Assessment of Environmental Effects for the Use of Endothall in Four Hydrilla Affected Lakes in Hawke's Bay

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Prepared for

MAF Biosecurity New Zealand

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Executive Summary

MAF Biosecurity New Zealand have contracted NIWA to prepare an assessment of environmental effects for the use of endothall in the four hydrilla affected lakes in the Hawke's Bay.

Hydrilla (*Hydrilla verticillata* (Lf) Royle) is an alien submerged aquatic weed, which is currently restricted to the Hawkes Bay region in three lakes, Lake Tutira, Waikōpiro (also called Waikapiro) and Opouahi, with historic weed beds known from a fourth lake on the privately owned Eland farm.

Hydrilla is listed as a notifiable organism and an unwanted organism, and was identified as a pest for eradication through the National Interest Pests Response Programme. MAF Biosecurity New Zealand have developed an operational plan to manage hydrilla to achieve the goal of eradication (MAF Biosecurity New Zealand 2008) using two tools the herbivorous fish grass carp (White Amur, *Ctenopharyngodon idella*) and the aquatic herbicide endothall.

Endothall (dipotassium endothall) has been used in the USA since 1960, and breaks down in the environment to naturally occurring compounds. It is a selective contact herbicide with proven efficacy on hydrilla both in the USA and in New Zealand, and was registered for aquatic use in New Zealand in 2004. The proposed use of endothall is to reduce the risk associated with the hydrilla weed beds spreading to other lakes and waterways. Endothall will be used to reduce hydrilla biovolume by ca 80%, prior to introducing grass carp which will graze the hydrilla. Endothall will also be used to target potential hydrilla regrowth sites that may be inaccessible to grass carp. A monitoring programme will be used to assess the need for repeat endothall applications in the high-risk sites.

The lakes have multiple uses including boating, fishing, camping, walking, picnicking, water takes for domestic and stock supply, and provide habitat for native flora and fauna. Lake Tutira and Waikōpiro in particular are of significance to the Ngāti Kahungunu hapu, Ngāti Pahauwera and Ngāti Tu.

There are limited potential environmental effects from the use of endothall, other than the removal of the hydrilla weed beds. Water quality and aquatic fauna are unlikely to be affected, there may be some off target effects on native flora, but this is minimal as hydrilla has largely displaced native plants in the target areas.

There are water use and activity restrictions imposed by ERMA after the application of endothall. These are a three day restriction on taking fish for consumption, a 24 hour swimming restriction and a 25 day withholding period for water takes for domestic or livestock supply.

Mitigation measures include stake holder consultation, an assessment of air-boat noise to determine whether birds are likely to be disturbed by its use, the proposed timing of endothall application to avoid periods of high lake use (e.g., public holidays) where possible and thereby minimise user inconvenience; and an undertaking from MAF Biosecurity New Zealand to make provision for alternative water supply where necessary for domestic and stock use during withholding periods. The process of stakeholder and user consultation by MAF Biosecurity New Zealand is ongoing.

1. Introduction

Hydrilla (*Hydrilla verticillata* (Lf) Royle) is an invasive aquatic macrophyte, which has earned worldwide recognition as one of the worst weeds amongst submersed plant species. It is characterised by its prolific growth over a wide range of ecological conditions, its vegetative reproduction and long-lived propagules (tubers and turions), and its ability to displace native vegetation and form mono-specific stands that can locally degrade fish and wildlife habitat. Weed beds of hydrilla are also a direct nuisance to lake users such as bathers, anglers and boaties, and plant material washed ashore by wind and wave action (later putrifying on the beaches) reduces the aesthetic value of the lakes, and access to the water. Hydrilla poses a significant threat to the amenity, cultural and biodiversity values of other waterways (DOC 2001, Hofstra et al. 2000, Walls 1994). If it spreads to rivers used in hydroelectric power generation it would add a major economic cost to the existing cost of weed management in these reservoirs.

Hydrilla is currently restricted to the Hawke's Bay region in three lakes:, Lakes Tutira, Waikōpiro (also called Waikapiro) and Opouahi, with historic weed beds known from a fourth lake on the privately owned Eland farm. In Lake Tutira, the largest of the affected lakes, hydrilla was first positively identified in 1963, at which time it formed extensive weed beds (Tutira Technical Committee 1977). Today hydrilla occupies an estimated 25ha and excludes native vegetation between ca 1.5 to 7m water depth in Lake Tutira, and the 1 to 6m water depth zone in Lake Waikōpiro. In Lake Opouahi hydrilla was first recorded in 1984, and today forms discrete clumps of vegetation with a discrete band at the jetty (Hofstra et al. 2008). In contrast Lake Eland had extensive beds of hydrilla that covered an estimated 1ha of this small 4ha lake (ie the 1.5 to 4m water depth zone). Because physical and chemical control measures had met with little success for the control of hydrilla, and grass carp had previously been used to remove similar weed species in New Zealand (*Egeria densa* (Mitchell 1986, Rowe et al. 1999)) and to control hydrilla in the USA (de Kozlowski 1991, Kirk and Henderson 2006, Hanlon et al. 2000), grass carp were stocked in Lake Eland in 1988 (Clayton et al. 1995). Seventeen months after they had been introduced, grass carp had removed ca 99% of the hydrilla biomass, and although plants subsequently grew from the germination of tubers buried in the sediment, fish browsing pressure was maintained (Clayton et al. 1995), and no hydrilla has been recorded from Lake Eland in annual surveys since 2003 (NIWA divers observations).

However, the continued presence of hydrilla in the publically accessible Lakes Tutira, Waikōpiro and Opouahi, poses a threat to other lakes and waterways in New Zealand through human mediated behaviour. Hydrilla is listed as a notifiable organism and an unwanted organism under the Biosecurity Act 1993, and was identified as a pest for eradication through the National Interest Pests Response Programme completed in December 2006. MAF Biosecurity New Zealand has developed an operational plan to manage hydrilla to achieve the goal of eradication in New Zealand (MAF Biosecurity New Zealand 2008). Eradication is considered achievable over a period of twenty years through the use of grass carp (Hofstra and Rowe 2008), in tandem with the herbicide dipotassium endothall (referred to hereafter as endothall). The proposed use of endothall is in the areas that pose a high risk to hydrilla transfer such as the boat ramp and jetty in Lakes Tutira and Opouahi respectively, and other recreational sites in all three lakes (ie., including Lake Waikōpiro). As well there is the potential treatment of patches of hydrilla (hydrilla refugia/regrowth) inaccessible to grass carp in any of the hydrilla affected lakes including Lake Eland, should any further plants be found in the surveillance phase of the eradication programme.

Endothall is a key tool to complement the use of grass carp in achieving eradication of hydrilla from New Zealand. ERMA New Zealand (the Environmental Risk Management Authority) approval is required to use endothall in a waterbody. MAF Biosecurity New Zealand have contracted NIWA to provide and assessment of environmental effects (AEE) to support the application for permission to use endothall in the hydrilla affected lakes, Lake Tutira, Waikōpiro, Opouahi and Eland for the hydrilla eradication programme.

2. Natural Values of the Lakes

2.1 Lake Tutira

2.1.1 Location and Morphological Features

Lake Tutira is located ca. 36 km north of Napier (along SH2 from Napier to Wairoa (NZMS 260 V20 at grid reference 460 126, longitude 176.89231, latitude 39.22511) in the Arapaoanui River catchment (Hooper 1989). It lies adjacent to Lake Waikōpiro (Figure 1), separated by a narrow causeway and joined by the Tautenga culvert (Figure 2) which flows in periods of high water. During adverse storm events such as Cyclone Bola, water has also been known to cross the causeway (Rowe 2004).

The catchment on the eastern and southern sides of the lakes is steep, hill country, with peaks of 494 m above sea level. The lake lies at 155 m ASL. The lake most likely formed from the partial collapse of a ridge, which dammed the valley at the south end (Grant 1966, Tutira Technical Committee (TTC) 1977). Originally the catchment land area of the lake was ca. 2719 ha, but with the diversion of Sandy Creek (also referred to as Papakiri Stream) to bypass the lake to reduce the nutrient load going into the lake, the catchment area was reduced to 844 ha. Once in native forest (Walls 1994), the catchment and a larger block of land was leased in 1873 for farming and in 1882 by Guthrie-Smith (Tutira Recreation Board (TRB) 1982) who has described in detail the changes that occurred to the catchment and to the lake over from that time and into the early 1900s (Guthrie-Smith 1926). Having an interest in natural science and conservation, Guthrie-Smith fenced off an area of native forest on Tutira Station in the 1890’s. The catchment was then, as is today, predominately in pastoral farmland with sheep and cattle grazing the hillsides (Hooper 1989) (Figure 1).

Figure 1: Aerial photograph of Lakes Tutira and Waikōpiro (Survey Series Hawkes Bay 2000) showing the causeway between the two lakes and the immediate farmland catchment.

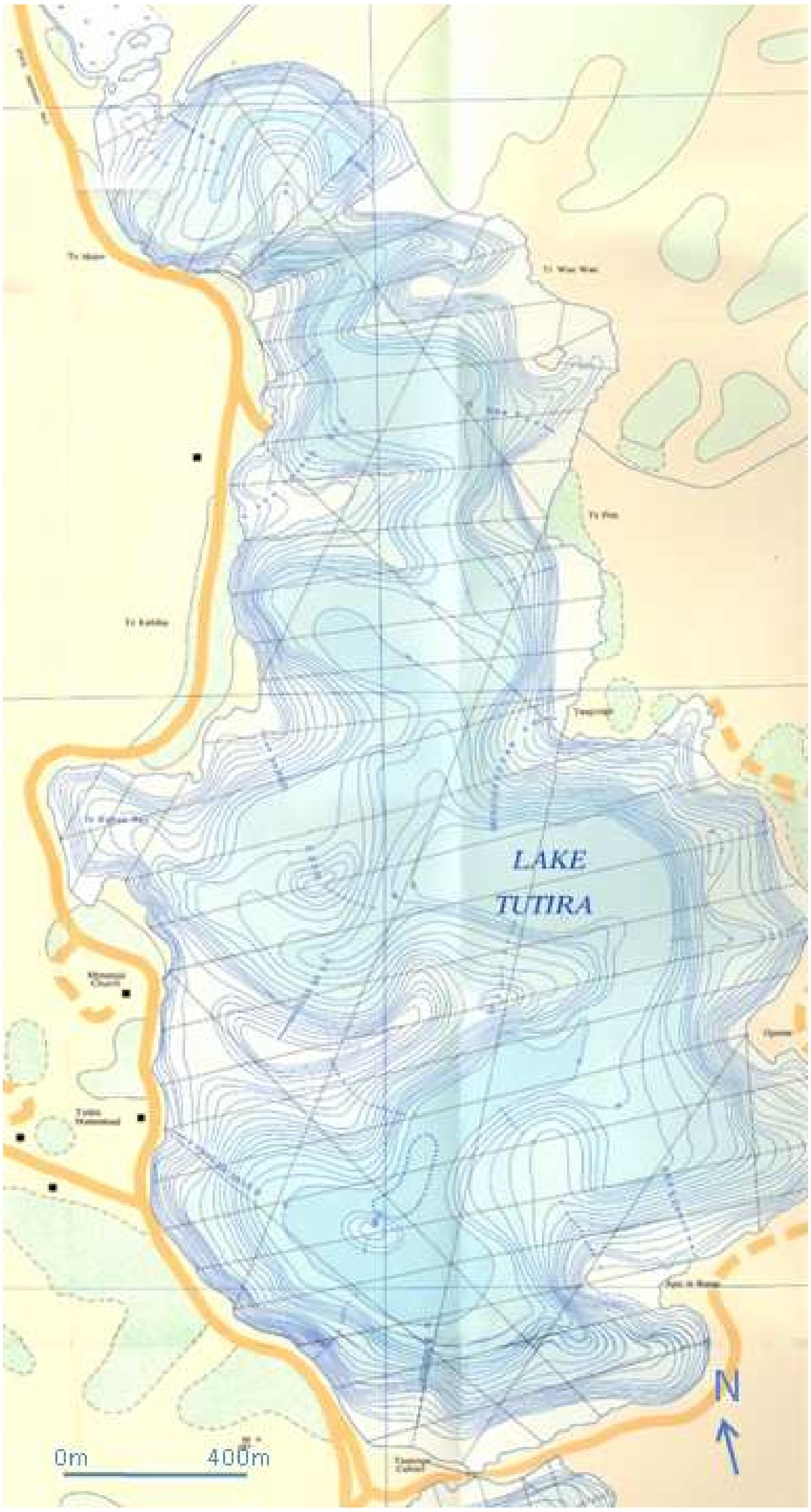

Figure 2: Bathymetric map of Lake Tutira showing the lake contours and the culvert to Lake Waikōpiro under the causeway (south end) from Irwin 1978).

Lake Tutira is ca. 174 ha with a mean depth of 20 m and a maximum depth of 42 m (Table 1), (TTC 1977). After the diversion of Sandy Creek in the north, the remaining inlet streams include the Kahikanui, Oporae, Hutt, the Tautenga culvert (from Lake Waikōpiro), House, Stockyard, and Church Streams. These streams drain 26% of the total Tutira catchment, the balance being held by Sandy Creek. There is one outlet stream (Tutira Stream) at the north end of the lake where it enters into the Mahiaruhe Stream (TTC 1977) until it joins the Waikoau River.

Table 1: Morphometric features of Lake Tutira.

	Data from Tutira Technical Committee Report (1977)	From S. Wadhwa (NIWA) using LINZ aerial photographs 2003-04
Area (ha)	174	172
Volume (m^3)	36.1 x10 ^{6}	
Shoreline (km)	7.99	7.86
Mean depth (m)	20.8	
Maximum Depth (m)	42	
Maximum Length (km)	2.4	2.39
Maximum Width (km)	1.2	1.16

2.1.2 Water Quality

Lake Tutira water quality has undergone many changes in the past including increased sediment loads produced by land slides and storm events, and as a consequence of the drain that was dug in the 1890's through the wetland at the north end of the lake. This connected Sandy Creek directly to the lake, thereby removing the filtering effect of the wetland and increasing the sediment load in the lake as documented by Guthrie Smith (1926). More recent catchment land use change has impacted on the lake water quality, with increased surface run off and the advent of topdressing both increasing nutrient loads in the lake (Teirney 1980). Concern was first expressed over water quality in 1959 with discolouration, algal growth, and the appearance of dead fish in the summer months (TTC 1977). An initial survey of the lake in 1970 confirmed its advanced state of eutrophication (Teirney 1980). Subsequently, the Tutira Technical Committee was set up and a lake monitoring programme initiated, as well as recommendations to improve lake water quality. These included reducing nutrient inputs through riparian plantings and diversion of Sandy Creek (Hooper 1989) and the installation of aerohydraulic guns to improve water mixing and oxygenation and hence trout habitat (Teirney 1980, 2008).

The diversion of the main inlet stream was designed to reduce sediment and nutrient loading into the lake by redirecting the water to the Mahiaruhe stream (TTC 1977, McColl 1978). Under normal stream flow conditions this diversion reduced Lake Tutira catchment from 2717 ha to 843 ha. However, under flood conditions the lake still receives most of the run-off from the entire catchment.

Aerohydraulic guns were installed and turned on in October 1975 to disrupt the thermal stratification of the lake in summer, to improve oxygenation for trout habitat and to reduce the release of nutrients from the lake sediments (Teirney 1980, Teirney 2008). However their use was discontinued in March 1979 due to increased running costs. Teirney (2008) considers it is unlikely that the aerohydraulic guns had an effect on trout stocks in Lake Tutira.

Water quality in the early 1970s is summarised by the Tutira Technical Committee (1976) (Table 2). The thermocline in Lake Tutira usually forms in October and persists until April/May (Teirney 2008). In winter when the lake is well mixed water temperature is ca. 10ºC and the DO (dissolved oxygen) in the bottom waters of the lake were usually 7 g/m^3. From December, the temperature of the epilimnetic water ranges from 20-24ºC, and at a ca. 6 m depth it drops to 9-10ºC characterising the hypolimnion (Teirney 2008). By January, the DO levels usually drop to 1-2 g/m^3 in the hypolimnion with the bottom waters (below ca. 8 m) being anoxic in February (Hooper 1989, Teirney 2008).

Water quality data for the 1980s is summarised by the Hawke's Bay Catchment Board (Hooper 1989). The lake is described as eutrophic but showed signs of improving water quality in the late 1980s, with increasing secchi depths (a minimum of 1.5m) from 1986, and declining chlorophyll-*a* (medians from 13 to 6 mg/m^3 in the summers of 1984/85 to 1986/87) (Hooper 1989). Total phosphorus above 0.05 g/m^3 is known to cause eutrophication problems in lakes, and although values above this occurred 25% of the time during the monitoring period, there was a distinct downward trend in total phosphorus, which along with the nitrogen data indicated an improvement in lake condition at that time (Hooper 1989). Median total phosphorus concentrations from 1984 to 1987 ranged from 0.04 g/m^3 in 1984 to 0.02 g/m^3 in 1987. Similarly, a decline in inorganic nitrogen and total nitrogen occurred over this period from medians of 0.26 g/m^3 to 0.08 g/m^3 and 0.7 g/m^3 to 0.4 g/m^3 for inorganic nitrogen and total nitrogen, respectively (Hooper 1989).

From 1992 to 1996, Lake Tutira was part of a national lakes monitoring programme aimed at evaluating cost effective water quality indicators of trophic state and trophic level change (Burns and Rutherford 1998a). Two sampling stations were set up on the lake to sample the epilimnion and hypolimnion when stratified or from two depths when isothermal (Burns and Rutherford 1998c). Tutira did not change in trophic status over this period, however there was a general decrease in the numbers of dinoflagellates and an increase in cyanobacterial species (*Anabeana*, *Oscillatoria* and *Microcystis* sp), which indicate a small decline in water quality for this lake (Burns and Rutherford 1998b). Tutira increased in temperature (surface water) by 0.39ºC over the monitoring period as did other lakes in the study (Burns and Rutherford 1998b).

Hawke's Bay Regional Council resumed water quality monitoring in Lake Tutira in May 2008 (pers com Ian Gear; P Arnold NIWA Napier). Initial monitoring data available are presented in Table 2.

Table 2: Lake Tutira Water Quality data summary from the 1970's to 2008.

	Tutira Technical Committee (1976)		Hooper (1989) data from 1982 to1986		Burns and Rutherford (1998) data from 1992-1996		HBRC
	Winter	Summer	Range in annual median values		Range in annual median values		May'08
			Min	Max	Min	Max	
Epilimnion/surface profile							
Temp ^{o}C			10	24	13.3	17.2	13.7
DO%	96	121.2			88.3	95	*
DO mg/l	9.6	10.3			8.9	9.8	*
Chl-*a* (mg/m^3)		16.5	6	13	3.5	7.1	
Secchi (m)	2.7 – 5.0	0.9 – 3.2	1.17	2.47	3.3	4.1	5.3
TP (g/m3)	0.0492	0.0363	0.022	0.063	0.0139	.0206	0.014
Total soluble P (g/m^3)			0.015	0.027			
Soluble Rx P (g/m^3)	0.0326	0.0084	0	0.021	0.003	0.0026	<0.004
P diff g/m^3)					0.011	0.018	
Total N (g/m^3)					0.209	0.324	0.37
total O Nitrogen (g/m3)					0.1993	0.2952	-
Kjeldahl N (g/m^3)			0.5	1			0.34
NH_4 (g/m^3)	0.0058	0.0109	0	0.056	0.0067	0.0131	0.011
NO_3 g/m^3			0	0.093	0.0016	0.0231	0.031
Reactive Nitrate N (mg/m^3)	372.5	6					
pH					8.2	8.4	7.6
EC (uS/cm)			129	167	154	169	150
Epilimnion/surface profile							
Temp ^{o}C		10.3	11.7	24	9.9	11.6	10.7
DO%	80.7	0	6.733	9.125	2.7	29.6	*
DO mg/l	8.8	0			0.3	3.4	*
TP (g/m^3)	0.0482	0.1075	0.015	0.048	0.0187	0.0269	0.069
Total soluble P			0.013	0.033	0.0041	0.013	0.064
Soluble Rx P (g/m^3)	0.0337	0.0542	0.005	0.026			
P diff(g/m^3)							
Total N (g/m^3)					0.328	0.369	0.328
Total O Nitrogen (g/m^3)					0.2326	0.2437	0.237
NH_4 (g/m^3)	0.0081	0.3023	0.005	0.089	0.0442	0.0538	0.046
NO_3 g/m^3			.037	0.297	0.022	0.0596	0.045
Reactive Nitrate N (g/m^3)	0.3764	0.0175					
pH					7.1	7.5	7.3
EC (uS/cm)			151	169	172	175	172

* Instrument error.

