and the bore fields that supply the town with good quality drinking water.

6.4 SWEK

The SWEK is responsible for the management of Foreshore Reserve 41812, Reserve 29167 (Kununurra Golf Club) and Reserve 30290 (racecourse). Reserve 41812 includes the areas known as Swim Beach and Ski Beach, Celebrity Tree Park (Reserve 42371) and Lakeside Caravan Park. The Shire manages

these public parks for recreation and leases other areas to sporting groups such as the ski, race, rodeo, and golf clubs.

The SWEK plays a pivotal role in the management of the foreshore due to its administrative jurisdiction over the area. Their involvement encompasses various responsibilities such as:

- Policy Development;
- Management of leases and reserves;
- Community Engagement;
- Environmental Conservation;
- Development Approval and Regulation; and
- Implementation of the Lake Kununurra Foreshore Plan.

6.5 DWER

The DWER is responsible for the sustainable management of the State's water resources and environment through investigation, planning, regulation, and management of these resources. Broadly, DWER is the lead agency responsible for waterways, floodplains, and estuaries, while the DBCA is responsible for wetlands. In the context of the Foreshore Plan, DWER is a management authority responsible for:

- Providing water-related advice and conditions for planning decisions;
- Implementing the Ord Surface Water Allocation Plan (2013), which specifies how water will be allocated to meet competing environmental, social and commercial water requirements;
- Protecting Kununurra's public drinking water source through the implementation of the Kununurra Drinking Water Source Protection Plan (2003) and Kununurra Drinking Water Source Protection Review (2012);
- Licensing surface and groundwater use, including water service providers such as the Ord Irrigation Cooperative (OIC) and Water Corporation and self-supply users in accordance with the RIWI Act;
- Issuing native vegetation clearing permits for the purpose of managing cumbungi and other aquatic and riparian vegetation;
- Measuring and monitoring the quality and quantity of groundwater and surface water in the Ord River catchment;
- Issuing permits to disturb the bed or banks of a water course for the purpose of vegetation clearing, water pump infrastructure installation, boat ramp/jetty construction or bank modification.

6.6 Department of Transport (DOT)

The purpose of DOT within the Foreshore is Marine Safety. DOT provide safe navigation and safe use of State waters, protect the marine environment and provide for an effective response to marine emergencies. Marine Safety fulfils this role through:

- Ensuring compliance by commercial and recreational boat owners with marine regulations and standards;
- Minimising the impact of marine pollution;
- Providing expert marine safety advice and infrastructure to aid safe navigation of State waters;
- Educating and training the community in safe, sustainable use of State waters;
- Gazetting and enforcement of speed restrictions, ski area and other gazettes; and
- Approving and administering moorings.

6.7 DPLH

The Land Use Management division of the DPLH administers Crown land under the *Land Administration Act 1997* and other legislation, providing functions such as:

- Creation and administration of easements, leases, licences, reserves and roads;
- Transfer of Crown land in freehold;
- Management of the Aboriginal Lands Trust and Crown land estates in association with other agencies;
- Negotiation and consultation with native title holders and claimants where the *Native Title Act 1993* provides rights to those parties in relation to Crown land; and
- Acquisition of land for government public works.

The Heritage and Property Services division provides support and advice in relation to Aboriginal cultural heritage in line with the *Aboriginal Heritage Act 1972* (AHA), including:

- Assistance in identifying known cultural heritage values prior to commencement of ground disturbing works;
- Guidance in relation to stakeholder engagement on matters of possible ground disturbing activities, cultural heritage obligations, and the requirement to consult under s18(1AA) AHA;
- Assistance with engagement with stakeholders, where required, to minimise the impact to the natural environment and maintain cultural heritage; and
- Assistance with consultation with stakeholders, where required, in the development of cultural heritage management plans to maximise the protection, preservation, and promotion of Aboriginal cultural heritage.

6.8 Miriuwung Gajerrong Corporation (MG)

The MG Corporation is a key stakeholder in all lands and waters surrounding Kununurra, representing the traditional owners of the land. MG Corporation is consulted before development and land use planning occurs.

This Corporation and its people are important in identifying sites of cultural significance and speaking the history of the area, and their involvement is required for any land development activities on which native title has not yet been resolved.

Including an MG representative in all decision making is critical to ensure the development continues to align with Miriuwung Gajerrong Corporation's vision for their country.

7. POTENTIAL THREATS

Threats to the maintenance of the ecological, social, economic and cultural values of the lake include:

- Fire;
- Ad hoc development;
- Weeds; In particular *Salvinia molesta* (salvinia) and *Leucaena leucocephala* (leucaena);
- Increased visitor use and access including increases in power boat activities;
- Unmanaged visitor use and access;
- Stormwater runoff;
- Feral animals;
- Use of pesticides and herbicides near the waterbody;
- Unauthorised clearing;
- Cumbungi and other aquatic vegetation that has become weedy, resulting in the loss of wading habitat, reduced biodiversity, or reduced access;
- Absence of a statutory Ramsar Management Plan; and
- Lack of resource allocation from land managers;

8. THE PLANNING FRAMEWORK

8.1 Land Management Units

In order to link this Plan with the Foreshore Plan, the six precincts used in the 2006 version of the Foreshore Plan are replicated here as Land Management Units (LMUs) (see Figure 1). It is important to note that these precincts are not an exact match with the five precincts detailed in the 2024 version of the Foreshore Plan however they have been retained in this Plan so that management of LMU's is consistent with past management strategies employed as a result of previous iterations of this Plan.

8.2 Vegetation Management Units

To gain an understanding of the floristic components of the Study Area, each LMU has been broken down into Vegetation Management Units (VMUs). These are Parkland, Conservation, and Riparian areas. Definitions for these Vegetation Management Units are listed at the start of this Plan whilst Figure 1 presents the VMUs and LMUs as a map.

8.3 Vegetation mapping

To map the extent and floristic structure of the vegetation within the Study Area, students from the Kimberley TAFE helped collect data from transacts and quadrats Which were then interpreted using a modified Vegetation Condition Scale as presented below. This scale uses both quantitative and qualitative assessment procedures to describe the state of the vegetation in a particular area. The vegetation condition tables for each LMU can be found in Appendix 3.

Table 1 – Vegetation Condition Scale (Adapted from Trudgen, 1991)

Good – Very Good	• 80-100% native flora composition • Vegetation structure intact or nearly so • Cover/abundance of weeds less than 5% • No or minimal signs of disturbance
Fair - Good	• 50-80% native flora composition • Vegetation structure modified • Cover/abundance of weeds 5-20% • Minor signs of disturbance
Poor	• 20 – 50% native flora composition • Vegetation structure completely modified • Cover/abundance of weeds 20-60% • High level of disturbance
Very Poor	• 0-20% native flora composition • Vegetation structure disappeared • Cover/abundance of weeds 60-100% • Very high level of disturbance

Transects were carried out on foot or by boat in each of the six precincts to determine placement of vegetation sampling quadrats. Areas with differing forms of vegetation or areas that appeared to represent the dominant vegetation within the precinct were chosen as quadrat sites (see Figure 2). The location of these sites was recorded with GPS (see Appendix 2). These 100m2 quadrat sites were used to determine:

- composition and percentage of native flora;
- composition and percentage cover of weeds;
- vegetation structure; and
- signs of disturbance such as clearing, rubbish disposal, fire and tracks.

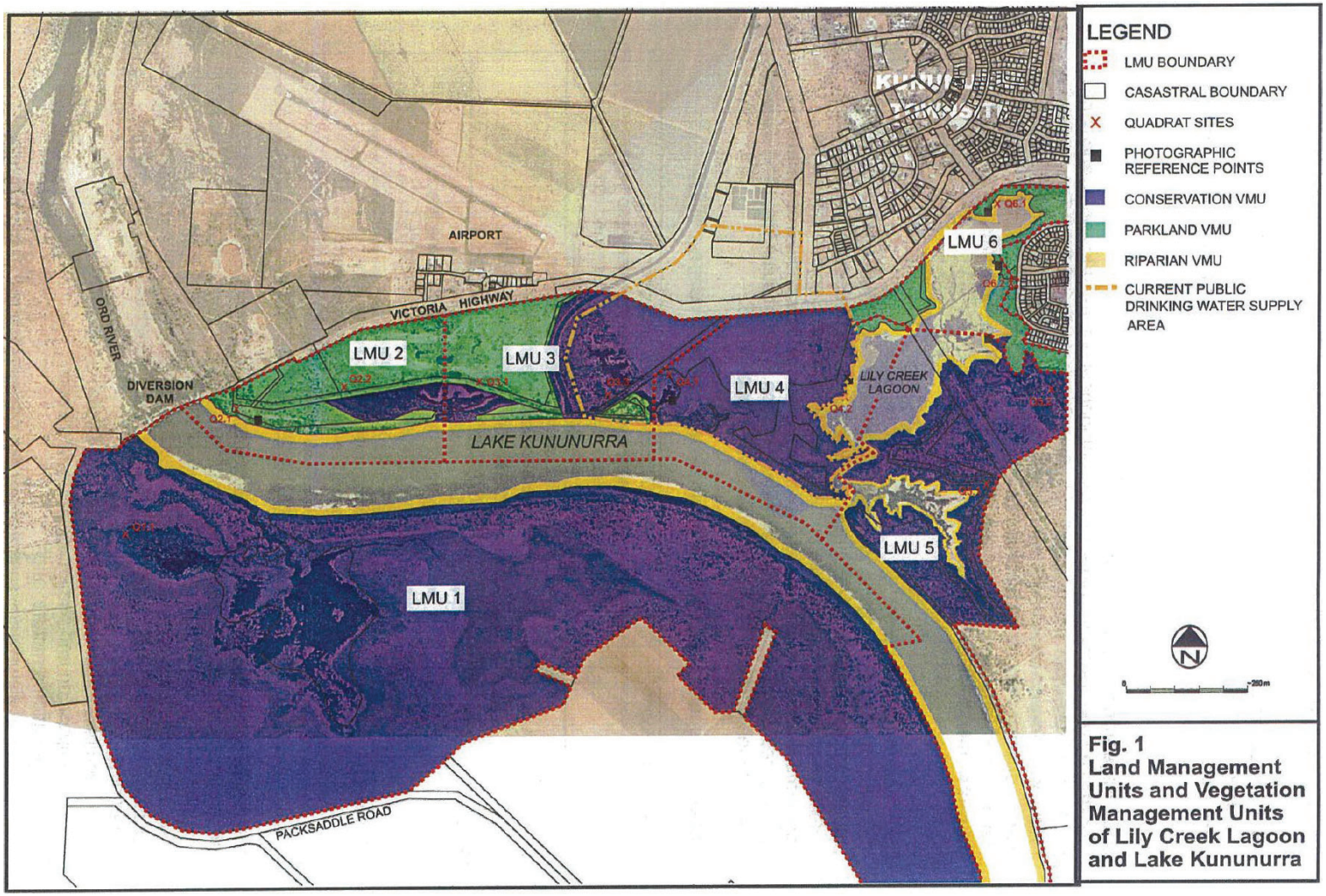

Figure 1: Land Management Units and Vegetation Management Units of Lily Creek Lagoon and Lake Kununurra

For each quadrat, the plant species and their numbers were used to give an indication of dominant species within each precinct.

This information forms the Vegetation Condition Tables for each Land Management Unit (LMU) (see Appendix 3) which in turn was used to help guide the recommended management actions. Improvement in the management of the LMUs should result in an improvement in vegetation condition and hence these condition ratings and species information can be used in the future to help assess whether vegetation condition has improved or degraded.

See Appendix 4 for the full species list.

Photographic Reference Points

To be able to better determine changes and rates of growth of target species such as weeds or recovery of endemic species, sites for Photographic Reference Points have been identified (see Figure 2). These sites have been chosen in areas of high activity or where the vegetation is of high conservation value. These sites should be photographed each year to help assess whether vegetation of the area is improving, declining or remaining stable.

Aerial Mapping

Past and present photographs were used to map the extent of cumbungi. This process was limited by the quality and different scales of the aerial photographs. However, when combined with ground-truthing, the photographs provided a useful starting point for the on-ground analysis as well as portraying some patternistic changes. See Section 10 for further information and discussion on cumbungi.

Future Surveys

In addition to the above, as part of a Master Planning initiative underway at the time of writing this Plan, SWEK is planning to undertake further biological surveys within the five precincts described in the Foreshore Plan and will ensure that these surveys are extended to include the Study Area defined in this Plan. These surveys are expected to include the identification and mapping of Threatened Ecological Communities (TECs), threatened and priority flora listed by DBCA, assessments of vegetation condition, and additional weed surveys.

Data obtained through these surveys will be used to validate the biological data collected to inform the development of future iterations of this Plan. It is anticipated that these surveys will be conducted during the 2026 calendar year.

8.4 Environmental values and general management of VMUs

Native vegetation is crucial to the ecological and social values of the Study Area. It provides habitat for terrestrial and aquatic wildlife, filters nutrients and other pollutants from the water, stabilises soil thereby reducing the sediment load entering the waterbody, provides material for food and cultural purposes, and increases the amenity value of the area by shading recreational areas. Exotic vegetation can also contribute to these values.

In all VMUs, and in particular the Conservation VMU where disturbance and weed invasion is minimal, remnant native vegetation contributes to and supports biodiversity within the Study Area. Native

vegetation endemic to the local environment also provides a sense of 'place' to the community (for example, boab trees are considered an *iconic* species around Kununurra). Retention of remnant vegetation helps to foster this feeling and can be used to facilitate greater understanding of the natural environment.

