Northern Territory Government

DEPARTMENT OF
NATURAL RESOURCES, ENVIRONMENT, THE ARTS AND SPORT

Northern Territory

Cabomba Eradication Program 2007/08 June 2009

Northern Territory Cabomba Eradication Program 2007/08

Department of Natural Resources, Environment, The Arts and Sport
PO Box 496
Palmerston NT 0831

Disclaimer:

The information contained in this report comprises general statements based on scientific research and monitoring. The reader is advised that some of the information may be incomplete or unable to be applied in areas outside the Darwin River region. Some information may be superseded by future scientific studies, new technology and/or industry practices.

ISBN 0978-1-921519-35-2
Front cover: *Cabomba caroliniana*

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1. Introduction

Cabomba caroliniana (cabomba) is a fully submerged, aquatic plant native to South America. Cabomba was first recorded in Australia in 1967, probably introduced through the aquarium industry trade.

Since its introduction to Australia, cabomba has become established in various water storage facilities, farm dams and river systems in an area extending from Victoria to the Charters Towers/Townsville region in Queensland. Cabomba is often problematic in irrigation drains and channels where low flow rates facilitate rapid development and spread. Cabomba was first recorded in the Northern Territory (NT) in 1996.

Cabomba is a declared Weed of National Significance (WoNS species). The Northern Territory *Weeds Management Act*, administered by the Department of Natural Resources, Environment, the Arts and Sport (NRETAS), declares all plants within the genus *Cabomba* as Class A (to be eradicated) and Class C (not to be introduced to the NT).

Nationally, cabomba has proven to be a very difficult weed to effectively manage once established because of the rate at which it grows, the plant's ability to spread rapidly and the difficulty of managing off-target impacts.

The Cabomba Threat

Cabomba is a fast growing plant. Growth appears to positively correlate to increasing light, high temperature and elevated nutrients. These requirements indicate that most freshwater bodies in the Top End would be susceptible including floodplains, backflow billabongs and water reservoirs, including Darwin River Dam.

Infestations interstate have clearly demonstrated cabomba's capacity to reduce aquatic biodiversity and ecosystem functioning, adversely affect water quality, reduce water storage capacity of dams, block water distribution infrastructure, severely impede recreational activities, including fishing and boating and create habitat suitable for mosquito breeding.

Cabomba spreads readily. Floating stem fragments, as short as one cm, with only a pair of leaves can take root and grow into new plants. Large infestations are also able to produce vast quantities of seed. Anything that moves through the water, including fishing lures, boats, trailers, outboard motors and animals, can act as vectors for the movement of either plant fragments or seeds.

As a result of these issues and associated costs, management programs in most jurisdictions target impact reduction rather than eradication. Given the currently limited range of cabomba in the NT, the enormous potential range and scope for extensive environmental, social and economic impacts (including the possible need to establish a drinking water supply treatment facility, in the event that Darwin River Dam became infested with cabomba), eradication was established as a priority.

Cabomba in the NT

Cabomba was first recorded in the NT in 1996 at Marlow's Lagoon, Palmerston. After multiple unsuccessful attempts at physical control, over a period of several years, a single application of the herbicide, *Agricrop Rubbervine Spray* (active ingredient 2,4-D-n-butyl ester) eradicated the weed from this isolated water body.

On 21 October 2004 the same species was reported and subsequently positively identified in the Darwin River area. Subsequent surveys identified cabomba at several locations along an 11 km stretch of the river. Chemical management of the Darwin River infestation commenced in November 2004 and provided satisfactory 'knock down' control results. The germination of seed after the 2004/2005 wet season however resulted in the plant's re-establishment in multiple locations within Lok Landji Billabong.

An awareness campaign was launched following the discovery of cabomba at Darwin River which resulted in a number of cabomba populations being identified in confined urban aquariums and ponds. Notably, in December 2004, a resident of Pine Creek reported that cabomba was regenerating from seed in a fish pond. Cabomba plants were persisting despite the pond having been drained the previous month and the weed removed. Weed Management Officers visited the property and found seeds attached to the roots of seedlings pulled from the soil. This was the first evidence of viable seed production in Australia.

The Task Force

When cabomba was discovered in Darwin River in 2004, a taskforce was formed to direct, coordinate and oversee the Cabomba Eradication Program. Stakeholder groups, including Amateur Fisherman's Association of the Northern Territory (AFANT), Local Government and the NT Environment Centre were consulted.

The Cabomba Taskforce disbanded in October 2007 and was replaced with the Cabomba Reference Group comprising government and community representatives. The Reference Group continues to provide support, guidance and encouragement for the eradication program and management of the quarantine zone.

Darwin River Quarantine

To minimise the chance of cabomba being spread further, the infested section of Darwin River was placed under quarantine in 2004 for a period of two years (until 8 November 2006), in accordance with section 21 of the *Weeds Management Act*. This was later extended until 8 November 2008. The area quarantined comprises the section of Darwin River between Cox Peninsula Road and Leonino Road.

The quarantine order prohibits the movement of people or any object, including boats, vehicles and fishing equipment, into or out of this section of river and the 5 metres of land adjacent to the water's edge, unless an appropriate permit has been obtained from NRETAS.

Vehicles are not to pass over causeways at Old Bynoe Road or Reedbeds Road if the river is flowing over these causeways. Non-compliance of this order is an offence with a maximum penalty of $50 000 for individuals and $250 000 for a body corporate. Minimum penalties of $5 000 or $25 000 respectively also apply.

Surveillance

Early detection of any new infestations is a vital part of the eradication program. NRETAS Weed Management Branch regularly monitors susceptible water bodies in the region including:

- unaffected reaches of the Darwin River;
- sections of the Blackmore River;
- Berry Springs Nature Reserve;
- Howard Springs Nature Reserve;
- McMinns Lagoon;
- Fairway Waters;
- Girraween Lagoon;
- Darwin River Dam;
- Manton Dam;
- Marlow Lagoon; and
- Knuckey Lagoon.

2. Purpose of the NT Cabomba Eradication Program

Overall the purpose of the Cabomba Eradication Program is to eradicate all known infestations of *Cabomba caroliniana* from the NT, and to prevent all future introductions of plants within the genus to the NT.

Seven specific objectives have been identified which guide the project and provide an avenue for monitoring and evaluation. This report details how each of these objectives were addressed during the 2007/08 reporting period.

3. Report against Project Objectives

This section of the report is broken into four components which address prevention of further introduction of cabomba, the active control program, the seed research program and the various monitoring programs. Within these four sections, seven project objectives are reported against.

3.1 Prevention of further introduction

Objective 1: Prevent all future introductions of plants within the genus Cabomba *to the NT.*

During 2007/08 NRETAS Weed Management Officers visited and provided information to nurseries and aquatic plant retailers detailing the prohibition of import and subsequent sale of cabomba in the NT. It was noted that at this time no retailers were selling the plant. Significant effort was made with regards to increasing public awareness of cabomba (See 3.3 below).

3.2 Active Control Program

*Objective 2: Eradicate all known infestations of the aquatic weed cabomba (*Cabomba caroliniana*) from the NT.*

Objective 3: Prevent re-establishment of plants within the genus Cabomba *at all sites where it has previously been recorded and subsequently been treated and/or removed.*

Objective 4: Prevent the production of seed from all sites where cabomba is currently found.

Options available for reducing cabomba populations include biological control, water level manipulation, shading, physical removal of plants and herbicide application.

Water level manipulation and physical removal

To date, water level manipulation and physical removal have failed to eliminate major cabomba infestations in the NT or elsewhere in Australia. In the case of the Darwin River site, water level manipulation and physical removal are not viewed as viable options due to the extent of the waterbodies the location of the infestation and potential presence of saltwater crocodiles.

Biological control

It takes many years to comprehensively assess the suitability of potential biological control agents for weed control in Australia. CSIRO are in the process of assessing the suitability of several host-specific insects for use in cabomba control. Immediate risks in the Northern Territory ruled out waiting for biological control research.

Effective dilution and application of 2,4-D to Darwin River.

Target herbicide concentration: 10,000 g of 2,4-D ester per megalitre of water

Product chemical concentration : 800g active (2,4-D ester) per litre of raw product.

Label requirement: 12.5 L product + 5 kg diatomaceous earth mixed in 200 L water per a megalitre of water.

1 megalitre = 1,000,000 litres of water. This is calculated through a combination of water depth and surface area.

10,000 g of product per megalitre =1g per 100 litres of water.

1g per 100 litres of water =10 mg per litre of water.

Actual herbicide application is calculated considering water depth, width of spray boom/number of spray nozzles, speed of boat and pump rate (litre/min)

Herbicide control

The application of *AF Rubbervine Spray* or *Agricrop Rubbervine Spray* (2,4-D-n-butyl ester, 800g/L active ingredient) under a permit issued by the APVMA was the only chemical control option as no other suitable products are available. 2,4–D-n-butyl ester functions as a systemic herbicide and is used to control many types of weeds. It is used internationally in cultivated agriculture, rangeland applications and to control aquatic vegetation.