2.1.3 Aquatic Plants

In the past, Lake Tutira supported a wholly native aquatic vegetation. However, at some time prior to 1963 the submerged aquatic weed hydrilla was introduced to its waters. By 1963, hydrilla had formed dense weed beds extending to a depth of 7.6 m and covering 16.9% of the total lake surface area (TTC 1977).

Aquatic plant surveys conducted on Lake Tutira since then have documented the increase in distribution of hydrilla around the lake, from 73% of the profiles in 1981 to 90% of the profiles in 2002 (NIWA, FBIS (Freshwater Biodiversity Information System)).

To control the infestation of hydrilla at the public boat ramp in Lake Tutira weed mat was used in 1988/1989, however this was largely unsuccessful (Clayton pers com). Today hydrilla dominates the littoral zone of the lake from water depths of 1.5 m and deeper, excluding native plants and developing dense monospecific stands up to 5.5 m in height (Table 3) (Hofstra et al. 2008). The alien plant *Elodea canadensis* is also present in Lake Tutira from 0.2 to 3.5 m water depths, reaching heights of 2.5 m (Table 3). The most diverse plant community occurs in the shallow water zone and includes the low mound or turf plant community or may include emergent species (e.g., *Typha orientalis*) (Table 3). The diversity of this zone includes 18 species of submerged, marginal, and emergent aquatic plants (Hofstra et al. 2008) from a total of 20 species in the lake that occurred in this shallow water zone (Table 3).

The decline in native plant species distribution and increase in hydrilla over the years since its introduction is reflected in the current LakeSPI (Lake Submerged Plant Indicator) scores for Lake Tutira. LakeSPI utilises the data on the diversity and extent of native plants and the degree of impact of invasive weed species, which, together with other components (eg depth of plants) give an indication of overall lake condition, expressed as a percentage of how close a lake is to its best possible condition. For Lake Tutira the invasive condition index is 90% (indicating a highly impacted lake), the native condition index is 17% and the overall lake condition is 18% (LakeSPI values based on 2008 survey data).

Table 3: Lake Tutira vegetation survey 2008 summary data.

Plant Species	No. of Sites	Depth range (m)	Max. Height (m)	Ave. Height (m)	Max. Cover	Median Cover
Callitriche sp.	1	0.2 - 0.3			1	
Chara australis	12	0.2 - 2.2	0.2	0.1	6	1
Chara globularis	12	0.1 - 2	0.3	0.1	6	1, 2
Elodea canadensis	13	0.2 - 3.5	2.5	0.4	6	1
Glossostigma cleistanthum	1	0.3 - 0.3				
Glossostigma elatinoides	4	0.1 - 0.2			3	1, 2
Hydrilla verticillata	15	0.1 - 7.5	5.5	2.3	6	5
Juncus sp.	2	0 - 0.2	0.7	0.5	4	2, 4
Lilaeopsis ruthiana	10	0.2 - 1.3			5	2, 3
Ludwigia palustris	3	0 - 0.3	0.2	0.2	6	1
Myriophyllum triphyllum	8	0.3 - 1.8	1	0.2	5	1
Nitella hyalina	8	0.2 - 1.2	0.1	0.1	3	1
Paspalum distichum	3	0 - 0.3	0.3	0.2	6	3
Persicaria decipiens	2	0 - 0.2	0.3	0.3	3	1, 2
Potamogeton ochreatus	5	0.5 - 1.3	0.2	0.1	3	1
Ranunculus limosella	10	0.2 - 1.3			5	2
Ranunculus trichophyllus	1	0.9 - 1	0.1	0.1	1	
Ruppia polycarpa	5	0.4 - 1.2	0.1	0.1	3	1
Schoenoplectus tabernaemontani	6	0 - 1.7	2.4	1.2	4	2
Typha orientalis	5	0 - 1.5	4	2.3	6	5
Unidentified mosses & liverworts	1	0.3 - 0.3				

NB: Data are averaged values from the fifteen survey sites.
For % Cover data 1=1-5%, 2=6-25%, 3=26-50%, 4=51-75%, 5=76-95%, 6=96-100%.

2.1.4 Fish and Invertebrates

Eastern brook trout (*Salvelinus fontinalis*) were introduced into Lake Tutira in 1890 by Guthrie-Smith but these liberations were unsuccessful (Appendix 1). Subsequent liberations of brown (*Salmo trutta*) and rainbow (*Oncorhynchus mykiss*) trout in the 1900's were successful, and from 1959 annual liberations of rainbow fingerlings was made by the Acclimatisation Society (Tutira Technical Committee 1977). Trout continue to be stocked by the Hawke's Bay Fish and Game Council. Although they previously spawned in the Sandy Creek catchment providing recruitment for a self sustaining population of brown and rainbow trout in Lake Tutira (Marine Department Report 1956) degradation of spawning habitat has occurred (Teirney 2008). Consequently, trout are now released into the lake to maintain the fishery.

The native fish fauna includes longfin (*Anguilla dieffenbachii*), and shortfin (*Anguilla australis*) eels, banded kokopu (*Galaxias fasciatus*), common bully (*Gobiomporphus cotidianus*) as well as the introduced mosquito fish (*Gambusia affinis*) (New Zealand Freshwater Fish Database, DOC 2002, Hofstra et al. 2008). Koaro (*Galaxias brevipinnis*) may occur in the upper reaches of the tributary streams provided a bush canopy is present. In a fish survey in May 2008, longfin and shortfin eels, common bullies (*Gobiomorphos cotidianus*) and trout were caught in the lake, while banded kokopu were only caught in an inlet stream (only one stream had suitable habitat). Gambusia were observed in the shallow-water, lake margins but were not caught (Hofstra et al. 2008). While live goldfish (*Carassius auratus*) were not found in Lake Tutira in the 2008 survey one possible well digested gold fish was retrieved from a trout gut. Since goldfish do occur in the adjoining Lake Waikōpiro they can be expected in Tutira. Amongst the eel catch, 79% were shortfins with the remainder longfin eels, two of which were the largest caught in the lake. Most of the shortfin eels caught were very similar in length indicating a narrow size class and few juveniles. Common bullies were abundant in the survey indicating a healthy population (Hofstra et al. 2008). Unlike eels and banded kokopu, bullies are not good climbers and so have a very limited ability to penetrate inland to high altitudes. They do not occur naturally in lakes such as Tutira and so will have been stocked to create a lacustrine population.

Koura (*Paranephrops planifrons*) have been reported from the lake (DOC 2002), but are scarce, with only two found in the lake in a recent survey and a third from an inlet stream (Hofstra et al. 2008). The current scarcity of koura is thought to be associated with a lack of suitable habitat. Historically, when water quality was high and hypolimnetic de-oxygenation minimal, koura will likely have been abundant in the sub-littoral zone of the lake (Hofstra et al. 2008). Similarly freshwater mussels (kakahi, *Hydriella menziesi*) were only found in the shallow water zone ca 1.5 m, but historic mussel beds at the bottom limits of the hydrilla weed beds (ca 9 m) were reported (Hofstra et al. 2008).

Nineteen invertebrate taxa were recorded from Lake Tutira in 2008, including, mites (Acarina), worms (Oligochaetes), chironomids, ceratopogonids, waterboatmen, dragonflies and damselflies (Odonata), caddisflies (Trichoptera), snails, leeches and flatworms (Hofstra et al. 2008). The highest diversity is associated with the shallow water zone and the macrophyte weed beds, both with 16 taxa, compared with 6 taxa that were present in the benthic sediments, below the maximum depth of the weed beds (Hofstra et al. 2008). Amongst the benthic sediments where the taxonomic diversity was lower, the abundance of the invertebrates present was greater than the abundance of those same invertebrates in the shallows (Hofstra et al. 2008).

2.1.5 Birdlife

Populations of black teal (pateke, *Aythya novaeseelandiae*), New Zealand dabchick (weweia, *Poliocephalus rufopectus*), Australian coot (*Fulica atra*), mallard (*Anas platyrhynchos*), grey duck (parera, *Anas superciliosa*), pukeko (*Porphyrio porphyrio*) and black swan (*Cygnus atratus*) have all been reported from Lake Tutira in the 1970s, while many native species of bird including tui (*Prosthemadera novaeseelandiae*), bellbird (korimako, *Anthornis melanura*), kingfisher (kotare, *Halcyon sancta vagans*), pigeon **(**kereru / kukupa, *Hemiphaga novaeseelandiae*) and morepork (ruru, *Ninox novaeseelandiae*) became less abundant returning to the bush (Tutira Technical Committee 1977).

In a more recent survey (2008) of birds on the lake, eight species were recorded from the lake at the dawn (Table 4). In addition to swan numbers noted on Lake Tutira many other swans were observed on the shoreline (in marginal vegetation) and not counted, along with frequent pukeko. All of the bird species (Table 4) were previously observed at the lakes (Heighway and Mackenzie 1963, TRB 1982, Hooper 1987, Walls 1994).

Table 4: Species and number of birds observed on Lake Tutira (2008).

Bird Species	**Number**
Black Shag (Kawau, *Phalacrocorax carbo)*	2
Black Swan *(Cygnus atratus)*	81
Australian Coot *(Fulica atra)*	78
New Zealand Dabchick (Weweia, *Poliocephalus rufopectus*)	5
Kingfisher (Kotare, *Halcyon sancta vagans)*	2
Little Black Shag (Kawaupaka, *Phalacrocorax sulcirostris*)	4
Mallards (*Anas platyrhynchos)*	55
White faced heron *(Ardea novaehollandiae)*	2

2.1.6 Recreational, Education and Farming

Herbert Guthrie-Smith created a wildlife refuge around the lake edges (Tutira and Waikōpiro) at the turn of the 20th century (Appendix 1). The Government recognised the importance of the lakes when it declared them a Wildlife Refuge in 1957. In 1973 the Lake Orakai, Tutira, and Waikōpiro Wildlife Refuge Order 1973 was issued preventing the use of motorised craft on the lakes. The lakes are used during moulting by Paradise shelduck (putangitangi, *Tadorna variegata*) and black swans. The Wildlife Refuge status and absence of motorised craft makes the lakes ideal places for ornithologists to observe a wide range of waterfowl such as New Zealand dabchick and Australian coot.

Following the First World War, Guthrie-Smith subdivided much of his holding for settlement by returning soldiers. Upon his death in 1940 the remaining 2000 acres was left in trust for the nation. The Guthrie Smith Arboretum, established in 2002, covers 200-acres and is progressively being planted in exotic and indigenous trees. Guthrie-Smith had set aside some 15 acres of land to regenerate naturally in the 1890s. This regrowth forest is incorporated in the arboretum.

The Guthrie-Smith Outdoor Education Centre provides an educational link for New Zealand's youth and New Zealanders generally through school camps and provides activities such as climbing and abseiling, canoeing, sailing, tramping, survival courses and environmental studies.

The Tutira Recreation Reserve was created in 1976. Later the Hawke's Bay Regional Council purchased 463 ha on the eastern side of the lake from the Guthrie-Smith Trust. This land is now managed by the Hawke's Bay Regional Council as it works toward retiring the Tutira catchment from farming. A combined Department of Conservation and Hawke's Bay Regional Council camping ground, shelters, toilets, tracks and observation points provide facilities for both day trippers and those choosing to stay over night.

While rainbow trout (*Oncorhynchus mykiss*) were first liberated in Hawke's Bay rivers in 1867 following the arrival of 42,000 ova from Otago, trout were not introduced to Tutira until later. The first attempt to naturalise trout in Lake Tutira occurred in 1890 when Guthrie-Smith received a consignment of brook trout (*Salvelinus fontinalis)* eggs from North America. Taking delivery of a case of ova at Tangoio, and despite his best efforts frequently bathing the eggs in the waters of the streams he crossed on the way to Tutira, the ova, which were in good condition, failed to establish.

The lakes, particularly Tutira, are popular with anglers fishing for Loch Leven browns and 'R' type rainbow trout. Lake Tutira is stocked annually with both rainbow and a lesser number of brown trout. Both shore and lake fishing techniques are used. Surveys of angler usage carried out by NIWA for the Fish and Game Council New Zealand do not distinguish between Lake Waikōpiro and Tutira. In the 2001/2002 survey, fishing effort on the Tutira Domain lakes was estimated at 2,300 (±380) angler days per year (Unwin and Image, 2003). This is a 25% reduction on the 1994/95 figure of 3,090 (±150) angler days per year. Usage of local rivers is much higher (Mohaka River 7000, Tutaekuri River 6700, Ngaruroro River 6200, Tukituki River 17,000).

Lake Tutira is the second largest lake in the Hawke's Bay Region (Waikaremoana is larger). Consequently its trout fishery is considered to be of regional importance.

Historically angler usage nearly doubles during winter months (June-September) suggesting that it is a winter rather than a summer fishery.

Following concern over the degradation of the lakes' water quality, which had been largely due to nutrient run-off from the surrounding farm land, Hooper (1987) indicated where, as part of a series of measures to improve water quality in the lakes, stock access to the lake's shores had been restricted. Cattle and sheep are still able to graze some margins of the lakes. The Hawke's Bay Regional Council has established a management plan for the land surrounding the lakes. A programme of replanting has commenced. No water takes have been consented for Lakes Tutira and Waikōpiro (HBRC).

2.1.7 Cultural Usage

Ka kāti a Tangitū
Ka tūwhera a Maungaharuru
Ka kāti a Maungaharuru
Ka tūwhera a Tangitū.

The whakatauākī (proverb) talks about the boundary of Ngāi Tatara, from the foreshore of Tangitū to the mountain range of Maungaharuru and explains the right times of gathering food resources.

When the kaimoana and fish at sea is at its leanest the season is closed.
We then turn to land like that of Maungaharuru and Tutira and our rivers, to gather food.
When the food resources are scarce inland (Maungaharuru) we then return to the sea (Tangitū).

This is supported by the whakatauākī:

Te wai-ū o koutou tīpuna
The milk of your ancestors.

Tutira was an important place for Māori as the coastal people moved from the coast to the inland rivers and mountains and the inland people moved from the mountains to the coast following the cycle of food. The hapū, Ngāti Pahauwera and Ngāti Tū have a long association with Tutira, Waikōpiro, and Opouahi. Both hapu are vitally interested in the well being of the streams, rivers, lakes and the sea and the maintenance and restoration of the mauri of the waters.

Māori have long recognized that healthy waters are essential for life. Water is the essence of life. To Māori the mauri (the life force) is the essence or life force of both animate and inanimate objects binding the two parts, body and spirit, together.

Local people would have been concerned about the future of Tutira when massive alterations to the catchment occurred following the arrival of European farming settlers in 1873. Surface run off increased as land was cleared and sheep and cattle began consolidating the soils. Between 1890 and 1900 a canal was cut through the swamp at the northern end of the lake. Papakiri (Sandy Creek) flowed into this swamp, which served as a filter before the water passed into Tutira stream, the outflow for surplus water from the lake. Silt would be carried off the hills to create the delta where Papakiri flows into the lake. Guthrie-Smith wrote:

> *"…….in ancient times the waters of the considerable Papakiri stream (Sandy Creek) never directly reached the lake; they soaked through a morass of several hundred acres, finally dripping into the creek Tutira, the creek that carries off the surplus water of the lake."*

Having observed and knowing that eels inhabited the swamp local inhabitants would have become more concerned when the swamp was drained.

> *"The Māoris believe that in this great sponge of peat and root-fibre lived immense numbers of eels which never visited the lake, and which communicated with the creek by means of holes in the banks. They state, in confirmation, that although eel-weirs built on the bank require the whole width of the stream Tutira, catches as heavy are obtained in the lowermost as in the uppermost patuna (eel weirs)."*

The advent of aerial top dressing further added to concerns as superphosphate fell directly from the aircraft into the lake. That combined with the phosphate burden from incoming waters from the creeks flowing into the lake led to reports in 1959 that algal blooms and proliferating macrophytes were present in Lake Tutira.

When the Hawke's Bay Regional Council was preparing a management plan for part of the Tutira Station it was developing Mr Fred Reti (Ngāti Tū) observed that the lake was important to Māori, asking that the well being of the eels in Tutira, Waikōpiro and the rivers not be over looked and forgotten.

The three types of eel recognized by Māori:

> *" ….the common lake kind—tātārākau; another, also from the lake, rarely caught, much larger, and bronze in colour—riko; and thirdly, the eel of the creek Tutira—pakarara."*

are strongly inter-twined with Māori, lore and Tutira. The carving, 'Tiwaewae' completed by Ngāti Tū carver John Taylor to commemorate the ancestors, situated at the southern end of Tutira on the low hill Tautenga bears testimony to this.

Pollution of water through the use of chemicals and the discharge of waste is an anathema for Māori and many Pākehā. When the use of Endothall was raised on 17 December 2007 with Kaumātua Charlie King he expressed grave concern regarding the use of chemicals in the lakes. Bevan Taylor strongly reiterated this view on 11 February 2008. MAFBNZ has provided hapu with information about the project and endothall, invited participation in key stakeholder meetings and asked both hapu to advise MAFBNZ who should sit on the Technical Advisory Group to provide advice on Mātauranga Māori. Charles Lambert (supported by Charlie King) and Bevan Taylor fulfill those roles.

At the closing of the Technical Advisory Group meeting held in Napier on 3 April 2008 at which the Operational Plan for the project was endorsed by the members present, Kaumātua Charlie King observed during his poroporoake (summing up) that he while he had been concerned about the proposed use of Endothall, he now understood this chemical much better. He appreciated that "*only a very, very small amount – about a teaspoon in each cubic meter of water - would be used*". He understood that Endothall was not residual, breaking down quickly to form water, carbon dioxide and potassium. All of these things are found in water and the human body. Noting that hydrilla was a plant alien to New Zealand "*it is not one of us*" he believed that every thing that can be done should be done to eradicate this weed and in doing so help return the mauri of Tutira and Waikōpiro.

2.1.8 Summary of Lake Values

The Tutira recreation reserve was created in 1976. Hawke's Bay Regional Council purchased 463 ha on the eastern side of the lake from the Guthrie-Smith which is now managed by the Hawke's Bay Regional Council as it works toward retiring the Tutira catchment from farming. A combined Department of Conservation and Hawke's Bay Regional Council camping ground, shelters, toilets, tracks and observation points provide facilities for both day-trippers and those choosing to stay over night. Today, Lake Tutira is a recreation reserve that is administered by the Department of

Conservation as a public facility (Walls 1994). The northern end of the lake is owned by Ngāti Tū a hapu within Ngāti Kahungunu (Walls 1994) and leased to Fish and Game.

Lake Tutira is a eutrophic lake with low water quality. There were some signs of lake recovery, but the lake still deoxygenates below ca. 8m (Teirney 2008) each year, creating a large dead-water zone in the hypolimnion. This now limits the lake as habitat for fish and deep-water invertebrates such as koura.

Hydrilla, which was first positively identified from the lake in 1963, now occupies an estimated 25 ha in Lake Tutira, where the weed beds extend from 1 to 9 m water depth (at some sites) and is on average 3 m in height, with 100% cover (i.e., dense monospecific stands) (Hofstra et al. 2003). However a relatively high diversity of aquatic macrophytes was present amongst the turf plant community in the shallow water zone (Hofstra et al. 2008).

Lake Tutira is a regionally significant trout fishery and contains stocked rainbow and brown trout. Because of its altitude and distance inland, native fish are restricted to the diadromous climbing species (i.e., eels and banded kokopu). Although the lake provides good habitat for eels, the deoxygenation of the hypolimnon prevents eels from inhabiting deeper waters and now limits them to the shallow (<10 m) lake edge during summer months. Similarly, banded kokopu are confined to a single stream because of both habitat degradation and the predatory impact of trout. Bullies and gambusia (a pest fish species) were stocked into this lake and have established breeding populations. Both koura and freshwater mussels will have once been more abundant in the lake but are now scarce because of poor water quality. Trout and eels dominate with invertebrates and common bullies providing the main food sources for these species. No rare fish species occur in this lake and its fishery values are confined to the trout fishery, to eels and a single population of banded kokopu.

Nineteen invertebrate taxa have been recorded from Lake Tutira, with the highest diversity associated with the turf plant community and the tall macrophytes. Taxa included mites (Acarina), worms (Oligochaetes), chironomids, ceratopogonids, waterboatmen, dragonflies and damselflies (Odonata), caddisflies (Trichoptera), snails, leeches and flatworms. The lake's koura and mussel populations have been reduced by habitat degradation related to poor water quality.

Populations of black teal, New Zealand dabchick, Australian coot, mallard, grey duck, pukeko and black swan have all been reported from Lake Tutira in the 1970s (Tutira Technical Committee 1977). Additionally in 2008 black shags, kingfishers, little black shags and white-faced herons were also recorded on the lake (Hofstra et al 2008).