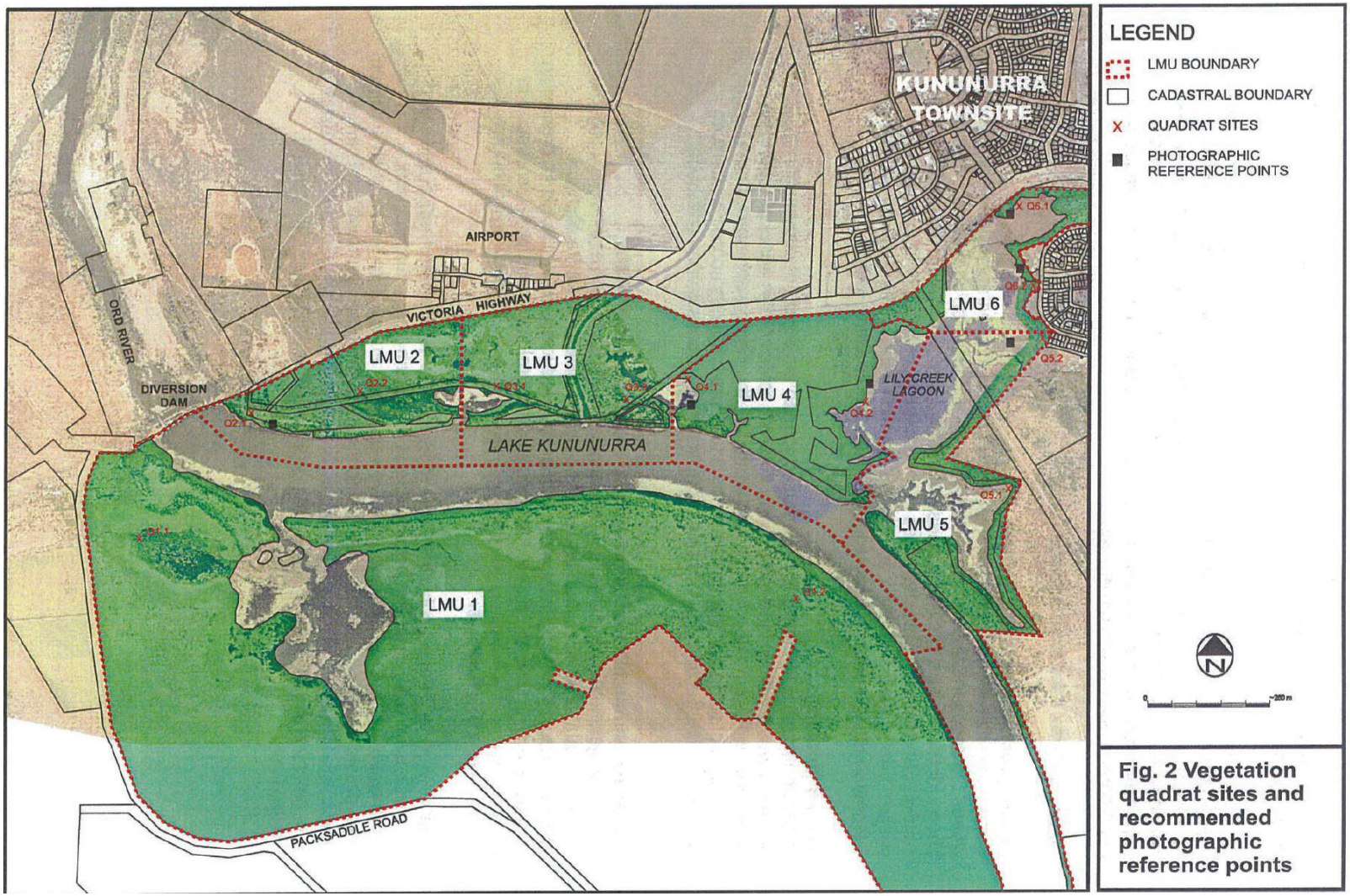

Figure 2: Vegetation Quadrat Sites and Recommended Photographic Reference Points

Conservation Vegetation Management Unit

The primary role of the Conservation VMU is the conservation and preservation of native vegetation. The key environmental values of the vegetation include:

- habitat for fauna and flora;
- a source of ethnobotanical material for traditional owners;
- a sense of 'place' that is synonymous with Kununurra and the Ord River; and
- values as listed under the riparian VMU such as erosion control and filtering of nutrients.

To maintain consistency with the Foreshore Plan, no vegetation removal or slashing is permitted within Conservation VMU with the exception of road verges, fire breaks and weeds. No development is permitted with the exception of interpretation facilities such as pathways, signage, and bird hides. Rehabilitation should use local native species only.

Parkland Vegetation Management Unit

The Parkland VMU is specifically recognised as providing a place for people to enjoy the environment including space for recreational pursuits. The values of the vegetation in contributing to this experience include:

- providing the opportunity to gain knowledge on plants, e.g., Celebrity Tree Park;
- providing structure; and
- providing shade, wind protection and temperature mitigation for plants, animals, and people.

Due to these values and in order to maintain consistency with the Foreshore Plan, vegetation removal shall be limited to slashing or mowing, and trees shall not be removed unless specifically recommended. Weeds shall be removed. Pockets of remnant bushland (unslashed) can also be maintained within a Parkland area for conservation purposes.

Riparian Vegetation Management Unit

The riparian zone within the Study Area provides both conservation and social values. As a VMU, the riparian area includes the vegetation of the foreshore and the waterbody. Key values of the native vegetation within the Riparian VMU include:

- habitat (food, shelter, and breeding sites) for aquatic and semi-aquatic animals;
- nutrient reduction and management through the filtering of sediments, nutrients and pollutants and trapping of gross pollutants (rubbish);
- bank stability and erosion control during storm events and from the ongoing impact of waves from motorised vessels; and
- aesthetic enhancement of the waterbody by defining the water's edge as well as providing screening of developments along the foreshore.

Observation along the foreshore strongly suggests that development precipitates a large reduction in habitat complexity of riparian vegetation. Clearing of riparian areas can result in increased sediment and nutrient inputs, increased surface water runoff, reduced habitat, decreased canopy cover, increased weed invasion, and increased erosion potential. Therefore, in order to retain the values

identified above, it is recommended that riparian habitats be managed to maintain them in good condition, as defined by the Vegetation Condition Scale (see Table 1).

Recommendation 1. Intact riparian vegetation should be managed to ensure 50-80% native flora composition and cover and abundance of weeds kept below 5-20%.

Recommendation 2. Where areas identified for access and views in the Foreshore Plan are hindered by cumbungi resulting in its removal, then revegetation with suitable alternative native sedges and scattered trees should occur.

Recommendation 3. Continued monitoring of sediment, nutrient, and chemical concentrations in Lily Creek Lagoon. Identify pollutant inputs and sources. Implement actions to manage and reduce these.

Recommendation 4. Conduct local research into the importance of cumbungi as habitat for endemic flora and fauna.

Recommendation 5. Research tropical native aquatic flora species that may be increased with the removal of the dominant aquatic vegetation species of cumbungi, lilies, pond and ribbon weed.

Recommendation 6. Trial cumbungi and other aquatic plant harvesting. Monitor effects of this on water quality.

Recommendation 7. Encourage the establishment of a local 'Friends of Lily Creek Lagoon' group to help manage and control weeds.

8.5 Plants of ethnobotanical importance

Lily Creek Lagoon and Lake Kununurra contain many plants of indigenous cultural importance. The majority of these species are endemic to the region however some weed species are now also part of Aboriginal culture.

Elders have expressed their desire to conserve endemic species in the Study Area. There is recognition that not all species have an ethnobotanical use, but Aboriginal belief is that all the endemic species are of importance in maintaining a healthy landscape.

Whilst weed control within the Study Area is seen as important, some weed species, like the wild passionfruit (*Passiflora foetida*), have contemporary value to local aboriginal people.

8.6 Rare flora, fauna and ecological communities

Desktop biodiversity (flora and fauna surveys were conducted by Sterling Environmental (on behalf of Hassell Studios) in May 2025 as part of a Lake Kununurra Foreshore Master Planning initiative initiated by SWEK.

As part of this desktop assessment, all five precincts identified in the 2024 Foreshore Plan were assessed against publicly available databases for threatened and priority flora and vegetation communities. This search identified:

- Potential presence of two **Priority Flora** species within the development footprint.
- The majority of the development footprint overlapping with a **TEC**.

Furthermore, under the EPBC Act an action will require approval from the Minister if the action has, will have, or is likely to have, a significant impact on Matters of National Environmental Significance (MNES).

A Protected Matters Search for MNES using the PMST identified that:

- 21 listed threatened species,
- 17 listed migratory species, and
- 3 listed marine species may occur in and around the foreshore development footprint.

See Appendix 5 for details on searches.

As described above, as part of the Master Planning initiative, SWEK is planning to undertake further biological surveys within the five precincts and will extend these to include all of the Study Area defined in this Plan. These surveys are expected to include the identification and mapping of TECs, threatened and priority flora listed by DBCA, assessments of vegetation condition, and additional weed surveys.

In addition, targeted ecological surveys will be undertaken to confirm the presence or absence of listed or significant species, and to identify suitable habitat for listed or significant species within the project area.

Data obtained through these surveys will be used to validate the biological data collected to inform the development of future iterations of this Plan. It is anticipated that these surveys will be conducted during the 2026 calendar year.

8.7 Fire

Initial fire scar mapping for the 2008 version of the Plan was undertaken in 2005 (see Appendix 6).

To support this (2025) version of the Plan, fire scar mapping was undertaken in July 2025 (see Appendix 7). This mapping indicates that areas within the Study Area were burnt as recently as 2023 and 2024. This mapping also indicates that fires occurred within the Study Area in 2014, 2016, 2017 and 2019. Most of the fires appear to have occurred between April and June, with one fire taking place during December of 2019.

Impacts of hot, late dry season fires can include the removal of understory and sensitive riparian species and ultimately a change in the vegetation composition including an increase in weeds and cane grass (*Sorghum stipoideum*). Cool burns maintain these more sensitive species and therefore result in less loss of biodiversity.

A management plan for the purposes of minimising the impact of frequent uncontrolled burning of 'non-management' areas of vegetation within the six LMU areas is to be prepared in conjunction with Department of Fire and Emergency Services (DFES), DWER, SWEK, local fire brigades, and the relevant land management agency.

The plan will be prepared early 2008 with a view to implementation for the end of the 2007/08 wet season. Elements of the plan will include designation of 'cool burn' areas, development of strategic fire breaks (slashed or mown), designation of protection areas, and fire response protocols.

Due to fire vulnerable vegetation occurring within riparian zones, careful consideration will need to be given to these areas and may require the use of breaks rather than regular preventative burning.

8.8 Current vegetation management

The table below outlines the current vegetation management activities within the Study Area as well as authorities responsible for parcels of land.

DWER is responsible for administering environmental and water regulation processes that support the protection of Ramsar values at Lakes Argyle and Kununurra. This includes the regulation of native vegetation clearing under the EP Act.

As Cumbungi is a native species in Western Australia, its removal is considered clearing of native vegetation and generally requires a Native Vegetation Clearing Permit (NVCP) unless an exemption applies.

In addition, if the proposed activity is likely to result in interference with the watercourse's bed or banks, a permit may be required under the RIWI Act.

There are also various other agencies and land managers responsible for specific areas of land within the Study Area.

From this table it can be seen that much of the management of the Study Area is undertaken by SWEK, recreational clubs with leases or freehold landowners.

A comparison of this table to the recommended activities table (Table 9) indicates that greater vegetation management is required than what is currently occurring. In particular, weed removal, rehabilitation and fire control is lacking.

Maps indicating the current areas of slashed land by SWEK can be found in Appendix 8.

Table 2 – Current vegetation management activities

Land Management Unit	Reserve/Lot No.	Managing Authority	Current Management Tasks
LMU1			
Packsaddle Conservation Area	Lot 959 on Deposited Plan 31611 (UCL)	DWER/MG	Packsaddle Conservation Area
LMU2			
Swim Beach Park	Reserve 41812	SWEK DWER	Mowing and slashing of 'park land' area, retention of trees, planting of local tree species. Nil
Proposed Commercial Boat Harbour site	Reserve 41812	SWEK DWER	Present - slashing of access road verges, control/removal of neem trees Future - mowing and slashing of 'park land' area, retention of trees, planting of local tree species Nil
Water Ski Club Lease	Reserve 41812	SWEK	Nil

Land Management Unit	Reserve/Lot No.	Managing Authority	Current Management Tasks
		DWER Ski Club	Nil As detailed by Ski Club - mowing and slashing, control/removal of neem trees
Golf Course Lease	Reserve 29167	SWEK Golf Club Muster Committee	Nil As detailed by Golf Club- mowing and slashing, control/removal of neem trees. Removal of passionfruit vine and cumbungi removal
UCL (Lake Kununurra)		DPLH SWEK	Nil Removal of cumbungi from swimming area
Botanic gardens site	Reserve 38368	SWEK	Mowing and slashing of park land area, retention of trees, planting of local tree species, removal of neems, and control of luecaena
Levee bank	Reserve 46172	Water Corp SWEK	Nil Nil
LMU3			
Golf Course Lease	Reserve 29167	SWEK Golf Club	Nil As detailed by Golf Club - mowing and slashing, control/removal of neem trees
Kona Caravan Park	King Locations 274, 439,440 &	Caravan Park	As detailed by Caravan Park - mowing and slashing, control/removal of neem trees
Foreshore	441	SWEK DWER	Nil Nil
UCL (Lake Kununurra)	Reserve 41812	DPI	Nil Control/removal of cumbungi by Kona
Pl area		DWER Water Corp	Nil Management of Town Water Supply
Ml Channel	King Location 324	OIC Water Coro	Spraying of weeds Nil
Levee bank	Reserve 30211	Water Corp SWEK	Nil Nil
LMU4			
Kimberley Land Caravan Park	Kununurra Lot 1519	Caravan Park	As detailed by Caravan Park - mowing and slashing, control/removal of neem trees
Foreshore	Reserve 41812	SWEK DWER	Nil Nil
UCL (Lily Creek Lagoon)		DPLH	Nil Cumbungi control by Kimberley Land
Pl area	King Location 715and324	DWER Water Corp	Nil Management of Town Water Supply

Land Management Unit	Reserve/Lot No.	Managing Authority	Current Management Tasks
LMU5			
Foreshore	Reserve 41812	SWEK DWER	Nil Nil
UCL (Lily Creek Lagoon / Lake Kununurra)		DPLH	Nil
LMU6			
Celebrity Tree Park	Reserve 42371	SWEK	Mowing and slashing of 'park land' area, retention of trees, occasional planting of trees
Foreshore	Reserve 41812	SWEK DoW	Mowing and slashing of'park land' area, retention of trees, planting of local tree species, control/removal of neem trees. Nil
Lakeside Resort and Caravan Park	Kununurra Lot	Caravan Park	As detailed by Caravan Park - mowing and slashing, control/removal of neem trees
UCL (Lily Creek Lagoon)		DPLH	Nil SWEK carries out cumbungi removal along Vic Hwy and around celebrity Tree Park and Boat ramp Lakeside Resort and Celliston Nominees also carry out cumbungi control

9. LAND MANAGEMENT UNITS

9.1 Land Management Unit 1 (Precinct 1)

LMU 1 is on the southern side of Lake Kununurra and includes Packsaddle Lagoon and the land bounded on the south by Packsaddle Road and private property (see Figure 3). This area is currently undeveloped and subject to provisions under the Ord Final Agreement. Vegetation was sampled from two quadrats (see Figure 2).

As in the 2006 version of the Foreshore Plan, this LMU has been allocated as Conservation with the addition of a Riparian VMU. The only future development discussed by the Foreshore Group at that time was the potential for the relocation of the current P1 PDWSA to this LMU and the installation of eco-recreational and interpretive facilities such as a bird hide, trail and jetty. The boundaries of the PDWSA were changed in 2012.

The vegetation in LMU 1 is predominantly endemic to the region. Vegetation is most dense nearest the water's edge. The heavily vegetated Riparian component is dominated by cumbungi, dragon tree (*Sesbania formosa*) and pandanus (*Pandanus aquatica*). Moving away from the water's edge there are dense stands of dragon tree, cajuput (*Melaleuca leucadendra*) and the introduced rain tree (*Albizia lebbeck*).

There is some weed encroachment along the water's edge, the most dominant being the wild passionfruit (*Passiflora foetida*). The majority of the weeds in this LMU appear to be establishing themselves away from the water's edge including occurrences of neem (*Azadirachta indica*) which are the subject of a local eradication program. This could be due to the susceptibility of the endemic vegetation to fires, higher likelihood of human activity, and the more open nature of the vegetation allowing weed species to get a foothold more easily than in the dense riparian zone.

LMU 1 is in fair to good condition showing good native flora composition and only minor signs of disturbance (mainly access tracks and weeds). Management of this area should focus on controlling weeds, fire and access to the site.

