DEPARTMENT OF
ENVIRONMENT AND NATURAL RESOURCES

Darwin River Cabomba Eradication Program Interim Report

December 2017



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Executive summary

Cabomba (*Cabomba caroliniana*) is an aquatic plant native to the Americas. In Australia, this highly invasive weed can rapidly outcompete native aquatic plant species, alter water chemistry, increase siltation and stagnate freshwater systems.

Cabomba was first reported in Darwin River in 2004 and surveys established that an 11 kilometre stretch of the river was affected. Significant control efforts by the Department of Environment and Natural Resources' Weed Management Branch resulted in an estimated reduction of up to 95 percent of the original infestation. However, complete eradication of cabomba had still not been achieved by 2015; a resilient infestation of cabomba persisted in a 1.2 kilometre stretch of the Darwin River, known as Lok Landji Billabong.

A review of the Cabomba Eradication Program was undertaken in 2015 and changes were recommended to progress the eradication goal. In 2016, funding was received enabling the temporary recruitment of two staff with operational support, including a new vessel, 'high tech' monitoring equipment and herbicide. Additional funding was received in 2017 which allowed for the continuation of the intensified Eradication Program.

The funding also enabled a treatment program using Shark™ Aquatic Herbicide. This program was supported by an extensive aquatic and riparian monitoring program and measures to mitigate off-target impacts including the construction of a temporary downstream bund wall at the Cox Peninsula Rd Bridge.

Shark herbicide is not registered for use on cabomba in flowing waterbodies; however, given the level of risk posed by cabomba, the Australian Pesticides and Veterinary Medicines Authority (APVMA) issued the Department with two permits authorising spot spraying and limited large scale applications. In accordance with permit conditions, a major treatment was applied to Lok Landji Billabong in both 2016 and 2017.

Results indicate that cabomba in the treated upstream area has been severely impacted by the herbicide. While no healthy cabomba can be detected in treated areas, experience interstate indicates that recovery is possible. One strand of healthy cabomba was detected downstream of the treated area in January 2017 prior to the second herbicide application. No sign of viable cabomba, fragment or rooted plant, has been detected since then. This is the single longest period without detection since it was first found in Lok Landji in 2004.

Intensive efforts to detect and destroy any surviving plants in Darwin River must be continued but consideration could be given to lifting the quarantine area upstream of Lok Landji Billabong, where cabomba has not been detected for over 10 years. The WMB is confident that cabomba has been eradicated from this stretch of Darwin River.

If cabomba were to spread from the current infestation area, the cost to the environment and tourism would be immense but difficult to quantify. Should cabomba infest Darwin River Dam, the cost of a water treatment plant has been estimated at approximately $80 million.

Background

Cabomba (*Cabomba caroliniana*) is an aquatic weed native to the Americas and was most likely introduced to Australia via the aquarium industry. It is a declared Class A weed in the Northern Territory (NT) and is to be eradicated. It is also a Weed of National Significance.

Cabomba grows in slow moving or still water to depths of over five metres and forms dense columns that outcompete native aquatic vegetation and impedes the movement of aquatic fauna. Left unmanaged, cabomba can choke out the entire water body below the surface. In this situation, cabomba infestations generally die back with seasonal change which deoxygenates the water, suffocating fish and other aquatic life.

In the NT, cabomba spreads by seed and floating fragments. The NT is understood to be the only region in Australia where cabomba produces viable seed. This is a significant risk factor for spread to other water bodies as seeds are very small and can be moved inadvertently by people or animals. Cabomba also fragments easily and can be spread via fishing equipment and boats.

There have been a number of cabomba infestations found in the NT; most have been limited to small man-made ponds or aquariums. The two most significant infestations have occurred at Marlow Lagoon in Palmerston and in Darwin River.

The Marlow Lagoon infestation was discovered in 1996. The last cabomba plant found in the lagoon was in 2002 after significant management efforts were undertaken for its eradication. This infestation is deemed eradicated as more than ten years has passed since the last plant was found.

The only known remaining cabomba infestation in the NT lies in a 1.2 kilometre stretch of the Darwin River, downstream of Darwin River Dam. This infestation remains under a Cabomba Eradication Program.

Risk to the Territory

Freshwater rivers and water bodies in the NT are at a significant risk to the adverse effects of cabomba as they provide ideal habitat conditions for its growth. Cabomba could devastate freshwater fishing and other recreational activities if it were to spread from Darwin River (Plate 1).

If cabomba were to spread into Darwin River Dam, Power and Water Corporation estimate a water treatment plant would cost around $80 million to build with additional funds required indefinitely to run and maintain.

Cabomba infestations taint water and are a threat to potable water sources as treatment of the water is required to maintain palatability. It can also decrease the volume of water bodies and cause significant siltation as the plants trap any sediment in suspension.