Lake Tutira and its surrounds have a long history of use by Māori and are highly valued.

2.2 Lake Waikōpiro

2.2.1 Location and Morphological Features

Lake Waikōpiro is a small (ca 11 ha) lake located in Hawke's Bay (NZMS 260 V20 at grid reference 463 115 (latitude 176.89450, longitude-39.23676)). It lies to the south of Lake Tutira and is connected to it via the Tautenga culvert (Figure 3). A small causeway separates these two lakes and was increased in height during the 1940s (Hooper 1987). The lake is trapezoidal in shape and its basin is pan shaped (i.e., flat bottomed with steep shelving sides). The northern shoreline is characterised by a relatively flat, shallow (<2 m deep) shelf that extends some 10-40 m out from the shoreline. However, on the western, eastern and southern sides of the lake, the bed shelves steeply down to the lake bottom, which is at 18 m (Table 5). A small sandy beach occurs on the north-eastern side of the lake.

The catchment is only 116 ha and is mostly in pasture apart from a small area of wetland to the southeast of the lake (Figure 4). A small inlet stream drains into the lake from the wetland (Figure 4). During summer when rainfall is low or absent, this stream is dry. Water drains from Lake Waikōpiro through the Tautenga culvert into Lake Tutira in periods of high water (Figure 3). The Lake Waikōpiro catchment in the 1980s underwent riparian planting on the eastern and southern make margins and the lower reaches of the inlet stream, and a lake shore reserve was established on the northern and western margins, preventing stock access to the lake (Hooper 1987).

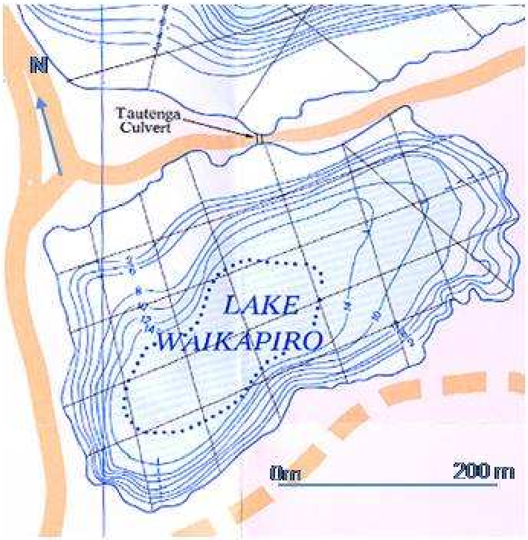

Figure 3: Bathymetric map of Lake Waikōpiro showing depth contours and the Tautenga Culvert joining it to Lake Tutira (from Irwin 1978).

Table 5: Morphometric features of Lake Waikōpiro.

	Data from Hooper (1987)	From S. Wadhwa (NIWA) using LINZ aerial photographs 2003-04.
Area (ha)	11	10.1
Shoreline (km)		1.379
Maximum Depth (m)	18	
Maximum Length (km)		0.495
Maximum Width (km)		0.261

Figure 4: Aerial photograph of Lake Waikōpiro showing the riparian vegetation around the lake's margin (mostly willow trees), the wetland area to the southwest, and the single inlet stream from the wetland (stream entrance to lake is arrowed).

2.2.2 Water Quality

Recent measures of water quality are not available for Lake Waikōpiro, however monitoring by Hawke's Bay Regional Council will resume in June 2008 (I. Gear pers. comm.). Historic data on water quality are available and were summarised by the Hawke's Bay Catchment Board (Hooper 1987). This report provides a good picture of water quality in the lake in the mid 1980s.

In 1984/85, Lake Waikōpiro was described as eutrophic (Hooper 1987). This was because of its high nutrient loading (both nitrogen and phosphorous), the complete deoxygenation of its hypolimnion (waters below about 6 m) during summer months, its poor water clarity (median secchi disc of 0.69 m), the presence of periodic blue-green algal blooms (including potentially toxic *Microcystis* spp.), and the dense beds of the exotic weed *Hydrilla verticillata*. Water temperatures over the sampling period ranged from 14.6 to 23.8 ºC and are typical for such a low altitude (155 m a.s.l.) lake. Other relevant water quality parameters are noted in Table 6 (adapted from Hooper 1987). Acidity (pH) was not recorded at this time.

Table 6: Water quality parameters in Lake Waikōpiro (after Hooper 1987).

Variables	Parameters		
	Min	Median	Max
Temperature (ºC)	14.6	22.0	23.8
Conductivity (µmho/cm)	120	148	168
Secchi disc (m)	0.34	0.69	1.53
Suspended solids (g/m^3)	3	8	26
Chlorophyll *a* (mg/m^3)	7	17	58
Total P (g/m^3)	<0.01	0.07	0.12
Total soluble P (g/m^3)	0.01	0.02	0.04
Soluble reactive P (g/m^3)	<0.01	0.01	0.03
Nitrate N (g/m^3)	<0.01	0.11	-
Ammonia N (g/m^3)	<0.02	0.02	-

Thermocline when present is at 4 to 6m.
Monitoring period was Feb-Mar 1984 (sampled twice); October – April 1985 (sampled 6 times).

Low water clarity in Lake Waikōpiro was often associated with high chlorophyll *a* levels and the lowest secchi disc measurements coincided with a bloom of *Microcystis* (Hooper 1987). Comparison of total nitrogen to phosphorus ratios in this lake indicated that in 1984/85 phosphorus may have been more limiting than nitrogen.

In November 2000 and March 2001, NIWA obtained a continuous 23-day record of oxygen, pH and temperature in the lake related to a trial on endothall (Hofstra et al. 2001). These data show that the water temperatures in November ranged from 16-20ºC with little daily variation, and in March were mostly above 20ºC. DO levels varied diurnally, ranging from 4-14 mg/l in November, and 6-15 mg/l in March. The pH was close to 8 in November, and 7.5 in March.

2.2.3 Aquatic Plants

Hydrilla is thought to have entered Lake Waikōpiro at some time after it had established in Lake Tutira, where it was positively identified in 1963 (Tutira Technical Committee 1977). A survey conducted on Lake Waikōpiro in 1992 showed that hydrilla had an extensive distribution within the lake to depths of 5.9 m with dense cover (100%) and stands averaging 2 m in height (NIWA, FBIS). In 2001 hydrilla in two plots (each c. 1 ha in area) in Lake Waikōpiro was treated with endothall (dipotassium endothall), which significantly reduced the hydrilla biovolume for a year (Hofstra and Champion 2001, Hofstra et al. 2003). Subsequently hydrilla was reported to occupy an estimated 3.2 ha in the lake (Hofstra et al. 2003).

In a more recent survey, hydrilla continues to dominate the littoral zone of the lake, although a small band of native plants form the turf community found in the shallow water zone (Table 7) (Hofstra et al. 2008). For example, twelve aquatic plant species were recorded in the shallow lake water (up to 1.2m water depth), and beyond that only two species occurred (the introduced *Elodea canadensis* and hydrilla) and water from 2.2m down to ca. 6.4m became exclusively dominated by hydrilla (Table 7). Aquatic plant species also known from previous surveys and/or diver observations include *Myriophyllum pedunculatum*, *Potamogeton ochreatus*, and *Glossostigma diandrum* (NIWA unpublished data, 2002).

The impact of hydrilla in Lake Waikōpiro as indicated by its LakeSPI invasive condition index (93%) is high. The native condition index is low (14%) as is the overall lake condition (16%) reflecting the relatively poor ecological condition of the lake compared with its potential (Lake SPI values from 2008 survey data).

Table 7: Lake Waikōpiro vegetation summary data from 2008 (Hofstra et al. 2008).

Species	No. of Sites	Depth Range (m)	Max. Height (m)	Ave. Height (m)	Max. Cover	Median Cover
Chara australis	1	0.5 - 0.5			1	
Elodea canadensis	3	0.3 - 2.2	1.5	0.4	6	6
Glossostigma elatinoides	3	0.1 - 0.8			5	1
Hydrilla verticillata	5	0.3 - 6.4	4.6	2	6	6
Lilaeopsis ruthiana	4	0.1 - 0.7			2	1
Ludwigia palustris	3	0 - 0.2	0.1	0.1	2	1
Myriophyllum propinquum	4	0.1 - 0.5	0.1	0.1	2	1
Paspalum distichum	1	0 - 0.4	0.3		3	
Potamogeton cheesemanii	4	0.4 - 0.6			1	1
Lobelia perpusilla	1	0 - 0.1			1	
Ranunculus limosella	1	0.2 - 0.2			1	
Schoenoplectus tabernaemontani	2	0.5 - 1.2	2.5	2.1	3	1, 3

NB: Data are averaged values from the five survey sites.

2.2.4 Fish and Invertebrates

Hooper (1987) noted that common bullies were present in Lake Waikōpiro, that eels were likely to be present, and that the lake was periodically stocked with rainbow trout. Observations by NIWA divers during botanical surveys in 2001 and 2002 confirmed the presence of eels (mainly shortfin), and goldfish (*Carassius auratus*) were also observed.

A 2008 fish survey of lake reported rainbow trout, shortfin eels, good numbers of common bullies (*Gobiomorphos cotidianus*), juvenile goldfish and gambusia (Hofstra et al. 2008). Both longfin and shortfin eels were expected to be present, but low in abundance because of the deoxygenated hypolimnion and poor summer water quality

(Rowe 2004). However the eel catch was dominated by shortfin eels, which is the case for most New Zealand lakes subject to eel fishing (Hofstra et al. 2008).

Juvenile goldfish were caught in fyke nets, and gambusia were present in the shallows of the lake. This pest fish species can reduce populations of galaxiids and displace common bullies from shallow littoral zones during mid-summer and autumn months. It also has the capacity to reduce the aquatic insect larvae of some invertebrates including Odonata (dragonfly) (Rowe et al. 2007). There were no rare or threatened native fish species in this lake.

Live freshwater mussels were noted by NIWA divers at one of nine stations in 2001/2002. Freshwater crayfish are potentially present, but like mussels are likely to be rare because of the poor water quality in this lake, the summer deoxygenation of its hypolimnion, and smothering by exotic weed beds (Rowe 2004). No crayfish have been observed by divers since 2001/2002 indicating that if still present, they are scarce (Hofstra et al. 2008).

A survey to determine the diversity and abundance of smaller littoral and benthic invertebrates in Lake Waikōpiro has shown that 16 taxa are represented including mites (Acarina), worms (Oligochaetes), chironomids (Diptera), ceratopogonids (Diptera), waterboatmen, dragon- and damselflies (Odonata), caddisflies (Trichoptera), snails and flatworms (Hofstra et al. 2008). The shallow water zone and areas with macrophytes had a higher diversity of taxa (13 and 12 respectively) than the benthic sediments below the weed beds (4 taxa). However the benthic sediments had a higher abundance of those taxa (e.g., ceratopogonids and chironomids) that were present (Hofstra et al. 2008).

2.2.5 Birdlife

Black swans (*Cygnus atratus)* are reported as the main birdlife present on the lake. Hooper (1987) also noted Australian coot (*Fulica atra*), grey teal, and paradise shelduck (*Tadorna variegata*) (when moulting). It is likely that black teal (New Zealand scaup, *Aythya novaeseelandiae*) and New Zealand dabchick (weweia, *Poliocephalus rufopectus)* will utilise the lake as a feeding area at times because they are known to occur on Lake Tutira. However, they are more likely to prefer Lake Tutira to Waikōpiro as the former provides more habitat. Because it is more sheltered than Tutira, Lake Waikōpiro may be utilised more by these birds when strong north-westerly winds occur and foraging is prevented in Lake Tutira by large waves.

Pukeko and several small black shags were seen around the lake in April 2004. There was also evidence that herons stalk small fish such as common bullies and gambusia in the shallows.

Hooper (1987) noted that lakes in the Tutira Domain supported the largest breeding population of Australian coot in the region. Falla (1982) indicated that they only occur in some lakes and prefer those where the aquatic vegetation is in deeper waters, beyond the diving depth of other ducks. As the depth of aquatic macrophytes in Lake Waikōpiro is limited to 5.7 m, this lake is unlikely to be as attractive to Australian coots as Lake Tutira.

More recently a dawn survey of birds on Lake Waikōpiro reported five species including two black shags (*Phalacrocorax carbo*), eight black swans (*Cygnus atratus*), four New Zealand dabchicks (weweia, *Poliocephalus rufopectus*), fifteen Mallards ducks (*Anas platyrhynchos*) and two Paradise shelducks (putangitangi, *Tadorna variegata*) (Hofstra et al. 2008).

2.2.6 Recreational, Educational and Farming Uses

Hooper (1987) noted that Lake Waikōpiro was utilised for walking, camping, ornithology, picnicking, fishing and boating (no motors are permitted). The marginal fringe of willows and other trees has recently been felled on the southern and western shoreline permitting better access and views.

No water takes have been consented for Lake Waikōpiro (HBRC), however, stock (mainly sheep) have had access to the lake for drinking.

Some anglers fish in Lake Waikōpiro for trout and it has been periodically stocked by the Hawke's Bay Fish & Game Council. Trout can also enter Lake Waikōpiro from Tutira via the Tautenga culvert. Surveys of angler usage carried out by NIWA for Fish & Game New Zealand do not distinguish between Lake Waikōpiro and Tutira. Smaller lakes such as Waikōpiro and Opouahi are clearly less important but can provide speciality fishing (e.g., for species such as brook trout, or hybrid fish such as tiger trout).

Lake Waikōpiro is occasionally used by school parties visiting the Guthrie-Smith Outdoor Centre. Because the lake is small and relatively sheltered, it has been used as a venue for learning aquatic skills such as kayaking.

2.2.7 Summary of lake values

Lake Waikōpiro acts as a small and more sheltered adjunct to Lake Tutira. Although Tutira is the main lake for wildlife, angling, and boating purposes, Waikōpiro is likely to prove more popular for walking as it can be circumnavigated within 30 minutes. Because it is more sheltered than Tutira, its value for wildlife as well as for recreation and education is likely to be increased during periods of strong winds, which restrict such activities on Tutira.

There are no rare or threatened species in Lake Waikōpiro and it does not contain any ecological communities of special interest because of their diversity. In general, the natural values of Lake Waikōpiro are restricted mainly to its wildlife (i.e., fish & birds). The natural values of its plant fauna, its macro-benthic invertebrates (i.e., mussels and koura), and its water quality have been largely compromised over the years by the clearing of surrounding forest, the invasion of exotic plants and by high nutrient loadings from the use of agricultural fertilisers.

The main social values of the lake include its use for recreational and educational activities including walking, picnicking, camping, ornithology and kayaking. It also contributes, albeit in a small way compared with Lake Tutira, to angling. It is not currently utilised (at least legally) for commercial eel fishing, but local iwi can be expected to have used it as an important customary eel fishery in the past (see Section 2.1.7).

2.3 Lake Opouahi

2.3.1 Location and Morphological Features

Lake Opouahi is the smallest (ca. 6ha) and highest (480 m a.s.l.) of the hydrilla affected lakes and is located in the hills north of Lake Tutira and inland (NZMS 260 V19 (longitude 176.835831, latitude 39.14872)). It is situated in the Department of Conservation administered Opouahi Scenic Reserve, which more recently under a joint venture arrangement with the Environment, Conservation and Outdoor Education Trust has also become home to the Pan Pac Kiwi Crèche following the construction of predator proof fencing..

Lake Opouahi has high scenic value and is surrounded by native bush and swampland (Figures 5 and 6), with ca. 20 to 30% of the lake's catchment (44 ha) in farm land (Hooper 1987). The lake is likely to have formed from a landslide which blocked the valley, as evidenced by the drowned trees in the lake (Bennett 1968, Department of Lands and Survey 1981). The lake sides drop steeply to a relatively flat bottom at 24 m (Table 8) (Rowe 1980, 1987, Walls 1994). There are several small inlet streams that pass through the northern wetland and the main inflow to the lake from the swamp is the Waipapa Stream (Figure 5). The lake outflow on its southern side is the Awatamatea Stream which eventually joins the Waikoau River (Hooper 1987).

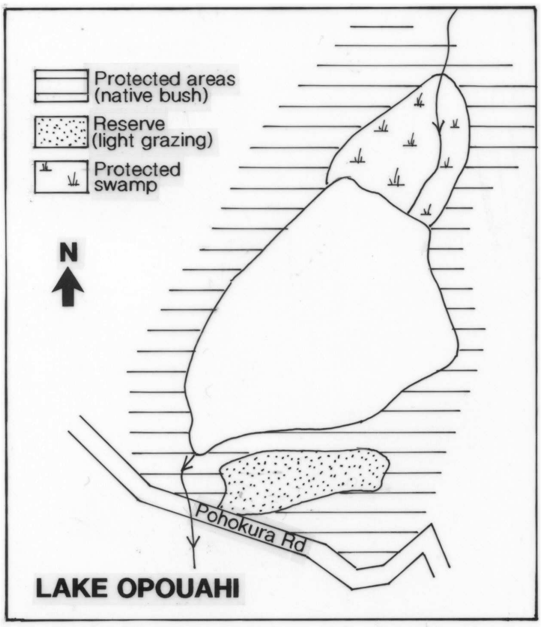

Figure 5: Lake Opouahi.

Figure 6: Lake Opouahi viewed from the northern wetland looking south to the jetty showing the bush lined lake shore (photo by R Wells).

Table 8: Morphometric features of Lake Opouahi.

	Data from Hooper (1987)	**From S. Wadhwa (NIWA) using LINZ aerial photographs 2005-06.**
Area (ha)	5.83	5.67
Shoreline (km)		0.981
Maximum Depth (m)	24	
Maximum Length (km)		0.356
Maximum Width (km)		0.227

2.3.2 Water Quality

Historic data on water quality are available for Lake Opouahi and were summarised by the Hawke's Bay Catchment Board (Hooper 1987). Reported nutrient loadings of Lake Opouahi in the 1980s were 0.37 $g/m^2/y$ of phosphorus and 3.8 $g/m^2/y$ of nitrogen, with an N:P ration of 10.3:1 (Hooper 1987). These estimated loadings indicate that at the time of these data Lake Opouahi was borderline eutrophic (Table 9) (Hooper 1987). However with regards to overall lake classification (transparency, dissolved oxygen, algae, plants) Lake Opouahi has been described as oligotrophic to mesotrophic (Hooper 1987). For example the lake can be relatively clear with secchi disc reading of ca. 10 m (Nov 1984), although these are reduced over the summer months to readings of 3.3 m (Feb) due to phytoplankton growths (Table 9) and there is little suspended matter and low dissolved colour (Hooper 1987).

Hawke's Bay Regional Council resumed water quality monitoring of Lake Opouahi in May 2008. These data are presented in Table 8.

Table 9: Water quality parameters in Lake Opouahi.

Variables	October 1984 – April 1985 (Hooper 1987)			May 2008 (HBRC Monitoring Programme)	
	Min	Median	Max	Epilimnion	Hypolimnion
Temperature (ºC)	10.5(9)	15.5	22(24.5)	11.4	9.8
Secchi disc (m)	3.29	8.82	10.47	4.4	
Chlorophyll *a* (mg/m^3)	1.3	3.4	9.6		
Dissolved Oxygen (% Sat)				*	*
Dissolved Oxygen (g/m^3)				*	*
Total P (g/m^3)	<0.01	<0.01	0.03	0.025	0.1
Total soluble P (g/m^3)	<0.01	<0.01	0.03		
Soluble reactive P (g/m^3)	<0.01	<0.01	0.02	0.0057	0.098
Nitrate N (g/m^3)	<0.01	<0.01	0.12	0.0039	<0.002
Ammonia N (g/m^3)	<0.02	<0.02	0.04	0.031	0.2
Conductivity (µmho/cm)	165	180	190	190	210
Suspended solids (g/m^3)	<1	1	2	<3.0	<3.0

Thermocline when present is at 12 to 13m (Hooper 1987), and 15m (May 2008).
* Instrument error. Lake depth was 22.7 m and Lake height was 0.810 m (May 2008).
Additional temperature data in brackets from Rowe (1980).

2.3.3 Aquatic Plants

Hydrilla infestation in Lake Opouahi probably originated from fragments moved from Lake Tutira (Clayton et al. 1995). The Lake Opouahi infestation was first noted in 1984 (Walls 1994), and is likely to have established at some time between 1970 and its first record, because it was not reported in a lake vegetation survey in 1970 (Department of Lands and Survey 1981).