Table 3 – Recommended actions

Issue	Action and targets	Who	When
Weeds	Eradicate neem infestations	OLW	Once yearly
	Control and if possible reduce weed infestations. Follow up control	DWER/MG Corp	
Access	Control and if possible reduce traffic access	DWER/MG Corp	Next 3 months
Fire	Write Fire Management Plan	DWER/MG Corp	Feb 08
	Implement preventative burning regime	DWER/MG Corp	Once yearly

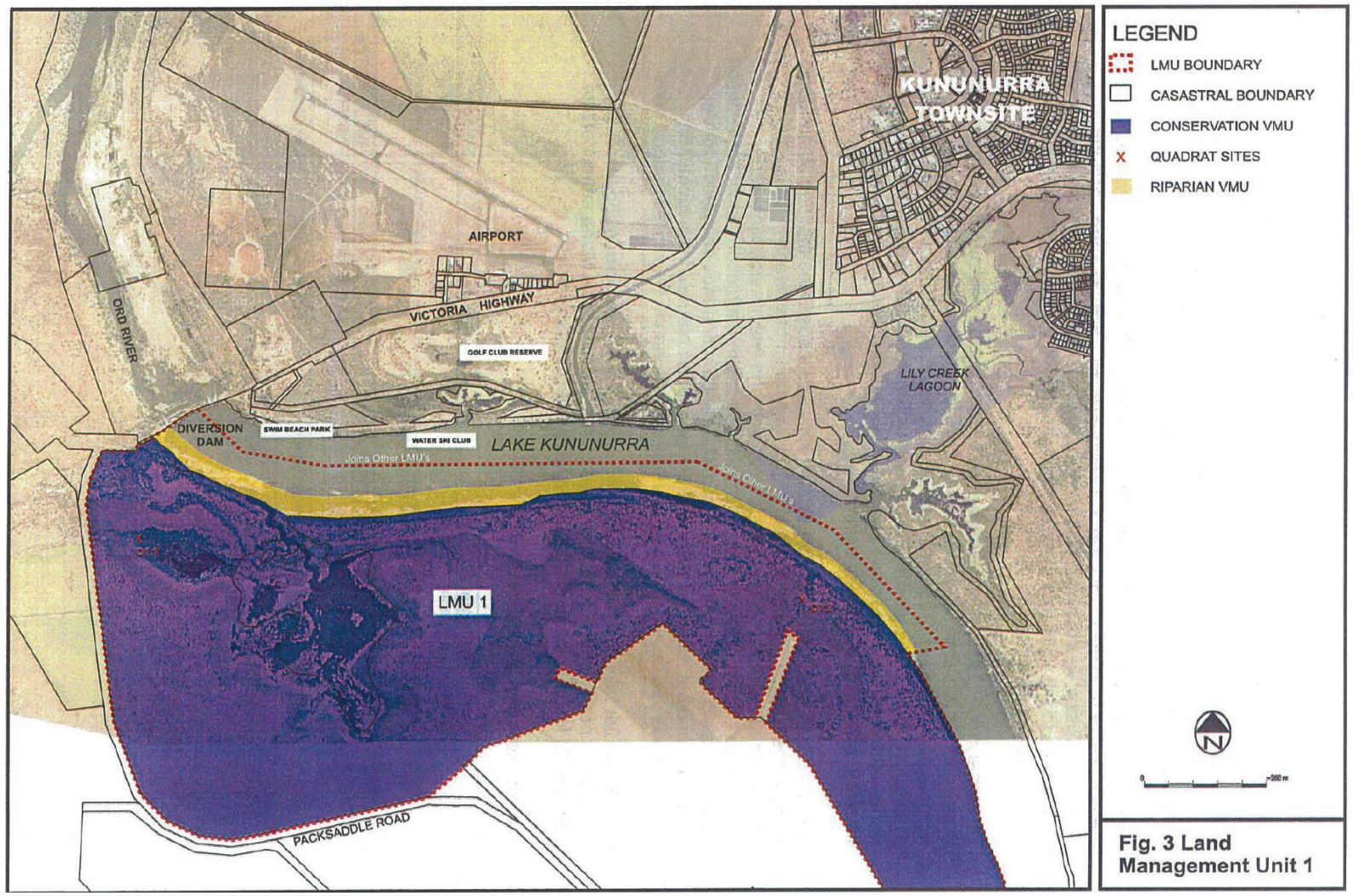

Figure 3: Land Management Unit 1

9.2 Land Management Unit 2 (Precinct 2)

LMU 2 is on the western part of the area north of Lake Kununurra immediately adjacent to the Diversion Dam, bounded by the Victoria Highway to the north and LMU 3 to the east. It currently contains part of the Golf Club, Swim Beach, Water-ski Club and Sailing Club (see Figure 4). Two vegetation quadrats were identified (see Figure 2).

LMU 2 contains Conservation, Parkland, and Riparian areas. Areas identified as Parkland include the existing golf course, swim beach, and ski club, as well as the future botanical gardens site and commercial boating facility site. These areas are used heavily for recreational purposes and are highly modified with cleared access to the water and grassed areas. As such, from a vegetation condition point of view, these areas are in fairly poor condition with poor native vegetation flora composition. The dominant endemic upper-storey vegetation consists of river red gums (*Eucalyptus camaldulensis*) and dragon trees. The weed species include wild passionfruit, rubber bush (*Calatropis gigantean*), many grasses, leucaena (*Leucaena leucocephala*) and neem. It appears that the levee bank road may be helping spread weeds, either by traffic moving plant material along the road or just the easier mobility for plant material along this cleared zone.

As with the Parkland, the Riparian VMU is also heavily impacted by human activity. The water's edge has been cleared for human access and weed species appear to compete with the riparian vegetation. Dominant endemic vegetation includes cumbungi, pandanus (*Pandanus aquatica*) and river red gum. Dominant weed species are wild passionfruit and convulvulus creeper (*Merrimia dissecta*).

The Foreshore Plan recommends the swim beach area be expanded to allow for a separate dog swimming area. If this was to occur riparian vegetation would need to be removed to allow access for swimming yet it is recommended that intact areas of riparian vegetation be left between the cleared areas.

The area set aside for conservation is the undeveloped Cumbungi Inlet which is almost completely full of cumbungi (estimated at 75 - 95% full). This area has been recommended in the 2006 Foreshore Plan to be reserved and vested in DBCA for conservation. Apart from the inlet itself, this area appears to be in fairly good condition The adjacent terrestrial vegetation is a mixture of endemic species such as river red gum, green plum (*Terminallia platyphylla*) and another unidentified gum (*Eucalyptus*) tree. The weed species amongst the endemic species is dominated by leucaena (*Leucaena leucocephala*) with many other species present in small numbers. The relatively low weed cover and high native flora composition suggests that management in this area is of lower priority than the Parkland and Riparian VMUs.

Management of this LMU should focus on removal of the weed species that are out- competing native vegetation, such as leucaena (*Leucaena leucocephala*) and the convulvulus creeper (*Merrimia dissecta*), and the replacement of these weeds with local native species. A small area of parkinsonia (*Parkinsonia aculeate*) has been found in this LMU and needs follow up control and monitoring.

Improvement in the condition of the riparian area through the planting of riparian vegetation is recommended for points that are not required for recreational access, yet the maintenance of recreational access points to the waterbody at Swim Beach, the Sailing Club, and the Water-ski Club is required. These actions of weed removal and maintaining access are in line with the specific actions listed in the Foreshore Plan.

The Golf Club and Water-ski Club have leases over areas within this LMU and therefore need to manage these areas in accordance with this and the Foreshore Plan. The Foreshore Plan recommended that these Clubs develop a simple Vegetation Management Plan. These clubs should be able to use this plan to guide their vegetation management activities.

Table 4 – Recommended actions

Issue	Action and targets	Who	When
Weeds	Reduce weed infestations. Focus on leucaena, neem, the convulvulus creeper and passionfruit vine covering riparian vegetation. Areas of concern are the riparian area and levee bank. Undertake follow-up control. Follow up control of Parkinsonia	SWEK/DoW /OLW/Water Corp (levee)/ Golf Course	Once yearly
Cumbungi Management	Remove cumbungi from swimming areas	SWEK	Once yearly
Rehabilitation	Plant native species following weed removal Plant native botanical gardens Remove weeds and rehabilitate with native species	SWEK/SEEKS Golf Club/Ski Club	Once yearly March 08 Once yearly
Slashing	Maintain slashed areas	SWEK	3 times yearly
Fire	Write Fire Management Plan Implement preventative burning regime	DEC/SWEK SWEK/Local Fire Brigades	Feb 08 Once yearly

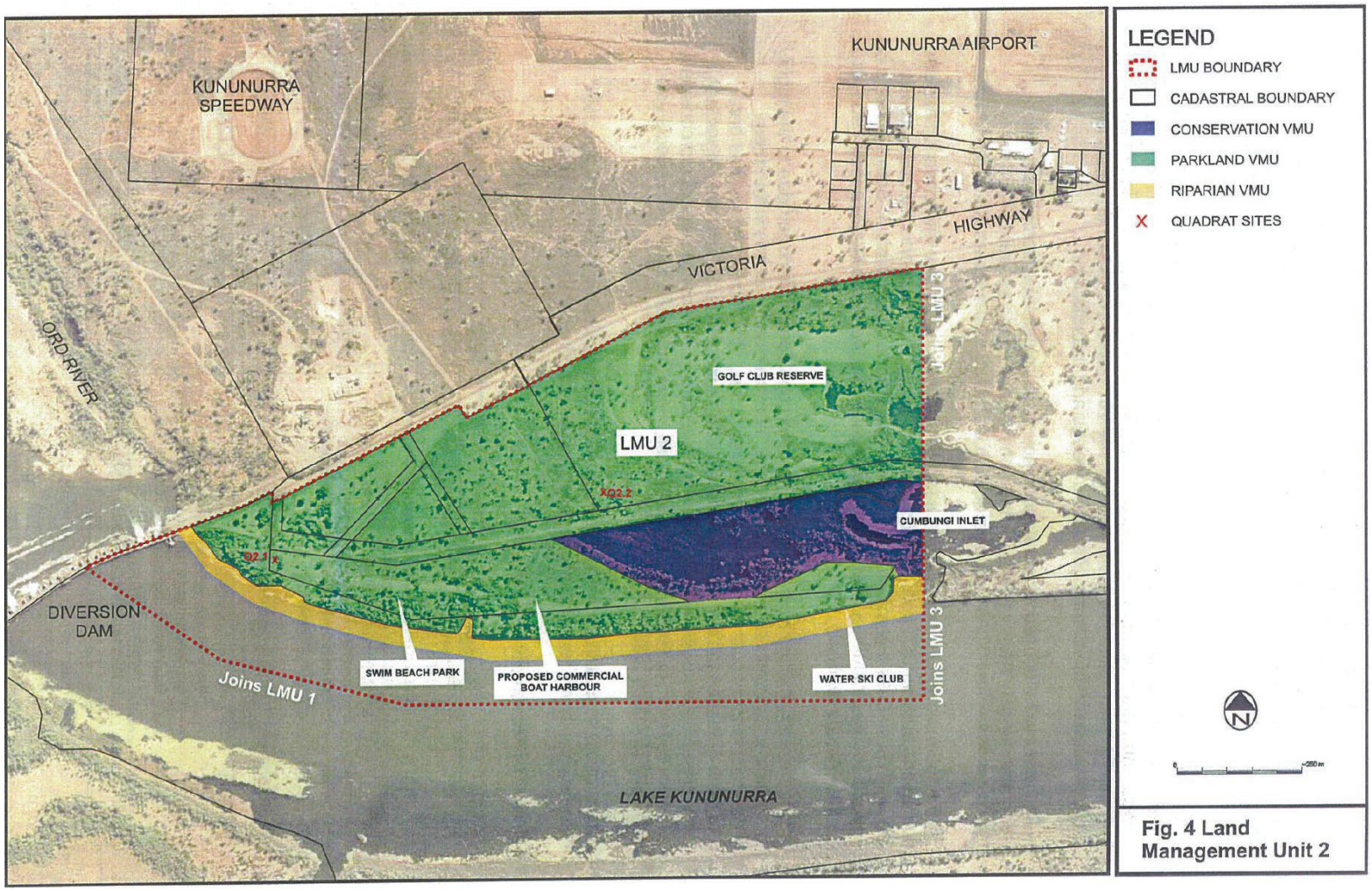

Figure 4: Land Management Unit 2

9.3 Land Management Unit 3 (Precinct 3)

LMU 3 is the central part of the area north of Lake Kununurra, bounded by the Victoria Highway and the Kana access road. This precinct contains the remainder of the golf course, the amphitheatre, M1 pump house, the PDWSA and bore field and a caravan park (see Figure 5). Two vegetation sampling quadrats were established (see Figure 2).

This LMU contains both Parkland, Conservation, and Riparian areas. The P1 PDWSA is considered Conservation VMU and is managed by the DWER and Water Corporation. The only vegetation management within this area is around the bore field for fire prevention. SWEK would like to see this area more actively managed in terms of access, weeds, and rehabilitation.

The other area identified for conservation is Cumbungi Inlet which was recommended in the 2006 version of the Foreshore Plan to be reserved and vested in DEC (now DBCA) for conservation. The issues associated with Cumbungi Inlet are as stated for LMU 2.

The Riparian zone in this LMU is well vegetated predominantly with endemic species including cumbungi, dragon tree, green plum, and pandanus. Some pockets of weed species include a dense stand of leucaena and rain trees (*Albizia lebbeck*).

The Golf Course and Kona Caravan Park are considered Parkland due to the highly maintained grounds and recreational use. The majority of weeds within these Parkland areas occur within the remnant bushland. The dominant species here consist of leucaena (*Leucaena leucocephala*), rubber bush (*Calatropis gigantean*), rain tree and many vine species. The endemic vegetation consists of river red gum, an unidentified Eucalypt species and cajuput .

Management should focus on weed control and rehabilitation in the P1 area, the riparian area and the remnant bushland areas found within the Golf Course.