The Australian Pesticides and Veterinary Medicines Authority (APVMA) is the national independent regulator of pesticides and veterinary chemicals. As 2,4–D-n-butyl ester is not a registered herbicide for cabomba, any usage of 2,4–D-n-butyl ester can only be made with the successful application of an off-label permit from APVMA for use of the product, *Agricrop* or *AF Rubbervine spray*.

Comprehensive testing of 2,4-D-n-butyl ester has demonstrated that continued, direct exposure or ingestion can harm humans and animals. (See Appendix D for further explanation of possible off-target impacts). In aquatic environments, 2,4–D-n-butyl ester is broken down by micro-organisms. Increased nutrients, sediment load, high levels of oxygenation and dissolved organic carbon are conducive to more rapid breakdown.

The 1996 Australian Drinking Water Guidelines (Australian Government, 2004) contain specific recommendations for concentrations in potable water. The Guidelines state, “2,4-D should not be detected in drinking water”. If present in drinking water, 2,4-D would not be a health concern unless the concentration exceeded 0.03mg/L. If detected then remedial action should be taken to stop contamination.” The Health Value of 0.03mg/L in drinking water is derived from the Australian ADI (acceptable daily intake based on daily lifetime exposure) of 0.01mg/kg/day for a 70kg adult with an average water consumption of 2 L/day.

Given earlier experience, continued use of 2,4-D-n-butyl ester remained the preferred management option and NRETAS applied successfully for an off-label permit to continue use of the herbicide during 2007/08. The permit for use of 2,4-D-n-butyl ester stipulates spot application directly into cabomba infestations. Submerged nozzles are used to apply a mixture of the product and diatomaceous earth. This light silica soil absorbs the herbicide and makes it less mobile. This method of application ensures that the control is as targeted as possible and minimises extent of herbicide spread. Herbicide is applied in the dry season when water is clear and water flow is minimal. A high degree of sub-surface visibility is essential for targeted application and minimal flow means the herbicide will remain in the required area for sufficient time to control target plants. Preferentially the herbicide should be applied prior to flowering, to prevent any seed production.

The herbicide is not allowed to be used in potable water supplies. This fact is one of the main drivers for effective control of cabomba, so it does not reach Darwin River Dam. For this reason an alternate water supplies was provided by the Northern Territory Government to those who depended on Darwin River for drinking water and for horticulture irrigation.

In 2007/08 chemical management of the Darwin River cabomba infestation involved applying 2,4–D-n-butyl ester to limited infestations in the Lok Landji Billabong. Chemical treatment for the reporting period commenced on 17 July 2007 with an initial application of 3.5 litres of herbicide.

Table 1: Application of 2,4–D-n-butyl ester to Cabomba populations: Lok Landji Billabong 2007/08

Date	Volume Applied
17-Jul-07	3.5 litres
7-Aug-07	2.5 litres
21-Sep-07	3.0 litres
19-Oct-07	4.0 litres
28-Oct-07	3.5 litres
03-Nov-07	4.5 litres
12-Nov-07	3.5 litres
19-Nov-07	5.0 litres
26-Nov-07	4.5 litres
07-Dec-07	5.5 litres
14-Dec-07	9 litres
17-Dec-07	12 litres
21-Apr-08	500 mls
29-Apr-08	2 litres
15-May-08	3 litres
23-May-08	3 litres
3-Jun-08	1.5 litres

All application of 2,4-D-n-butyl ester was in accordance with the standards imposed by the APVMA, with specific reference to location, concentration, application technique and frequency of application. The application regime at Darwin River, as determined by the off-label permit, was not expected to have a significant impact on the ecology of Darwin River, given the highly targeted mode of application. Precautions, including the provision of an alternate water supply where necessary and a comprehensive communication program, ensured no impact to human health or industry eventuated.

On-site inspections conducted during 2007/08 estimated that infestation levels in Lok Landji Billabong were at a level less than 1% of those found in November 2004 at all times. No cabomba has been found in any area upstream or downstream of Lok Landji since 2005/06. These inspections continue to support observations that flower and seed production have effectively been prevented at all sites since the 2004/05 reporting period.

Shading and Booms

All shading and floating "booms" were removed at the end of the 2006 dry season prior to the commencement of high wet season flows. These were not replaced in the 2007 and 2008 dry seasons as cabomba did not reappear at any site upstream of Lok Landji Billabong.

Capacity Building – NRETAS staff and public

Staff training continued to be recognised as a vital component of addressing Objectives 2, 3 and 4. Constant communication has also been maintained with interstate government agencies to ensure NRETAS staff have access to the most up to date information. All staff have been involved in regular inspections of all previously recorded sites.

3.3 Public Awareness and Education Strategy 2007/08.

Objective 5: Educate the NT community as to the identification of plants within the genus Cabomba *and their potential negative impacts.*

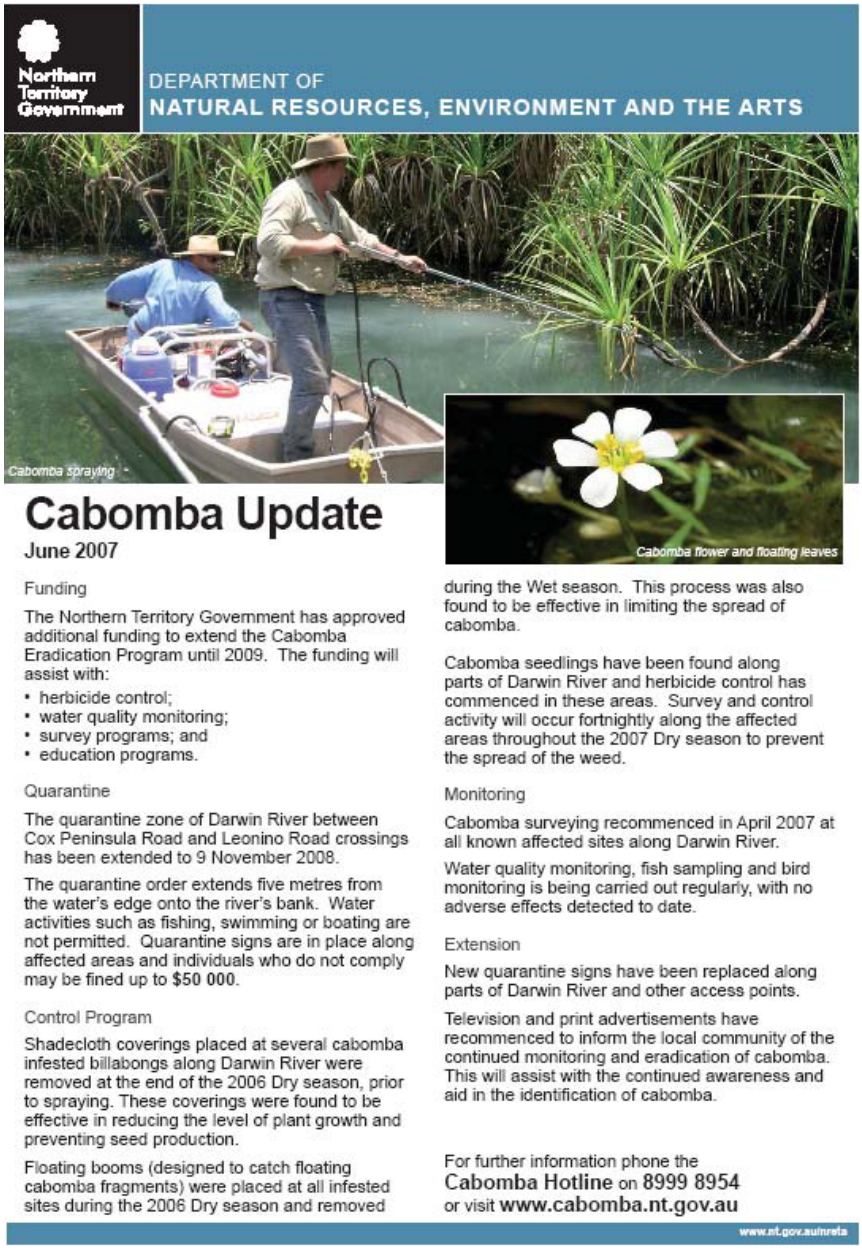
NT Cabomba Eradication Communication Strategy

A Communication Strategy was developed in 2004 as an integral part of the NT Cabomba Eradication Program. This strategy was developed through significant consultation with all stakeholders.

In 2007/08 the program included:

- the production of media releases communicating eradication efforts;
- TV advertisements;
- quarantine awareness advertisements;
- information sites at shows and field days;
- website information;
- on-site quarantine signage;

- the continued administration of the *Cabomba Hotline*, allowing members of the public to contact NRETAS Weed Management Officers as required; and
- dissemination of water quality monitoring results (herbicide levels) in Darwin River, with particular reference to observed impacts on the Darwin River ecosystem and aquaculture establishments as necessary.



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Cabomba spraying

Cabomba flower and floating leaves

Cabomba Update

June 2007

Funding

The Northern Territory Government has approved additional funding to extend the Cabomba Eradication Program until 2009. The funding will assist with:

- herbicide control;
- water quality monitoring;
- survey programs; and
- education programs.

Quarantine

The quarantine zone of Darwin River between Cox Peninsula Road and Leonino Road crossings has been extended to 9 November 2008.