Hand weeding of hydrilla was attempted in Lake Opouahi, where widespread occurrences of low density weed growth was common, and weed mat was used in 1988/1989 to control the main infestation in the lake at the jetty. Regrowth of hydrilla was noted at all sites where hand weeding was attempted, the rhizomatous nature of the plant and inter-twined growth with surrounding charophytes, reducing the effectiveness of hand weeding (J. Clayton pers. comm.). Hand weeding was considered unsuitable for further use due to the rhizomatous nature of hydrilla and risks of spread associated with fragmentation. The use of weed mat however appeared to slow down the spread of hydrilla within Lake Opouahi (Clayton et al. 1995), although is considered to be of limited use generally (Hofstra et al. 2003).

Subsequent plant surveys in 2002 and 2008 (Hofstra et al. 2003, 2008) have shown that hydrilla continues to form discrete clumps within the lake rather than broad bands of vegetation, with the exception of the jetty region. At the jetty hydrilla covers an estimated area of 300m^2 with ca 90% cover between ca 1 to 4 m water depth, and a maximum height of 2 m (Hofstra et al. 2003). At other sites in the lake both hydrilla and the introduced weed elodea (*Elodea canadensis*) extend into the deeper water (7.5m), as did charophytes in some profiles (Table 10). A diverse community of native plants occurred in the shallow water zone (ca less then 1m), with a total of twelve aquatic plant species recorded from the lake (Table 10).

Lake Opouahi is unique amongst the hydrilla affected lakes in that the distribution of hydrilla is patchy and native charophytes still exist in some of the deeper water zones. This is corroborated by its higher native condition index (28%), lower invasive weed impacts (65%) and overall better lake condition (31%) than the other hydrilla affected lakes (LakeSPI values from 2008 survey data).

Table 10: Lake Opouahi vegetation survey summary data.

Species	No. of Sites	Depth range (m)	Max. Height (m)	Ave. Height (m)	Max. Cover	Median Cover
Baumea arthrophylla	1	0 - 1	1	1	4	
Carex secta	1	0 - 0.8	0.4	0.4	3	
Chara australis	3	1.5 - 7	0.3	0.2	5	4
Chara globularis	5	0.2 - 5.7	1.2	0.6	6	5
Elodea canadensis	5	0.2 - 7.5	5.8	1.7	6	3
Hydrilla verticillata	2	1 - 7.5	3.7	2	6	5, 6
Nitella hyalina	1	0.2 - 0.5			1	
Nitella pseudoflabellata	1	0.2 - 0.5			1	
Paspalum distichum	1	0 - 0.5			2	
Potamogeton crispus	1	1 - 1.5	0.5	0.4	2	
Ranunculus trichophyllus	2	0.2 - 2	1.1	0.55	3	1, 2
Typha orientalis	2	0 - 0.8	2	1.65	5	3,4

NB: Data are averaged values from the five survey sites

2.3.4 Fish and Invertebrates

Historically, Lake Opouahi has been stocked with both rainbow trout (*Oncorhynchus mykiss*) and brook char (*Salvelinus fontinalis*) (Rowe 1980), however they were not recorded in a recent survey and may be extinct in this lake although further sampling would be required to confirm this (Hofstra et al. 2008). Smelt have been in the lake since they were stocked sometime prior to 1994 and they continue to thrive. Common bully numbers in Lake Opouahi are relatively low compared with the other hydrilla affected lakes and this is likely to be related to the presence of large, piscivorous longfin eels. Lake Opouahi has a good population of medium to large longfin eels (3.25 CPUE) and smaller-sized shortfins were also present (Hofstra et al. 2008).

Koura are present but scarce, with only one being caught by electric fishing in the inlet stream in a recent Lake Opouahi survey (Hofstra et al. 2008). The current scarcity of koura may, as is the case for the common bully may be associated with eel predation, as koura are a major prey species for eels (McDowall 1990). Historically, when water quality was high and hypolimnetic de-oxygenation minimal, koura will likely have been abundant in the sub-littoral zone of Lake Opouahi (Rowe 1980).

Climbing galaxiids, especially banded kokopu generally occur in lakes accessible by eels, however, none were reported in this lake or its inlet stream although this provides good habitat for galaxiids. The absence of galaxiids is likely to be related to the historic stocking of both trout and smelt into this lake. Trout predation reduces juvenile and adult galaxiids whereas adult smelt compete with juvenile galaxiids for planktonic prey and prey on fish larvae. Restoration of galaxiids may now be prevented by the presence of smelt. Additionally, it is possible that this stream may be reduced to a low flow during summer months, and since the construction of the predator proof fence around Lake Opouahi, fish access into the lake maybe restricted, even though a bypass system has been constructed. Monitoring of its effectiveness should be undertaken by DoC and the ECOED Trust to ensure native fish access is maintained (Hofstra et al. 2008).

Macroinvertebrate sampling in Lake Opouahi has shown a relatively high diversity and abundance of snails on native charophytes compared with hydrilla and elodea, and compared with other hydrilla affected lakes. The diversity and abundance of invertebrate taxa is generally related to habitat, with the shallow water zone and areas with macrophytes having a higher diversity of taxa (15 and 13 respectively), with 11 taxa reported from the benthic sediments (Hofstra et al. 2008). The taxa recorded in Lake Opouahi include chironomids, caddisflies (Trichoptera), damselfly (*Xanthocnemis*), dragonflies (*Hemicordulia*), snails (*Gyraulus*, *Physa, Potamopyrgus*), pea mussels (Sphaeriidae), ostracods, mites (Acarina), oligochaetes, and waterboatmen (Hofstra et al. 2008).

2.3.5 Birdlife

Lake Opouahi is described as a lake of moderate to high value (Hooper 1987). Hooper (1987) notes that although the swampland in the catchment provides excellent wildlife habitat, waterfowl are not abundant on the lake, as a consequence of the small littoral zone, due to the steep sloping lake margins. The spotless crake (puweto, *Porzana tabuensis*), a small rail, has been seen in the wetland at the head of the lake

(Hooper 1987) along with more recent sightings of New Zealand dabchick (weweia, *Poliocephalus rufopectus)*.

In a 2008 dawn survey at Lake Opouahi mallard ducks (*Anas platyrhynchos*), black swans (*Cygnus atratus*), a black shag (*Phalacrocorax carbo)* and kingfisher (kotare, *Halcyon sancta vagans)* were reported (Hofstra et al. 2008).

2.3.6 Recreational, Educational and Farming Uses

Lakes Opouahi is surrounded by remnant forest and set aside primarily for conservation as the Lake Opouahi Scenic Reserve. The forest is now the core of the "Pan Pac Kiwi Creche" which is an open pest proof sanctuary that the public can access freely. The crèche is a joint venture between the Department of Conservation and the Environment, Conservation and Outdoor Education Trust raising kiwi chicks to be released back into the Kaweka Range and other sites in Hawke's Bay. Work commenced in 2002 to raise money to build the 5km predator proof fence encompassing the Lake Opouahi catchment. The first six kiwi chicks were released into the creche in March 2008 ranging from 10 to 30 days old.

The Lake Opouahi Scenic Reserve has a number of tracks that allow access around the lake and into the adjoining forest.

Adjoining farms draw water for drinking and farm water from Lake Opouahi. Three rights to take from the lake are recorded by the Department of Conservation. A fourth party draws water from one of the supply lines to one of the right holders. Opouahi Station uses water flowing in the stream from Lake Opouahi for stock water. From about September onward and through the summer stock drink water directly from the stream.

2.3.7 Summary of Lake Values

Lake Opouahi is situated in the Department of Conservation administered Opouahi Scenic Reserve. The Department of Conservation and the Environment, Conservation and Outdoor Education Trust in a joint venture operate the Pan Pac Kiwi Crèche. Lake Opouahi is a small (6 ha) lake of high scenic value, surrounded by native bush and swamp land.

Hydrilla infestation in Lake Opouahi probably originated from fragments moved from Lake Tutira (Clayton et al. 1995). The Lake Opouahi infestation was first noted in 1984 (Walls 1994), having established at some time between 1970 and its first record, because it was not reported in a lake vegetation survey in 1970 (Department of Lands and Survey 1981). Despite the presence of hydrilla, Lake Opouahi still has a relatively diverse community of aquatic plants, particularly in shallow water (ca less than 1 m).

Historically, Lake Opouahi was stocked with both rainbow trout and brook char, which no longer appear to be present in the lake. The lake is no longer stocked with trout and does not provide a fishery. Smelt were introduced and continue to thrive. Now that trout are no longer present in this lake, smelt can be regarded as a pest species. Common bully numbers are relatively low compared with the other hydrilla affected lakes and this is likely to be related to the presence of large, piscivorous longfin eels. Lake Opouahi has a good population of medium to large longfin eels and smaller shortfins were also present (Hofstra et al. 2008). Koura are scarce and only reported from the inlet stream in 2008 (Hofstra et al. 2008).

Macroinvertebrate sampling in Lake Opouahi has shown a relatively high diversity and abundance of snails on native charophytes compared with hydrilla and elodea, and compared with other hydrilla affected lakes. The taxa recorded in Lake Opouahi include chironomids, caddisflies, damsel- and dragonflies, snails, pea mussels, ostracods, mites, oligochaetes, and waterboatmen (Hofstra et al. 2008).

Lake Opouahi is described as a lake of moderate to high value to birds, with the only at risk species (rated sparse by Hitchmough 2002) being the spotless crake (Hooper 1987). Other birds recorded on the lake include mallard ducks, black swans, black shag and kingfisher (Hofstra et al. 2008).

The lake and scenic reserve are enjoyed by people for walking and picnicking, and the lake water is used (through water takes) for drinking and farm supply.

2.4 Lake Eland

2.4.1 Location and morphological features

Lake Eland is a small (4 ha) man-made dam on the privately owned Eland Farm, situated in the Esk River catchment (Sander 1994) (NZMS260 V20, 2833820E, 6202030N) (Figure 7). It drains an almost exclusively pastoral catchment with no defined input stream or channel (Hooper 1987, Sander 1994). The lake is relatively shallow with a maximum depth of 7-8 m (Hooper 1987, Clayton et al. 1995).

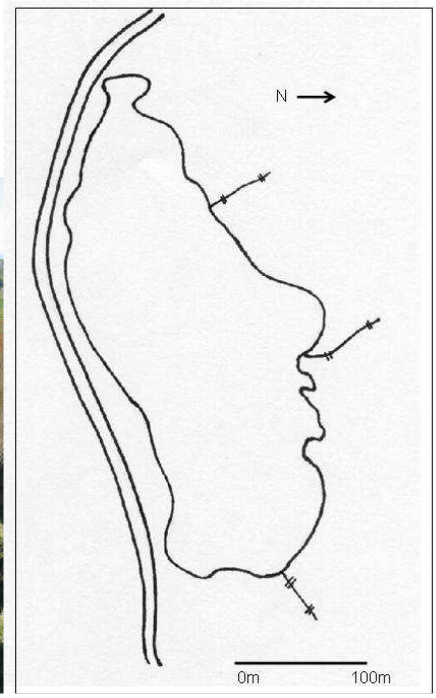

Figure 7: Lake Eland viewed from eastern shoreline (June 2004) (left), and the lake outline showing the size and shape of the lake (right).

Water quality

Water quality data for Lake Eland from 1984 to 1993 has been summarised (Table 11) from reports by Hooper (1987) and Sander (1994). Lake Eland is eutrophic, receiving high nutrient loads from its pastoral catchment (Sander 1994), as indicated by summer mean chlorophyll values (chl-*a*) and phosphorus concentration, and subject to algae blooms. A thermocline forms occasionally at ca 2 m depth, with bottom waters becoming anoxic in the late summer and the temperature of the hypolimnion was recorded at 13ºC. Water quality results indicate little change as a result of the introduction of grass carp to Lake Eland. Secchi depth appears to have declined. Nutrient and chlorophyll-a concentrations also appear to have decreased since 1988 indicating a possible improvement in the trophic status of the lake. However determination of water quality changes over time is difficult based on the data available as sampling was irregular (Sander 1994).

Table 11: Lake Eland water quality monitoring – summary data from 1984 to 1993.

Data from Sander 1994	1984-1988 Oct			Nov 1988-1993		
	Min	Median	Max	Min	Median	Max
Temperature Surface (ºC)	11	17.5	23.7	9	19	24
Secchi disc (m)	0.51	1.14	1.77	0.6	1	1.42
Chlorophyll *a* (mg/m^3)	7.5	30	76	1	17.1	55.8
Total P (g/m^3)	<0.01	0.047	0.098	0.01	0.06	0.12
Total soluble P (g/m^3)	0.021	0.027	0.03	<0.01	0.03	0.09
Soluble reactive P (g/m^3)	<0.01	0.01	0.02	<0.01	0.01	0.03
Nitrate N (g/m^3)	0.011	0.02	0.68	<0.01	0.03	0.34
Ammonia N (g/m^3)	<0.02	0.03	0.05	<0.01	0.03	0.54
Conductivity (µmho/cm)	55	70	100	50	65	130
Suspended solids (g/m^3)	3.0	10	13	16*	31*	84*

* denotes limited sampling
Dissolved oxygen (DO) (% sat) was 92 and 23 for epilimnion and hypolimnion respectively and DO (g/m^3) was 8.7 and 2 for epilimnion and hypolimnion respectively (Nov 1983 to Dec 1994)

2.4.2 Aquatic plants

In the 1980s hydrilla covered ca 1 ha of the Lake Eland occupying a dense band from 1 m to ca 4.5 m depth (Clayton et al. 1995). As it had no inlet or outlet streams and was isolated it became a grass carp trial site in1988, to determine their effectiveness to control and potential to eradicate hydrilla (Neale 1988).

An aquatic plant survey in 1987 included five emergent species (*Typha orientalis, Schoenoplectus tabernaemontani, Juncus edgariae, Bolboschoenus fluviatilis, Eleocharis acuta),* four marginal species (*Persicaria decipiens, Ludwigia palustris, Lobelia perpusilla, Callitriche stagnalis*) and twelve submerged species (*Glossostigma elatinoides, Glossostigma submersum, Lilaeopsis ruthiana, Elatine gratioloides, Potamogeton crispus, Potamogeton cheesemanii, Potamogeton ochreatus, Chara corallina, Nitella cristata, Myriophyllum propinquum, Elodea canadensis* and hydrilla) (Clayton et al. 1995). Amongst the submerged species all but hydrilla occurred in less than ca 1m of water, five species had less than 5% cover, the *Glossostigma* species and elodea had 76-95% cover and the hydrilla had 100% cover to 4m and occurred to depths of 4.5m (Neale unpublished report ca 1988). Hence the native plants that are present in the lake had a limited distribution and abundance with hydrilla dominating the littoral zone of the lake-bed (Neale unpublished report ca 1988).

Triploid grass carp were stocked by MAFFish in December 1988. Initially 100 fish/ha of ca 270 mm in length were stocked in November 1988 (Clayton et al. 1995). An assessment of vegetation in April 1990 revealed a major reduction in hydrilla, 17 months after grass carp were released. At this time the native plants *Glossostigma* and *Typha* were not visible reduced, however in April 1991 evidence of grass carp browsing on *Typha* was first noted, whilst the dense beds of *Glossostigma* and *Lilaeopsis* remained to a depth of ca 2m and were abundant to 1m (Clayton et al. 1995). In November 1991 extensive searches at depths of 1-1.5m revealed occasional hydrilla plants regrowing from tubers or buried stems, predominately in areas supporting low growing turf plants and amongst fallen tree branches (Clayton et al. 1995). Sediment sampling down to 3m water depth also revealed viable tubers. However no plants or regrowth occurred in areas of the lake deeper than 1.5 m down to 4.5m the predominant depth range of hydrilla before grass carp (Clayton et al. 1995). Annual (April) vegetation survey of Lake Eland has continued since then, with a plant last found in 2003, and more recent surveys reporting only the continued presence of the turf plant community (Hofstra et al. 2008) and young raupo (Hofstra et al. 2004).

2.4.3 Fish and invertebrates

As a landlocked lake, Eland had no fish of an intrinsic value in the absence of migration pathways to the sea eg., no self sustaining eels population. However, common bullies were deliberately introduced and were present in low numbers at that time of the grass carp introduction (Neale unpublished report ca 1988) are now abundant in the absence of hydrilla weed beds (and any major predators) (Hofstra et al. 2008). Fish fauna in the lake currently include common bullies and grass carp (Hofstra et al. 2008).

Aquatic invertebrates sampled in 1987 included snails (*Potamopyrgus*, *Physa* and *Ferissia*), waterboatmen (*Sigara*), chironomids, trichoptera (*Oxyethira* and *Paroxyethira*), moths (*Hygraula nitens*), damselflies (*Xanthocenemis*) and tubifex worms (Neale unpublished report ca 1998). Eighteen years after 95% of the hydrilla weed beds were removed (Clayton et al. 1995) the macroinvertebrate fauna were dominated by chironomids, mites and oligochaetes, with other taxa (Ceratopogonidae, Trichoptera (*Triplectides*), *Xanthocenemis*, *Hemicordulia*, *Oecetis* and *Sigara*) also reported (Hofstra et al. 2008). Although the number of taxa has remained similar over this period there appears to be a shift in diversity i.e., snails were not found in the 2008 survey, but mites were.

2.4.4 Birdlife

Bird counts on Lake Eland were undertaken as part of the grass carp trial programme on the lake in the late 1980s (Neale unpublished report 1998b). Species reported since 1984 include mallard, paradise and grey ducks, black swan, scaup, black shag and little shag, New Zealand dabchick and pukeko (Neale unpublished report 1998b). More recently, on a day survey black swan, mallards, little black shag and kingfisher were reported (Hofstra et al. 2008). The presence of these species are comparable with single day bird surveys from Lake Eland from 1988 to 1989 where from two to ten species of bird were recorded on the day of survey (authors unpublished data April 1989).

2.4.5 Recreational and farming use

Lake Eland was built as a farm dam for stock water. It is used for this purpose. In the past it has also been used for private recreation eg., swimming and fishing.

3. Nature of the Discharge

3.1 Endothall

Endothall, a dicarboxylic acid, is a selective contact herbicide that acts as both a desiccant and defoliant. Endothall is available in different chemical forms, each varying in toxicity. The dipotassium salt of endothall is the form of endothall least toxic to aquatic organisms. It has been used in the USA since 1960 (Sprecher et al. 2002). Two different formulations of endothall are registered for use in New Zealand; a liquid (Aquathol® K); and granule (Aquathol® Super K). The difference between the formulations is the concentration of the dipotassium salt of endothall (the liquid contains 40.3% active ingredient (a.i.) and the granule 63% a.i.) and their effectiveness in different environments. The granule releases endothall over a period of 12 hours (Netherland et al. 1998) and therefore is more effective where slower product release is desirable (e.g., in flowing water).

Several mesocosm experiments have been carried out in New Zealand on endothall to investigate its efficacy on aquatic weeds and its effects on native aquatic plants (Wells and Clayton 1993; Hofstra and Clayton 2001). In addition two field trials have been carried out in Lake Waikōpiro in Hawke's Bay and Barton's Lagoon in Wairarapa (Hofstra et al. 2001; Reeves and Champion 2002; Hofstra et al. 2003). These experiments and field trials established that endothall was effective at controlling hydrilla and other aquatic weeds at concentrations between 0.5 – 5 ppm, with only minor environmental effects. The results of these and overseas studies on the likely effects of endothall are discussed in section 5.

3.2 Environmental fate

Endothall degrades in the environment, mainly as a result of microbial action and plant uptake, to CO_2 and other non-toxic natural products (Sprecher et al. 2002). Estimates of endothall degradation rates in aquatic environments vary from <1 day to approximately 30 days (Keckemet 1980; WSDE 2000). The wide variation occurs because degradation rates are affected by both biological and physical factors.

Biological factors include the abundance of the microbial population present in the receiving environment at the time of endothall application. Microbes that break down endothall require aerobic conditions and therefore degradation will occur more quickly in well-oxygenated water. The hydrilla affected lakes are known to be well oxygenated above the thermocline (see section 3 (Burns and Rutherford 1998; Hofstra and Champion, 2001, letter to HBRC)). It is anticipated that since all target sites are above the thermocline then degradation of endothall should be relatively rapid.

Physical factors include dilution and mixing rates in the receiving waters. In larger more exposed lakes, it is more likely that endothall residues will be rapidly dispersed and diluted to below detection limits. At Lake Waikōpiro, endothall residues were less than 2 ppm, 7 days post-application and were not detectable at the 28 days post-application monitoring (Hofstra and Champion, letter to HBRC, 1/6/01). Dispersion and dilution may be slower in Lake Opouahi and Lake Eland as these are more sheltered sites with little mixing. Endothall is likely to disperse faster in Lake Tutira particularly if windy conditions prevail following treatment.