Table 5 – Recommended actions

Issue	Action and targets	Who	When
Weeds	Prepare a weed management plan for the P1 area Reduce weed infestations in P1 area. Focus on leucaena and neem Remove weeds along foreshore reserve. Follow up control Remove weeds and rehabilitate with native species	Water Corp/DoW Water Corp/Dow SWEK/DoW Kona CP/Golf Club	Mid 08 Ongoing yet at least once a year Once yearly
Rehabilitation	Plant native species following weed removal	Water Coro/DoW/SWEK	As needed
Access	Control and reduce unnecessary access into P1 area and install signage as recommended in the Kununurra Water Reserve Drinking Water Source Protection Plan	Water Corp	Feb 08
Fire	Implement preventative burning regime	Water Corp/Local Fire Brigades	Once yearly

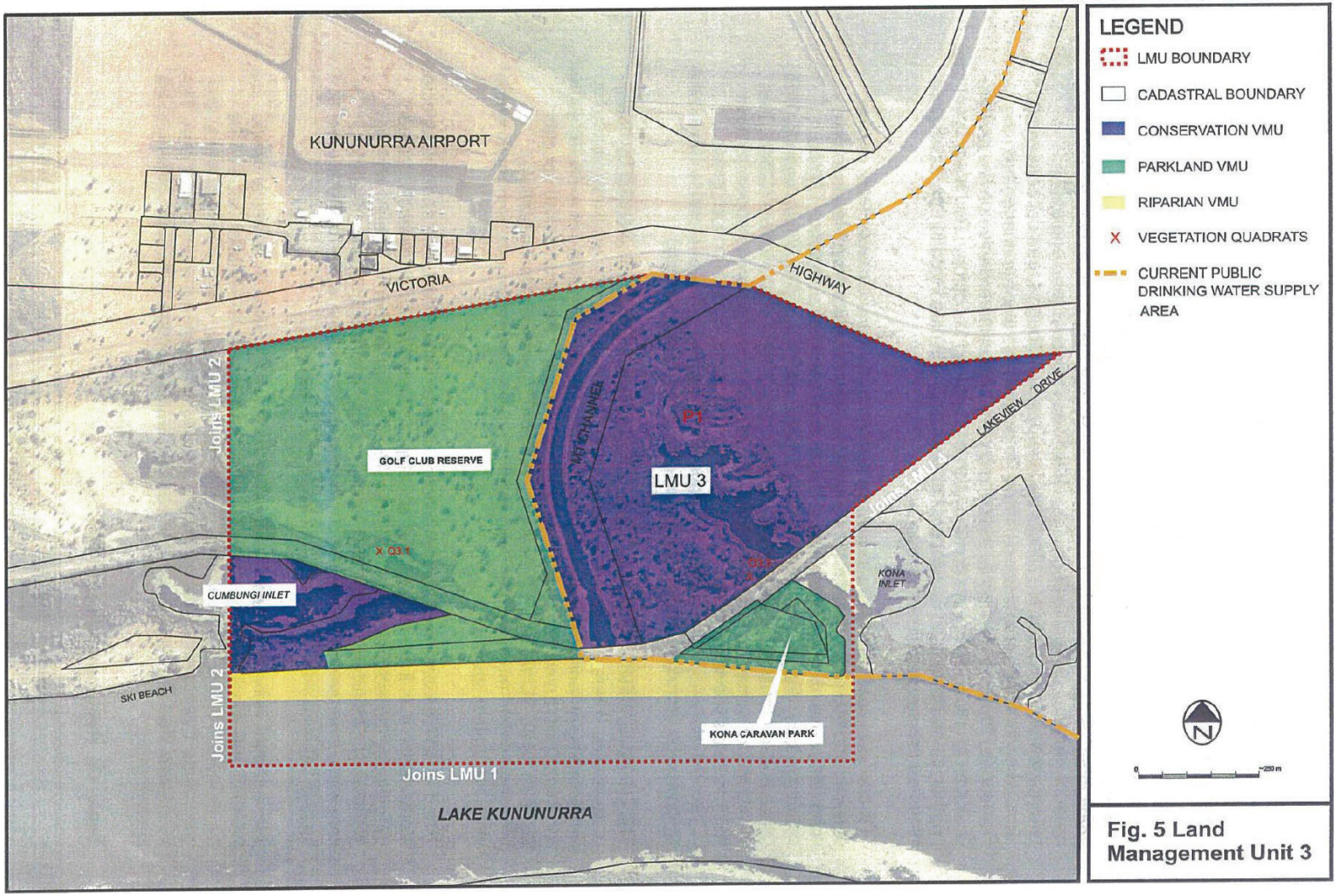

Figure 5: Land Management Unit 3

9.4 Land Management Unit 4 (Precinct 4)

LMU 4 consists of the eastern part of the area north of Lake Kununurra, bounded by the Victoria Highway, Lily Creek Lagoon, and the Old Darwin Road. LMU 4 currently contains part of the PDWSA bore field and a caravan park (see Figure 6). Two vegetation sampling quadrats were established (see Figure 2).

The P1 PDWSA covers most of this LMU and is considered Conservation VMU. The only Parkland in this LMU is Kimberleyland Caravan Park which is developed and utilised for tourism activities and accommodation. The 2006 Foreshore Plan highlights the preference for changes to the P1 boundary and development of the area for tourism/residential purposes. Given that these changes to the PDWSA boundaries occurred in 2012, the vegetation management needs to reflect the development though areas of Conservation VMU should be identified and retained. The 2006 Foreshore Plan also stated that if the P1 boundaries were to change then the building of a cultural/interpretive centre and the creation of a reserve for the conservation of the flying fox colony should also occur. Pathways and other eco recreational infrastructure are also discussed in the 2024 Foreshore Plan and are supported in this Plan.

The riparian vegetation from the public boat ramp to Kona Caravan Park can be divided into two parts. The first is an endemic species suite which tends to be a complete cover of the water's edge. This is dominated by cumbungi, dragon tree, pandanus and green plum. The second part is areas where clearing has occurred for access or visual amenity. The present cleared areas appear to have more weed species and include planted exotic species such as couch grass (*Cynodon dactylon*). The areas that have been cleared in the past tend to have been colonised by dense stands of leucaena.

The Parkland VMU is Kimberleyland Caravan Park and is characterised by heavy disturbance. There are also many exotic species which were most likely planted for landscaping purposes within the caravan park. There is a variety of exotic trees that do not appear anywhere else at present in the vicinity. Dominant weed species include neem and leucaena. Management of this Parkland VMU should focus on weed removal and replacement with local native species.

The P1 PDWSA area makes up the entire Conservation VMU. The endemic species composition is in fair condition with eucalypt, cajuput, and bauhinia (*Buhinia cunninghamii*). The P1 area is relatively undisturbed yet has high amounts of weed infestations particularly leucaena. The bat colony is also within this VMU and is heavily infested with leucaena.

Management actions should therefore focus on the P1 area, in particular weed removal and rehabilitation, and control of access. Due to the habitat value of the leucaena at the bat colony site, weed management in this area of the Conservation VMU needs a specific removal and replacement plan. The Foreshore Plan (2024) also discusses weed control as specific actions to be implemented.

Table 6 – Recommended actions

Issue	Action and targets	Who	When
Weeds	Prepare a weed management plan for the P1 area Remove dense stands of leucaena in P1 area and levee bank. Follow up control. Reduce weed infestations and replant with local native species.	Water Corp/DWER Kimberley Land Caravan Park	Once year Once year

Issue	Action and targets	Who	When
	Develop plan to systematically remove woody weeds and replace with native vegetation for bat colony	SWEK/DWER	Feb 08
Rehabilitation	Plant native species following weed removal in P1 area.	Water Corp/DWER	Once yearly
Access	Control and reduce unnecessary access into P1 area and install signage as recommended in the Kununurra Water Reserve Drinking Water Source Protection Plan	Water Corp	Dec 07
Conservation of remnant vegetation	Identify and protect stands of remnant vegetation to be conserved if development of P1 area is approved	SWEK/DWER	Before development occurs
Cumbungi Management	Remove cumbungi where it has been shown to have rapidly increased. Leave buffer. Remove cumbungi where access and views are needed. Replant banks with smaller native sedges	SWEK Kimberleyland Caravan Park	Once yearly
Fire	Implement preventative burning regime	DWER/Water Corp	Once yearly

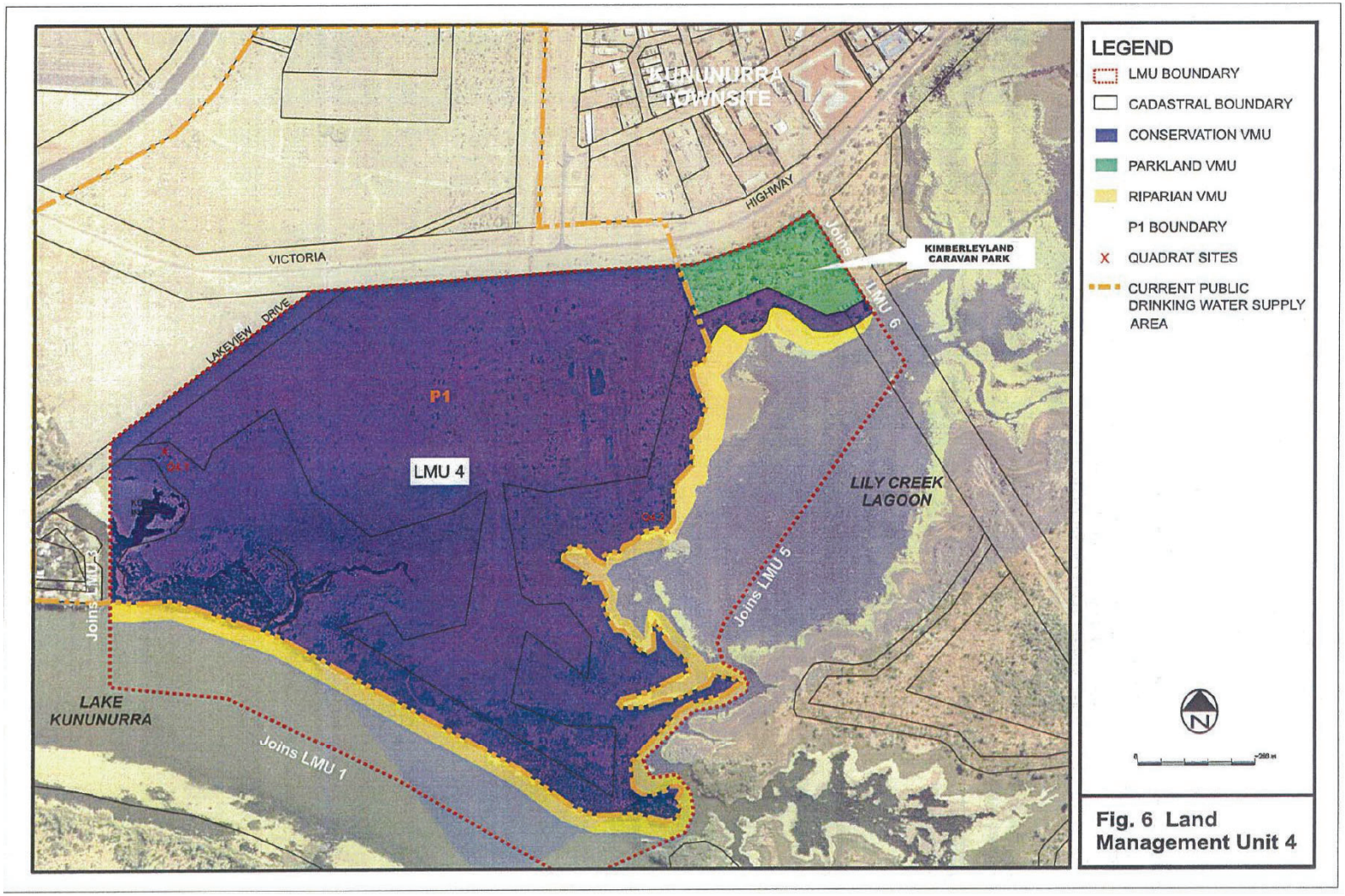

Figure 6: Land Management Unit 4

9.5 Land Management Unit 5 (Precinct 5)

LMU 5 contains the southern shore of Lily Creek Lagoon including Hamilton Inlet and surrounds, southeast to the Rowing Club. The area is currently undeveloped (see Figure 7). Two vegetation sampling quadrats were established (see Figure 2).

As in the 2006 version of the Foreshore Plan, LMU 5 is primarily for conservation purposes, the water in the LMU is highlighted as a cumbungi control area and the need for implementation of a cumbungi management plan is discussed. Cumbungi management is discussed in Section 10 of this Plan. The 2006 Foreshore Plan also refers to the use of this LMU for eco-recreation such as the building of a bird hide and interpretive signage.

Vegetation within this Conservation VMU and respective Riparian areas (Hamilton Inlet and Rowing Club) is dominated by endemic species, most noticeably cumbungi and dragon trees along the lagoon's edge and raintree, cajuput, bauhinia, and cane grass further inland. Cumbungi is dominant in the drains and inlets into Lily Creek Lagoon completely removing open water habitat from a large creek inlet.

The areas closer to the Old Darwin Road and Casuarina Drive contain a higher proportion of weed species, in particular neem, purpletop chloris (*Chloris barbata*) and rubber bush.

This LMU is all Conservation and respective Riparian VMUs and is in good condition with relatively few weed species. Weed species seem to be occurring close to the residential development of Lakeside and the creek inlet has become choked with cumbungi. Management should therefore focus on the weed and cumbungi removal in these areas. This is consistent with specific actions listed in the 2006 Foreshore Plan.

Table 7 – Recommended actions

Issue	Action and targets	Who	When
Weeds	Reduce neem infestations. Follow up control	OLW	Ongoing
Cumbungi Management	Reduce cumbungi infestation but leave cumbunqi in and around drain outlets	SWEK	Once yearly
Fire	Implement preventative burning	DWER/SWEK	Once yearly

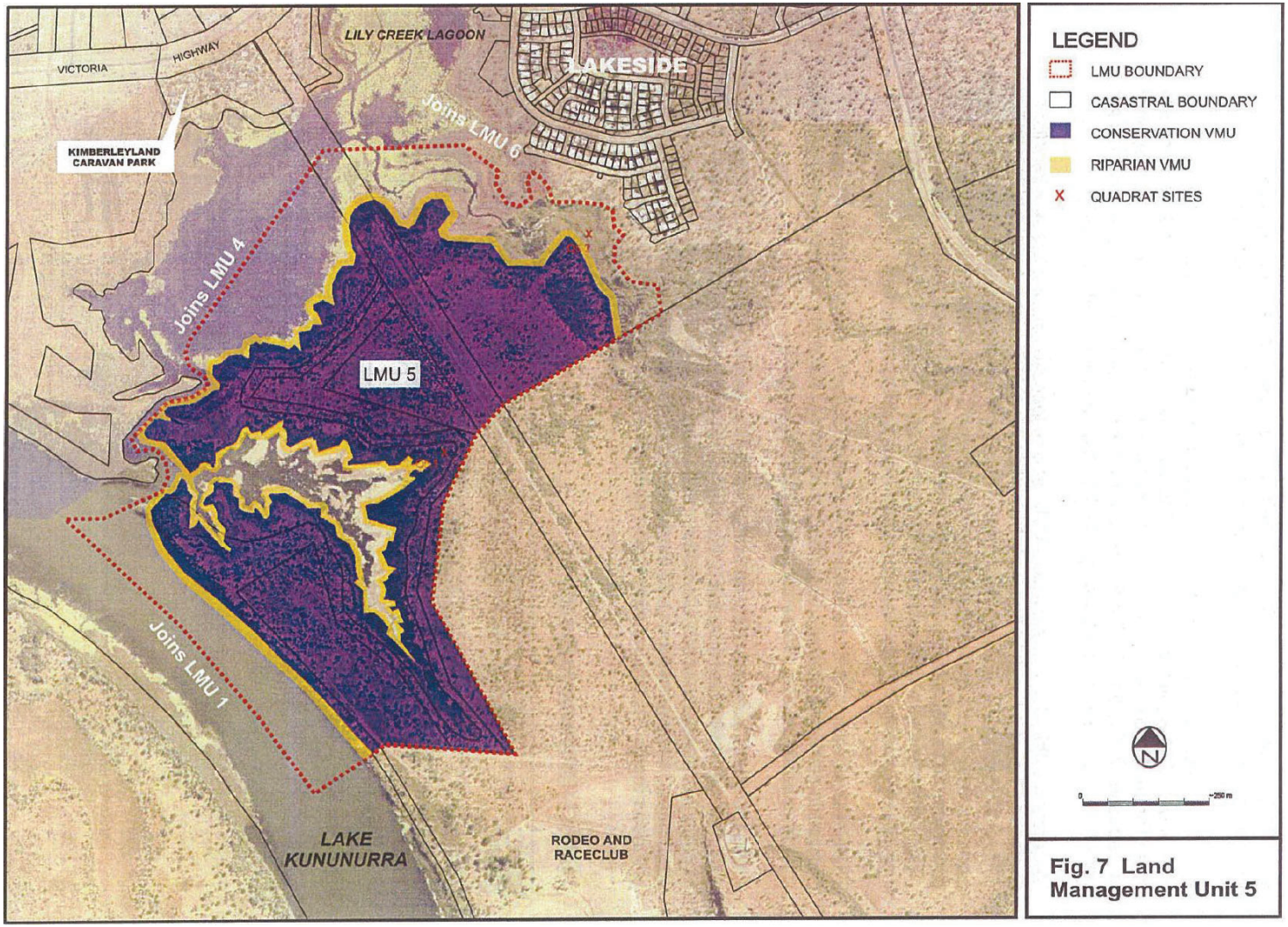

Figure 7: Land Management Unit 5

9.6 Land Management Unit 6 (Precincts 6)

This LMU encompasses the northern shore of Lily Creek Lagoon, bounded on the west by the Old Darwin Road. It contains Celebrity Tree Park, the current public boat ramp (Town Jetty), and the eastern side of Lily Creek Lagoon including the Lakeside foreshore (see Figure 8). Two vegetation sampling quadrats were determined (see Figure 2).