The quarantine order extends five metres from the water's edge onto the river's bank. Water activities such as fishing, swimming or boating are not permitted. Quarantine signs are in place along affected areas and individuals who do not comply may be fined up to **$50 000**.

Control Program

Shadecloth coverings placed at several cabomba infested billabongs along Darwin River were removed at the end of the 2006 Dry season, prior to spraying. These coverings were found to be effective in reducing the level of plant growth and preventing seed production.

Floating booms (designed to catch floating cabomba fragments) were placed at all infested sites during the 2006 Dry season and removed during the Wet season. This process was also found to be effective in limiting the spread of cabomba.

Cabomba seedlings have been found along parts of Darwin River and herbicide control has commenced in these areas. Survey and control activity will occur fortnightly along the affected areas throughout the 2007 Dry season to prevent the spread of the weed.

Monitoring

Cabomba surveying recommenced in April 2007 at all known affected sites along Darwin River.

Water quality monitoring, fish sampling and bird monitoring is being carried out regularly, with no adverse effects detected to date.

Extension

New quarantine signs have been replaced along parts of Darwin River and other access points.

Television and print advertisements have recommenced to inform the local community of the continued monitoring and eradication of cabomba. This will assist with the continued awareness and aid in the identification of cabomba.

For further information phone the
Cabomba Hotline on **8999 8954**
or visit **www.cabomba.nt.gov.au**

www.nt.gov.au/nreta

Plate 1: Cabomba update brochure 2007.

3.4 Seed research program 2007/08

Objective 6: Determine the viability and longevity of Cabomba seed in the NT.

An increased understanding of cabomba reproduction in the NT's environments will greatly benefit continued management, eradication and monitoring programs.

Seed Research

Seed production research was not continued during 2007/08 as potential production levels were ascertained during 2005/06.

Seed Viability

Seed viability research was not undertaken during 2007/08 as seed viability was determined during 2005/06.

3.5 Monitoring potential off-target impacts

Objective 7: Monitor the impacts of all management activities and provide an 'early warning' mechanism in order to avoid potential off-target impacts to the environment, community and industries of the NT.

The significant implications of further *Cabomba* infestations in the NT were key factors in the Task Force's decision to attempt to control *Cabomba* with herbicide in 2004. The use of the herbicide required that a program monitoring was established to assess the impacts of the herbicide use and guide management response to protect the important public values and uses of the Darwin River environment.

In 2007/08 monitoring included:

- surface water quality assessments included testing for 2,4-D-n-butyl ester, and dissolved oxygen;
- macro-invertebrates as biological indicators of river health; and
- Avian surveys.

Appendix A provides a brief overview of the monitoring programs and findings.

3.5.1 Water quality monitoring program

Surface water samples were collected from two sites, identified as Sites AB and C, for analysis of the herbicide 2,4-D-n-butyl ester. Site locations are described below and shown in Figure 1.

- Site AB is in the lower freshwater reach of Darwin River below all infestations of Cabomba; and
- Site C is downstream of the Darwin-Blackmore Rivers confluence adjacent to the intake for an aquaculture operation.

Water quality sites were rationalised as a consequence of the limited extent of *Cabomba* in 2008 and the lack of 2,4-D detection in previous years in addition to the reduced herbicide application. Two additional sites would be monitored if herbicide was detected at Site AB and the monitoring regime and response to the detection of the 2,4-D-n-butyl ester would follow the 'Adaptive assessment approach' outlined in Appendix B and formerly described in the 2006-07 public report.

Figure 1: 2007-08 water quality monitoring sites Darwin river

It was predetermined that if the concentration of 2,4-D-n-butyl ester exceeded a 'trigger value' concentration of 1.0 mg/L at Site AB, action would immediately be taken to prevent any further increase (e.g. reduce/cease application volumes) or spread to downstream areas. Action would also be taken if herbicide was detected at Site C.

Analyses of water samples were carried out at DPIFM laboratory, Berrimah where the detection limit or minimum detectable concentration was 0.02 mg/L for the herbicide 2,4-D-n-butyl ester.

Volumes of herbicide being applied would be reassessed if sampling at Site AB recorded concentrations of 2,4-D > 1 mg/L , or if 2,4-D was detected at Site C.

Physical chemical parameters were found to be within the recommendations for the Darwin Region Water Quality Objectives (Fortune, 2009). Electrical Conductivity (EC), Turbidity and Dissolved Oxygen varied considerably (Table 2) and are typically a result of tidal influences, freshwater runoff or altered flows.

The herbicide 2,4-D-n-butyl ester was detected on one occasion at the Darwin River monitoring site AB in the 2008 year. On the 13/06/2008 a sample registered 0.04mg/L (Table 2). A follow up sample was carried out within 24 hours however the second sample was unable to detect any chemical presence above 0.02 mg/L. This departure was not regarded as a threat to the aquatic ecosystems as the sample remained below the trigger value of 1 mg/L. There was no detectable herbicide found down stream at Site C on the Blackmore River for this sampling event.

Table 2: Water monitoring schedule, physical water quality parameters and results for 2,4-D-n-butyl ester testing at Darwin River monitoring sites May to December 2008

Date sampled	G code	Sample code	Lab no.	2,4-D mg/L detection limit 0.02	Turbidity (NTU's)	pH	EC (us/cm)	DO (mg/L)	Temp ˚C	DO % saturation (calculation)
23/05/2008	G8155644	AB002	R08 0097	<0.02	2.61	n/a	n/a	n/a	n/a	n/a
30/05/2008	G8155644	AB003	R08 0107	<0.02	1.79	7.53	316	6.8	22.7	78.82
30/05/2008	G8155646	C002	R08 0108	<0.02	18	7.69	42483	5.48	24.61	77.51
06/06/2008	G8155644	AB004	R08 0115	<0.02	6.7	7.1	15607	5.32	25.17	75.85
13/06/2008	G8155644	AB005	R08 0124	0.04	1.81	7.23	477.5	8.12	24.86	98.01
13/06/2008	G8155646	C003	R08 0125	<0.02	23.8	7.28	44601	7.48	25.41	91.20
20/06/2008	G8155644	AB006	R08 0134	<0.02	n/a	7.2	5184	5.5	25.55	67.23
26/06/2008	G8155644	AB 007	R08 0144	<0.02	2.03	7.5	494	7.2	24.8	86.81
26/06/2008	G8155646	C 004	R08 0145	<0.02	n/a	7.45	48655	5.54	24.24	66.10
04/07/2008	G8155644	AB008	R08 0151	<0.02	n/a	7.35	18347	5.06	24	60.11
11/07/2008	G8155644	AB 009	R08 0157	<0.02	n/a	n/a	n/a	n/a	n/a	n/a
11/07/2008	G8155646	C005	R08 0158	<0.02	n/a	n/a	n/a	n/a	n/a	n/a
18/07/2008	G8155644	AB009	R08 0177	<0.02	2.02	7.41	1978	6.27	23.3	73.51
24/07/2008	G8155644	AB010	R08 0170	<0.02	1.99	7.76	3203	7.21	25.11	87.43
24/07/2008	G8155646	COO6	R08 0171	<0.02	28	7.28	56752	5.41	30.39	72.05
08/08/2008	G8155644	AB013	R08 0185	<0.02	n/a	n/a	n/a	n/a	n/a	0.00
08/08/2008	G8155646	C008	R08 0186	<0.02	n/a	n/a	n/a	n/a	n/a	0.00
15/08/2008	G8155644	AB014	R08 0197	<0.02	n/a	7.65	1322	7.92	21.9	90.41
22/08/2008	G8155644	AB015	R08 0206	<0.02	n/a	6.87	25759	5.4	24.67	64.95
22/08/2008	G8155646	C009	R08 0207	<0.02	n/a	7.19	63914	5.8	24.77	69.89
28/08/2008	G8155644	AB016	R08 0212	<0.02	2.21	7.31	1581	6.66	25.39	81.18
05/09/2008	G8155644	AB017	R08 0247	<0.02	3.1	7.12	27458	4.43	27.41	56.00
05/09/2008	G8155646	C10	R08 0248	<0.02	16.7	7.28	40802	6.22	28.22	79.77
12/09/2008	G8155644	AB018	R08 0249	<0.02	n/a	7.79	2489	6.74	29.71	88.72
19/09/2008	G8155644	AB019	R08 0300	<0.02	n/a	7.32	26365	4.27	29.32	55.83
19/09/2008	G8155646	C011	R08 0301	<0.02	n/a	n/a	n/a	n/a	n/a	n/a
28/09/2008	G8155644	AB020	R08 0302	<0.02	3.78	7.65	34433	n/a	28.47	n/a