In most aquatic fauna endothall does not bioconcentrate, nor bioaccumulate or effects are only transient and not passed to higher trophic levels (Westerdahl and Getsinger 1988, Sprecher et al. 2002). Hence in the United States of America no fishing or swimming restrictions are imposed after the application of endothall. However, the Environmental Risk Management Authority NZ (ERMA) has adopted a cautionary approach for endothall use with water take, fishing and swimming restrictions (see section 6).

3.3 Gel additive

A gelling agent can be used with herbicide application in an aquatic environment to alter the viscosity of the product, and hence the way it behaves in the water, to achieve more targeted weed control at lower herbicide rates (i.e., increasing the contact time and concentration around the target plants).

Guar gum is the proposed additive for endothall applications if required.

4. Assessment of any potential effects on the environment

The proposed use of endothall is to apply a concentration of less than 5 ppm endothall in November 2008 (subject to satisfactory plant growth) to cause a ca 80% reduction in hydrilla biovolume in areas in the lakes that pose a high risk of hydrilla transfer to other lakes and/or waterways. Control of these weed beds will continue until such time as their biovolume is removed by the stocking of grass carp (MAF Biosecurity New Zealand, Hofstra and Rowe 2008). The high-risk areas include; the hydrilla weed beds along the causeway in both Lakes Tutira and Waikōpiro; adjacent to the camp site and boat ramp in Lake Tutira; and, at the jetty in Lake Opouahi (see Section 6 for maps). These areas equate to ca 4%, 13% and 2% of the total lake area in Lake Tutira, Waikōpiro and Opouahi respectively. In addition endothall is proposed for future use within the lakes to manage hydrilla regrowth in areas where there are obstacles to grass carp grazing, e.g., shallow water (<30cm), or where fallen branches occur. The use of endothall in these situations will be determined by vegetation monitoring during the hydrilla eradication project. This latter type of responsive endothall treatment is also considered for Lake Eland should the need arise.

4.1 Ecological effects

4.1.1 Water quality

Little or no change in water quality is expected as a result of endothall application in these lakes, with only a small fraction of the lakes weed beds targeted for treatment with endothall. As weed beds die and plant matter decays there may be a drop in dissolved oxygen concentration and an increase in nutrients (potentially triggering algal growths) in the immediate vicinity of the treated area (WSDE 2000). The magnitude of these impacts depends on the amount of macrophyte biomass that is being controlled in relation to physical lake characteristics such as area, volume, and flushing rate (Getsinger et al. 2002). The impacts would be greatest in low fertility lakes (where nutrients are limiting algal growth) with low flushing and where the volume of biomass being treated is a high proportion of the total volume of the lake (WSDE 2000; Getsinger et al. 2002).

While it is possible that there will be a localised temporary decline in dissolved oxygen concentrations following treatment at the target areas it is unlikely that this will have any impact on the wider lake environment and aquatic fauna due to the small proportion of biomass being controlled compared to the total lake volume. The threshold limit for ensuring dissolved oxygen remains at ambient levels for aquatic life is to treat no more than 25% of the volume of a lake at any one time. All target areas are below this volume. At Lake Waikōpiro following application of Aquathol® K oxygen levels remained close to saturation despite warm conditions (~20 °C) (Hofstra and Champion, letter to HBRC, 1/6/01).

Biomass removal may also result in an increase in turbidity particularly in areas affected by wind exposure as the opening up of macrophyte beds increases sediment re-suspension (WSDE 2000). This is only likely to be an issue at the exposed causeway/reserve target area at Lake Tutira and to a much lesser extent on the northern shoreline of Lake Waikōpiro. At Lake Tutira this will be partially mitigated by the coarse sandy substrate present along the shoreline and the remaining macrophytes that are not susceptible to endothall which dominate areas shallower than 1 m deep. Turbidity is likely to be less of an issue at Lakes Waikōpiro and Opouahi as the wave fetch is much shorter, the lakes are more sheltered by the surrounding hills and the shoreline drops away more quickly than at the causeway in Lake Tutira.

4.2 Aquatic plants

Hydrilla is effectively controlled by endothall. Within 3-4 days of application parts of the hydrilla plant which have come into contact with endothall (usually the tops of the stems) should start to turn a dull grey-green colour and should eventually lose all green colouring (i.e. chlorosis will occur) within a week. As the colour changes the leaves and shoots will begin to soften before fragmenting and decaying and the weed bed collapses (Wells and Clayton 1993; Hofstra and Clayton 2001).

The effects of endothall have been observed on a number of species present in Lakes Tutira, Waikōpiro and Opouahi during tank and field trials in New Zealand (Table 12). Several species of *Myriophyllum* and *Potamogeton* are identified as being susceptible to endothall (Table 12) although they were not affected during the Lake Waikōpiro field trial, which is most likely related to less exposure time and/or concentration of endothall in Lake Waikōpiro.

Unlike hydrilla, native plants produce seed, and germination from long-lived seed banks in bottom sediments is likely once treatment has been completed. For example, this has been demonstrated in Lake Parkinson where native plants regenerated following the removal of aquatic weed *Egeria densa* (Tanner et al. 1990, Rowe and Champion 1994).

Table 12: Observed effects of endothall at 5 ppm on plant species (other than hydrilla) present at Lakes Tutira, Opouahi and Waikōpiro.

Species	Effect of Aquathol K at 5 ppm	Site	Citation
Native			
Chara globularis	No effect No effect	Hamilton tank trials Lake Waikōpiro	Hofstra & Clayton 2001 Hofstra et al. 2003
Glossostigma diandrum	No effect	Lake Waikōpiro	Hofstra et al. 2003
Glossostigma elatinoides	No effect	Lake Waikōpiro	Hofstra et al. 2003
Lilaeopsis ruthiana	No effect	Lake Waikōpiro	Hofstra et al. 2003
Myriophyllum propinquum	Temporary*	Hamilton tank trials	Hofstra & Clayton 2001
	No effect	Lake Waikōpiro	Hofstra et al. 2003
Myriophyllum triphyllum	Temporary*	Hamilton tank trials	Hofstra & Clayton 2001
	No effect	Lake Waikōpiro	Hofstra et al. 2003
Nitella hookeri	No effect	Hamilton tank trials	Wells & Clayton 1993
	No effect	Hamilton tank trials	Hofstra & Clayton 2001
Potamogeton cheesemanii	Killed No effect	Hamilton tank trials Lake Waikōpiro	Hofstra & Clayton 2001 Hofstra et al. 2003
Potamogeton ochreatus	Temporary*	Hamilton tank trials	Hofstra & Clayton 2001
Schoenoplectus tabernaemontani	No effect	Lake Waikōpiro	Hofstra et al. 2003
Exotic			
Elodea canadensis	No effect	Lake Waikōpiro	Hofstra et al. 2003
Potamogeton crispus	Killed No effect	Hamilton tank trials Bartons Lagoon	Wells & Clayton 1993 Hofstra et al. 2001

* Temporary effects included discoloration and loss of turgor, which lasted for up to a month before the plants recovered.

4.3 Aquatic invertebrates and fish

A number of studies have tested the toxicity of endothall on a range of invertebrates (including crustaceans and molluscs) and fish species finding that even the most sensitive species were not affected by exposure to endothall at 5 ppm (Table 13).

Table 13: Acute toxicity of Aquathol® K to fish and invertebrates. From WSDE (2000).

Species	No observed effect concentration (ppm)	Margin of safety at 5 ppm
Fish		
[1]Rainbow trout (*Oncorhynchus mykiss*)	41- 51	8.2 –10 times
Bluegill sunfish (*Lepomis macrochirus*)	50-51	10 times
Walleye (*Stizostedion vitreum*)	5.6[2] – 22.6	1.12 – 4.52 times
Largemouth bass (*Micropterus salmoides*)	49	9.8 times
Coho salmon (*Oncorhychus kisutch)*	>100	20 times
Chinook salmon (*Oncorhychus tshawytscha)*	32 - >100	6.4 – 20 times
Goldfish (*Ciprinus carpio*)	372	75 times
Invertebrates		
Daphnia magna	29 -41	5.8 – 8.2 times
Dragonfly and damselfly larvae	> 141	>28 times
Mysid shrimp (*Mysdidopsis bahia*)	15	3 times
Eastern oyster (*Crassostrea virginica*)	<44	< 8.8 times
Fiddler crab (*Uca pugilator*)	320	64 times

[1]Present in Lakes Tutira, Waikōpiro and Opouahi. [2]8 - 10 day old fish.

While there have been no equivalent toxicity tests carried out on native species, Hickey (2000) has compared the sensitivity of some native fish species (e.g., smelt, inanga, common bully, longfin and shortfin eels) with rainbow trout for other organic chemicals and found that inanga and smelt generally had similar sensitivities to rainbow trout while the other species were generally much less sensitive.

A rapid reduction in hydrilla biovolume may affect fish and invertebrate populations within the lakes through effects on habitat. Aquatic snails and insects associated with weed beds (e.g., caddis larvae, dragonfly larvae etc.) may decline and predation by shags and eels on bullies may increase as a result of reduced macrophyte cover (Rowe 2004). However the magnitude of these indirect changes as a result of endothall application is relatively minor as only a small portion of the weed beds are being targeted by endothall.

4.4 Birds and other mammals

There are two common routes of exposure for birds, livestock and other terrestrial wildlife to aquatic applications of endothall. These are through drinking treated water or eating aquatic plants, fish or other aquatic organisms from the treatment sites. Based on studies of the acute oral and dietary toxicity of endothall to birds and mammals (summarised in Table 14) it is very unlikely that there will be any effect when endothall is applied at 5 ppm.

Table 14: Acute toxicity of Aquathol® K to birds and mammals. From WSDE (2000).

Species	LD50[1] (mg/kg)	Toxicity ranking[2]
Mallard	> 5000	Practically non-toxic
Bobwhite quail	> 5000	Practically non-toxic
Rat	99.5	Moderately toxic

[1] LD50 is the statistically derived single dose from which 50% of dosed animals die after a specified exposure time in a toxicity test. The larger the LD50 number the less toxic the substance is to a species.
[2]United States Environmental Protection Agency ecotoxicological categories.

Livestock have access to Lakes Waikōpiro, Tutira and Eland and there are water takes from Lake Opouahi along with stock accessing the Awatamatea Stream from, September onward over summer, as it flows through the Opouahi Station. However restrictions on water takes for 25 days following treatment with endothall at 5 ppm should mitigate any risks (see section 5).

The bird species most likely to be affected by a reduction in the biovolume of hydrilla are black swan as hydrilla is a prime food source (Rowe 2004). This is only likely to have an effect (i.e., a decline in black swan numbers) at Lake Waikōpiro as the control of hydrilla here will reduce a larger portion of the weed bed than on other lakes.

The use of a motorised boat on the lake to apply the endothall, and its associated noise may also be of potential concern with regard to bird disturbance.

4.5 Effects on people and communities

Recreational

ERMA has placed restriction on some activities involving water use when endothall has been applied. These include a withholding period for taking water for drinking or watering livestock (for 25 days when treatments are at 5ppm); a restriction on the taking of fish for consumption for 3 days; and a 24 hour swimming restriction.

Cultural

Māori have a long history of association with Tutira and its surroundings. Moreover, Māori are concerned about the addition of any chemicals to water. Kaumātua Charlie King observed during his poroporoake (summing up) at the Technical Advisory Group meeting on 3 April 2008, that while he had been concerned about the proposed use of endothall, he now understood this chemical much better. He appreciated that "*only a very, very small amount – about a teaspoon in each cubic meter of water - would be used*". He understood that endothall was not residual, breaking down quickly to form water, carbon dioxide and potassium. All of these things are found in water and the human body. Noting that hydrilla was a plant alien to New Zealand "*it is not one of us*" he believed that everything that can be done should be done to eradicate this weed and in doing so help return the mauri of Tutira and Waikōpiro (see section 2.1.7).

4.6 Summary of effects

There are two main types of effects that may arise from the use of endothall to control hydrilla. These are the direct eco-toxicological effects of endothall on aquatic flora and fauna and the indirect affects of the decay and reduction of hydrilla biomass on the lake ecosystem. The extent of these effects depends on the species present and the ratio of the volume of endothall applied to the total volume of the waterbody.

From research carried out in New Zealand and overseas it is anticipated that applying endothall at 5 ppm should result in no eco-toxicological effects on aquatic fauna, while there will be a reduction in the targeted hydrilla weed beds and possibly some temporary effects on non-target aquatic plant species (e.g., *Myriophyllum* and *Potamogeton* species). There will be little or no change in water quality as a result of endothall application. There may be localised indirect reduction in dissolved oxygen from weed bed decay, but this is unlikely to be sufficient to affect aquatic organisms within the lakes due to the target areas being only a small proportion of each lake. Removal of hydrilla biomass in the target areas along the exposed southern shorelines of Lake Tutira may result in a temporary decrease in clarity from sediment re-suspension prior to re-establishment of macrophyte beds.

Reduction in biomass of the targeted high risk hydrilla weed beds will decrease the risk of accidental hydrilla spread to other lakes and waterways.

5. Mitigation to minimise any effects on the environment

Mitigation measures to date (and ongoing) have included key-stakeholder communication by MAF Biosecurity New Zealand to ensure an awareness of user concerns and to address those concerns where possible.

As a result of this process, concern was raised that birds may be indirectly affected (disturbed) by the noise from the motorised boat used on the lakes to apply the endothall. This was tested at an operating speed of 10 km/hr by Aqua-Ag (Geoff Angel) with his airboat, Department of Conservation staff, and Ian Gear (for MAF Biosecurity New Zealand on 16th May 2008), and is no longer considered by the Department of conservation to be an issue (John Adams pers. comm. with Ian Gear).

Other than localised concerns (as above) and effects relating to the removal hydrilla, there will be little or no change in water quality, flora or fauna in the lakes, as a result of the endothall application. Overall, the effects will be less than minor.

Given the ERMA controls on endothall use, with regard to swimming and fish consumption, it is recommended that applications be timed where possible to minimise disruption to lake users. While application early in the week will avoid constraints (such as the three day fishing restriction) on weekend activities it is noted that this may conflict with outdoor education use during the week. MAF Biosecurity New Zealand will need to weigh the needs of the project to apply the endothall in a timely manner to have the best possible effect against user needs. Frequent application of endothall will not be required.

Water use constraints will affect the holders of water takes from Lake Opouahi and stock access to other lakes when endothall is applied. For water treated at 5 ppm endothall, there is a 25 day withholding period for the taking of water for drinking, watering livestock, or preparing agrichemical sprays or irrigation, unless it can be shown that the water at the point of take has concentrations of endothall below the tolerable exposure limit (TEL) water and environmental exposure limit (EEL) water values established (ERMA decision 2004). The TEL water has been set at 0.28 mg/L dipotassium endothall (equivalent to 0.20 mg/L endothall acid) and the EEL water has been set at 0.086mg/L dipotassium endothall (equivalent to 0.061 mg/L endothall acid) (ERMA decision 2004). Given that only 2% of the total lake area of Opouahi is being treated, contamination of water in-takes is unlikely to be an issue, unless they are close to or within the target area, or immediately downstream, then the withholding period will stand unless/until water testing for endothall residues is below the TEL and EEL. The location of the approved water in-takes is known. MAF

Biosecurity New Zealand is aware of the potential need to seek/negotiate alternative water sources for affected parties over the short term (up to 25 days) treatment period, or to relocate the water in-takes. For example, water takes close to the outlet of Lake Opouahi could be relocated further out into the lake rather than some 10 – 15 metres from the shore as is the case at present. Therefore, water takes would not be within the treatment zone and not require a withholding period as they will be below the TEL and EEL.

Additional mitigation measures for endothall effects are best assessed on a responsive basis following post application monitoring (section 6.8).

6. Operational plan for hydrilla control

The use of endothall at high-risk sites is proposed to reduce the biovolume of hydrilla to less than 20% within the target areas and reduce the risk of spreading hydrilla to other water bodies (also see section 5).

6.1 Sourcing Endothall and Meeting statutory requirements

Endothall is a product of Cerexagri (Appendix 2 Endothall labels and MSDS), and is available in New Zealand from Elliot Chemicals (agent Mr Bill Chisholm). Although registered for use, prior approval for use is required from ERMA.

In the Hawke's Bay the discharge of agrichemicals that have been approved for aquatic use does not require a consent under Rule 10 of the HBRC Resource Management Plan (2006) provided certain conditions are met. These conditions are listed in Appendix 3 and have been taken into account in the following sections.

6.2 Application method

Endothall comes as either a liquid, Aquathol® K pre-mixed in 2.5 gallon (9.5 L) containers, or as a pellet formulation Aquathol® Super K. The recommended method for applying Aquathol® K at all 3 lakes is by airboat with weighted, trailing hoses (Figure 8) to maximize uniform distribution of the herbicide in the water column. An airboat is recommended as it is powered by a large aerial propeller rather than a submerged propeller, and therefore can move easily over weed beds minimising disturbance. Hoses should be weighted to trail just above the surface of the weed bed to limit drift and increase contact time. In some of the target areas hydrilla is at or near the lake surface (e.g., the jetty site at Lake Opouahi). In these situations either a handgun from the airboat or a boom at the water surface would be appropriate. Alternatively Aquathol® Super K could be broadcast. Aquathol® Super K may also be best suited for spot treatment of hydrilla regrowth that is in accessible to grass carp.

Figure 8: An airboat (Aqua-Ag) dispensing herbicide with weighted trailing hoses.

Timing: Application should occur in November subject to active plant growth. Endothall uptake in hydrilla is enhanced by high temperatures, probably as a result of faster respiration in the plant (Sprecher et al. 2002). Endothall efficacy may be greater when water temperatures are warmest.

Environmental conditions: For best results it is important to maximise the contact time between endothall and hydrilla. To be effective, hydrilla should be exposed to endothall for at least 12 hours at 5 ppm (Wells and Clayton 1993). This can be best achieved by applying the herbicide in low wind conditions (< 3 m/s).

Application rate: To reduce biovolume by at least 80% at target sites, an application rate of 5 ppm (equivalent to 5 mg a.i./L) is recommended at all lakes (Hofstra et al. 2003). To calculate the amount of endothall (Aquathol® K or Aquathol® Super K) needed at this concentration the following table can be used (Table 15).

A registered chemical applicator will determine how to distribute the herbicide evenly over an area. Most applicators use global positioning technology for speed, and course bearing and have spray tanks with digital chemical rate read-out to achieve the desired application rate. Appendix 4 contains a list of chemical applicators registered for aquatic herbicide use.

Table 15: Amount of Aquathol® at 5ppm needed to treat 1 hectare of a water body at different depths (use average depth over the area). (Sourced from the Cerexagri label for Aquathol®, and converted to metric units (Appendix 2)).

Average Water depth (m)	Aquathol® K per hectare Litres	Aquathol® Super K per hectare Kilograms
1	98	79
2	196	159
3	294	238
4	392	318
5	490	397
6	588	477

6.3 Target areas at Lake Tutira

The high risk/high use target areas for hydrilla control at Lake Tutira are along the southern shoreline adjacent to the causeway and reserve; and, at the boat ramp on the western side of the lakes (Figure 9). These areas cover ca. 4% of the lake area. The target area at the boat ramp is approximately 500 m^2 with hydrilla forming a dense bed at about 1.5 – 8 m depth range with a maximum height of 4 m (Hofstra et al. 2003). The average depth of the bed is 4 m and therefore 19.6 L of Aquathol® K is needed to treat the boat ramp area.

The target area at the causeway and reserve is approximately 7.6 ha with hydrilla forming a dense bed at about 1 – 9 m depth range with a maximum height of 6 m. The average depth of the bed is 4.5 m and therefore 3351 L of Aquathol® K is needed to treat this area.