This LMU is mainly Parkland and Riparian with a small amount of Conservation. In the 2006 Foreshore Plan there is reference to the future visitor's centre, Rotary Park, and Casuarina Foreshore Park. The zoning of this precinct as Parkland caters for these future developments and their associated infrastructure such as BBQs, play and picnic areas, and pathways. The 2006 Foreshore Plan also highlights all of the water in the LMU as a cumbungi control zone and the need for implementation of a cumbungi management plan. Cumbungi management is discussed in Section 10.

The Riparian VMU is dominated by endemic species cumbungi, dragon tree, and some cajuput. Some weed species are present, particularly in areas where the native vegetation at the water's edge has been cleared. The more common weed species are wild passionfruit, rain tree, and leucaena. The declared aquatic weed salvinia (*Salvinia molesta*) was found in an area of the lagoon in 2000. A collaborative control and eradication program is underway. The whole riparian area of this LMU is dominated with cumbungi which has been allowed to flourish unchecked. Such high abundance of cumbungi creates environmental and recreational issues which are discussed in Section 10.

The Parkland VMU consists of many deliberately planted exotic species, weeds, and endemic species. Endemic species are predominately cajuput, dragon tree, green plum, and river red gum. Weed species include many vines, rain tree, leucaena, and a variety of grasses.

This LMU is heavily modified consisting of Parkland and Riparian VMUs with no Conservation VMU. This LMU is allocated as parks and recreational areas in the2006 Foreshore Plan and therefore should be managed accordingly. Vegetation management should focus on cumbungi removal, slashing, weed removal, conservation of remnant stands of vegetation, and increased planting of native species. In particular eradication of salvinia is a priority. Weed, cumbungi removal, and the maintenance of this area as parkland for recreation is consistent with actions listed in the 2006 Foreshore Plan.

Table 8 – Recommended actions

Issue	Action and targets	Who	When
Weeds	Reduce weed infestations with a focus on leucaena, exotic vines and neem. Eradicate salvinia	SWEK/OLW/DWER OLW/SWEK/DPIRD	Once yearly
Slashing	Maintain slashed areas	SWEK	3 per year
Cumbungi Management	Remove cumbungi in front of caravan park, proposed tourist bureau, boat ramp and other infrastructure such as pump intakes, Celebrity Tree Park, creek inlet and any floating islands	SWEK/Lakeside Resort	Once yearly

Issue	Action and targets	Who	When
Conservation of remnant vegetation	Identify and protect stands of remnant vegetation to be conserved	SWEK/DWER	Before development occurs
Rehabilitation	Plant a smaller native rush/sedge where cumbungi has been removed from banks Replant riparian vegetation using native species	SWEK/SEEKS SWEK/Lakeside Resort	Once yearly Once yearly
Fire	Implement preventative burning regime	DWER/SWEK	Once yearly

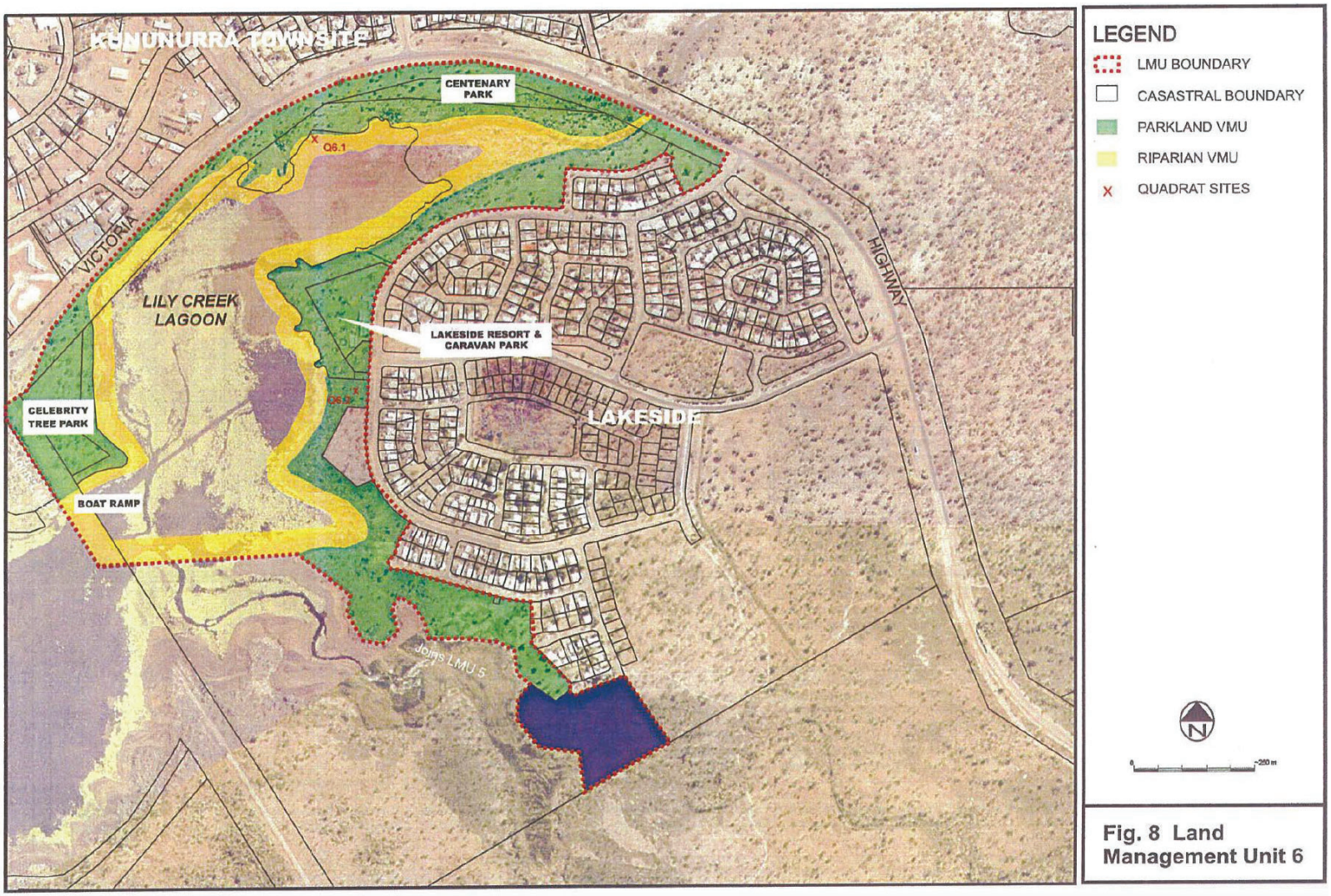

Figure 8: Land Management Unit 6

Table 9 – Summary of recommended vegetation management activities

Issue	LMU1	LMU2	LMU3	LMU4	LMU5	LMU6
Weed removal and control (includes follow up control)	Eradicate neem infestations. Control and if possible, reduce weed infestations Follow up control	Reduce weed infestations. Focus on leucaena, neem, convutvulus creeper, and passionfruit vine covering riparian vegetation. Areas of concern are the riparian area and levee bank. Undertake follow up control	Prepare a weed management plan for the P1 area Reduce weed Infestations in P1 area. Focus on leucaena and neem Follow up control Remove weeds along foreshore reserve Follow up control	Prepare a weed management plan for the P1 area Remove dense stands of leuceana in P1 area and levee bank Follow up control Reduce weed infestations in Parkland and Conservation VMUs managed for Kimberteyland and replant with local native species Develop plan to systematically remove woody weeds and replace with native vegetation for bat colony	Reduce neem Infestations Follow up control	Reduce weed infestations with a focus on leueaena, exotic vines, and neem Eradicate salvinia
Cumbungi Management (see Section 10)		Remove cumbungi from swimming areas		Remove cumbungi where it has been shown in aerial photos and mapping to have rapidly increased. Leave buffer	Reduce cumbungi infestation where it has been shown in aerial photos and mapping to have rapidly increased i.e., around creek inlet but leave cumbungi	Remove cumbungi in front of caravan parks, boat ramp, Celebrity Tree Park

Issue	LMU1	LMU2	LMU3	LMU4	LMU5	LMU6
				Remove cumbungi where access and views are Impeded. Replant banks with smaller less invasive native sedges	in and around drain outlets	
Slashing	SWEK to maintain current slashed areas					
Rehabilitation		Plant native species following weed removal Plant native botanical gardens Golf course and Water-ski area- remove weeds and rehabilitate with native species	Plant native species following weed removal Golf course and Kona Caravan Park - remove weeds and rehabilitate with native species	Plant native species following weed removal		Plant a smaller native rush/sedge where cumbungi has been removed from banks Replant riparian vegetation using native species Identify and protect stands of remnant vegetation to be conserved
Fire management	DWER to assist in developing Fire Management Plan for the area. SWEK and Local Fire Brigade to implement					
Access	Water Corporation and DWER to control and reduce access into P1 area DWER and MG Corp to control and reduce access into Conservation Areas					

10. CUMBUNGI MANAGEMENT

10.1 Introduction

Narrow leafed cumbungi (*Typha domingensis*) is native to the Ord River. The damming of the Ord River created Lake Kununurra and Lily Creek Lagoon with the resultant permanent, slow flowing, shallow water, warm temperatures, and high nutrient levels providing optimum conditions for rapid cumbungi establishment and growth.

Within the Study Area, cumbungi has flourished and is considered by many to be a nuisance, particularly in Lily Creek Lagoon. Its tendency to dominate, its rapid spread and the need for management was noted to be of concern in the Lake Kununurra Foreshore Draft Management Plan (1987) and then again in the Draft Management Plan for Lake Kununurra (1995).

As cumbungi is native to the Ord River and its associated wetlands, a permit to clear native vegetation is required. These permits can be applied for through the DWER. A permit to disturb the bed and banks may also be required and can also be obtained through DWER.

The following section of the report focuses on cumbungi; its biology, the change in the Study Area covered by cumbungi, the advantages and disadvantages it can provide as well as recommendations for its control.

10.2 Biology

Cumbungi is a tough, rapid growing perennial sedge that can eventually become the dominant or climax species within shallow wetlands. It is an aggressive coloniser of wetlands with a muddy substrate, especially following disturbance such as cultivation of the soil surface (Watkins & McNee, 1985).

It is a prolific seed producer that can produce 300,000 to 400,000 seeds per plant. Seeds can live for four years before germination, are very light and are easily spread by wind or water movement (SWEK, 1987). The seed is also carried to new places by animals and birds, and on earth moving or agricultural equipment.

Cumbungi colonises new areas from both seed and rhizome growth. Seeds germinate in 5 to 20cm of water and a single seed can produce a rhizome (running root) system up to 3m in length (SWEK, 1987). These rhizomes can move from relatively shallow water to water depths in excess of 2m as they grow. These rhizomes can increase the size of existing colonies each year. Rhizomes survive from harvest most of the year, however less growth and recovery occurs if the plant is harvested during the cool dormant period.

Cumbungi thrives in fresh or lightly brackish water of less than 2 metres in depth. Nutrient rich sediment provides the ideal substrate for flourishing cumbungi plants. Their thick fast-growing rhizomes act to trap more and more sediment, thus promoting their further exploitation of these ideal conditions. Its ability to use slow flowing, nutrient rich water in irrigation channels, dams, lakes, and along riverbanks enables it to dominate these preferred habitats.

10.3 Disadvantages of cumbungi

Cumbungi is a troublesome weed in most states of Australia, as well as countries such as Papua New Guinea, New Zealand, Indonesia, Malaysia, and the Philippines (Tasmanian Department of Primary Industries and Water, 2007).

Disadvantages or adverse effects associated with the spread of cumbungi include:

- Formation of dense monocultures that may reduce habitat heterogeneity and eliminate other plants (Apfelbaum, S);
- Reduction in the holding capacity and access to dams and waterways (Department of Primary Industries and Water, 2007);
- Restriction and, in extreme cases, almost totally blockage of water flow in rivers, creeks, and irrigation and drainage channels (Department of Primary Industries and Water, 2007);
- Destruction of the weed can result in a large amount of decaying vegetation which may pollute the water, increase nutrients, or block pump intakes, channels, and ditches;
- The dark, thick environment of cumbungi stands create suitable environments for mosquito larvae and other pests;
- Reduce waterbird habitat and adversely affect fringing vegetation (Bartle, J *et al*., 1986)
- Creation of a fire hazard (e.g., each dry season a number of unplanned cumbungi fires occur around Lake Kununurra and Lily Creek Lagoon and these fires can have a detrimental effect on sensitive riparian vegetation) (Watkins, D *et al*., 1997); and
- Restricted views over the water and access to the water's edge.

10.4 Advantages of cumbungi

Cumbungi is a natural part of many Australian wetland systems and has a number of important attributes. Cumbungi:

- Stabilises banks to prevent erosion;
- Uses nutrients and acts to strip nutrients from run off;
- Provides a natural looking wetland fringe;
- Acts as a litter trap; and
- Provides cover, food, nesting places, and habitat for water birds, aquatic insects, native fishes, freshwater invertebrates (e.g., cherabin), and frogs.

10.5 Change in area of cumbungi

From relative obscurity, cumbungi now occupies broad tracts around the margins of Lake Kununurra and Lily Creek Lagoon. For example, the perimeter of Lily Creek Lagoon was over 75% cumbungi free in 1978 but by 1993 almost the entire margin was colonised (Watkins, D *et al*., 1997).

A survey by Gowland in 1981 estimated that the total area of cumbungi in Lily Creek Lagoon had increased approximately 100% between 1978 and 1981 (Sinclair Knight Mertz, 1995). The same

report produced a diagram which identified the changes in area covered by cumbungi from 1978 to 1993. Estimates in the change of cover between 1978 and 1993 indicated a 500% increase to an area of approximately 39.5ha (Sinclair Knight Mertz, 1995).