Plate 1: Physical attributes and implications of cabomba

Darwin River Cabomba Eradication Program 2004-15

When it was discovered in 2004, the Darwin River cabomba infestation spanned over 10 kilometers (Plate 2). Immediate eradication efforts were made by the Weed Management Branch (WMB). As no registered herbicides were available for use in Australia to control cabomba, an off-label permit was issued by the Australian Pesticides and Veterinary Medicines Authority (APVMA) for the use of an aquatic herbicide (2,4-D ester). This herbicide was used successfully as part of the Eradication Program (Plate 3) for over 10 years; however it is now deregistered for use in Australia and is no longer available for purchase.

Concerted management efforts by the WMB reduced the Darwin River cabomba infestation to a 1.2 kilometer section located within Lok Landji Billabong (Map 1). **No cabomba plants have been found upstream of Lok Landji since 2007.**

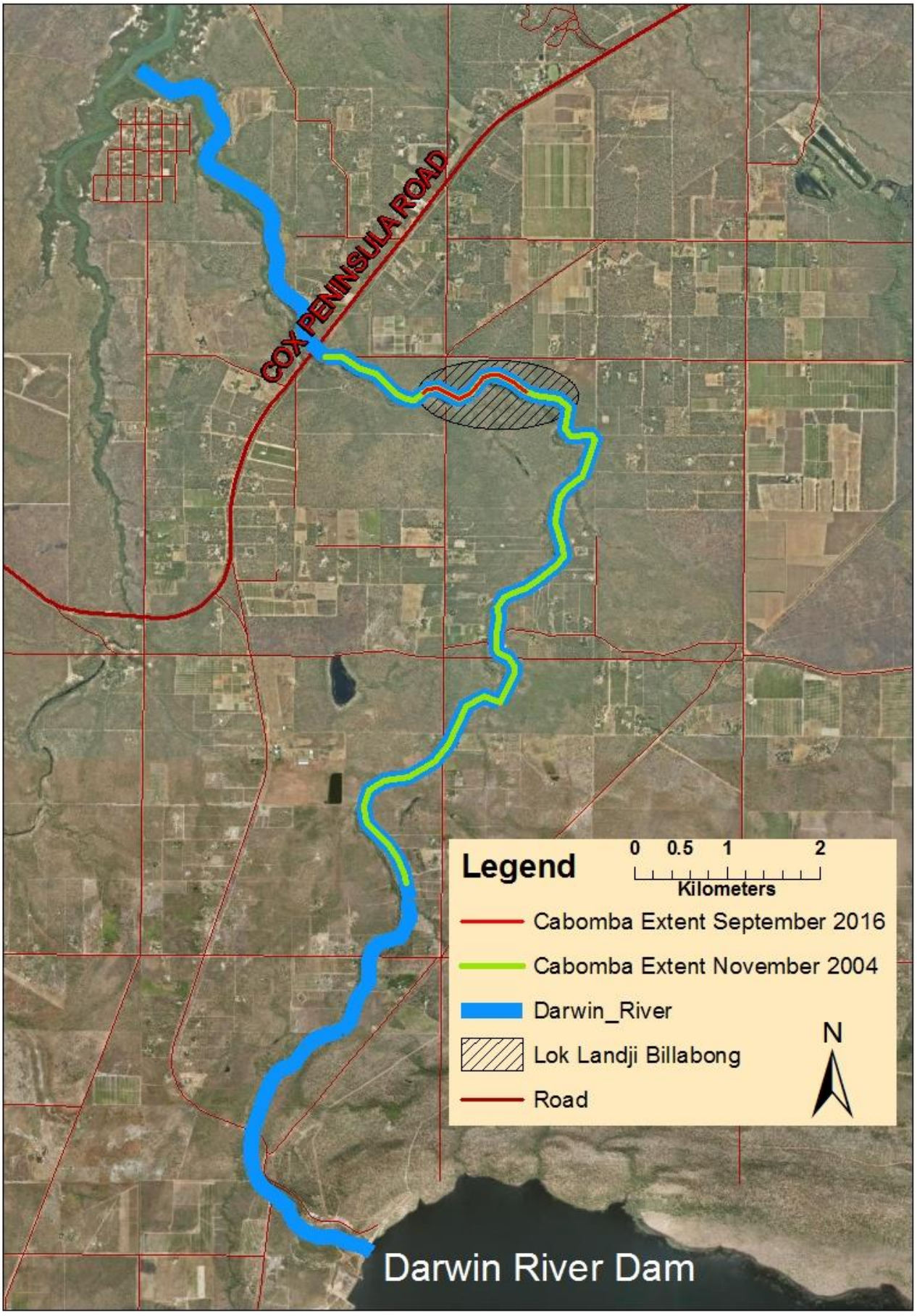
With the billabong infestation still persisting, in 2015 the WMB undertook a review of the Cabomba Eradication Program. This review, with input from aquatic weed expert Dr Tony Dugdale (Senior Scientist, Agriculture Victoria Research), found that changes were required to maintain progress towards the eradication target.