Date sampled	G code	Sample code	Lab no.	2,4-D mg/L detection limit 0.02	Turbidity (NTU's)	pH	EC (us/cm)	DO (mg/L)	Temp ˚C	DO % saturation (calculation)
03/10/2008	G8155644	AB021	R08 0303	<0.02	n/a	7.3	25973	5.17	29.85	68.22
03/10/2008	G8155646	C013	R08 0304	<0.02	n/a	7.56	57107	4.8	30.3	63.83
10/10/2008	G8155644	AB022	R08 0317	<0.02	3.89	7.98	3674	5.43	28.06	69.44
17/10/2008	G8155644	AB023	R08 0356	<0.02	n/a	n/a	n/a	n/a	n/a	n/a
17/10/2008	G8155646	C014	R08 0357	<0.02	n/a	n/a	n/a	n/a	n/a	n/a
24/10/2008	G8155644	AB024	R08 0389	<0.02	n/a	n/a	n/a	n/a	n/a	n/a
31/10/2008	G8155644	AB025	R08 0390	<0.02	13.1	7.22	21950	4.32	30.62	57.77
07/11/2008	G8155644	AB026	R08 0434	<0.02	5.29	n/a	n/a	n/a	n/a	n/a
14/11/2008	G8155644	AB027	R08 0435	<0.02	9.69	7.36	17990	5.02	31.24	67.84
17/11/2008	G8155646	C016	R08 0436	<0.02	33.5	7.56	57255	5.41	31.12	72.96
21/11/2008	G8155644	AB028	R08 0437	<0.02	6.78	7.78	1061	5.44	30.03	72.01
28/11/2008	G8155644	AB029	R08 0454	<0.02	7.61	7.58	3185	5.56	30.87	74.66
28/11/2008	G8155646	C017	R08 0455	<0.02	96.9	7.38	30.5	7.08	30.01	93.68
05/12/2008	G8155644	AB030	R08 0456	<0.02	5.84	7.17	1.71	5.29	30.8	70.95
12/12/2008	G8155644	AB031	R08 0460	<0.02	9.5	7.21	0.341	5.04	29.11	65.65
19/12/2008	G8155644	AB032	R08 0461	<0.02	38.2	6.83	490	6.35	27.2	79.97
19/12/2008	G8155646	C018	R08 0462	<0.02	23.2	6.9	10680	6.03	27.55	76.42

3.5.2 Biological monitoring

3.5.2.1 Macroinvertebrate Assessment

To evaluate the impact of the herbicide application on the river's health after the wet season, the macroinvertebrate community was monitored in the early dry season at site DW47 (Figure 1) before the application of the herbicide. This has been a regular monitoring site since 2002. Due to the restricted extent of *Cabomba* in 2008, sampling was rationalised and undertaken at two control sites (CON1 and CON2) and the one impacted site, Lok Landji Billabong (IMP1). The analysis of this monitoring was undertaken using the AUSRIVAS methodology as previous applied (Lamche 2006, Lamche 2007). The results of monitoring for the years 2007 and 2008 are reported in the following section.

Materials and Methods

Macroinvertebrate sampling was carried out in June and October 2008 according to the Darwin Daly region AUSRIVAS manual (Lamche 2007). Briefly, one operator disturbed the edge habitat with a rake while a second person collected the sample from the disturbed substrate and adjacent water column using a sweep net. Abiotic parameters were measured *in situ* and water samples for alkalinity were collected and analysed in the laboratory.

The samples were sorted and identified in the laboratory and analysed using the 'Darwin Daly region-early dry season–edge habitat–family level AUSRIVAS model'. Results were calculated as OE50 score, displaying the number of Observed to the number of Expected or predicted taxa if the site was similar to reference condition. The OE50 score is assigned to a band, which enables easy interpretation of the results (Table 3):

Table 3: The bands provided through AUSRIVAS

Band	Description	Interpretation
X	More biologically diverse than reference	More families found than expected. Potential biodiversity "hot-spot" or mild organic enrichment. Continuous irrigation flow in a normally intermittent stream.
A	Similar to reference	Expected number of families within the range found at 80% of the reference sites. Reference sites are defined as pristine or least disturbed.
B	Significantly impaired	Potential impact either on water and/or habitat quality resulting in a loss of families.
C	Severely impaired	Many fewer families than expected. Loss of families from substantial impairment of expected biota caused by water and/or habitat quality.
D	Extremely Impaired	Few of the expected families and only the hardy, pollution tolerant families remain. Severe impairment.

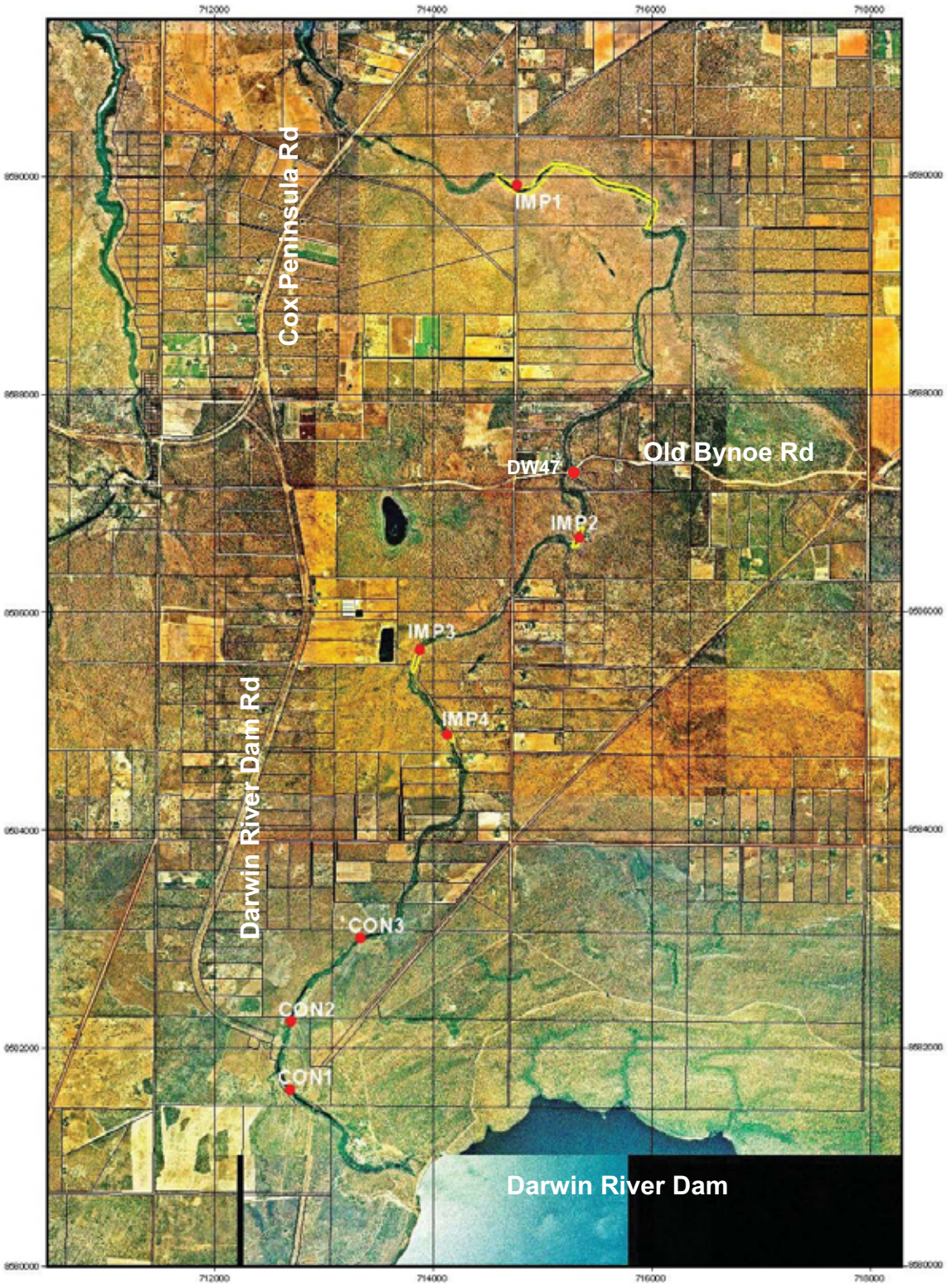

Figure 2: Aerial photograph of the Darwin River. The locations where Cabomba was detected in 2004 are marked yellow. Macroinvertebrate sample sites are shown in red. Lok Landji billabong is located at site 'IMP1'.

Results and Discussion

Long-Term Monitoring Site Assessment

The results of the AUSRIVAS analysis using the family level model are presented in Table 4 and compared to the preceding years for historical site DW47 (Upstream of Lok Landji Billabong). Although there is some variability on the OE50 score over the years, there is no observable trend and the scores are classed as Band A throughout the monitoring period.

Table 4: Regular AUSRIVAS monitoring data for the site DW47; Darwin Daly region-early dry season–edge habitat–family level AUSRIVAS model

	2002	2003	2004	2005	2006	2007
OE50	1.10	0.87	Not	1.00	1.11	0.99
Band	A	A	sampled	A	A	A

Note: 2008 data to be modelled – no departure from previous years is expected.

Impacted and Control Site Assessment

As a consequence of the limited extent of *Cabomba* only three sites were sampled in 2008 in addition to the longer term site established upstream (DW47). The three sites sampled were (Figure 1):

- *Control site 1* is located on the Darwin River 470 metres upstream of the Darwin River Road causeway.
- *Control site 2* is located 370 metres downstream of the Darwin River Road causeway.
- *Impacted site 1* is located at the Reedbeds Road crossing.