In an attempt to understand the changes that have occurred to the growth of cumbungi in Lily Creek Lagoon, the Sinclair Knight Mertz diagram was compared to a set of aerial photographs from 1999, 2002, and 2006. Followed by ground-truthing, this enabled the production of a new map that included the changes from 1993 to 2006 (see Figure 9 below).

In the period from 1978 to 1993, cumbungi growth spread rapidly along the water's edge. Much of this growth mirrors the Lagoon edge contour. Since then, the growth has not been as rapid yet the growth that has occurred has tended to fill the contoured edges and small inlets. This appears to be creating a more uniform edge to the Lagoon.

This may be a result of natural colonisation (whereby cumbungi is growing out to cover water depths less than 2 meters) or there may be excessive amounts of sediment entering the lagoon which is trapped by the cumbungi enabling further growth into the lake.

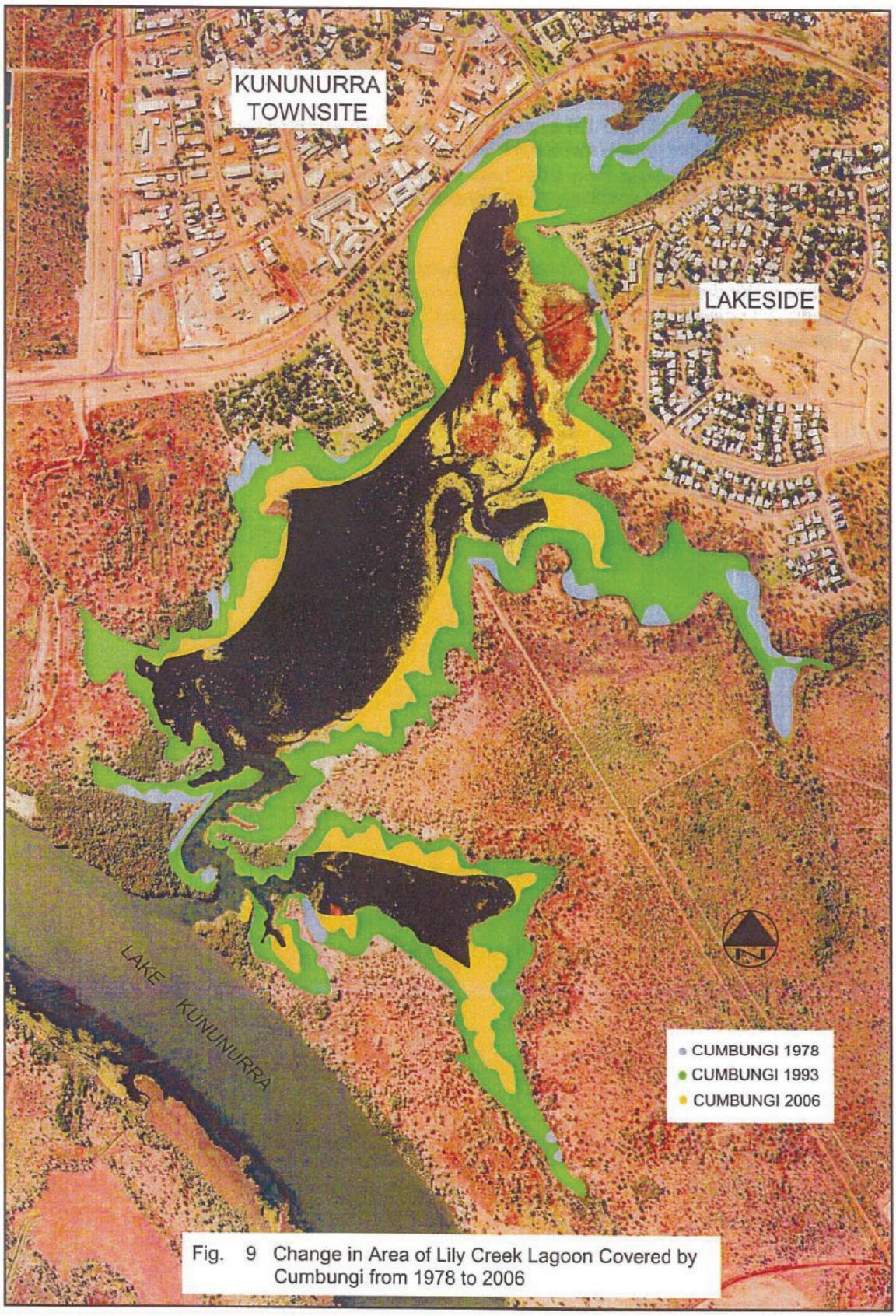

Figure 9: Change in Area of Lily Creek Lagoon Covered by Cumbungi from 1978 to 2006

10.6 Predicted area available for colonisation by cumbungi

It was predicted in the Sinclair Knight Mertz report that, if left unchecked, cumbungi would continue to spread until all areas of Lily Creek Lagoon less than 2 meters in depth were colonised. Its ability to trap sediment will increase the area of the Lagoon suitable for colonisation whilst the floating rhizomatous rafts will allow it to encroach into deeper waters.

The total area of the lagoon is estimated to be 135ha. The area currently colonised by cumbungi is estimated to be 71.43ha or 52.91%. This was estimated using aerial photography and mapping. In order to estimate the potential areas for cumbungi to spread to, depth readings of the lagoon were undertaken by boat. Figure 10 presents the points where depth was measured and the area available for colonisation estimated.

It is interesting to note that in areas of LMUs 4 and 5 where the depth was greater than 2 meters the cumbungi growth had seemed to reach its limit of growth. This area could be assumed to be stable in that cumbungi should not continue to grow out over the lagoon. However, the other end of the lagoon, upstream of the current boat ramp at Celebrity Tree Park, was shallow with the majority being less than 2 meters in depth. It can therefore be assumed that cumbungi has the potential to cover this area completely if not controlled.

10.7 Management Strategies

The Sinclair Knight Mertz report (2005) recommended the short-term management of cumbungi through the removal of 23.5ha of cumbungi or 60% of the existing cumbungi in Lily Creek Lagoon at the time. Removal was recommended in areas from which views and access are desired and for the prevention of further expanse of cumbungi dominated areas. It also recommended maintaining areas of untouched riparian vegetation.

In the Lake Kununurra Foreshore Draft Management Plan (1987) it was stated that "cumbungi's prolific growth represents a problem in areas where there is a need for foreshore access for recreational activities or tourism development. Priority areas will need to be established in eradicating the weed".

In response to this recognised problem, some locals take cumbungi control into their own hands through unauthorised and illegal spraying, fires, and mechanical excavation. In order to manage this, a plan that outlines a coordinated approach to cumbungi control and removal is needed.

It is recognised that some removal of cumbungi needs to be performed. Removal should occur in sections where the need has been identified (as below) whilst other areas of untouched riparian vegetation of sufficient size should be maintained to support the reliant biological community. To have only cumbungi or open water reduces habitat diversity and biodiversity. Therefore, the aim of cumbungi removal is control, not eradication. Planned cumbungi control should address community concerns as well as increase the interface between open water and cumbungi to provide a diversity of habitats, in turn, increasing biodiversity.

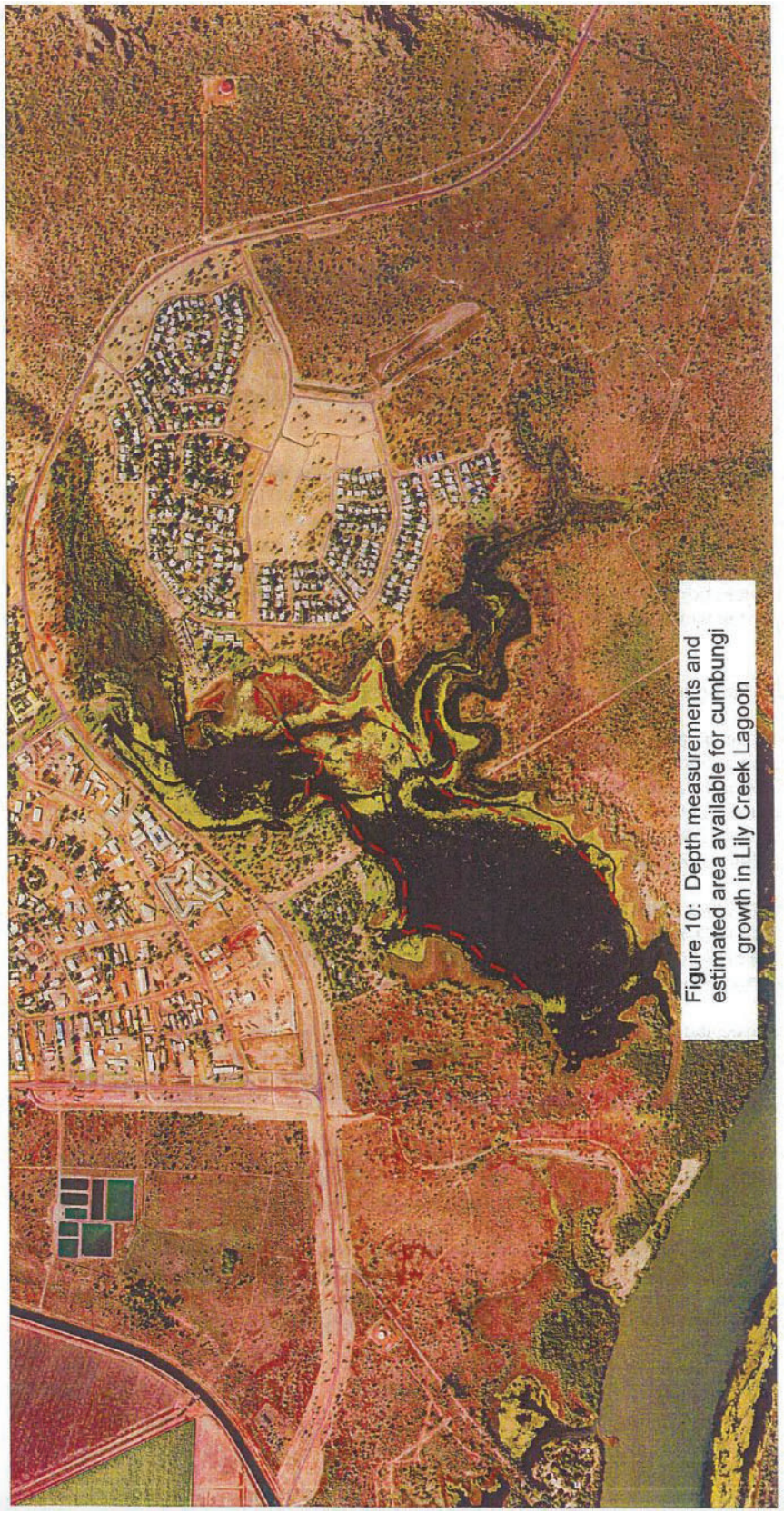

Figure 10: Depth Measurements and estimated area available for cumbungi growth in Lily Creek Lagoon

10.8 Areas and amounts for control

Total exclusion of cumbungi will not be possible, nor would it be desirable as cumbungi provides a number of key roles in the waterbody.

The 2006 version of the Foreshore Plan highlighted a large portion of Lily Creek Lagoon for cumbungi control (see Figure 11). Specific areas of high motor traffic and high aesthetic values or commercial and recreational use were listed within the lagoon for specific cumbungi removal. The specific areas identified are:

- Lily Creek Lagoon boat ramp;
- Kimberleyland Caravan Park;
- Lakeside Resort;
- Celebrity Tree Park;
- Celestin Nominees lease area;
- Swim Beach; and
- Ski Beach.

Another area identified was parallel to the Victoria Highway yet due to erosion of the steep banks this Plan recommends that the cumbungi be left along here until the banks can be stabilised and reshaped through infilling.

The initial areas highlighted for ongoing control (see Figure 12) make up a total approximate area of 5.51 ha or 0.76% of the area currently colonised by cumbungi. This area is recommended for immediate and ongoing removal of cumbungi.

Available removal methods, the effect of cumbungi removal on water quality, and the need for planned future developments will all guide the identification of additional future cumbungi removal areas within the cumbungi control zone highlighted in the Foreshore Plan (2006) and presented in Figure 11.

From discussions with DWER it was recommended that a precautionary approach be taken and that some uncleared strips be left between the cleared areas, to provide alternate habitats for biodiversity. Along the banks of the wetland, it is recommended that cumbungi stands of no larger than 100m in length be removed. In between these areas cumbungi stands of no less than 20m in length should be left.

By targeting cumbungi removal in specific areas, the majority of cumbungi in Lake Kununurra and Lily Creek Lagoon will remain as uninterrupted and undisturbed. Due to its effectiveness in nutrient stripping and sediment control, cumbungi should not be removed around drains or in areas prone to erosion.

Where cumbungi is to be removed right to the foreshore then other species of rushes and sedges that will not obstruct access and view should be planted. Some recommended species are listed in Table 10 yet others may also be suitable as long as they are locally native. If the bank is not suitable for this type of planting, then a formalised structure such as a retaining wall may be considered yet is not preferred. Bank treatment and protection is necessary to prevent undercutting of banks from boat wash and change in water levels.

A permit to clear native vegetation as well as a permit to interfere with the bed and banks of a waterway will be needed for ongoing cumbungi control. These permits can be applied for through the DWER.