Plate 2: Cabomba infestation in Lok Landji 2004.

Plate 3: Aquatic herbicide application (left)

Plate 4: Booms used to catch cabomba fragments (right)

Map 1: Reduction in cabomba since 2004 and location of infestations relative to Darwin River Dam



Darwin River Cabomba Eradication Program 2016-18

The 2015 review of the Cabomba Eradication Program identified issues in the program that needed addressing, including:

- Greater concentrated program efforts
- Requirement for dedicated staff
- New herbicide
- Better survey techniques
- Safer equipment
- Upgrade to boat ramp
- Risk mitigation of enhancing the program

In response to these recommendations, the Department received $850 000 from the NT Government in 2016 to improve the Program to finally eradicate the persisting infestation from Darwin River. The funding provided for two dedicated WMB staff with full operational support for 12 months. A further $600,000 was made available in 2017 to allow for follow up control, including herbicide application and monitoring.

New equipment

The additional funding received by the Department allowed the purchase of a more appropriately-sized vessel with level floatation for enhanced buoyancy for officer safety and also for better carrying capacity of herbicide and seaworthiness. The new vessel (Plate 5) was also fitted with a GPS enabled trolling motor (Minn Kota®) to allow the vessel to stay stationary for the purposes of survey and monitoring.

Plate 5: '*Carolin*', the new cabomba eradication program vessel

New survey techniques

Surveying for aquatic weeds in the Top End presents a challenge due to the presence of saltwater crocodiles (Plate 6). Four crocodiles measuring between 3.8 and 4.4 metres were trapped within freshwater Darwin River between 2010 and 2014 (T Nichols 2015, pers. comm.). This restricts entry into the water and thus limits the use of survey techniques commonly employed elsewhere, e.g. diving.

Plate 6: A 3.25 m saltwater crocodile pulled from the permanent crocodile trap in Lok Landji, Sept 2017

An underwater camera with live feed back to the surface was purchased in December 2015. This camera was used extensively during 2016 to observe the riverbed in real-time to identify cabomba. The camera revealed cabomba growing at depths and locations within Lok Landji that it had previously not been known to occur (Plate 7).

Plate 7: Detection of cabomba using underwater camera

Under advice from Dr Dugdale, a simplistic approach was used to get samples of cabomba up from the riverbed for assessment. Two rake heads were fastened back to back on a length of chain and rope. This apparatus (known as a 'grapnel') was able to be thrown into the water, dragged along the bottom then

retrieved with cabomba fragments attached. Weed officers could visually inspect treated cabomba to determine the level of health post-herbicide application (Plate 8).

Plate 8:Physical sampling and monitoring of cabomba at depth using a grapnel.

New herbicide

In 2012, a new herbicide registered for cabomba control, Shark™ Aquatic Herbicide, became available for use in Australia. This herbicide (containing carfentrazone-ethyl) was only registered for use in contained, non-flowing, water bodies. This meant it could only be used in Lok Landji with an appropriate permit (due to it being a flowing water body). In 2015, the WMB applied to the APVMA for an off-label permit to use Shark for spot treatment of cabomba in Lok Landji. In November 2015 the permit was granted.

Following the issue of the spot spray permit and subsequent use of Shark for spot treatment, it was apparent the herbicide showed reasonable results but the method would not be sufficient for eradication. In 2016, another application was submitted to the APVMA for Shark, this time to treat 50% of the volume of Lok Landji in one application. This permit was approved in July 2016 with the conditions that:

- Only two treatments are permitted per calendar year with each treatment not to exceed 50% by volume of the water body.
- 90 days must pass between treatments (however due to tropical conditions and late application of the first treatment, 50 days between treatments was approved by the APVMA for the second treatment in 2016 only).
- Apply as late in the dry season as possible, or at other times when the flow rate of water through the billabong is at its lowest.
- Do not apply once the wet season commences.

The Water Resources unit of the Department of Environment and Natural Resources conducted a bathymetry (water volume) survey and calculated the entire Lok Landji Billabong volume to be approximately 170 mega litres. As per the APVMA permit, only 85 mega litres could be treated per application, some 25 mega litres short of the total infested volume of nearly 110 mega litres. The upstream infestation was deemed the most important and therefore targeted first for treatment.

A total of 700 litres of herbicide would be required to treat half the billabong volume, as per the permit conditions, at a cost of approximately $85 000 per treatment.

Rationale for half billabong treatment

To be effective, aquatic herbicides require a minimum exposure time on the plant at a minimum concentration. Lethal exposure times for cabomba to Shark herbicide are at least a few hours if not longer at a concentration of 2ppm of the active ingredient. Spot spraying patches was assumed to be under-dosing the infestations from movement of the water through the billabong due to input from springs. This flow would move the herbicide off the plants in a relative short time period reducing the exposure time and diluting the concentration.