Two analytical approaches were adopted in 2008. Firstly, the Darwin-Daly genus level AUSRIVAS model was used to generate condition scores (OE50 scores). Secondly, ordination methods were used to compare the composition of macroinvertebrate communities of test sites and those of monitoring sites throughout the Darwin region in the early dry season of 2007 (Dostine 2009).

Results of AUSRIVAS modelling (Table 5) suggest that the macroinvertebrate communities of impacted and control sites are equivalent to reference condition, and there is no evidence of significant ecological impairment.

Table 5. Results of AUSRIVAS modelling of macroinvertebrate community structure at 10 sites in Darwin region streams

Site code	Site name	Sample date	OE50	Band
DW21	Rapid Creek, u/s v-weir	17-May-07	0.41	C
DW23	Mitchell Creek, d/s Lambrick Ave drain	18-May-07	0.64	B
DW26	Bee's Creek at Horne Road Crossing	16-May-07	0.9	A
DW31	Berry Creek, u/s road crossing	14-May-07	0.82	B
DW37	Peel Creek, u/s road crossing	11-May-07	0.96	A
DW40	Elizabeth River, u/s gauging station	16-May-07	0.66	B
DW47	Darwin River, d/s Old Bynoe Road Crossing	06-Jun-07	0.99	A
DW57	Darwin River, Control site 1*	28 Oct 08	0.99	A
DW58	Darwin River, Control site 2*	28 Oct 08	1.07	A
DW63	Darwin River, Impact site 1*	28 Oct 08	0.86	A

(*) Darwin River sites assessed in conjunction with the Cabomba eradication program

The results of MDS ordination present an equivalent description of site similarities, with some separation of the three Darwin sites from other sites (Figure 3). There is no clear gradient of disturbance in the ordination space (Dostine 2009).

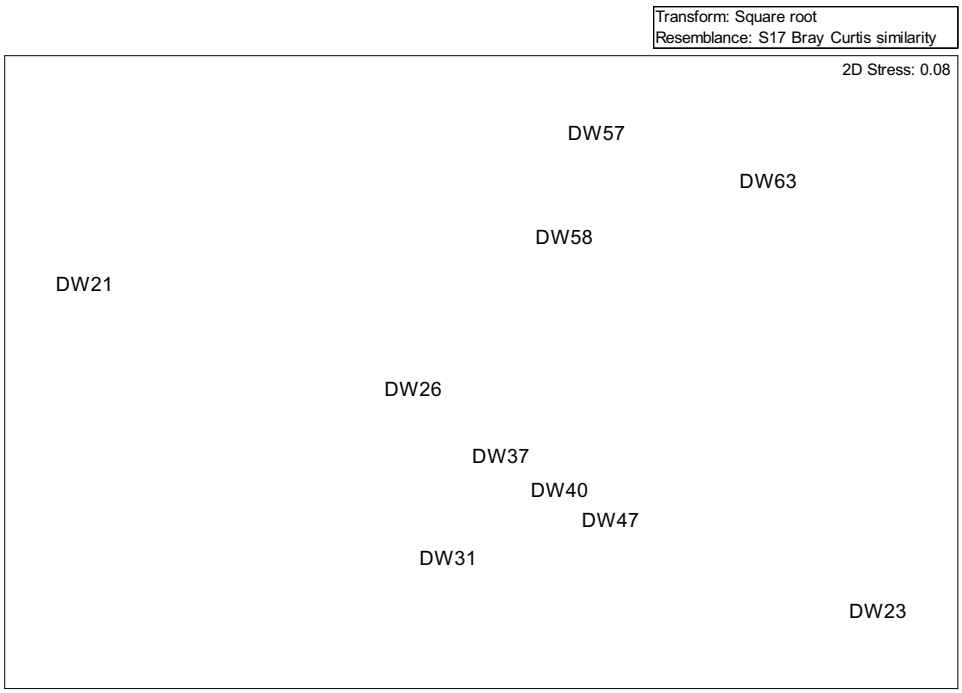

Figure 3. MDS ordination of macroinvertebrate community structure at seven sites in the Darwin streams sampled in early dry 2007, and 3 sites on Darwin River sampled in late dry 2008. DW57 and DW58 = upstream sites; DW63 = impacted site

Conclusions

These assessments failed to detect large and obvious differences between macroinvertebrate indices of impacted sites and those of spatial and temporal control sites, and concluded that there were no significant impacts on these communities (and thus the ecological health of the Darwin River) following eradication measures for *Cabomba*.

Fauna monitoring program

Fauna surveys were initially undertaken in November and December 2004, pre and post treatment targeting birds, turtles and crocodiles. All survey results indicated no measurable impact on any populations occurred as a result of the application of 2,4-D to Darwin river. Further fauna (bird) survey occurred during the 2007/08 reporting period.

The bird survey conducted during the 2007/08 reporting period was aimed at detecting any changes in the abundance of four key bird species and species groups along three sections of the river where *C. caroliniana* occurs. This study aimed to be consistent with a survey by Price (2005) of bird responses to treatment at these sites in 2004.

The bird monitoring program followed the BACI design: Before-After Control-Impact (Bernstein and Zalinski, 1983, Underwood, 1993), which was the same design used by Price (2005) for the original bird surveys in 2004. In this case, “impact” refers to sites sprayed with 2,4-D herbicide, and “control” to similar sites not sprayed. Three impact and three control pools were surveyed (Table 6) and all were biophysically similar – between ten to 20 metres wide, two to four metres deep and densely lined by vegetation dominated by *Pandanus aquaticus*. All of the control pools were located upstream of the impact pools (Figure 4). The surveys occurred on the 16th and 17th July 2008.

Each pool was subdivided into 200 m sections, as this is the approximate home range of the smaller birds (i.e. flycatchers and kingfishers). There were 18 sections in total throughout the control and impact pools, including six in the longest and one in the shortest. Each section was surveyed four times: once on the outward trip at dawn or dusk, the second on the return trip, and then repeated on a separate visit closer to midday on the same day. Travelling in a small boat at 1 km/hr with an electric motor, all birds observed within the riparian vegetation or in the water were recorded.

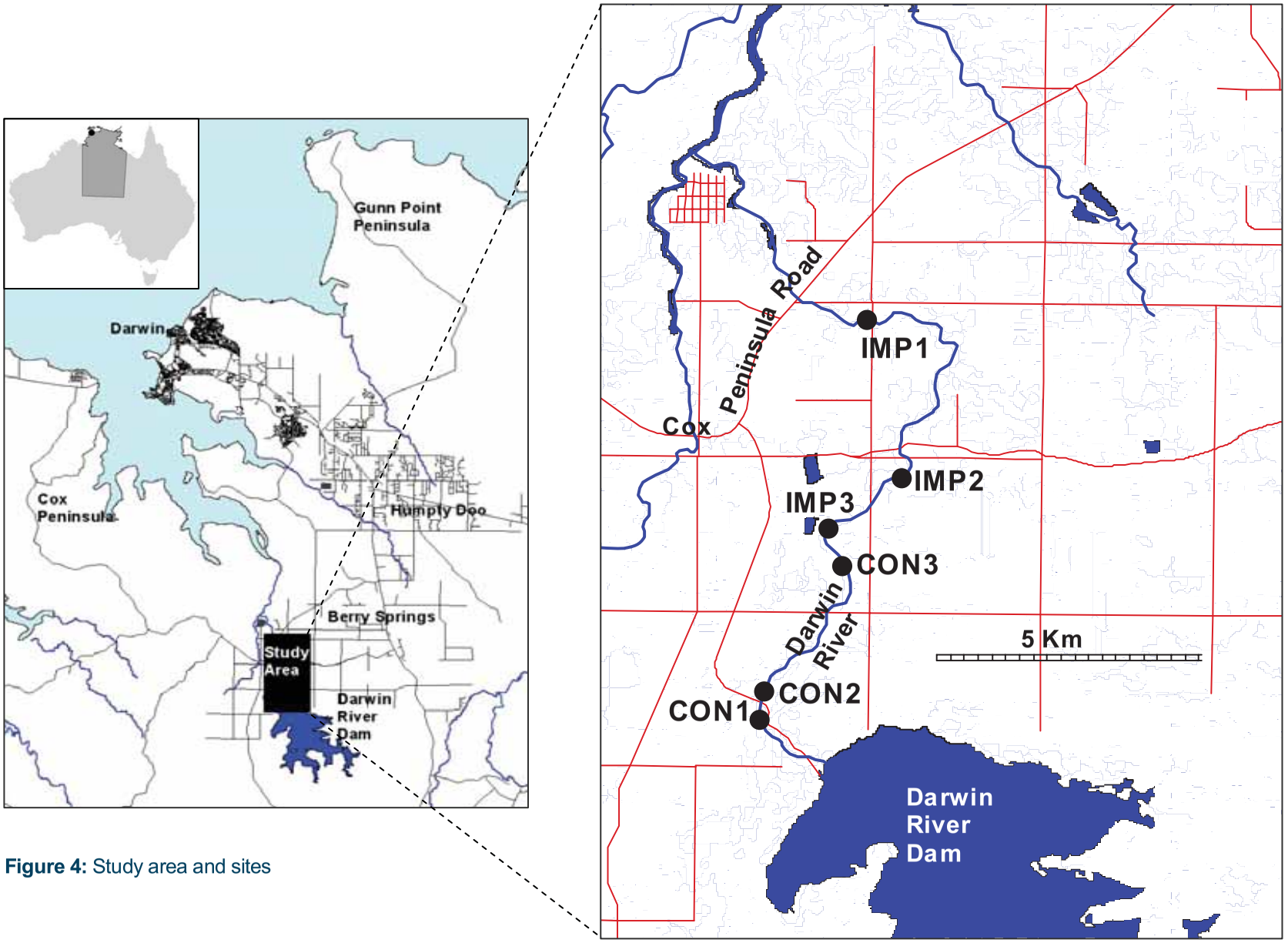

Figure 4: Study area and sites

Data were summarised as the total number of birds of each species recorded in the control and impact pools. The analysis focussed on four species and species groups - Shining flycatcher, all kingfishers, all herons and bitterns, and all cormorants and darters.