Figure 11: Cumbungi Control areas as identified in Lake Kununurra Foreshore Plan (2006)

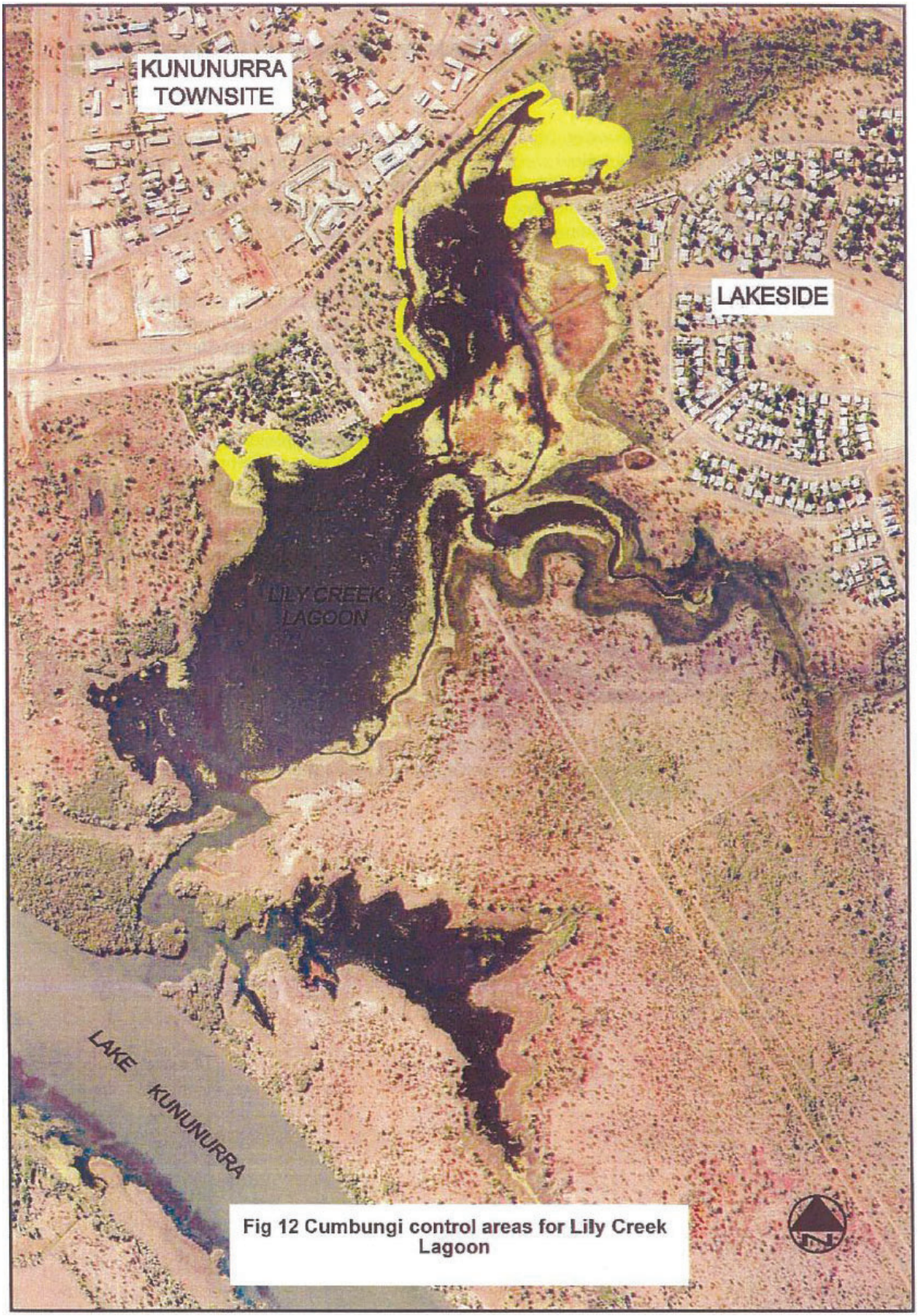

Figure 12: Cumbungi control areas for Lily Creek Lagoon

10.9 Recommended control methods

(for a full list of removal options please see Appendix 9)

Harvester (preferred)

With the use of an aquatic weed harvester, cumbungi and other water plants and weeds could be harvested below water level throughout most areas of Lily Creek Lagoon and Lake Kununurra. Harvesting is recommended for the cooler months of June and July when growth is slowest, and removal will impact least on the comb crested jacana and purple swamp hen that use the cumbungi for breeding (WA Museum, 2005).

This method has the least physical impact and does not add chemical residue or decomposing biomass to the water. Mechanical harvesting could also reduce populations of ribbon weed and Potymogeton, subsurface weeds that can be a nuisance in critical areas of boating and recreation (see the 2006 Foreshore Plan or Sinclair Knight Mertz report).

Kimberley Environmental Solutions has expressed interest in providing a service by contract to harvest cumbungi and other aquatic weeds such as pond and ribbon weed. The proposal involves the construction of a suitable harvester and the use of the harvested weed for cattle feed. Such a commercial venture would be welcomed.

Excavation and removal of rafts (if harvester not available or economically viable)

- Excavation of cumbungi with long reach excavator from areas that have historically been controlled. Manual mechanical cutting of regrowth with whipper snipper or shears. Digging of bed next to banks to a depth of 2 metres or more to ensure the whole plant is removed and to prevent rapid regrowth.
- Machete rafts from main colonisation. Loop chain or rope around raft and then drag out to lake with boat so that rafts go through Diversion Dam gates. This would need to be approved by Water Corporation.
- Care must be taken when using heavy equipment near waterways to avoid damage to the structure of the waterway.

11. OTHER AQUATIC PLANT MANAGEMENT

Submerged aquatic plants have also proliferated in Lake Kununurra and Lily Creek Lagoon. The seasonally dry Ord River probably supported very little submerged aquatic plants prior to the construction of the dam. Present conditions are ideal for the growth of these plants, and it was clear after the first five years of stable water levels that the growth of floating and submerged aquatic plants was becoming a problem. As a control measure from 1977 to 1980, the Lake was drained annually for two weeks (Watkins, et al, 1997).

The high level of tourism and recreational use of the Lake has resulted in increased public pressure to manage the growth of wetland plants such as floating pond weed, ribbon weed and water lilies as they interfere with power boat and swimming activities (Watkins, et al, 1997).

The idea of dredging a boating channel to manage the growth of these weeds has previously been suggested by community members and tourism operators. Dredging is digging, gathering, or pulling out material to deepen waterways, create harbours, channels, etc. As it involves disturbance to the waterbody's bed it is therefore not recommended.

Instead, if an aquatic weed harvester became available, it could clear a small boating passage of aquatic vegetation that recreational boat owners and tourism operators could then utilise (see Figure 13).

As with cumbungi these plants play an important role in wetland ecology. The specifics of their role are not included in this Plan, and it is recommended that further research into their growth and control be carried out.

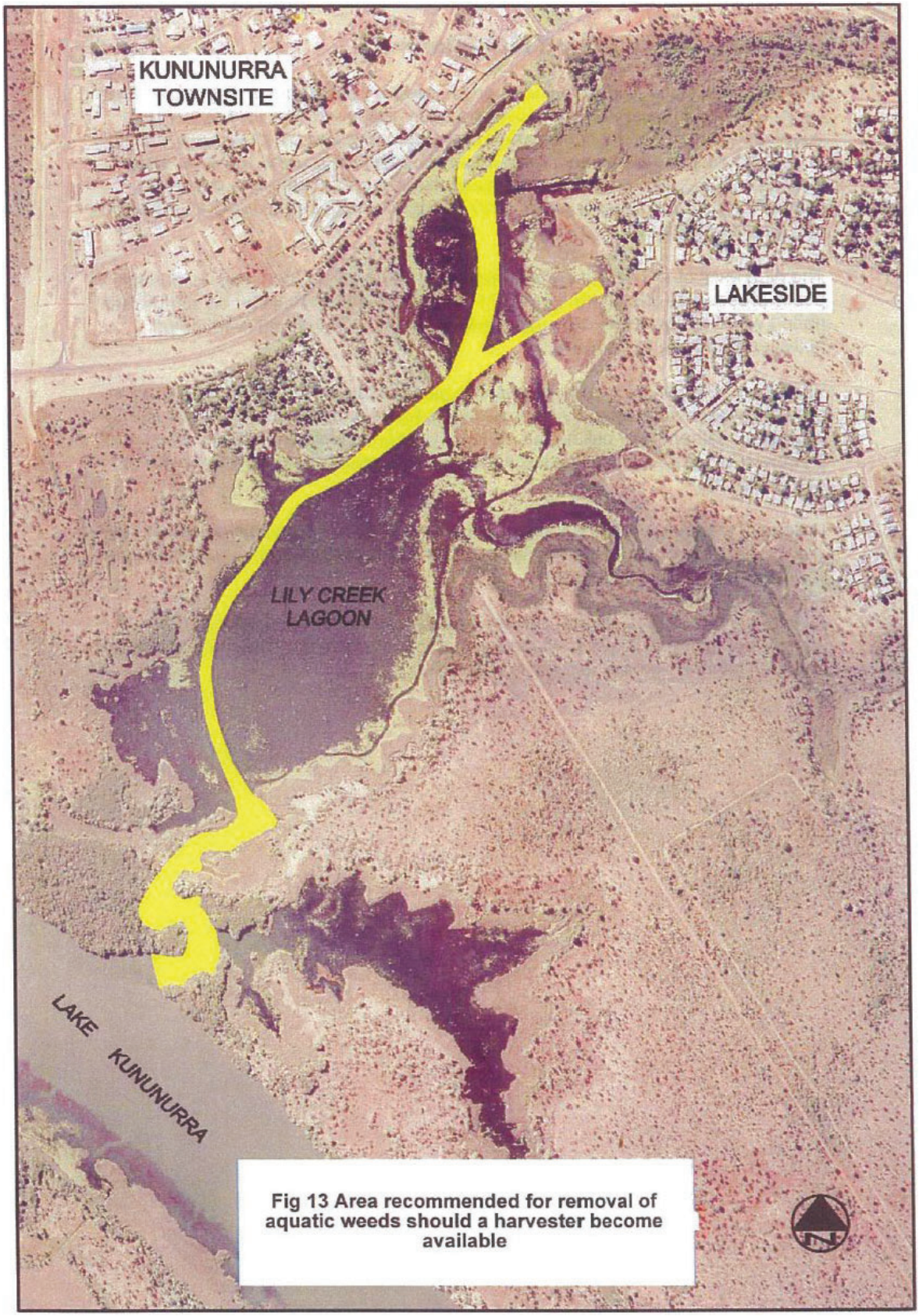

Figure 13 Area recommended for removal of aquatic weeds should a harvester become available

12. INTRODUCED WEEDS

Weeds and exotic species result in the smothering of native plants, and compete for light, water, and nutrients. They can also increase fire fuel loads, reduce plant biodiversity, reduce habitat for native animals, and increase refuge for feral animals (Dixon, 1997). Some native species can be so successful that they then act as a weed. The most common weeds in the Study Area are neem, leucaena, date palms, calotropis, passionfruit vine, and merrimia which are all introduced species. High impact riparian weeds that occur in the Study Area were identified by Dixon and Douglas (1997) as wild passionfruit, calotropis, parkinsonia, neem, and leucaena. These weeds are a priority for removal.

The floating fern, *Salvinia molesta*, was found in Lily Creek Lagoon in 2000. Salvinia is a Declared Pest and Prohibited Organism under the *Biosecurity and Agriculture Management Act 2007*. As such all Landholders, including Government will have a responsibility for its management. Under its current designation, salvinia is a C1 (Exclusion) species, meaning its movement, trade, and possession are prohibited, and it must be eradicated if found. The responsibility for managing Declared Pests lies with the landowner. In this case that would be DPLH, however it was previously decided that a joint coordinated approach between the Shire, DoFA (now DPIRD), DPLH, OLW and DWER was a more effective approach.

Salvinia eradication attempts to-date have been hampered by a lack of funding, a lack of co-ordination, and access difficulties. This Declared weed has the potential to cover the entire surface of Lake Kununurra and Lily Creek Lagoon and severely restrict recreational and commercial water use (Watkins *et al.,* 1997). The implications of the infestation getting out of control would be far reaching. Infestations block irrigation structures, pollute drinking water, impact wetland biodiversity, and prevent recreational activities such as swimming, fishing, and boating. Lake Kununurra is not an isolated waterbody and hence salvinia also has the potential to spread downstream into the Ramsar listed wetlands of the lower Ord River.

Through the Lake Kununurra NAP funded project, a coordinated, agreed, and up-to-date control and eradication plan has been formed and implemented. This plan was developed in conjunction with the Kununurra Weeds Working Group, a multi-stakeholder group that helps to monitor and guide priority weed projects. Actions under the plan include:

- A second groyne to be built parallel to existing groyne;
- Cumbungi to be removed between the two groynes using excavator;
- 2 x 25 metre fence booms to be strung between the two groynes;
- Spraying to be carried out to kill any remaining vegetative material in the bunded area;
- The DPIRD to carry out a yard-to-yard search of houses that are connected to the drainage system from where it is believed the infestation has originated;
- SWEK to check drainage sumps for salvinia;
- Signage to be erected in appropriate areas for public awareness and media releases made intermittently to keep the public informed and aware of the project; and
- Monitoring in 2008 to ensure that another outbreak does not occur.

The potential for aquatic plant introductions such as salvinia into Lake Kununurra is high. Water hyacinth, *Eichhornia crassipes*, would be equally devastating if introduced and not contained.

Introduction can occur through escape from aquaria and plant material from boat and boat trailers being brought from other locations particularly the Northern Territory (NT). It is therefore important for the quarantine service in Western Australia to be aware of and conduct strict search regimes for such plants.

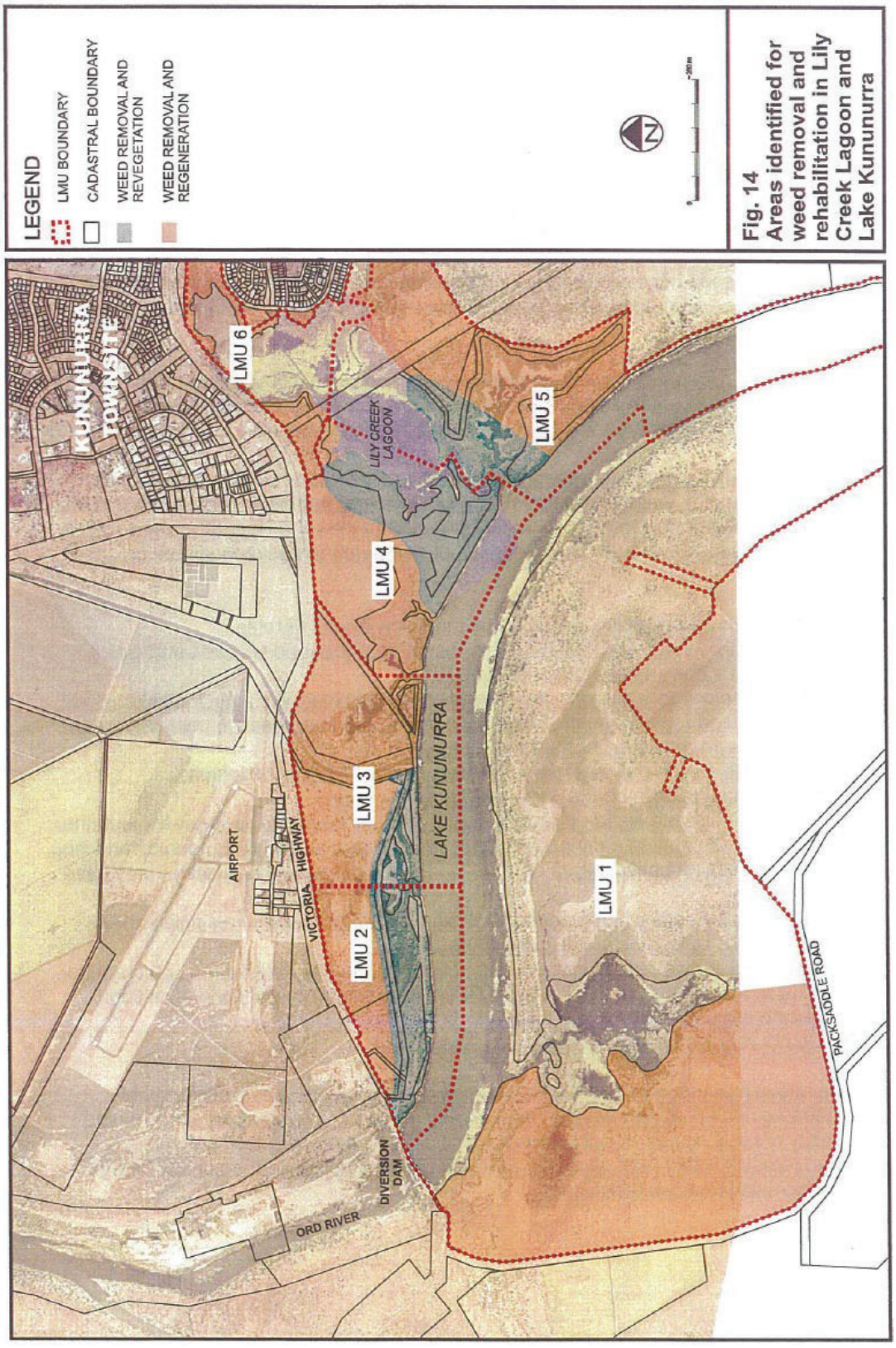

Figure 14: Area recommended for removal of aquatic weeds should a harvester become available

13. REGENERATION PRINCIPLES

The Bradley Method of bush regeneration (Weeds CRC, 2004) appears to be the most cost effective, low impact, and sustainable from of weed removal and rehabilitation for the Study Area. This method has, as its basis, three principles:

1. Work from areas of least disturbance and prioritise areas where significant species occur (i.e., from areas where indigenous or desired vegetation is at its healthiest with few unwanted species). Native plant seed will more likely be in the ground in areas where native plants are growing and weed propagules are more likely to be in the ground in areas where weeds are growing.
2. Make minimal disturbance using careful hand removal techniques or herbicides. Even careful weeding will disturb the soil, increase available nutrients, and activate weed seed, increasing the opportunity for weed species to propagate.
3. Let native plant regeneration dictate the rate of weed removal. Regeneration slows down as the weed numbers increase so ensure that the weeding rate matches the regeneration rate. Do not over clear. Ensure that the area weeded is not so large that other weeds now have the chance to out-compete the desired indigenous species.