With improved cabomba surveillance techniques implemented in late 2015 and 2016, weed officers concluded that it would be nearly impossible to find and then spot spray every cabomba patch in the infestation zone. The infestation zone is about 1.2 kilometres long and on average about 20 to 30 metres wide with depths down to nine metres. It would be physically impossible to accurately survey every square metre of riverbed as cabomba does not always reach the surface as previously assumed. The only way to be sure to get every infestation would be to treat the whole infestation zone in one application. This would eliminate missing any patches that would otherwise go undetected and untreated.

Treatment schedule for half billabong applications of Shark Aquatic Herbicide

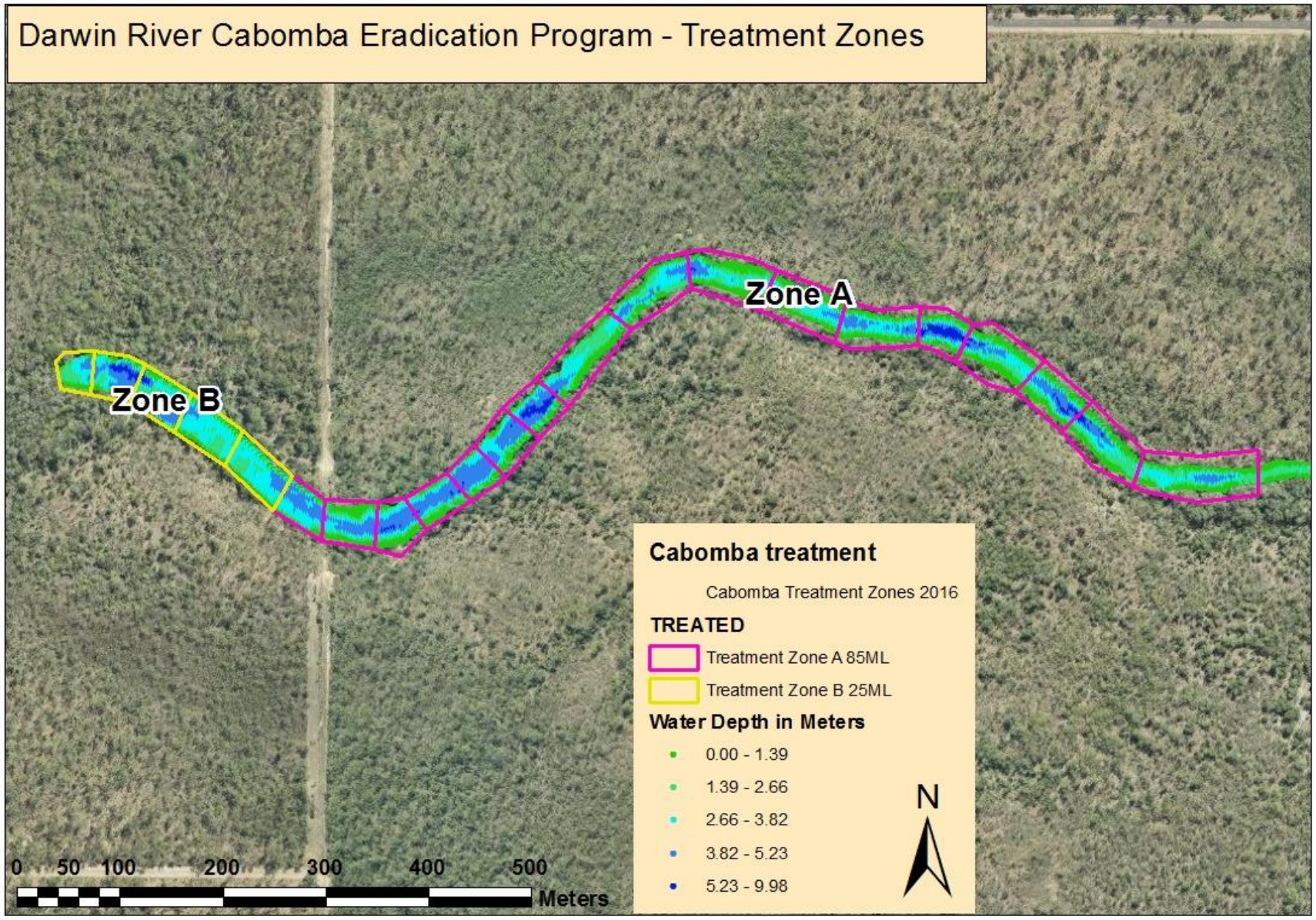
The ideal treatment schedule, as shown in Table 1, incorporates six half-billabong treatments over three years. Herbicide application is timed to coincide with ideal treatment conditions, those being healthy and actively-growing cabomba and high sunlight penetration in to the water. Best results from the herbicide are achieved under high light conditions with clear water and low water flow through the billabong. Upstream areas (Zone A as shown in Map 2) are treated first to completely remove the risk of upstream reestablishment.