These were chosen because they are dependent on aquatic food (e.g. insects and fish) and occur in sufficient numbers for statistical analysis. Grouping was necessary because for most individual species there were too few records.

The analysis comprised the four surveys in each section as a sample, and each sample abundance was calculated as the total number of birds recorded per species. Data from the initial surveys in 2004 (before and after initial treatment) were included, and 95% confidence intervals of the mean were calculated for all data.

Table 6: Summary of sites

Site	Site name	Easting	Northing	Length (m)	No. sections	Notes
1	IMP1	714902	8590081	1200	6	Impact. Lok Landji Billabong (site of main infestation)
2	IMP2	715471	8586848	200	1	Impact
3	IMP3	714015	8585811	400	2	Impact
4	CON1	712823	8581779	600	3	Control. 1km downstream of Dam Wall
5	CON2	712819	8582403	600	3	Control
6	CON3			600	3	Control

Results

A total of 67 bird species with 1352 records were observed (Appendix C). A summary of results for the four species groups is shown in Table 8. The data from both surveys conducted in 2004 were incorporated into the analysis, seen in Table 9.

Table 7: Total abundance of bird groups in impact (IMP) and control (CON) pools in the 2008 survey

Species Group	No. observed in IMP sites	No. observed in CON sites	Total no. observed
Shining Flycatcher	27	22	49
Kingfishers (Azure / Little / Sacred)	8	14	22
Cormorant / Darter	1	7	8
Herons (Nankeen / Black Bittern)	11	7	18

Table 8: Comparison of data between the three surveys showing means of total abundances across all nine sections in each impact / control pool. 'Before', 'after 1' and 'after 2' are relative to the initial herbicide treatment in late November 2004.

Sampling period (date)	Species group	Impact	Control
Before (November 2004)	Shining Flycatchers	2.67	2.89
	Kingfishers	0.78	0.67
	Cormorants & darters	0.22	0.56
	Herons & bitterns	0.78	0.44
After 1 (December 2004)	Shining Flycatchers	3.11	5.44
	Kingfishers	0.67	1.89
	Cormorants & darters	0.11	0.67
	Herons & bitterns	1.22	0.11
After 2 (July 2008)	Shining Flycatchers	3.00	2.44
	Kingfishers	0.89	1.56
	Cormorants & darters	0.11	0.78
	Herons & bitterns	1.22	0.78

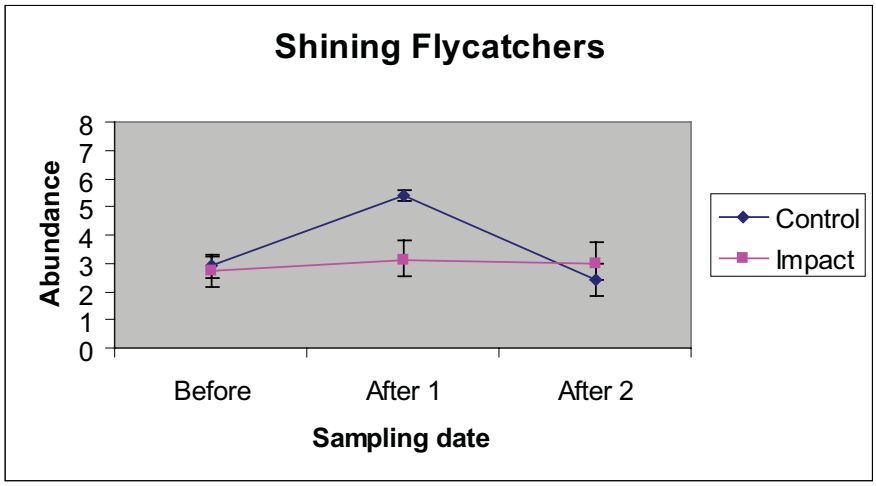

Figure 5: The mean of the total abundance per section of Shining Flycatchers in the control / impact sites from before the initial treatment ('before'), after the initial treatment ('after 1') and in 2008 ('after 2'). Whiskers denote 95% confidence interval.

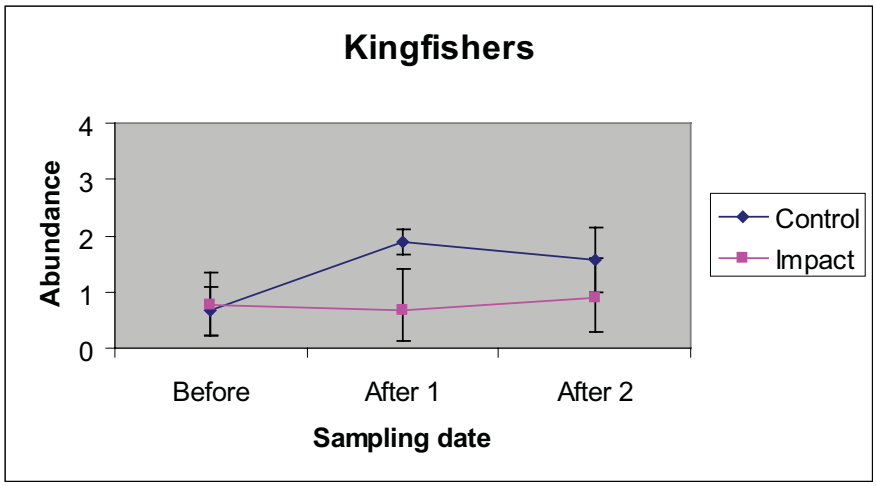

Figure 6: The mean of the total abundance per section of kingfishers in the control / impact sites across the three surveys. Whiskers denote 95% confidence interval.

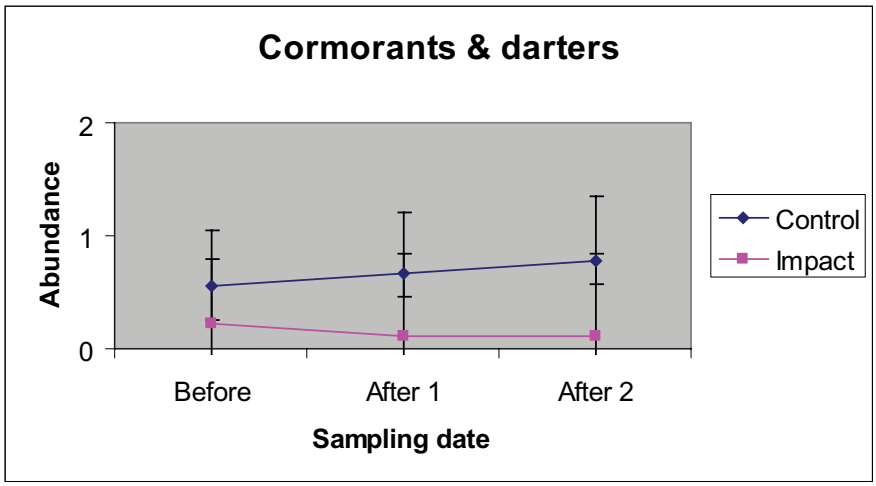

Figure 7: The mean of the total abundance per section of cormorants & darters in the control / impact sites across the three surveys. Whiskers denote 95% confidence interval.

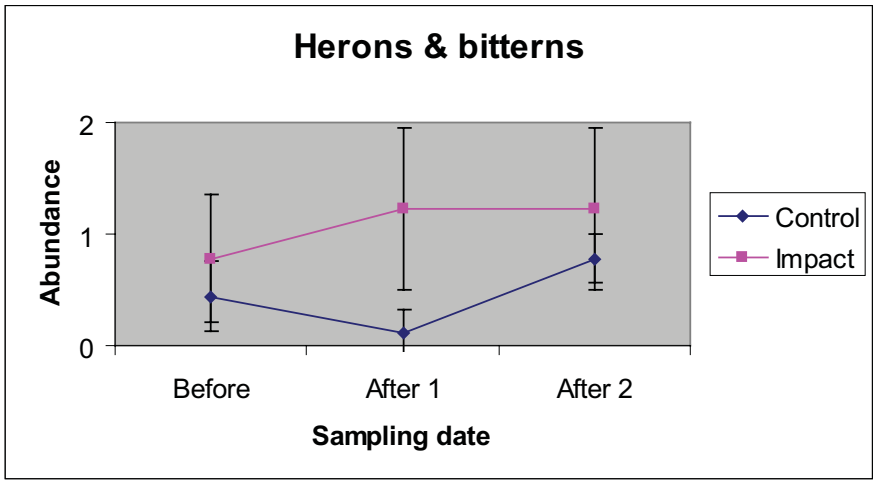

Figure 8: The mean of the total abundance per section of herons & bitterns in the control / impact sites across the three surveys. Whiskers denote 95% confidence interval.