The three principles above are guided by the following set of rules:

1. Watch where you tread. Minimise the impact from foot and vehicle traffic as all disturbance has an impact on vegetation.
2. Disturb the soil as little possible. Simple hand tools have the least impact on soil.
3. Preserve and replace mulch. Mulch acts as a weed suppressant, conserves soil moisture and provides habitat for soil fauna.
4. Mulch with weeds provided they are free of seed, bulbs, or rhizomes.
5. Do not pile weeds in heaps. Disperse them as mulch.
6. Never pile or hang weeds on other weeds. The surviving weeds grow through the dead weeds creating a difficult tangle to remove as well as necessitating double handling. Hang weeds on native plants or remove them as piles and burn when they have dried out.
7. Remove all weeds when weeding an area. Do not just remove a single species but remove all weed species simultaneously.
8. Work with the weather. Avoid weeding areas during the wet that may be prone to erosion following a heavy rain event. Weeding in very dry soil conditions can disturb soil until the next rain event.
9. Do not remove a plant that cannot be identified.

The above process, whilst the most cost effective, does require a considerable timeframe and is not always fully achievable, particularly on sites containing a high density of large woody weeds. These principles are recommended as a guide to weed removal within Australia yet will not always be applicable. See below for more specific weed removal techniques.

13.1 Weed removal methods

(As taken from Weeds CRC, 2004)

A key consideration to weed removal is possible adverse environmental impacts. Examples of adverse impacts include

- Loss of fauna habitat, e.g., leucaena provides habitat for flying foxes or parkinsonia protection for small mammals from predation.
- Weed substitution: a weed is removed only to be replaced by a weed which is more difficult to remove, e.g. Neem substituted by Luecaena.
- Chemical effects on fauna, e.g. impact on frogs by chemical sprays used for weed control.
- Increased erosion e.g., when leucaena is the most dominant or only vegetation growing on foreshore areas and is acting to control soil erosion.

Many potential adverse impacts of weed management can be prevented by trying to implant the principles and rules listed above and through revegetation with appropriate local species at the same time as weeds are removed. This approach maintains habitat values and reduces the risk of weed substitution.

The following methods are the most widely used and easiest to apply. Figure 14 indicates the areas within SWEK management that require weed removal. At the time of writing, a weed map indicating specific infestations of certain weeds was being developed, informed by OLW.

Herbicides

The use of herbicides near waterways or where herbicides may eventually enter waterways requires careful consideration and care. It is best if possible, to avoid or at least minimise herbicide use in these situations. If they are used, then they need to be registered for use near waterways by the Australian Pesticides and Veterinary Medicines Authority (APVMA) and label instructions strictly adhered to.

In PDWSAs, their use should also comply with the DWER's water quality protection guidance, including *WQPN 65 – Toxic and hazardous substances*.

There should be no use of 'weed n feed' products as these contain the chemical dicamba which is harmful to human health.

- Foliar spraying: Application of herbicide diluted with water or sometimes diesel, applied at a specific rate using spray equipment onto the foliage of plants until every leaf is wet (not dripping). High potential for offsite damage. Important to check the mode of action of the herbicide; herbicides with surfactants spread across the leaf surface and so a fine spray with less volume can be sufficient.
- Basel bark spraying: This method involves mixing an oil-soluble herbicide in diesel and spraying the full circumference of the base of the trunk or stem right down to the ground. Often used to treat woody weeds. The downfall of this method is that dead wood is left in the area which can reduce access, get covered in weeds, and increase fuel loads.
- Cut and paint: Particularly useful for woody weeds. Cut the stem horizontally as close to the ground as possible then apply herbicide as soon as possible using a paint brush, sprayer, or similar. This method does not always provide a 100% kill rate and follow up

and monitoring of treated plants will be required. Removing the cut wood and burning in piles will reduce the fire risk. Remove woody debris that may become covered in weeds and restrict access and incinerate attached weed seed (or weed seed accumulated on or near to the soil surface surrounding the weed). A cut and painted plant that needs to be re-sprayed at a later date has an advantage in that less herbicide is used than an initial aerial or foliar spray and there is less chance of an off-target kill.

- Stem injection: This method targets individual plants. A cordless drill, injection gun or similar is used to drill angled holes into the base of the plant. Herbicide is then injected into the holes within 10 seconds. The downfall of this method is that dead wood is left in the area which can reduce access, get covered in weeds, and increase fuel loads.

Hand

- Hand pulling: Useful for isolated occurrences of seedlings or other small, soft, non-bulbous weeds.
- Digging, hoeing, or grubbing: Can be effective for isolated weed occurrences and are useful follow up techniques. Larger woody weeds are more effectively treated with herbicides.

Mechanical

- Grooming: earthmoving equipment fitted with specialised grooming arms may be effective for treating large infestations of woody weeds in hard-to-reach places. The grooming device shreds plant material down to ground level, reducing biomass. Follow up treatments of any regrowth, using herbicides or manual methods, requires far less chemical and effort than would have been the case if the original infestation had been treated. This form of weed removal should only be used where resources exist to carry out necessary follow up work and rehabilitation/restoration of the site with suitable vegetation.

13.2 Weed removal and self-regeneration

Weed removal and self-regeneration of existing native plant species is recommended in stable areas where large stands of native vegetation still exist and/or where weed species tend to be scattered individual plants or vines. Seed banks and/or remaining or adjacent vegetation will result in self-regeneration of species. These trees tend to be very tough, do not need watering, and have a high survival rate.

1. Remove weeds using the lowest impact yet effective method (see weed removal methods).
2. If in a slashed area, stake seedlings so that the slasher driver can avoid them.
3. Ongoing weed removal and management of the site through follow up spraying and/or hand pulling.

13.3 Weed removal and rehabilitation

Weed removal and planting of the site with either seedlings or seed of local native species is recommended in areas that have been identified as parkland and where a weed species has outcompeted the native vegetation to become the most dominant species resulting in a low diversity of native vegetation. Physical rehabilitation techniques such as bank stabilisation, mulching, or gabion construction may need to be undertaken prior to replanting.

In some instances, due to the high density and physical stature of some weeds (i.e., rain trees and leucaena) then a mechanical mulching machine may be needed. In this circumstance then a precautionary approach to weed removal should be used with the maximum area of weeds to be cleared at any one time being that which is able to be followed up regularly and be easily replanted with native species (refer to Bradley Regeneration Principles in Section 13 above). If accessible then another option would be to remove all seeder (mature) and semi mature trees from an area, plant, and then return the following year to remove the remaining immature weeds.

Direct seeding using pioneer species is an option in areas where immediate cover is needed. In a less intact site this would need to be followed up with planting of native seedlings at some stage to increase biodiversity at the site.

It is important for slasher and other machine operators to follow appropriate hygiene practices so that weeds are not spread from one area to another via the slasher.

Rehabilitation in parkland areas should be implemented as outlined below:

1. Remove weeds using the lowest impact yet effective method (see weed removal methods).
2. Unless plants will be hand watered, plan weed removal and planting for the wet season (December - February) as this will give plants the best chance of establishment.
3. Inform and involve the community in planting days as this gives a sense of ownership over the project which helps to reduce vandalism and encourage maintenance of the seedlings.
4. Select species that are most suitable for the location. Seedlings selected for shade, shape, longevity, safety, and other parkland/recreational values are best.
5. Select small plants 300-400mm high. These require less work in digging and site preparation and the younger, smaller plants suffer less in transplant shock.
6. Using either a stake or paint, mark out where you want the plants to go.
7. Make sure seedlings are at least 15 meters apart to allow a slasher to manoeuvrer between them. Seedlings should be a minimum of 2 meters from a footpath or road.
8. If using more than one species and a particular planting pattern is needed, then mark this pattern on a site map and give to the planters.
9. Make sure you dig a large hole. The Shire auger may be available. A large hole gives the seedling's roots room to grow.
10. Fill the hole with good dirt. If the dirt removed is too rocky or clayey then bring in better dirt from elsewhere.

11. Create a shallow bowl or depression around the planted seedling so that any rain that falls is captured and contained by this bowl.
12. Push down hard around the base of the seedling to compact the dirt and remove any air that is trapped.
13. Plant the seedlings with a stake for support and so that they are easily identified by the slasher driver.
14. Water seedlings immediately after planting, this will also help with compaction around the roots.
15. Stake any local native trees that have self-generated so that they are not slashed.
16. Inform slasher driver of the new trees that have been planted and staked.
17. Follow up weeding will be needed. Remove stakes once the trees are big enough to be seen by the slasher driver.

13.4 Suitable species for rehabilitation

Plant species to be used for regeneration of conservation areas should be predominantly endemic to the area. Past documents contain plant lists representing the most common vegetation that used to occur in and around Lake Kununurra (see Information Sheet on Ramsar Wetlands, Gowan, 1981). Table 10 below lists these species.

Due to the modified environment and therefore continual vegetation succession, species may need to be varied to suit the current conditions. Species should however be limited to those that occur within the local Kununurra area.

Areas identified as parkland and that receive regular maintenance can have a more diverse range of species planted including species widely known from the Kimberley region.

Limiting factors for selection of suitable species include unknown propagation techniques, unreliable germination rates, and difficulty in gaining supply of plant material.

Tree and shrub seeds for rehabilitation work can be sourced from commercial suppliers such as *Kimberley Seeds* and can be grown by Kimberley TAFE or contracted out to a commercial grower. Sedge species can be sourced as plants from providers such as *Greening Australia* in the NT although it would be preferable to source and grow seeds from local species.

Kimberley TAFE in conjunction with a number of Aboriginal communities is currently researching and trialling propagation and development of market-ready endemic plant varieties. Work will continue and plants suitable for rehabilitation work and parkland planting will be made available to SWEK.

Table 10 – Local plant species for rehabilitation

Shrubs	Trees	Trees Cont.	Grasses
Acacia translucens (poverty bush)	*Adansonia gregorii* (boab)	*Ficus opposita* (sandpaper fiq)	*Cyperus a/bomarqinatus*
Cochlospermum fraseri (kapok bush)	*Atalaya hemig/auca* (whitewood)	*Grevil/ea striata* (beefwood)	*Cyperus macrostachyos*

Shrubs	Trees	Trees Cont.	Grasses
Carissa lanceolata (conkerberry)	*Barringtonia acutangula* (freshwater manqrove)	*Gyrocarpus americanus* (helicopter tree)	*Echinochloa kimberleyensis*
Eucalyptus pruinosa (silver leaf box)	*Bauhinia cunninghamii*	*Lophostemon grandiflorus*	*Eleocharis atropurpurea*
Aquatic	*Cathormion umbellatum* (Cathormium)	*Mela/euca leucadendra* (cadieput)	*Eleocharis brassii* (spike rush)
Nymphoides indica	*Erythrina vespertilio* (yulbah)	*Melalueca viridiflora* (broad leaf paper bark	*Eleocharis philippinensis*
Nymphaea gigantean (giant waterlily)	*Erythrophleum Chlorostachys* (ironwood)	*Nauclea orientalis* (leichhardt Pine)	*Eleocharis spiralis*
Hydrilla verticillate (water thyme)	*Eucalyptus camaldulensis* (river gum)	*Owenia vernicosa* (emu apple)	*Eleocharis sphacelata* (tall spike rush)
Myriophyllum verrucosum (red Water Milfoil)	*Eucalyptus microtheca* (Coolibah/flooded box)	*Pandanus spiralis* (screwpine)	*Eriachne sulcata*
Potamogeton tricarinatus (floating pond weed)	*Eucalyptus foelscheana* (smooth barked bloodwood)	*Sesbania Formosa* (white dragon tree)	*Oryza australiensis* (Australian wild rice)
Vallisneria spiralis (ribbon weed)	*Eucalyptus grandifolia*	*Tristania grandiflora* (wild Plum)	
	Excoecaria parvifolia (quttapercha Tree)		

14. RECOMMENDATIONS

In writing this report it became clear that there was a lack of data and information for the wetland ecosystem in general. Increased data and information will lead to a better understanding of Lily Creek Lagoon and Lake Kununurra and enable improved management of the waterbody and its vegetation. Therefore, the Plan also includes additional recommendations aimed at improving water quality of the wetland and increasing available information.

Recommendation 1. Form a Lily Creek Lagoon and Lake Kununurra Foreshore working group that focuses specifically on the Study Area defined in this report. Members should be those responsible for management of the foreshore (SWEK and DWER) with Water Corporation, OLW, and other stakeholders if and when needed.

Recommendation 2. Vegetation areas that are largely untouched should be protected and retained for conservation purposes.

Recommendation 3. In view of the time required for their establishment, mature native trees should be retained, and seedlings planned as replacements for any that die or are removed.

Recommendation 4. Rehabilitate stormwater drains, actively regulate developments through SWEK's *Kerb and Footpath Deposit Policy*, and employ best management practices for stormwater to reduce sediment loads entering the system.

Recommendation 5. Establish Sediment Load Monitoring Points to evaluate sediment loads entering Lily Creek Lagoon.

Recommendation 6. Conduct mammal surveys at night, and bird surveys at dawn and dusk, to update out-of-date baseline biodiversity information.

Recommendation 7. Employment of a Park and Gardens Officer who also has a role in Bush Regeneration.

Recommendation 8. DWER to develop a Ramsar Wetland Management Plan.

15. MONITORING, EVALUATION, AND REVIEW

Monitoring and Evaluation
Water Quality Monitoring including sediment loads
Photo points and quadrats
Cumbungi regrowth
Cumbungi growth – aerial photography every 3-5 years to monitor growth
Survey
Weed map
Rush and sedge growth
Aquatic and fringing vegetation
Mapping of wetland plant communities

'Who' implements these recommendations will depend upon available funding and responsible landholders taking ownership over the management of this waterbody. To implement the various recommendations included in this Plan, the many agencies involved in the management of the foreshore will be required to contribute additional resources. A working group that has a specific focus on the Study Area and its management has been recommended to be established. This group would need to decide early on who would be implementing the above actions and source of funding.

Review

This Plan should be considered a *working document* and should be reviewed annually and updates as required.

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