Table 1: Ideal treatment schedule to achieve cabomba eradication

Treatment	Zone	Year	Month
1	A	2016	July (not undertaken – delayed by bund wall)
2	A	2016	October (completed)
3	A	2017	June (not undertaken – elevated river flow)
4	A	2017	September (completed)
5	B	2018	June
6	A	2018	September

Only one half billabong application of herbicide was able to be applied in 2016 due to permit requirements and time taken to build a bund wall as part of the risk mitigation of off target damage. A follow up treatment was undertaken in mid-September 2017. It was not done earlier because of elevated river flow and turbidity levels associated with the above average 2016/17 wet season, creating poor growing conditions for cabomba and thus rendering a treatment in June a wasted effort.

Map 2: Cabomba treatment zones, Lok Landji Darwin River



Mitigation of potential environmental impacts

Given the intended broad-scale application of herbicide to over one kilometre of Darwin River, a taskforce was formed to discuss the proposed treatment, the likely off target impacts, what should be monitored and what could be done to minimise those impacts. The members comprised individuals from the Department of Environment and Natural Resources' Water Resources and Flora and Fauna Divisions and WMB (Rangelands Division).

The intensified Eradication Program incorporated a range of factors to mitigate impacts on local aquatic and riparian environments, human health and downstream reaches of the Darwin River, including:

- The use of Shark Aquatic Herbicide, a broad leaf selective contact herbicide with little or no residual activity.
- Shark herbicide is moderately stable at pH 7 and has a relatively short half-life of 8.6 days at this pH.
- No more than 50% (by volume) of Lok Landji will be treated in a single application. This enables mobile vertebrates to actively leave treated areas, limiting local fauna impacts.
- Only two applications of Shark herbicide are permitted per year, these must be separated by at least 90* days to limit off-target impacts and maximise efficacy on any cabomba regrowth (*a reduced period of 50 days was permitted by the APVMA in 2016 only).
- A monitoring program that assesses baseline values and changes on cabomba infestation levels, water quality, fish populations, crocodiles, and terrestrial, riparian (Plate 9) and aquatic vegetation was administered.
- The three current holders of water extraction licences in the downstream estuarine extent have been contacted with respect to the transition to Shark herbicide. All three have advised they are not currently extracting water.
- A temporary bund wall was constructed to prevent movement of treated Darwin River water to Darwin Harbour during periods of herbicide application or high deoxygenation.
- Impacts on river flow were minimised as the bund wall was only temporary.
- The bund wall was required to remain in position for less than two months at a time that correlated with lowest annual river flow rates.
- The construction of the bund wall was within a road reserve on a natural rock bar; this limited impacts on vegetation and soil disturbance.

During the previous Eradication Program, the following was also undertaken for risk mitigation purposes:

- Prior to the commencement of herbicide application in 2004, all landholders drawing water from the river were contacted and provided with alternative water sources. This included the provision of bores to some landholders.
- All pumping infrastructure in the river was physically disconnected to ensure that no inadvertent use of treated water occurred.

Plate 9:Baseline riparian vegetation survey being undertaken with drone - pre herbicide treatment

Bund wall construction and deconstruction

Construction of a bund wall was a precautionary measure that recognised the application of Shark herbicide on this scale was unprecedented in tropical flowing water bodies in Australia (Plate 10). While the break down rates of Shark could be estimated, they could not be guaranteed. The construction would also provide members of the public with visible assurance that downstream environments were being protected from herbicide impacts.

The bund wall construction was a major undertaking with inter departmental and agency assistance and advice coming from a suite of Northern Territory Government business units.

It was necessary to deconstruct the bund wall once it was determined, through water quality testing, that no downstream impacts were likely to occur as a result of the herbicide treatment. Its physical removal prevented 'blow out' during intensive rain events and the associated risk of sedimentation of the estuary.

The bund wall budget was approximately $250 000 to build and deconstruct. All material used for the bund wall had to be safely transported and then stockpiled to avoid any inadvertent spread of cabomba seed.

Waste Discharge License

To enable limited release of potentially herbicide-contaminated upstream water and to avoid overflow (through a 900mm pipe in the bund wall), the WMB applied to the Northern Territory Environment Protection Authority (NT EPA) for a Waste Discharge License.

The NT EPA stipulated that water could not be released from the bund wall until the herbicide reached a concentration of 100 micrograms per litre of water, equivalent to 0.1 parts per million (ppm). For comparison, sea water has a salt concentration of 35 000 ppm; the average person can taste salt in water at a concentration of 2000 to 3000 ppm. The NT EPA also stipulated a significant monitoring program of water quality be developed and carried out, over and above what WMB had intended to do.

Plate 10: Bund wall construction at Cox Peninsula Bridge

Results

Water quality testing showed that within three days of treatment a very low concentration (2.05 micrograms per litre or 0.002ppm) of the herbicide was detectable at the downstream end of the untreated zone. By ten days after treatment, no herbicide was detectable anywhere in the river and at no time was any herbicide detected outside of the infestation zone, including the water held back by the bund wall. These results indicated that water could be released at the bund wall to avoid overflow and/or destruction from wet season flows. Results show the future requirement for a bund wall is negated with the same application of the Program.