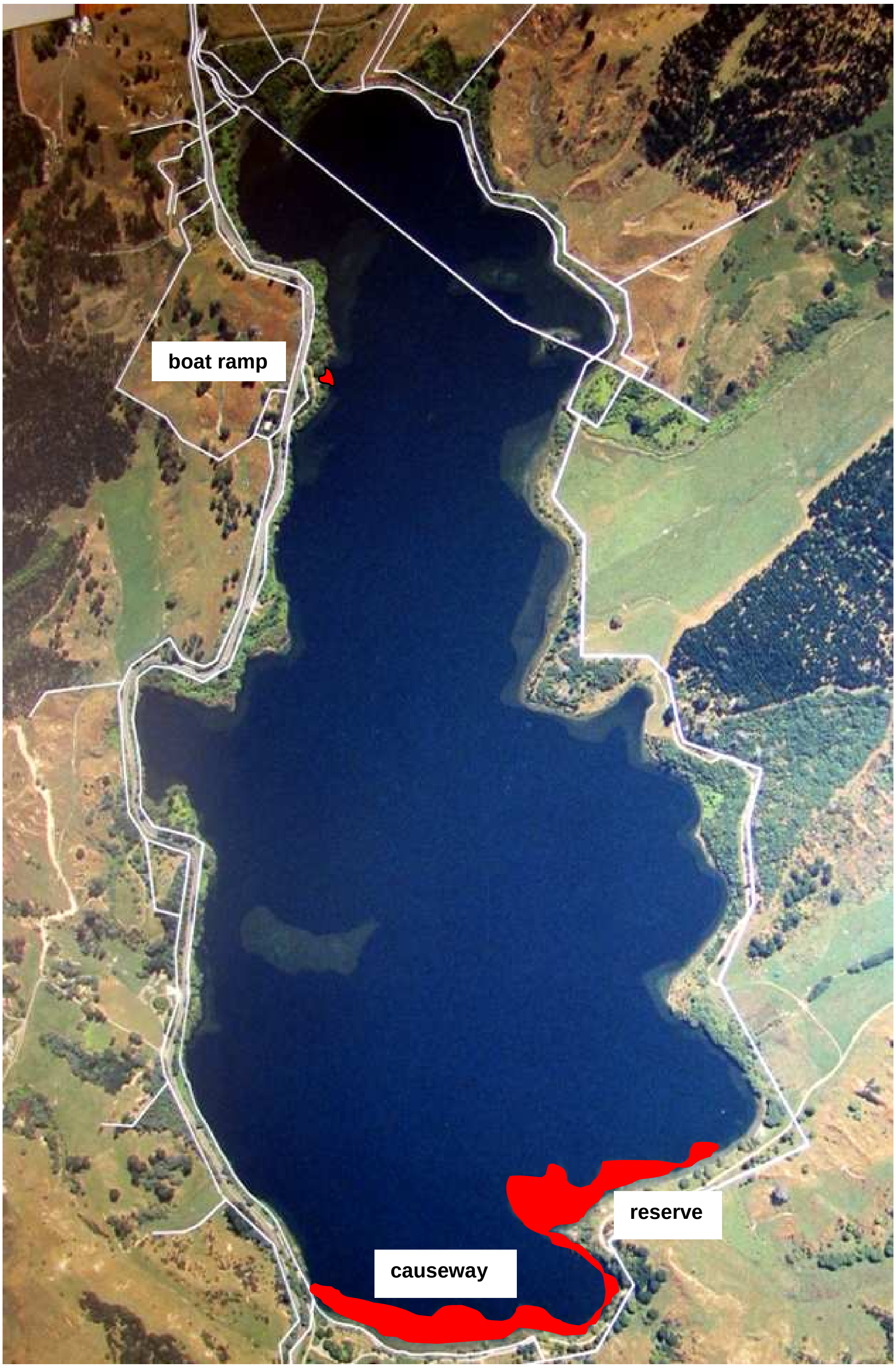

Figure 9: The target areas for hydrilla control in Lake Tutira (aerial photograph from Survey Series Hawkes Bay 2000).

6.4 Target area at Lake Waikōpiro

At Lake Waikōpiro the high risk hydrilla weed beds are along the causeway/northern shoreline (Figure 10). The area is approximately 1.34 ha which is ca 13% of the lake area. Hydrilla forms a dense bed at about 1 – 6 m depth range with a maximum height of 2 m (Hofstra et al. 2003). The average depth of the bed is 4.5 m and therefore 590 L of Aquathol® K is needed to treat this area.

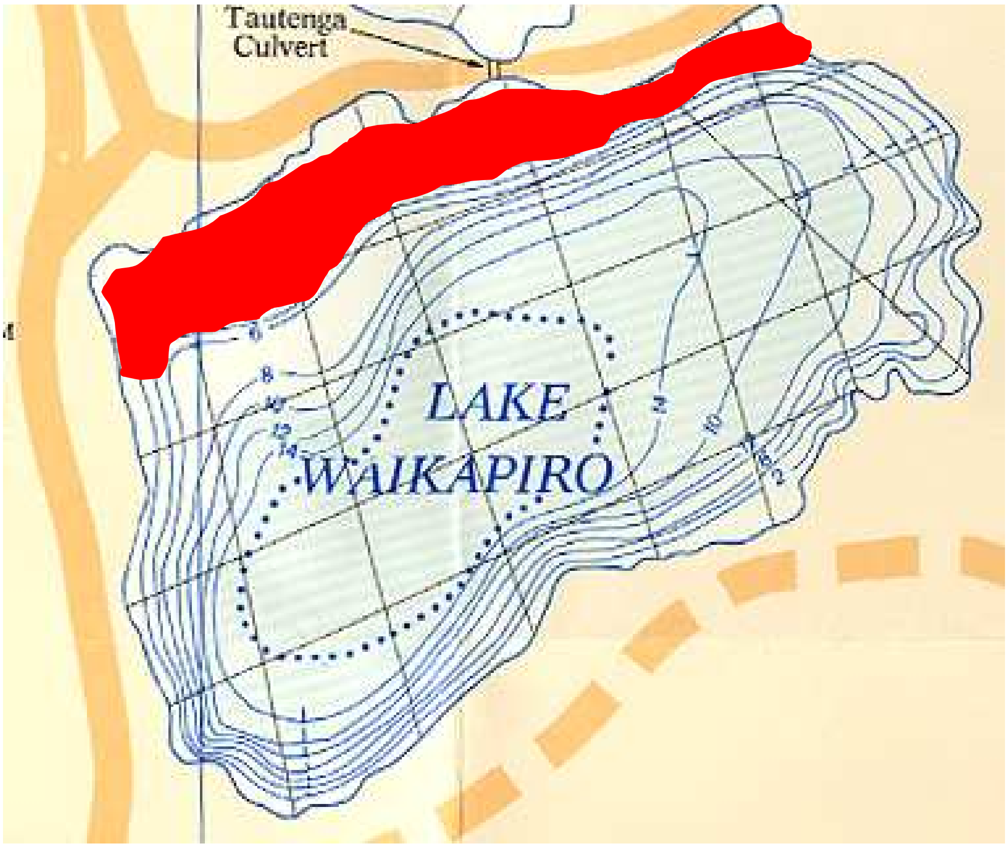

Figure 10: The target area for hydrilla control in Lake Waikōpiro (map after Irwin 1978).

6.5 Target area at Lake Opouahi

The aim of hydrilla control at this site is to reduce the dense bed of hydrilla that has formed around the high-use jetty area (Figure 11). The area is approximately 1200 m^2 which is less than 2% of the lake area, in which 300 m^2 is hydrilla and the rest elodea. At this site hydrilla forms a dense bed at about 1 – 4 m depth range with a maximum height of 2 m that reaches the water surface in some parts (Hofstra et al. 2003). The average depth of the bed is 2.5 m and therefore 29.5 L of Aquathol® K is needed to treat this area.

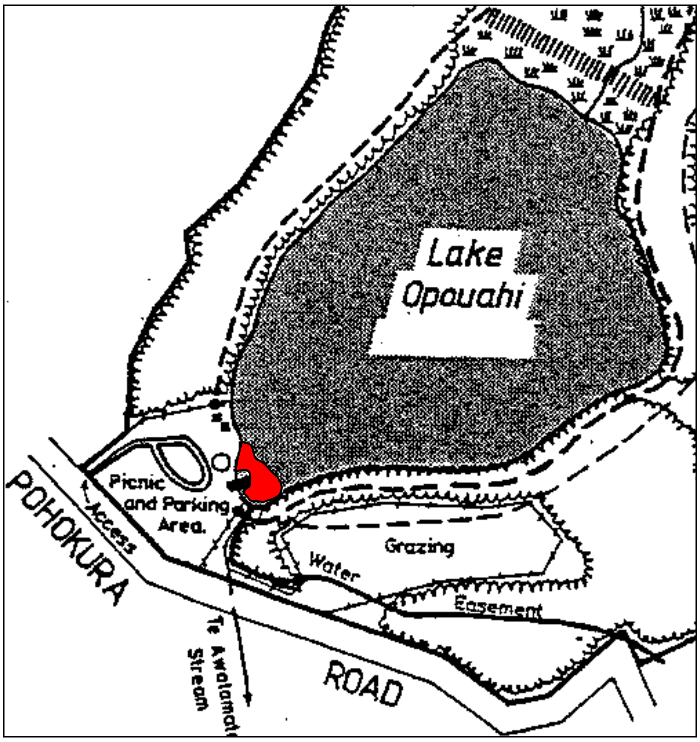

Figure 11: The target area for hydrilla control in Lake Opouahi (map after Department of Lands and Survey 1981).

6.6 Target area at Lake Eland

There are no specific areas in Lake Eland that are targeted for control, as no hydrilla plants have been found there since 2003. However endothall will be used in Lake Eland should hydrilla be rediscovered there in the future.

6.7 Management of endothall on-site

Signage: At each lake signs should be erected at access points 1 week before application to inform lake users when herbicide application will take place and restrictions on using the lake. An example of appropriate signage is shown in Figure 12.

NOTICE

This area was treated on *day of treatment* with the approved aquatic herbicide(s) Aquathol® K in accordance with regulations of the Hawke's Bay Regional Council and requirements of the Environmental Risk Management Authority New Zealand.

DO NOT use this water for household uses, irrigation, animal watering, or similar purposes until *25* days after treatment.*
DO NOT take edible vegetation from this treated area until *3* days after treatment.*
DO NOT take fish from this treated area until *3* days after treatment.*
No swimming or bathing for *24* hours after treatment*.

Treated by *name of chemical applicator*.

MAF BIOSECURITY NEW ZEALAND logo and contact details.

* These withholding periods are the use restrictions applied by ERMA.

Figure 12: Example of signage to alert lake users to restrictions on use of the waterbody.

Handling procedures: Procedures for the handling and mixing of herbicides are described in full in the NZ Standard 8409:1999. Additional information specific to the handling of endothall products, Aquathol® K and Aquathol® Super K (also see Appendix 2) follows:

The risk of hazardous spillage during handling are significantly reduced for Aquathol® products as no mixing is required. The herbicide should be poured directly into the spray-tank (or pellet broadcaster) on board an airboat, which is already on the water to minimise the risk of rupturing the spray-tank during boat launching (Figure 13). Empty containers should be passed back onto shore before application and temporarily stored in an area not accessible to livestock, wildlife and un-authorised people.

Endothall is corrosive and can cause irreversible eye damage. Contact with skin and breathing vapours should be avoided. During handling applicators and other handlers should wear the following protective clothing; long sleeved shirt and long trousers, waterproof gloves, shoes and socks and protective eyewear.

Figure 13: Filling the spray-tank onboard an airboat.

Spillage contingency plan: The greatest hazard on-site is the risk of spillage. The USA Aquathol® K label recommends that in event of spillage that sand or another inert material is used as an absorbent. The most likely scenario is that up to a container of Aquathol® K is spilled on land or in the boat during transfer into the spray-tank and therefore enough absorbent for up to 9.5 L (the container quantity) of liquid should be on hand during tank-filling. If Aquathol® K is spilled directly into a waterbody there is little that can be physically done to contain the spill and dilution will be the main mitigating factor.

Documentation of herbicide application: The applicator must maintain records as follows:

a) Objective of the treatment.
b) Identification of the target for treatment.
c) Identification of sensitive areas that may be affected by the application.
d) Application method.
e) Agrichemical to be used.
f) Application rate (total volume, litres/ha) or dose rate.
g) Identity of the operator.
h) Date of application.
i) Weather conditions (including wind speed, wind direction and temperature).

6.8 Monitoring

Assessment of hydrilla control: Vegetation assessment is recommended ca one month following application of endothall to assess reduction in biovolume and to record any effects on other aquatic plants. Assessment includes recording the height and cover of hydrilla and other aquatic plants along profiles in treated and untreated areas for reference. Using the same profiles surveyed in the 2008 will facilitate comparison with the baseline state of the lakes (Hofstra et al. 2008). GPS locations of the profile sites are available from the NIWA Aquatic Plant Database or Hofstra et al. (2008).

Monitoring at nine and/or twelve months post application is also recommended to evaluate whether further hydrilla control at these high risk sites is required. These are time frames based on initial application date. Ideally post application survey is the following spring and summer, to assess regrowth in the new growing season. These surveys may be done in conjunction with vegetation assessments for grass carp impacts (Hofstra and Rowe 2008). Again height and cover of hydrilla should be recorded along treated and untreated profile sites (Hofstra et al. 2008). If hydrilla has regained over 50% of its pre-treatment biomass and is in good condition then further control will be needed. This should be done as soon as possible. While temperature may be cooler at this time of year (Sept – December) endothall will be effective at reducing biovolume as long as the plants are actively growing.

Other monitoring requirements: There are no regulatory requirements to monitor the lake environment following application of endothall at the proposed rates (Hawke's Bay Regional Council 2006). However lake environmental monitoring is scheduled as part of the grass carp introduction (MAF Biosecuirty New Zealand 2008, Hofstra and Rowe 2008) that is proposed to occur in tandem with the endothall treatment.

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9. Appendix

9.1 Appendix 1: Historic timeline

Appendix 3: Hydrilla eradication project – Tutira Lakes Historic Timeline (I Gear)

Year (M/D)	Event	Reference
Pre-European times	Māori had established both permanent and temporary dwellings, gardens of kumara and taro, and managed wild crops such as aruhe (bracken fern) close to Tutira and Waikōpiro. The lake and the area surrounding it was well known for its eels, kakahi (fresh water muscles), birds along with its rongoa (medicine). Mokihi (rafts) were made from raupo, flax growing in the water on the lake shores for transport on the lake. Flax growing on land was used for ropes, nets and weaving.	
1787	Hand written note on HB F&G copy of the Tutira Catchment Control Scheme 1980 records "L.W. Clarry [of] Moeangiangi [Station]. Tutira overflow at southern end of the lake was blocked off in 1787." NB: Guthrie-Smith (1965) reported that Te Whatu-I-Apiti, a chief of the Heretaunga tribe diverted Papakiri Stream so that the lake would decompose killing off the eels on which the local tribes depended. The story goes that a frightful stench followed but later the embankments were destroyed "the fresh healing waters of the stream stayed the process of decomposition".	Tutira Technical Committee, 1976. Lake Tutira: Technical Committee Report. Hawke's Bay Catchment Board and Regional Water Board
1861 (13 Mar)	William Herbert Guthrie-Smith was born at Helensburgh on the Clyde in Scotland	http://www.teara.govt.nz/1966/G/Guthrie-smithWilliamHerbert/Guthrie-smithWilliamHerbert/en
1867	A. M. Johnson, Otago receives the first consignment of brown trout *Salmo trutta* for introduction into New Zealand	McDowell R M 1989 New Zealand Freshwater Fishes. Heinemann Reed
1868	The genesis of the Hawke's Bay Acclimatisation Society occurred as interested Hawke's Bay people imported birds and animals from 'the homeland'.	Wellwood J M 'Hawke's Bay Acclimatisation Society Centenary 1868 - 1968.
1873	Some palisades of deserted pa still standing at sites around Tutira.	Wellwood J M 'Hawke's Bay Acclimatisation Society Centenary 1868 - 1968.
1873	Tutira Station 61,140 acres first leased from Māori owners.	
1880s	First black swans reported at Tutira.	Wellwood J M 'Hawke's Bay Acclimatisation Society Centenary 1868 - 1968.

1880	William Herbert Guthrie-Smith emigrates from Scotland to New Zealand settling at Tutira. NB: In 1880, accompanied by Arthur Cunningham, a Rugby friend, Guthrie-Smith sailed for New Zealand, and on arrival went to work as cadet on the estate of his uncle, George Dennistoun, of Peel Forest Station, South Canterbury. Two years later he and Cunningham jointly bought Tutira estate in Hawke's Bay for £9,750, the amount for which it was mortgaged.	http://www.teara.govt.nz/1966/G/Guthrie-smithWilliamHerbert/Guthrie-smithWilliamHerbert/en; Wellwood J M 'Hawke's Bay Acclimatisation Society Centenary 1868 - 1968.
1881 (17 Nov)	Hawke's Bay Acclimatisation Society was gazetted.	Wellwood J M 'Hawke's Bay Acclimatisation Society Centenary 1868 - 1968.
1882	W.H. Guthrie-Smith and A.M. Cunningham take over the lease of Tutira station. NB: Guthrie-Smith reports that there were some 800 - 900 teal on Lake Tutira when he first arrived.	http://www.teara.govt.nz/1966/G/Guthrie-smithWilliamHerbert/Guthrie-smithWilliamHerbert/en; Wellwood J M 'Hawke's Bay Acclimatisation Society Centenary 1868 - 1968.
1883	Californian Rainbow trout introduced into New Zealand	
1884	Trout ova (48,000) were imported from Otago and liberated in Hawke's Bay rivers.	Wellwood J M 'Hawke's Bay Acclimatisation Society Centenary 1868 - 1968.
1884	Guthrie-Smith first 'leased' Tutira. NB: Guthrie-Smith, never had all the 36 owners (or successors) sign his lease. He only ever held, therefore, an incomplete ‘holding title’, and farmed with the possibility that at any time, those non-signatories could have a portion of his lease partitioned out for themselves.	http://www.waitangi-tribunal.govt.nz/reports/viewchapter.asp?reportID=d6d0c6a3-efe6-4507-b4b3-6dd4bf5c5552&chapter=14#H201.9.8. also: http://www.waitangi-tribunal.govt.nz/doclibrary/public/researchwhanui/district/11B/Chapt06.pdf
1890's	First attempt by Guthrie-Smith to introduce trout - brook trout (*Salvelinus fontinalis*) using imported ova - this was unsuccessful.	Wellwood J M 'Hawke's Bay Acclimatisation Society Centenary 1868 - 1968.
1890	During this decade a drain was cut through the swamp at the head of the lake. This swamp had previously seeped into Tutira - the outlet of the lake. The filtering effect of the swamp was destroyed leading to the building up of a delta where Papakiri (Sandy Creek) now flowed into the lake.	Tutira Technical Committee, 1976. Lake Tutira: Technical Committee Report. Hawke's Bay Catchment Board and Regional Water Board
1893	6 ha (15 acres) directly behind the Tutira Station homestead was set aside by Guthrie-Smith to regenerate.	

1895	Guthrie-Smith writes that black swans are rarely, if ever, seen on Lake Tutira.	H. Guthrie-Smith. 1895 Bird-life on a Run. Art. XXXIV. Transaction s of the New Zealand Institute: Read before the Hawke's Bay Philosophical Institute, 12th August, 1895; http://www.teara.govt.nz/1966/G/Guthrie-smithWilliamHerbert/Guthrie-smithWilliamHerbert/en
1899-1900	Willows grown from a weeping willow that grew next to Napoleon's Tomb on St Helena, pines and eucalyptus were planted around the lakes. Guthrie-Smith established the area immediately around the lake as a wild life sanctuary.	Tutira Technical Committee, 1976. Lake Tutira: Technical Committee Report. Hawke's Bay Catchment Board and Regional Water Board
1901	First sods of the Napier - Wairoa road were cut.	Guthrie-Smith H 1926 Tutira: The Story of a New Zealand Sheep Station. Whitcombes and Tombs, Wellington.
1904	George Douglas Hamilton '*Trout-fishing and sport in Māoriland*' published by the Government Printing Office. NB: A keen sportsman, Hamilton may have been the first to establish a trout hatchery in the North Island. When not engaged in his legal battles he occupied himself in later years with stocking the rivers of southern Hawke's Bay with trout. He presided over the Hawke's Bay Bush Districts Acclimatisation Society in the 1890s, the Bush Districts Farmers' Club, both the Woodville District and Dannevirke Jockey Clubs and the Hawke's Bay Angling and Shooting Club from its inception in 1901 until his death.	
1911	Guthrie-Smith publishes 'Birds of Water, Wood and Waste'. Illustrated with many black and white images of birds on and around Lake Tutira.	
1917	650mm of rain fell over three days, drowning the principle habitat of fernbirds - raupo and cutty grass around the lake edge - and leaving 150mm of silt over it. Fernbirds were not seen at Lake Tutira after this event.	Guthrie-Smith 1927 Birds of Water, Wood and Waste. Whitcombes and Tombs, Wellington.
1919	Weka no longer found at Tutira.	
1920	Earlier liberations of Rainbow and Brown Trout into Lake Tutira were possible.	Wellwood J M 'Hawke's Bay Acclimatisation Society Centenary 1868 - 1968.
1921	*Tutira*, W Herbert Guthrie-Smith was published by William Blackwood and Sons, of Edinburgh.	