All species-groups were present in control and impact pools at all three sampling periods. At the 2008 sampling, there were no significant differences in abundance between control and impact sites, for any of the four species-groups. Three of the four species groups (Shining Flycatcher, kingfishers, herons and bitterns) increased slightly (but not significantly) in the impact pools since the first surveys in 2004 (survey number one). In contrast, the abundance of the cormorant-darter group remained low in the impact pools: the greater abundance of this group in control sites was not significant and in part reflected pre-treatment differences.

The conclusion from the study is that the 2,4D treatment has had no significant effect on the birds along the river, either immediately after the initial treatment or since 2004.

Fish Surveys

In 2004/05 the former NT Department of Primary Industry, Fisheries and Mines (now the Department of Regional Development, Primary Industry, Fisheries and Resources) conducted a series of fish surveys using gill nets and electro fishing techniques in both control and treatment sites. As no negative impacts were identified and herbicide applications dropped significantly since 2004/05 no further tests were deemed necessary in the 2007/08 period. Incidental sightings during all site visits in 2007/08 included water monitors, water dragons, barramundi, garfish, mangrove jack, mullet, damsel fish, bony bream and rainbow fish.

Flora Monitoring program

The application of herbicide has the potential to impact off-target species. Riparian plants with roots in the water, such as *Pandanus aquaticus* are also susceptible. Surveys assessing the vegetation cover from bank, dominants, vegetation cover from the top of water column and floristics were recorded before and after treatment in 2004/05. While localised and short term impacts were observed, including the death of individual trees and banks of lilies, there was no evidence that any irreversible impact on the vegetation structure and ecosystem function resulted.

The treatment areas are downstream of a four kilometre stretch of river which have not been impacted by cabomba or treated with herbicide. It is anticipated any aquatic and terrestrial plant communities harmed during the Cabomba Eradication Program will recover as native plant and seed material travels downstream and establishes in treated areas.

Plate 2: Macro-invertebrate sampling. G. Lamche and R. Spry, Aquatic Health Unit, NRETAS.

4. Conclusion

Public awareness, early detection, prevention of spread, prevention of seed production, prevention of establishment, the ability to manage with minimal off-target impacts, and targeted research are all components of an effective weed management program. Weed eradication may, as in this instance, require these components to be delivered concurrently.

The Cabomba Eradication Program has continued into 2007/08. Successes to date have already resulted in further refinement of management techniques and further significant reductions in cabomba populations. Continued vigilance with respect to monitoring and surveillance will play a vital part in achieving eradication in the long term. The production of viable seed has continued to provide a challenge. The extension of the quarantine order will play an important part in preventing spread of viable plant material and seeds.

During the 2007/08 reporting period all objectives of the NT Cabomba Eradication Program were met, with success being measured through the following observations:

No new infestations in the NT were identified

The implementation of the Education and Awareness Program, while resulting in a number of reports of potential new infestations, actually revealed no infestations of new sites in the NT.

The spread of populations of Cabomba into new areas was prevented

Prevention of spread from known sites of infestation was achieved through the implementation of quarantine restrictions in the project area and also through active management of all sites where germination was detected.

Re-establishment at existing sites was prevented through management activity

Throughout the 2007/08 reporting period, all infestations were actively managed using shades, herbicides, or a combination of both. These activities kept infestations to a level of at least 95% below those experienced in 2005/06. This reduced the potential for localised impact, further spread and subsequently reduced the amount of herbicide used.

Seed production at known infested sites was prevented through the implementation of weekly survey and subsequent treatment.

Once it had been determined that cabomba populations in the Darwin River were unfortunately producing viable seed every effort was made to prevent flower production, and therefore seed production, during the reporting period. The implementation of weekly survey and control activities prevented infestation expansion and any opportunity for seed production and/or transfer to into unaffected areas.

Monitoring programs did not indicate negative off-target environmental or economic impacts as a result of the implementation of the management program

Programs monitoring the effects of herbicide application on aquatic macro-invertebrates, riparian fauna and riparian vegetation failed to detect any significant negative impacts resulting from management activities.

Water quality monitoring in both freshwater and saline ecosystems, did not indicate the presence of the herbicide 2,4-D-n-butyl ester above the pre-determined trigger value during the reporting period.

5. References

AusRivAS (Australian River Assessment System) is a prediction system used to assess the biological health of Australian rivers. More information is available from http://ausrivas.canberra.edu.au/Bioassessment/Macroinvertebrates/.

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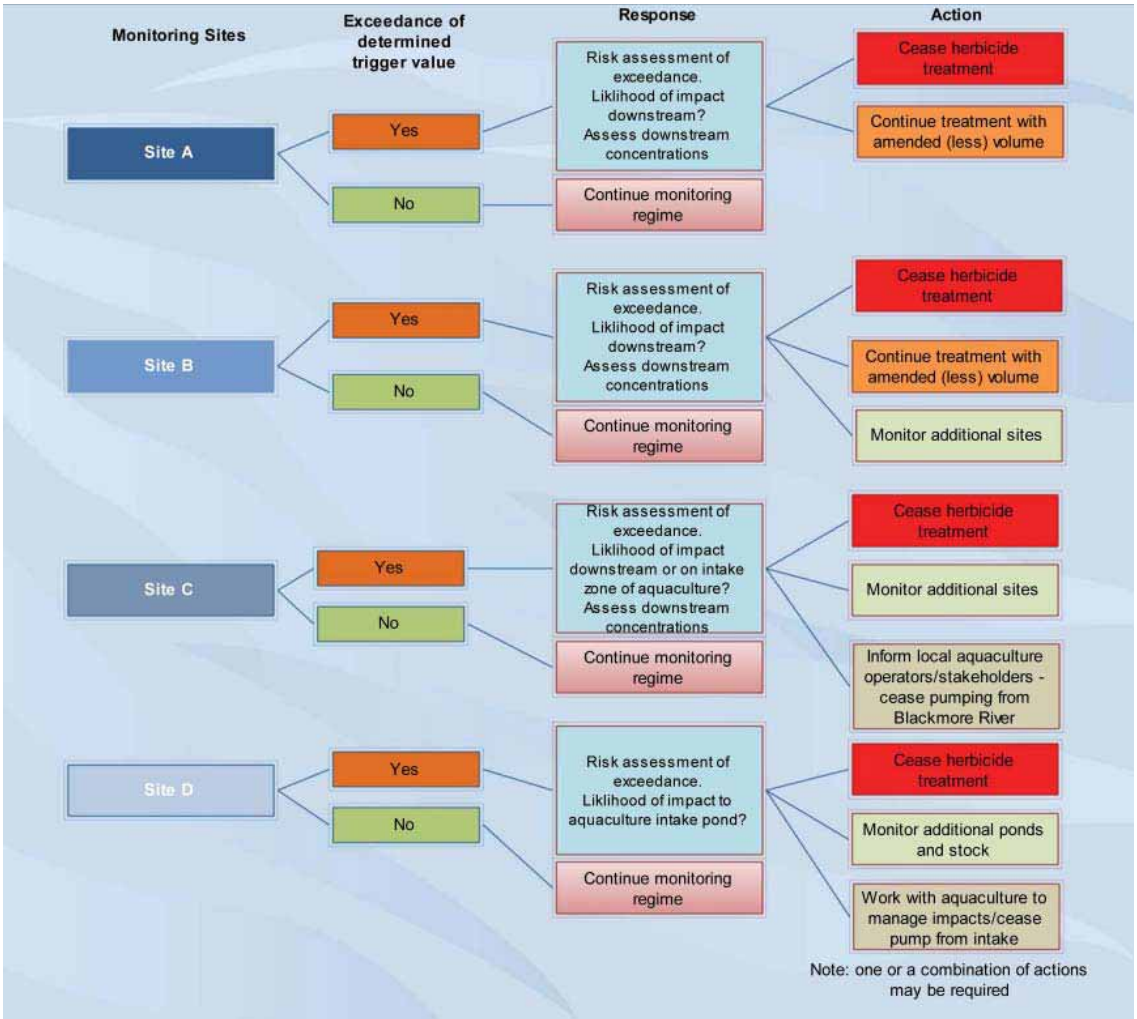
United States Department of Agriculture 2008, United States Department of Agriculture, Washington DC, USA viewed 25 February 2008 <http://www.ars.usda.gov/research/publications/Publications.htm?seq_no_115=177040)

Appendix A: Assessment and monitoring programs associated with use of 2,4-D-n-butyl ester in Darwin River