Spread risk - Quarantine Area

Cabomba can be spread by seed or plant fragments. Fishing and boating pose significant risk of spread. Lures and propellers can dissect cabomba stems, enabling fragments to be transported to new waterways on equipment or trailers. Cabomba cannot survive in saltwater.

A quarantine area under the *Weeds Management Act* has been in place since 2004 to prevent any spread of cabomba from Darwin River while the infestation remains under active treatment. The quarantine order has been in place since 2004 and prohibits the movement of people and any object, including boats, vehicles and fishing equipment, into or out of this section of river and within the five metres of land adjacent to the water's edge and in the road reserve.

Evidence of quarantine area breach, including destruction of fencing and locks has been common; indicating the threat of spread remains high while cabomba is growing. As part of the intensified Eradication Program, the Department has installed and monitored surveillance cameras in the area to identify offenders. In 2016, two fishermen were caught in the declared quarantine area of Darwin River, resulting in a fine for a third party who launched the recreational fishing boat. In 2017, a local resident was caught inside the quarantine area inspecting flood damage. He was issued with a warning.

Extension materials regarding the quarantine area and the ongoing nature of the Eradication Program formed a major part of the 2016-17 Program and into 2017 (Plate 11).

NB: An opportunity exists to revoke the quarantine order upstream of Lok Landji billabong. This is discussed further in the following section. If a lifting of the quarantine area for this stretch of Darwin River is approved, a communications plan will be developed to guide the public announcement.

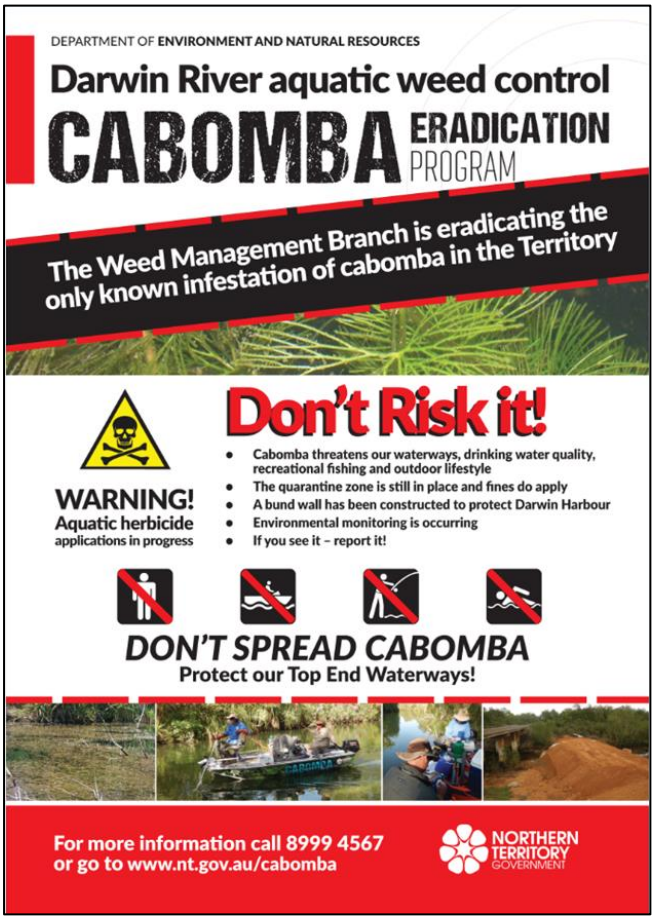


Plate 11: Eradication Program Poster 2016

Results

The first treatment was not undertaken in July 2016 as planned due to the delayed construction of the bund wall. The first half billabong treatment for cabomba using Shark Aquatic Herbicide was completed mid October 2016 under permit PER82571 issued by the APVMA.

In total, it took four Weed Management Branch Officers six days to treat 85 mega litres of the billabong, using two boats to subsurface inject over 700 litres of herbicide along a linear distance of just over one kilometre (refer to Plates 12 and 13 and Map 3).

Before the first half billabong treatment, cabomba fragments were readily found floating on the surface throughout the infested zone. Cabomba infestations growing from the riverbed were also reaching the surface in at least ten sites. Three months post-treatment; not a single cabomba fragment was found in the treated zone. One healthy fragment was found in the untreated zone downstream of where the herbicide was used.

In mid-September 2017, the second 50% by volume treatment for cabomba using Shark herbicide was completed. Four weed officers were able to treat 85 out of 170 mega litres of Lok Landji in four days. As in 2016, over 700 litres of herbicide was subsurface-injected along a linear distance of just over one kilometre. This herbicide application was applied as a follow up to the 2016 application.