1925 (July)	Guthrie-Smith completed a bathymetric survey of the lake taking 356 soundings	Tutira Technical Committee, 1976. Lake Tutira: Technical Committee Report. Hawke's Bay Catchment Board and Regional Water Board
1928	396 mm of rain fell in 11 hours.	Kidson, E. 1930 NZ Journal of Science and Technology 12: 53-60
1929	Guthrie-Smith had Lake Tutira and the surrounding land designated a sanctuary for imported and native game.	
1931 (3 Feb)	Napier earthquake: Raised the bed of the lake, and surrounding land, several feet and raised a large area of swampy ground along the lower reaches of Papakiri (Sandy Creek).	Wellwood J M 'Hawke's Bay Acclimatisation Society Centenary 1868 - 1968.
1931 (3 Feb)	Napier earthquake. Hawke's Bay Acclimatisation records destroyed. Only records from 1922-23 onward are held by Internal Affairs (the amended Animals and Game Protection Act 1921 required annual returns from Acclimatisation Societies).	Wellwood J M 'Hawke's Bay Acclimatisation Society Centenary 1868 - 1968.
1936	Lease of Tutira Station expired and Guthrie-Smith was allowed to purchase 809 ha.	
1938 (Apr)	ANZAC Day storm. 675mm (27 inches) of rain fell in the area over a period of four days. Made the course of the Papakiri Stream more direct - previously meandering. (39 inches of rain was recorded elsewhere in Hawke's Bay.)	Wellwood J M 'Hawke's Bay Acclimatisation Society Centenary 1868 - 1968.
1938	686 mm of rain fell over four days	Tutira Technical Committee, 1976. Lake Tutira: Technical Committee Report. Hawke's Bay Catchment Board and Regional Water Board
1940s	Height of the causeway between Tutira and Waikōpiro was increased by earth works.	Hooper, G. (1987). Hawke's Bay small lakes water quality survey. Unpublished report. Hawke's bay Catchment Board.
1940 (4 Jul)	Guthrie-Smith passed away aged 79. Leaving 2000 acres.	http://www.teara.govt.nz/1966/G/Guthrie-smithWilliamHerbert/Guthrie-smithWilliamHerbert/en
1942	Barbara Absolum (Guthrie-Smith's daughter establishes the Guthrie-Smith Trust for the benefit of New Zealand's youth.	http://www.workforce.ac.nz/training_programmes/outdoor_recreation/Guthrie.htm
1947	Trout liberated following the hatching of 310,000 rainbow trout ova at the Greenmeadows Hatchery operated by the Hawke's bay Acclimatisation Society. Fry were released into Lake Tutira and Hawke's Bay rivers during 1946 -47.	Wellwood J M 'Hawke's Bay Acclimatisation Society Centenary 1868 - 1968.

1950s	Presence of Hydrilla in Lake Tutira was known.	Walls, G., 1993. The New Zealand Hydrilla Problem: A Review of the Issues and Management Options. Department of Conservation.
1951	Hawke's Bay Acclimatisation Society Annual Meeting records "Lake Tutira produced some good bags and showed the possibility of the lakes being developed into a major fishing area."	Wellwood J M 'Hawke's Bay Acclimatisation Society Centenary 1868 - 1968.
1952	Trout trap installed on Papakiri Stream and the first ova stripped. This large scalestripping was disappointing. NB: Only 1000,000 of the 310,000 ova stripped were reared for liberation.	Wellwood J M 'Hawke's Bay Acclimatisation Society Centenar1868 - 1968.
1956	Marine Department, Freshwater Advisory Service, - Stream and Spawning Survey of Sandy Creek recommends that no further trout releases be made for a period of three years as the trout stock was thought to probably be self-supporting.	Marine Department, Freshwater Advisory Service. Report 23-30:7:56
1957	Waikōpiro, Tutira and Orakai declared a Wildlife Refuge under the Wildlife Act 1953.	
1958	The Hawke's Bay Acclimatisation reported "The establishment of smelt in the lakes was an innovation under consideration".	Wellwood J M 'Hawke's Bay Acclimatisation Society Centenary 1868 - 1968.
1958	Experimental fishing season continues.	Wellwood J M 'Hawke's Bay Acclimatisation Society Centenary 1868 - 1968.
1959 (30 Apr)	Lake Tutira research ends (Marine Department)	Wellwood J M 'Hawke's Bay Acclimatisation Society Centenary 1868 - 1968.
1959	The Hawke's Bay Acclimatisation Society made recommendations to the Secretary for Marine that:1. Lake Tutira be open for fishing year round; 2. There be no size or bag limits; 3. Fin clipped fingerlings be released in 1960 and 1961; 4. A further study of stock be made in 1961.	Wellwood J M 'Hawke's Bay Acclimatisation Society Centenary 1868 - 1968.
1959	Annual liberations of rainbow trout commenced by the HB Acclimatisation Society.	Tutira Technical Committee, 1976. Lake Tutira: Technical Committee Report. Hawke's Bay Catchment Board and Regional Water Board
1959	First reports of the proliferation of macrophytes by the Acclimatisation Society honorary ranger - Mr W.A. Gunn	Tutira Technical Committee, 1976. Lake Tutira: Technical Committee Report. Hawke's Bay Catchment Board and Regional Water Board

1960s	Smelt were released in Lake Opouahi some time since the 1960s.	
1960	Swan census 254 birds - W A Gunn Tutira identity and former honorary ranger. Gunn believed there was insufficient food to support a much larger population.	Wellwood J M 'Hawke's Bay Acclimatisation Society Centenary 1868 - 1968.
1960	Early 1960s - trout were reported as dying in Lake Tutira through lack of oxygen due to prolific oxygen weed growth.	Wellwood J M 'Hawke's Bay Acclimatisation Society Centenary 1868 - 1968.
1960	Papakiri (Sandy Creek) surveyed. It was concluded that the Lake Tutira fish population was predominantly brown trout not rainbow trout as was the local opinion. The survey concluded that there was adequate food available to support a larger trout population.	Wellwood J M 'Hawke's Bay Acclimatisation Society Centenary 1868 - 1968.
1960	"The weed problem continued to be unresolvable" and " remain so as long as aerial top-dressing as practiced."	Wellwood J M 'Hawke's Bay Acclimatisation Society Centenary 1868 - 1968.
1960	Stocking of Lake Elands with rainbow trout ceases.	
1961 (May)	A 5" fingerling trout released into Lake Tutira in August 1960 is caught weighing 3.5lbs.	
1962-63	Estimated that 717 angling days were spent at the lake by some 289 anglers from a survey of angler diaries	Tutira Technical Committee, 1976. Lake Tutira: Technical Committee Report. Hawke's Bay Catchment Board and Regional Water Board
1963	*Hydrilla verticillata* validated as being present in Lake Tutira and Waikōpiro	Walls, G., 1993. The New Zealand Hydrilla Problem: A Review of the Issues and Management Options. Conservation Advisory Science Notes #71. Department of Conservation. 42pp.
1963	P.J. Grant completed a bathymetric survey determining that the lake had a mean depth 1.1m shallower than the 1925 survey. This had occurred following sedimentation events. The volume of the lake had decreased 5.17%. 1.9×10^6 cubic meters of sediment had been contributed from the catchment. Grant recorded dense weed beds extending to a depth of 7.6 m and covering 16.9% of the total lake surface which had not been present in 1925	Tutira Technical Committee, 1976. Lake Tutira: Technical Committee Report. Hawke's Bay Catchment Board and Regional Water Board
1964	10,000 rainbow trout fingerlings were released in Lake Tutira. A further 10,000 unfed fry were released into Papakiri (Sandy Creek).	Wellwood J M 'Hawke's Bay Acclimatisation Society Centenary 1868 - 1968.

1964	Crown owned areas of the lake and lake edge declared a domain.	
1965	Lease of the Randall House huts on the shore of Lake Tutira was obtained by the Scinde Angler's Club.	Wellwood J M 'Hawke's Bay Acclimatisation Society Centenary 1868 - 1968.
1965	10,000 unfed fry were released into Lake Tutira along with 400 tagged fingerlings.	Wellwood J M 'Hawke's Bay Acclimatisation Society Centenary 1868 - 1968.
1965 (1 Aug)	The Hawke's Bay Catchment Board reports that between 1925 and 1963: 1. Lake Tutira is 490ft asl and covers 443 acres. 2. The water level has risen by approximately 1 foot; 3. There has been a reduction in the mean depth of about 3.5 ft. The represents sediment from a catchment of about 11 square miles; 4. Two exotic aquatic plants had become established; *Elodea canadensis* and a close relative of *Hydrilla verticillata*. Weed growth extends out to the 25ft contour; Average water temperature is 51 degrees F at 120 ft rising to 63 degrees F at the surface.	
1966	38 of the 400 tagged fish released in the previous year were subsequently caught between May and Sept 1966. These fish had an average weight of 2lbs and were 15 inches in length.	Wellwood J M 'Hawke's Bay Acclimatisation Society Centenary 1868 - 1968.
1966	Ngāti Tu agrees to lease 40 hectares at the northern end of Lake Tutira to the Hawke's Bay Acclimatisation. A fifty year lease is signed.	Wellwood J M 'Hawke's Bay Acclimatisation Society Centenary 1868 - 1968.
1967-68	3264 angling events estimated in a survey of angler diaries.	Tutira Technical Committee, 1976. Lake Tutira: Technical Committee Report. Hawke's Bay Catchment Board and Regional Water Board
1968	Quentin Bennett, Marv Carroll and Barry Short dive Lake Opouahi and confirm the drowned forest beneath the surface.	Pers. comm. And article ex Quentin Bennett.
1968	Tauranga Koau was a nesting site for "dozens of black teal". "Unfortunately with the large increase in the number of Black Swan, now permanent residents of the lake, the teal have suffered a severe set-back, …"	Wellwood J M 'Hawke's Bay Acclimatisation Society Centenary 1868 - 1968.
1968	Population of teal on Lake Tutira recognised to be "little more than a score."	Wellwood J M 'Hawke's Bay Acclimatisation Society Centenary 1868 - 1968.
1970s	Formation of the Lake Tutira Technical Committee to investigate the eutrophication of Lake Tutira and to make recommendations to improve the lake's trophic status.	Hooper, G. (1989). Lake Tutira water quality study. Unpublished report. Hawke's Bay Catchment Board.

1970	Full vegetation survey of Lake Opouahi - hydrilla not recorded.	
1971	Grass carp (White Amur) imported into New Zealand by MAF for the purposes of aquatic weed control	http://www.mfe.govt.nz/publications/water/lm-fish-in-nz-lakes-jun02.pdf
1972	Blue-green algal blooms reported in Lake Tutira	Tutira Technical Committee, 1976. Lake Tutira: Technical Committee Report. Hawke's Bay Catchment Board and Regional Water Board
1973	The Orakai, Tutira and Waikōpiro Refuge Order prohibits motorised boats and commercial eeling in the lakes.	
1973	The Ministry of Agriculture and Fisheries commence physical and biological parameter surveys in Lake Tutira.	Teirney, L. 1980. Tutira - A Lake worth saving. Soil and Water Feb 1980
1973	Fisheries Division of MAF and DSIR set up monthly sampling programme to investigate the problems in the lake.	Tutira Technical Committee, 1976. Lake Tutira: Technical Committee Report. Hawke's Bay Catchment Board and Regional Water Board
1974	Lake Tutira Technical Committee formed.	Tutira Technical Committee, 1976. Lake Tutira: Technical Committee Report. Hawke's Bay Catchment Board and Regional Water Board
1975 (Oct)	Aerohydraulic guns turned on to mix water through the summer months from October - March. Resulted in well defined thermocline that had previously occurred not developing. A gradual decrease in water temperature occurred throughout the water column - the 10 degree C characteristic of the hypolimnion was not reached until 27m depth in comparison to 12 m prior to 1976.	Teirney, L. 1980. Tutira - A Lake worth saving. Soil and Water Feb 1980
1976	Hawke's Bay Electric Power Board undertakes a preliminary study to determine the technical feasibility of building a power station drawing on Lake Tutira.	Letter from the Chief Engineer, Hawke's Bay Electric Power Board to the Chief Soil Conservator, Hawke's Bay Catchment Board 5 March 1980.
1977 (Apr)	Over 200mm of rainfall over 2 consecutive days.	Hooper, G. (1989). Lake Tutira water quality study. Unpublished report. Hawke's Bay Catchment Board.

1977	Reserves Act is enacted.	
1977	Tutira Recreation Reserve created.	
1979 (Mar)	Aerohydraulic guns turned off due to high running costs	Teirney, L. 1980. Tutira - A Lake worth saving. Soil and Water Feb 1980
1980 (Dec)	Over 200mm of rainfall over 2 consecutive days.	Hooper, G. (1989). Lake Tutira water quality study. Unpublished report. Hawke's Bay Catchment Board.
1981 (Aug)	Normal and low flow waters of Sandy Creek were diverted from Lake Tutira directly into the out-fall stream by passing the lake.	Hooper, G. (1989). Lake Tutira water quality study. Unpublished report. Hawke's Bay Catchment Board.
1982 (Feb)	Hydrilla gazetted a Class B Noxious Plant under the Noxious Plants Act 1978	
1984 (Apr)	Over 200mm of rainfall over 2 consecutive days.	Hooper, G. (1989). Lake Tutira water quality study. Unpublished report. Hawke's Bay Catchment Board.
1984-85	Lake Waikōpiro described as eutrophic by the Catchment Board because of high Nitrogen and Phosphorus loading and the complete deoxygenation of the hypolimnion (waters below 6m), poor water clarity and periodic blooms of blue-green algae and the presence of dense beds of *Hydrilla verticillata*.	Hooper, G. (1987). Hawke's Bay small lakes water quality survey. Unpublished report. Hawke's bay Catchment Board.
1984	Grass carp used in Lake Parkinson to remove exotic aquatic weeds	Mitchell et al (1984) Limnological changes in a small lake stocked with grass carp. New Zealand Journal of marine and Freshwater Research 18: 103-114.
1984	Hydrilla found to be in Lake Opouahi	
1984	1500 - 2500 Diploid grass carp escape from the Aka aka Drain in Waikato	http://www.doc.govt.nz/upload/documents/science-and-technical/casn257.pdf
1985 (13/14 Mar)	244 mm of rainfall was recorded.	
1985 (25/26 Jul)	Following a storm Sandy Creek over flows into Lake Tutira. 309mm of rainfall was recorded on 25/26 July.	Hooper, G. (1989). Lake Tutira water quality study. Unpublished report. Hawke's Bay Catchment Board.

1985	Effects that grass carp might have on trout is considered	Rowe, D. K., Schipper, C. M., 1985 An Assessment of the Impact of Grass Carp (*Ctenopharyngodon idella*) In New Zealand Waters. Fisheries Environmental Report 358. Fisheries Division of the Ministry of Agriculture and Fisheries
1987	Conservation Act is enacted.	
1987	Hawke's Bay Catchment Board report on small lake water quality in Hawke's Bay	Hooper, G. (1987). Hawke's Bay small lakes water quality survey. Unpublished report. Hawke's bay Catchment Board.
1987	Both *Hydrilla verticillata* and *Elodea canadensis* recorded as being present in Lake Waikōpiro by the Catchment Board	Hooper, G. (1987). Hawke's Bay small lakes water quality survey. Unpublished report. Hawke's bay Catchment Board.
1988	Rowe and Hill prove that grass carp are an efficient agent for eliminating exotic macrophytes in lakes	
1988	Hydrilla occupies 25 % of Lake Elands	
1988 (7 Mar)	Cyclone Bola - Sandy Creek over flows into Lake Tutira.	Hooper, G. (1989). Lake Tutira water quality study. Unpublished report. Hawke's Bay Catchment Board.
1988	Grass carp introduced to the Elands lake. 400 triploid fish.	
1988 (27 Sep)	Lake Elands vegetation survey, diquat applied [2ppm]	
1988 (2 Nov)	Lake Elands vegetation survey	
1988 (3 Nov)	Lake Elands grass carp (392) released	
1988-89	Weed mat used to control main infestation near jetty in Lake Opouahi and near the boat ramp in Lake Tutira. Hand weeding of low density infestations.	
1990 (Apr)	Hydrilla biomass in Elands lake reduced by 99% following the introduction of grass carp.	
1991 (Apr)	No trace of hydrilla in Elands lake other than regrowth from turions and tubers and occasional stem fragment.	
1991	Additional grass carp (200) released into Elands lake.	
1992	Clayton reports that grass carp have significantly reduced the biomass of grass carp in Lake Elands, Hawke's Bay.	

1993 (Aug)	DoC advocates the use of grass carp in combination with herbicide and weed matting to eradicate hydrilla in the lakes	Walls, G., 1993. The New Zealand Hydrilla Problem: A Review of the Issues and Management Options. Conservation Advisory Science Notes #71. Department of Conservation. 42pp.
1993 (Aug)	Unfavourable perception regarding the use of grass carp the lakes where hydrilla is found is noted by DoC	Walls, G., 1993. The New Zealand Hydrilla Problem: A Review of the Issues and Management Options. Conservation Advisory Science Notes #71. Department of Conservation. 42pp.
1993 (Aug)	Concerns of Māori documented in a DoC report - uncomfortable with the continued presence of Hydrilla in the lakes; because it constitutes a threat to other waterways in New Zealand, it prevents eeling, and prevents restoration of rongoa in the lake shallows	Walls, G., 1993. The New Zealand Hydrilla Problem: A Review of the Issues and Management Options. Conservation Advisory Science Notes #71. Department of Conservation. 42pp.
1993 (Sep)	DoC receive report from C.P. Mitchell - Control Options for Hydrilla verticillata in the Tutira Lakes.	Micthell, C.P., 1993. Control Options for Hydrilla verticillata in the Tutira Lakes - A report prepared for the Department of Conservation, Hawke's Bay Conservancy.
1994-1995	Fishing effort estimated at 3090 (plus or minus 150) angler days / annum	
1995	An Ecological Assessment of the Impact of Chinese Grass carp in Relation to Oxygen Weed (*Egeria densa*) Control at Lake Wainamu, Waitakere Ranges, Auckland is prepared by NIWA.	Champion, P. D., Rowe D. K., 1995 Ecological Assessment of the impact of Chinese Grass carp in Relation to Oxygen Weed (*Egeria densa*) Control at Lake Wainamu, Waitakere Ranges, Auckland. NIWA Report
1997 (Jun)	Hawke's Bay Regional Council prepares a management plan for land under its control.	Titchener, A. et al. 1997. Management Plan for part of Tutira Station located on the Eastern side of Lake Tutira. Prepared for Hawke's Bay Regional Council.
1997 (Jun)	Mr Fred Reti emphasised the need not to over look the health of the eels in Lake Tutira and their importance as a traditional food source.	Titchener, A. et al. 1997. Management Plan for part of Tutira Station located on the Eastern side of Lake Tutira. Prepared for Hawke's Bay Regional Council.

1999	Integrated control using grass carp and an initial treatment of herbicide reported to have been successful in eliminating *Egeria densa* in Lake Waingata, Northland.	Rowe et al 1999
2000	HBRC suspend monitoring of the water quality in Tutira / Waikōpiro	
2000	Fluridone trialled under lab conditions at Ruakura to control hydrilla. The hydrilla found in New Zealand did not succumb.	Hofstra D. E.; Clayton J. S. (2000). Evaluation of Fluridone for Hydrilla Control in New Zealand. Journal of Aquatic Plant Management.
2000 (Apr)	The impact of hydrilla is considered.	Hofstra D. E., Champion P. D., Clayton J. S., 2000. Hydrilla in the Hawke's Bay - A Discussion Document. NIWA Report
2000 (Nov)	NIWA obtains 23 day continuous record of oxygen, pH and temperature when trialling Endothall in Lake Waikōpiro.	Hofstra et al 2001
2001 (Mar)	NIWA obtains 23 day continuous record of oxygen, pH and temperature when trialling Endothall	Hofstra et al 2001
2001	NIWA trials Endothall in Lake Waikōpiro	
2001 (Nov)	DoC out line their recommendations for a strategy to manage hydrilla - immediate objective is containment. Eradication long term goal.	DoC (2001). Hydrilla in New Zealand: A review of the Problem and Recommendations for Future Action.
2001 (Aug)	Hydrilla declared an Unwanted Organism under the Biosecurity Act 1993	
2001-2002	NIWA undertakes a vegetation survey found on 9 transects spread around the lake's edge. 13 macrophyte species recorded in Lake Waikōpiro, included *Hydrilla verticillata; Elodea canadensis; Myriophyllum propinquum; M. pedunculatum; Potamogeton ochreatus; P. cheesemanii; Lilaeopsis novae-zealandiae; L. ruthiana; Chara australis; Persicaria decipens; Ludwegia palustris; Glossostigma elatinoides; G. diandrum*.	
2001-2002	Survey of fishermen shows they do not distinguish between Tutira and Waikōpiro. Fishing effort estimated at 2300 (plus or minus 380) angler days / annum. Lake Opouahi estimated at 10 (plus or minus 10) angler days / annum Compared with: Mohaka 7000; Tutaekuri River 6700; Ngaruroro River 6200; Tukituki River 17000.	
2002 (29 Oct)	NIWA and DoC staff meet to identify potential sites for hydrilla transfer that will be subject to surveillance.	
2003	No trace of hydrilla in Elands lake.	
2003	DoC contracts NIWA to prepare an operational plan for the containment of hydrilla and for research aimed at developing methods to eradicate hydrilla.	