Risk Area	Potential for impact	Monitoring	Conducted by	Results – 2007/08
Human Health	Contamination of water used for drinking, washing and irrigation. Any contamination of water used for these purposes would require an alternative water supply to be secured.	2,4-D-n-butyl ester Surface water - weekly samples collected from 4 monitoring sites on Darwin River.	NRETAS – Aquatic Health Unit	No detectable herbicide has been found in Darwin River surface water.
Environment	2,4-D-n-butyl is expected to kill cabomba and other plants in the immediate vicinity. The death of plants may deprive animals of food and cause anoxia in the water. Impacts on certain species can impact other animals, including higher order predators in the food web/chain. 2,4-D-n-butyl is also toxic to some animals, including fish. Macro-invertebrates are considered sensitive to certain chemicals including 2,4-D-n-butyl ester and as such can be used as bio-indicators.	BACI design monitoring programs developed (Before-After Control-Impact), including: macro-invertebrates surveys; and physico-chemical parameters, including dissolved oxygen (DO) were measured during sampling. Bird monitoring	NRETAS – Biodiversity Unit (Charles Darwin University – bird survey only) NRETAS – Aquatic Health Unit	*Crocodylus johnstoni* (freshwater crocodiles) were observed before and after treatment. Fish surveys in 04/05 indicated no significant difference between treated and untreated sites. Lower herbicide applications have not warranted further surveys. National methodologies did not indicate significant changes in macro invertebrate communities. DO levels did not fall below naturally observed minimums. (In 2004 low DO levels were detected and remediated using aerators).
	Native Flora (riparian and aquatic) The application of herbicide has the potential to impact off-target species. Riparian plants with roots in the water, such as *Pandanus aquaticus* are also susceptible.	Twenty eight 5 m X 1 m deep, plots established. Depth, vegetation cover from bank, dominants, vegetation cover from the top of water column and floristics recorded before and after treatment.	NRETAS – Biodiversity Unit	No major changes were observed during the previous reporting period (2005/06) and as such monitoring of riparian vegetation was not undertaken due to the significant reduction in herbicide use during the reporting period.
Industry	Possible impacts on aquaculture facilities on the Darwin River, where estuary water is routinely pumped into production ponds.	As above - Monitoring sites set up up-stream from aquaculture farm intake areas.	NRETAS – Aquatic Health Unit	No detectable herbicide has been found in the vicinity of aquaculture farms.

Appendix B: Adaptive assessment approach: water quality monitoring, response and management actions.



Appendix C: All birds recorded during the 2007/08 surveys.

Birds	IMP1	IMP2	IMP3	CON1	CON2	CON3	Total
Orange-footed Scrubfowl	15	1	0	0	0	0	**16**
Burdekin Duck	0	0	0	0	0	4	**4**
Australian Darter*	0	0	0	2	0	0	**2**
Little Pied Cormorant*	0	0	1	3	2	0	**6**
Nankeen Night Heron*	0	3	6	4	3	0	**16**
Black Bittern*	1	1	0	0	0	0	**2**
Whistling Kite	3	0	1	1	3	5	**13**
Black Kite	0	0	0	0	0	1	**1**
Black-breasted Buzzard	0	0	0	0	1	0	**1**
Collared Sparrowhawk	0	0	0	0	0	0	**0**
Wedge-tailed Eagle	2	0	0	0	0	0	**2**
Peaceful Dove	37	4	10	17	6	13	**87**
Bar-shouldered Dove	13	5	7	21	17	19	**82**
Rose-crowned Fruit-dove	1	0	0	0	0	0	**1**
Emerald Dove	3	0	0	0	0	0	**3**
Rainbow Lorikeet	23	0	0	1	0	1	**25**
Varied Lorikeet	0	0	0	0	7	0	**7**
Red-winged Parrot	0	0	0	4	0	0	**4**
Brush Cuckoo	0	1	0	0	0	0	**1**
Little Kingfisher*	2	0	0	0	1	0	**3**
Azure Kingfisher*	3	0	0	10	0	3	**16**
Blue-winged Kookaburra	1	1	1	1	1	0	**5**
Sacred Kingfisher*	3	0	0	0	0	0	**3**
Rainbow Bee-eater	35	4	0	26	3	6	**74**
Striated Pardalote	0	0	0	0	1	2	**3**
Green-backed Gerygone	6	2	4	1	0	1	**14**
Weebill	3	0	0	2	1	0	**6**
Little Friarbird	1	0	0	0	0	0	**1**
Silver-crowned Friarbird	10	3	2	4	5	6	**30**
Yellow-throated Miner	1	2	0	0	0	0	**3**
White-gaped HE	22	0	2	24	8	6	**62**
White-throated HE	27	5	7	15	20	20	**94**
Bar-breasted HE	1	0	3	6	1	6	**17**
Rufous-throated HE	3	2	0	4	1	1	**11**
Rufous-banded HE	14	0	1	6	12	2	**35**
Banded HE	0	0	0	0	1	1	**2**
Dusky HE	11	2	1	4	0	3	**21**
Brown HE	55	17	38	35	43	37	**225**

Birds	IMP1	IMP2	IMP3	CON1	CON2	CON3	Total
Lemon-bellied Flycatcher	14	1	3	7	0	7	**32**
Jacky Winter	0	0	0	0	0	1	**1**
Rufous Whistler	3	0	0	1	1	2	**7**
Grey Shrike-thrush	1	0	2	5	4	2	**14**
Broad-billed Flycatcher	0	0	0	1	0	0	**1**
Leaden Flycatcher	0	0	2	1	0	1	**4**
Shining Flycatcher*	21	1	5	10	3	9	**49**
Restless Flycatcher	5	0	2	7	1	4	**19**
Willie Wagtail	1	1	1	0	0	1	**4**
Northern Fantail	7	1	2	8	0	3	**21**
White-bellied Cuckoo-shrike	3	0	0	2	1	0	**6**
Black-faced Cuckoo-shrike	0	0	0	2	7	0	**9**
Cicadabird	0	0	0	1	0	0	**1**
White-winged Triller	1	0	0	1	1	0	**3**
Varied Triller	11	2	1	9	3	2	**28**
Olive-backed Oriole	0	0	0	0	0	1	**1**
Yellow Oriole	6	0	0	3	10	4	**23**
White-breasted Woodswallow	4	1	4	0	0	3	**12**
Little Woodswallow	7	3	4	1	2	0	**17**
Grey Butcherbird	0	1	0	0	0	0	**1**
Magpielark	0	0	1	1	1	2	**5**
Spangled Drongo	8	0	1	1	5	1	**16**
Torresian Crow	2	0	0	0	0	9	**11**
Great Bowerbird	7	0	0	1	0	0	**8**
Double-barred Finch	15	0	0	9	2	1	**27**
Crimson Finch	24	7	6	20	11	14	**82**
Chestnut-breasted Mannikin	0	0	0	0	2	0	**2**
Mistletoebird	6	3	0	2	5	0	**16**
Tree Martin	25	0	0	6	3	0	**34**
TOTAL (67 Species)	**467**	**74**	**118**	**290**	**199**	**204**	**1352**

* indicates a species used in the analyses.

Appendix D: Possible off-target impacts/risks associated with the use of 2,4-D in aquatic environments.

Risk Area	Potential for impact	Monitoring	Conducted by	Results - 2006
Human Health	Contamination of water used for drinking, washing and irrigation. Any contamination of water used for these purposes would require an alternative water supply to be secured.	2,4-D-n-butyl ester Surface water - weekly samples collected from 4 monitoring sites on Darwin River.	NRETAS – Aquatic Health Unit	No detectable herbicide has been found in Darwin River surface water.
Environment	2,4-D-n-butyl is expected to kill cabomba and other plants in the immediate vicinity. The death of plants may deprive animals of food and cause anoxia in the water. Impacts on certain species can impact other animals, including higher order predators in the food web/chain. 2,4-D-n-butyl is also toxic to some animals, including fish. Macro-invertebrates are considered sensitive to certain chemicals and as such can be used as bio-indicators.	BACI design monitoring programs developed (Before-After Control-Impact), including: macro-invertebrates surveys; and physico-chemical parameters, including dissolved oxygen (DO) were measured during sampling.	NRETAS – Biodiversity Unit (Charles Darwin University – bird survey only) NRETAS – Aquatic Health Unit	*Crocodylus johnstoni* (freshwater crocodiles) were observed before and after treatment. Fish surveys in 04/05 indicated no significant difference between treated and untreated sites. Lower herbicide applications did not warrant further surveys. National methodologies did not indicate significant changes in macro invertebrate communities. DO levels did not fall below naturally observed minima. (NB: In 2004 low DO levels were detected and remediated using aerators.)
	Native Flora (riparian and aquatic) The application of herbicide has the potential to impact off-target species. Riparian plants with roots in the water, such as *Pandanus aquaticus* are also susceptible.	Twenty eight 5 m X 1 m deep, plots established. Depth, vegetation cover from bank, dominants, vegetation cover from the top of water column and floristics recorded before and after treatment.	NRETAS – Biodiversity Unit	No major changes were observed during the previous reporting periods . Monitoring of riparian vegetation was not undertaken due to the significant reduction in herbicide use during the reporting period.
Industry	Possible impacts on aquaculture facilities on the Darwin River, where estuary water is routinely pumped into production ponds.	As above - Monitoring sites set up up-stream from aquaculture farm intake areas.	NRETAS – Aquatic Health Unit	No detectable herbicide has been found in the vicinity of aquaculture farms.