Major flooding was experienced in Lok Landji between January and May 2017. The 2016/17 wet weason for Darwin and surrounds was the third biggest on record. River flow increased during December 2016, and became significant by late January 2017 with flood levels experienced in February. The high flow rate of Darwin River coincided with the dam reaching capacity during February. The dam level was at or above capacity for a total of 68 days during the 2016/17 wet season with high river flows well into the early dry. This high river flow and subsequent high turbidity resulted in a period of around five months where cabomba growth would have been supressed due to suboptimal growing conditions.

From May to December 2017, in the entire infestation area of Lok Landji, surface surveys, boom inspections, underwater video surveillance and benthic raking failed to detect any sign of viable cabomba, fragment or rooted plant. This means that cabomba has not been seen in Lok Landji since January 2017, which is the single longest period without detection since it was first found in 2004.

Initial off-target damage was done to some small fish and pandanus trees. A fish survey was completed post-treatment by Fisheries NT, which indicated that fish stocks (based on number and species composition) were not adversely affected. The pandanus population is likely to recover given that most were unaffected by the herbicide.

Plate 12: Half billabong treatment and associated monitoring, October 2016

Map 3: Lok Landji Billabong showing cabomba infestation and treatment area relative to water depth (and subsequently volume)

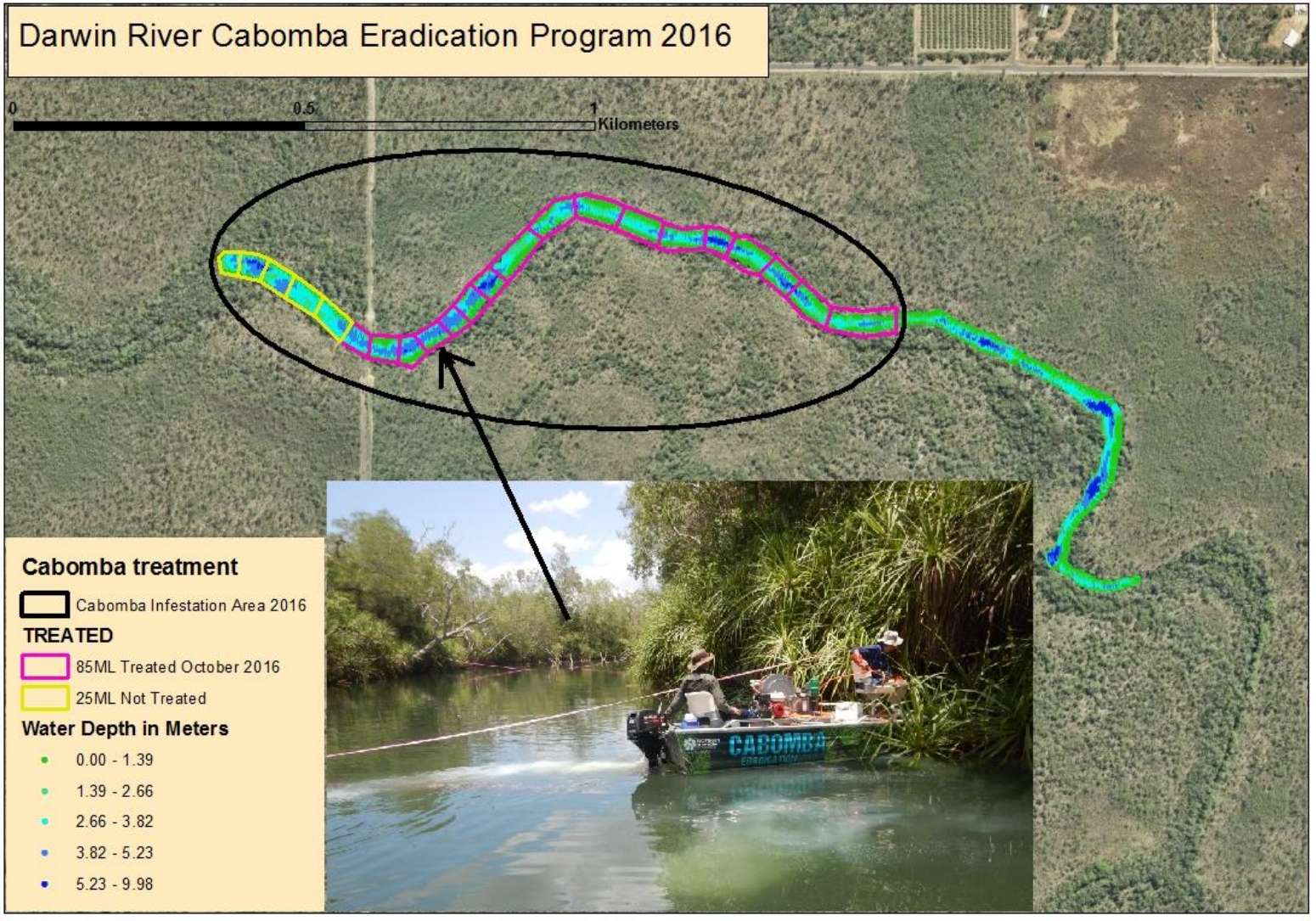


Plate 13: Weed officers applying Shark herbicide in one of the defined quadrats during the first half billabong treatment

Herbicide application results

One week post-first application (Oct 2016)

- Cabomba fragments were readily found floating on the surface in both the treated and untreated zones.
- The cabomba growing from the riverbed had begun to show some herbicide effect and was starting to lay flat on the riverbed.

Eight weeks post-first application (Dec 2016)

- No floating fragments were found in the treated zone or downstream in the untreated zone.
- No healthy cabomba was able to be found on the riverbed in either the treated or untreated zone (Plate 14).

Plate 14: No healthy cabomba eight weeks post-treatment

Three months post-first application (Jan 2017)

- No floating fragments could be located in either the treated or untreated zone.
- Surveillance techniques used in the treated zone could not locate any cabomba on the riverbed in any of the previously known infestation sites.
- In the untreated zone a single small, but healthy fragment was located on the riverbed (Plate 15). This healthy stem indicates that while some herbicide effect was observed in the untreated zone, targeted management would be required once the river stopped flowing in the 2017 dry season.

Plate 15: First sign of healthy cabomba three months post-treatment – only in untreated zone

Fourteen months post-first application/three months post-second application (Dec 2017)

- No fragments could be located in either the treated or untreated zone.
- Surveillance techniques used in the treated zone could not locate any cabomba on the riverbed in any of the previously known infestation sites.
- **No cabomba detected in Darwin River since January 2017.**

Expert advice

WMB officers contacted interstate experts to discuss the results of the aquatic herbicide application. One expert, involved with cabomba management in the Great Lakes region of NSW, confirmed that the results observed in the treated zone of Lok Landji compared well with what they observed with the Shark herbicide treatment of their cabomba. They conducted one 50% (volume) treatment of a lake in 2012 and have not seen a single cabomba plant since. On the other hand, infestations in the Blue Mountains in NSW and Benalla in Victoria returned after absences of four and five years respectively. Also, environmental conditions are quite different with our water body having flow and the fact that nowhere else in Australia, besides the NT, does cabomba produce viable seed.

Experts advise that eradication cannot be declared until there is 'a very high level of confidence that cabomba cannot return through propagation from either vegetative fragments or seeds'. Ten years without detection is considered an appropriate timespan over which to attain this level of confidence. (It is on this basis that the Marlow Lagoon infestation is deemed to be eradicated.)

Plate 16: Cabomba survey being undertaken after billabong treatment

Outcomes and recommendations

There has been a significant reduction in both cabomba density and location within the infestation area of Lok Landji due to the intensified chemical control, with minimal off-target impacts.

No cabomba plants have been detected in Lok Landji since January 2017. While this is very encouraging, it is too early to declare cabomba eradicated from Darwin River. Eradication, relative to pest plants, is the total removal of a species and its propagules from an area so that it cannot recur unless introduced from external sources. For eradication to be achieved, no viable propagules (plant parts or seeds) can remain in the area or be allowed to return.

Experience interstate has shown that, post active control measures and a subsequent period of five years with no detection, cabomba can return. The plant's rapid growth rates and ability to produce viable seed would likely facilitate complete recovery within one to two years if plant parts or seeds remain. Intensive efforts to detect and destroy any surviving plants in Darwin River must therefore be continued.

Treatment Zone B will require treatment in 2018 and again in 2019 if needed (herbicide drift from the A Zone has already had an effect). Cabomba surveys, river flow and turbidity levels in the 2018 dry season will determine when this herbicide can be applied and whether a follow-up treatment will be required.

Continued enforcement of the quarantine area around Lok Landji is also required to protect the Territory from inadvertent spread of this high biosecurity risk during ongoing treatment.

However, consideration could be given to lifting the quarantine area upstream of Lok Landji, where cabomba has not been detected for over 10 years. The WMB is confident that cabomba has been eradicated from this stretch of Darwin River.

Table 2 summarises the proposed management program for 2018 with ongoing investment in the longer term focused on survey.

Map 4 shows the stretch of Darwin River over which the quarantine area could be lifted, between Old Bynoe and Leonino Roads, Darwin River (shown cross-hatched in grey).

Table 2: Proposed action post-2017/18 (refer to Map 2 for Zone information)

	2018	2019 Onwards	2027
January	High rains, turbidity and river flow	High rains, turbidity and river flow	
February	Quarantine zone lifted (upper section)		
Mach			
April			
May	Survey	Survey	Survey
June	Chemical application Zone B		Quarantine zone lifted (lower section)
July			
August	Survey	Survey	
September			
October			
November	Survey	Survey	
December			

Map 4 (overpage): Stretch of Darwin River over which the quarantine area could be lifted

Quarantine Area to Manage Cabomba (*Cabomba caroliniana*)