2003 (Feb)	Operational Plan for the containment of hydrilla prepared by NIWA for DoC. Included research into eradication.	NIWA, 2003. Hydrilla - an Operational Plan for Containment and Eradication Research NIWA Client Report: HAM2002-052. NIWA Project: DOC03249
2004 (Apr)	Environmental Impact Assessment and Operational Plan for the Introduction of Grass Carp (*Ctenopharyngodon idella*) into Lake Waikōpiro, Hawke's Bay prepared by NIWA for DoC	NIWA, 2004. Environmental Impact Assessment and Operational Plan for the Introduction of Grass Carp (*Ctenopharyngodon idella*) into Lake Waikōpiro, Hawke's Bay. NIWA Client Report: HAM2004-025. NIWA Project: DOC0425
2006	MAF Biosecurity New Zealand, as the lead agency, accepts responsibility for Hydrilla	
2006 (May)	Organism consequence assessment of hydrilla prepared by NIWA for MAF BNZ	NIWA, 2006.Organism consequence *Hydrilla verticillata*. NIWA Client Report: HAM2006-058f. NIWA Project: MAF06205
2006 (Nov)	Management Options Assessment for hydrilla prepared by NIWA for MAF BNZ	NIWA, 2006.Management Options Assessment Report for *Hydrilla verticillata*. NIWA Client Report: HAM2006-159. NIWA Project: MAF07204
2006 (Oct)	Hydrilla designated a Notifiable Organism under the Biosecurity Act 1993.	
2006	Accountability for Hydrilla transferred from DoC to MAF BNZ	
2007 (Dec)	Victoria Lamb, Ian Gear meet with Charlie and Wynne King, Ngāti Pahauwera at Mohaka	
2008 (1 Feb)	Ian Gear met with Bevan Taylor, Ngāti Tu in Napier	
2008 (29 Feb)	MAFBNZ and Key stakeholders meet at Lake Tutira to discuss the eradication of *Hydrilla verticillata*	
2008 (3 Apr)	Hydrilla Technical Advisory Group meets in Napier. The Technical Advisory Group endorses the draft Operational Plan.	
2008 (12-16 May)	Base line flora and fauna surveys of the lakes is undertaken	

9.2 Appendix 2: Aquathol labels and MSDS (Material Safety Data Sheets) from Cerexagri

AQUATIC HABITAT MANAGEMENT

AQUATHOL® K

AQUATIC HERBICIDE

ACTIVE INGREDIENT:

Dipotassium salt of endothall*	40.3%
OTHER INGREDIENTS:	59.7%
TOTAL	100.0%

*7-oxabicyclo [2.2.1]heptane-2,3-dicarboxylic acid equivalent 28.6%
Contains per gallon 4.23 lbs. dipotassium endothall

KEEP OUT OF REACH OF CHILDREN

DANGER

FIRST AID:

IF IN EYES:
- Hold eye open and rinse slowly and gently with water for 15-20 minutes.
- Remove contact lenses, if present, after the first 5 minutes, then continue rinsing.
- Call a poison control center or doctor for treatment advice.

IF INHALED:
- Move person to fresh air. If person is not breathing, call 911 or ambulance, then give artificial respiration, preferably mouth-to-mouth if possible.
- Call a poison control center or doctor for treatment advice.

IF SWALLOWED:
- Call a poison control center or doctor immediately for treatment advice.
- Have person sip a glass of water if able to swallow. Do not induce vomiting unless told by a poison control center or doctor. Do not give anything by mouth to an unconscious person.

IF ON SKIN:
- Take off contaminated clothing.
- Rinse skin immediately with plenty of water for 15-20 minutes.
- Call a poison control center or doctor for treatment advice.

HOT LINE NUMBER: Have the product container or label with you when calling a poison control center or doctor, or going for treatment. You may also contact (303) 623-5716 for emergency medical treatment information.

NOTE TO PHYSICIAN: Measures against circulatory shock, respiratory depression, and convulsion may be needed.

EPA Registration No. 4581-204-82695 EPA Establishment No. 62171-MS-003

Net Contents ______________

Sold by:
Cerexagri-Nisso LLC
630 Freedom Business Center • Suite 402
King of Prussia, PA 19406
1 800-438-6071 • www.cerexagri-nisso.com

Cerexagri-Nisso LLC

GENERAL INFORMATION

AQUATHOL K is a liquid concentrate soluble in water which is effective against a broad range of aquatic plants with a margin of safety to fish.

Dosage rates indicated for the application of AQUATHOL K are measured in "Parts Per Million" (ppm) of dipotassium endothall. Only 0.5 to 5.0 ppm are generally required for aquatic weed control, whereas some fish species are tolerant to approximately 100 ppm or over.

DIRECTIONS FOR USE

It is a violation of Federal law to use this product in a manner inconsistent with its labeling.

HOW TO APPLY:

AQUATHOL K is a contact herbicide; consequently, do not apply before weeds are present. Application as early as possible after weeds appear and are actively growing is recommended for best results.

If an entire pond is treated at one time, or if the dissolved oxygen level is low at time of application, decay of weeds may remove enough oxygen from the water, causing fish to suffocate. Water containing very heavy vegetation should be treated in sections to prevent suffocation of fish. Sections should be treated 5-7 days apart. Carefully measure size and depth of area to be treated and determine amount of AQUATHOL K to apply from chart.

AQUATHOL K should be sprayed on the water or injected below the water surface and should be distributed as evenly as possible. It may be applied as a concentrate or diluted with water depending on the equipment. Some dilution will give better distribution. For best results apply when water is quiescent and/or flows are minimal.

In instances where the weed(s) to be controlled is an exposed surface problem (i.e., some of the broad-leaved pond weeds) coverage is important. For best results apply the concentrate or with the least amount of water compatible with the application equipment.

Necessary approval and/or permits should be obtained in states where required.

AQUATIC WEEDS CONTROLLED AND DOSAGE RATE CHARTS

AQUATHOL K is recommended for the control of the following aquatic weeds in irrigation and drainage canals, ponds and lakes at the rates indicated. Since the active ingredient is water soluble and tends to diffuse from the treated area, select the dosage rate applicable to the area to be treated. Use the lower rate in each range of rates where the growth is young and growing and/or where the weed stand is not heavy. Marginal treatments of large bodies of water require higher rates as indicated.

Aquatic Weed	RATES: Entire Pond/Lake or Large Area Treatment	Gallons per Acre Ft.	Spot or Lake Margin Treatment	Gallons per Acre Ft.
Bur Reed, Sparganium spp.	3.0-4.0 ppm	1.9-2.6 gal.	4.0-5.0 ppm	2.6-3.2 gal.
Coontail, Ceratophyllum spp.	1.0-2.0 ppm	0.6-1.3 gal.	2.0-3.0 ppm	1.3-1.9 gal.
Horned Pondweed, Zannichellia palustris	1.0-2.0 ppm	0.6-1.3 gal.	2.0-3.0 ppm	1.3-1.9 gal.
Hydrilla, Hydrilla verticillata	2.0-3.0 ppm	1.3-1.9 gal.	3.0-4.0 ppm	1.9-2.6 gal.
Hygrophila, Hygrophila polysperma	4.0-5.0 ppm	2.6-3.2 gal.	5.0 ppm	3.2 gal.
Milfoil, Myriophyllum spp.	2.0-3.0 ppm	1.3-1.9 gal.	3.0-4.0 ppm	1.9-2.6 gal.
Naiad, Najas spp.	1.0-3.0 ppm	0.6-1.9 gal.	2.0-4.0 ppm	1.3-2.6 gal.
Pondweed, Potamogeton spp.	0.5-3.0 ppm	0.3-1.9 gal.	1.5-4.0 ppm	1.0-2.6 gal.
Including:				
American, P. nodosus	2.0-3.0 ppm	1.3-1.9 gal.	3.0-4.0 ppm	1.9-2.6 gal.
Largeleaf (Bass Weed), P. amplifolius	2.0-3.0 ppm	1.3-1.9 gal.	3.0-4.0 ppm	1.9-2.6 gal.
Curlyleaf, P. crispus	0.5-1.5 ppm	0.3-1.0 gal.	1.5-3.0 ppm	1.0-1.9 gal.
Flatstem, P. zosteriformis	2.0-3.0 ppm	1.3-1.9 gal.	3.0-4.0 ppm	1.9-2.6 gal.
Floating-leaf, P. natans	1.0-2.0 ppm	0.6-1.3 gal.	2.0-3.0 ppm	1.3-1.9 gal.
Illinois, P. Illinoensis	1.5-2.5 ppm	1.0-1.6 gal.	2.5-3.5 ppm	1.6-2.3 gal.
Narrowleaf, P. pusillus	1.0-2.0 ppm	0.6-1.3 gal.	2.0-3.0 ppm	1.3-1.9 gal.
Threadleaf, P. filiformis	2.0-3.0 ppm	1.3-1.9 gal.	3.0-4.0 ppm	1.9-2.6 gal.
Sago, P. pectinatus	1.0-2.0 ppm	0.6-1.3 gal.	2.0-3.0 ppm	1.3-1.9 gal.
Variable Leaf, P. diversifolius	1.0-2.0 ppm	0.6-1.3 gal.	2.0-3.0 ppm	1.3-1.9 gal.
Parrot Feather, Myriophyllum aquaticum	2.0-3.0 ppm	1.3-1.9 gal.	3.0-4.0 ppm	1.9-2.6 gal.
Water Stargrass, Heteranthera spp.	2.0-3.0 ppm	1.3-1.9 gal.	3.0-4.0 ppm	1.9-2.6 gal.

RATE OF APPLICATION — LAKES AND PONDS

The following chart indicates the total quantity of material to be applied.

APPROXIMATE GALLONS OF AQUATHOL K FOR ONE ACRE (208' x 208') TREATMENT

	DOSAGE IN GALLONS FOR VARIOUS CONCENTRATIONS IN PPM						
DEPTH	0.5 ppm	1.0 ppm	1.5 ppm	2.0 ppm	3.0 ppm	4.0 ppm	5.0 ppm
1 ft.	0.3	0.6	1.0	1.3	1.9	2.6	3.2
2 ft.	0.6	1.3	1.9	2.6	3.8	5.1	6.4
4 ft.	1.3	2.6	3.8	5.1	7.7	10.2	12.8
6 ft.	1.9	3.8	5.8	7.6	11.5	15.3	19.2

RATE OF APPLICATION — IRRIGATION AND DRAINAGE CANALS**

The following indicates the total quantity of material to be applied.

GALLONS OF AQUATHOL K REQUIRED TO TREAT 1 MILE OF CANAL 1 FOOT DEEP*

	WIDTH OF CANAL IN FEET			
PPM	5	10	15	20
1.0 ppm	0.4	0.75	1.2	1.5
2.0 ppm	0.75	1.5	2.3	3.0
3.0 ppm	1.2	2.3	3.5	4.5
4.0 ppm	1.5	3.0	4.5	6.0
5.0 ppm	2.0	3.8	5.7	7.5

The minimum contact time with weeds for optimum results should be 2 hours.

*For deeper water, adjust rate accordingly.

** Not for this use in California.

PRECAUTIONARY STATEMENTS

HAZARDS TO HUMANS (AND DOMESTIC ANIMALS)

DANGER

CORROSIVE. CAUSES IRREVERSIBLE EYE DAMAGE. MAY BE FATAL IF SWALLOWED. HARMFUL IF INHALED OR ABSORBED THROUGH SKIN. DO NOT GET IN EYES, ON SKIN, OR ON CLOTHING. AVOID BREATHING VAPORS OR SPRAY MIST. PROLONGED OR FREQUENTLY REPEATED SKIN CONTACT MAY CAUSE ALLERGIC REACTIONS IN SOME INDIVIDUALS. Wear appropriate protective eyewear such as goggles, face shield, or safety glasses. Wash thoroughly with soap and water after handling and before eating, drinking, chewing gum, or using tobacco. Remove and wash contaminated clothing before reuse.

Applicators and other handlers must wear:
- long-sleeved shirt and long pants
- socks
- shoes
- chemical resistant gloves
- protective eyewear

USER SAFETY RECOMMENDATIONS:

Users should:
- Wash hands before eating, drinking, chewing gum, using tobacco or using the toilet.
- Remove clothing immediately if pesticide gets inside. Then wash thoroughly and put on clean clothing.
- Remove protective clothing and equipment immediately after handling this product. Wash the outside of gloves before removing. As soon as possible, wash thoroughly and change into clean clothing.

ENVIRONMENTAL HAZARDS

Avoid contact with or drift to other crops or plants as injury may result. Wash out spray equipment with water after each operation.

Not for use in brackish or salt water. Do not use water from treated areas for watering livestock, for preparing agricultural sprays for food crops, for irrigation or for domestic purposes within the following periods:

Up to 0.5 ppm dipotassium salt — 7 days after application

Up to 4.25 ppm dipotassium salt — 14 days after application

Up to 5.0 ppm dipotassium salt — 25 days after application

Treated water can be used for sprinkling bent grass immediately.

STORAGE AND DISPOSAL

Do not contaminate water, food, or feed by storage or disposal.

Pesticide Storage Instructions: Store in the original container. Do not store in a manner where cross-contamination with other pesticides, fertilizers, food or feed could occur. Storage at temperatures below 32°F may result in the product freezing or crystallizing. Should this occur the product must be warmed to 50°F or higher and thoroughly agitated. In the event of a spillage during handling or storage, absorb with sand or other inert material and dispose of absorbent in accordance with the Pesticide Disposal Instructions listed below.

Pesticide Disposal Instructions: Pesticide wastes are acutely hazardous. Improper disposal of excess pesticide, spray mixture, or rinsate is a violation of Federal law. If these wastes cannot be disposed of by use according to label instructions, contact your State Pesticide or Environmental Control Agency, or the Hazardous Waste representative at the nearest EPA Regional Office for guidance.

Container Disposal Instructions: Triple rinse (or equivalent). Then offer for recycling or reconditioning, or puncture and dispose of in a sanitary landfill, or incineration, or, if allowed by state and local authorities, by burning. If burned, stay out of smoke.

EMERGENCY TELEPHONE NUMBERS:

CHEMTREC: (800) 424-9300

MEDICAL: (303) 623-5716 Rocky Mountain Poison Control Center

CONDITIONS OF SALE AND LIMITATION OF WARRANTY AND LIABILITY

The Directions for Use of this product must be followed carefully. It is impossible to eliminate all risks inherently associated with the use of this product. Crop injury, ineffectiveness or other unintended consequences may result because of such factors as manner of use or application, weather or crop conditions, presence of other materials, resistant strains or other influencing factors in the use of the product. To the extent consistent with applicable law, all such risks shall be assumed by Buyer and User, and Buyer and User agree to hold Cerexagri-Nisso LLC, Manufacturer and Seller harmless for any claims relating to such factors. TO THE EXTENT CONSISTENT WITH APPLICABLE LAW, CEREXAGRI-NISSO LLC AND MANUFACTURER MAKE NO WARRANTIES OF MERCHANTABILITY OR OF FITNESS FOR PARTICULAR PURPOSE NOR ANY OTHER EXPRESS OR IMPLIED WARRANTY EXCEPT AS STATED ON THIS LABEL.

To the extent consistent with applicable law, Cerexagri-Nisso LLC, Manufacturer or Seller shall not be liable for any incidental, consequential or special damages resulting from the use or handling of this product. TO THE EXTENT CONSISTENT WITH APPLICABLE LAW, THE EXCLUSIVE REMEDY OF THE USER OR BUYER, AND THE EXCLUSIVE LIABILITY OF CEREXAGRI-NISSO LLC, MANUFACTURER AND SELLER FOR ANY AND ALL CLAIMS, LOSSES, INJURIES OR DAMAGES (INCLUDING CLAIMS BASED ON BREACH OF WARRANTY, CONTRACT, NEGLIGENCE, TORT, STRICT LIABILITY OR OTHERWISE) RESULTING FROM THE USE OR HANDLING OF THIS PRODUCT, SHALL BE THE RETURN OF THE PURCHASE PRICE OF THE PRODUCT OR, AT THE ELECTION OF CEREXAGRI-NISSO LLC, MANUFACTURER OR SELLER, THE REPLACEMENT OF THE PRODUCT.

Cerexagri-Nisso LLC, Manufacturer and Seller offer this product, subject to the foregoing conditions of sale and limitations of warranty and of liability, which may not be modified except by written agreement signed by a duly authorized representative of Cerexagri-Nisso LLC.

Aquathol is a registered trademark of Cerexagri, Inc.

4581-204-82695(060707-2382) Made and Printed in U.S.A.

AQUATHOL (R) K Aquatic Herbicide

Material Safety Data Sheet

Cerexagri-Nisso LLC

1 PRODUCT AND COMPANY IDENTIFICATION

Pre-Harvest Division
Cerexagri-Nisso LLC
630 Freedom Business Center, Suite 402
King of Prussia, PA 19406

EMERGENCY PHONE NUMBERS:
Chemtrec: (800) 424-9300 (24hrs) or (703) 527-3887
Medical: Rocky Mountain Poison Control Center
(866) 767-5089 (24Hrs)

Information Telephone Numbers	Phone Number	Available Hrs
R&D Technical Service	610-878-6100	8:00am to 5:00pm EST
Customer Service	1-800-438-6071	8:00am - 5:00 pm EST

Product Name	AQUATHOL (R) K Aquatic Herbicide
Product Synonym(s)	
Chemical Family	Dicarboxylic Acid
Chemical Formula	C8H8O5K2
Chemical Name	Dipotassium Endothall
EPA Reg Num	4581-204-82695
Product Use	Contact killer for submerged aquatic weeds

2 COMPOSITION / INFORMATION ON INGREDIENTS

Ingredient Name	CAS RegistryNumber	Typical Wt. %	OSHA
Endothal-potassium	2164-07-0	40.3	Y

The substance(s) marked with a "Y" in the OSHA column, are identified as hazardous chemicals according to the criteria of the OSHA Hazard Communication Standard (29 CFR 1910.1200)

3 HAZARDS IDENTIFICATION

Emergency Overview
Yellow brown liquid, very faint chlorine odor.
KEEP OUT OF REACH OF CHILDREN.

DANGER!

Causes irreversible eye damage
MAY BE FATAL IF SWALLOWED.
MAY BE FATAL IF INHALED.

HARMFUL IF ABSORBED THROUGH SKIN.

Do not get in eyes, on skin or on clothing.
Do not breathe vapor.

Potential Health Effects

Inhalation and skin contact are expected to be the primary routes of occupational exposure to this material. Based on single exposure animal tests, it is considered to be moderately toxic if swallowed, slightly toxic if absorbed through skin or inhaled, non-irritating to skin and causes irreversible eye damage.

4 FIRST AID MEASURES

IF IN EYES,
-Hold eye open and rinse slowly and gently with water for 15-20 minutes. Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye.
-Call a poison control center or doctor for treatment advice.

IF ON SKIN, immediately wash with cool/cold water. If irritation develops, immediately obtain medical attention.

IF SWALLOWED,
-Call a poison control center or doctor immediately for treatment advice.
-Have person sip a glass of water if able to swallow.
-Do not induce vomiting unless told to do so by a poison control center or doctor.
-Do not give anything by mouth to an unconscious person.

IF INHALED,
-Move person to fresh air.
-If person is not breathing, call 911 or an ambulance, then give artificial respiration, preferably mouth-to-mouth if possible.
-Call a poison control center or doctor for further treatment advice.

NOTE TO PHYSICIANS, Measures against circulatory shock, respiratory depression, and convulsion may be needed.

5 FIRE FIGHTING MEASURES

Fire and Explosive Properties

Auto-Ignition Temperature	N/A	
Flash Point	N/A	Flash Point Method
Flammable Limits- Upper	N/A	
Lower	N/A	

Extinguishing Media

Use water spray, carbon dioxide, foam or dry chemical.

Fire Fighting Instructions

Fire fighters and others who may be exposed to products of combustion should wear full fire fighting turn out gear (full Bunker Gear) and self-contained breathing apparatus (pressure demand NIOSH approved or equivalent). Fire fighting equipment should be thoroughly decontaminated after use.

Fire and Explosion Hazards

None known.

6 ACCIDENTAL RELEASE MEASURES

In Case of Spill or Leak

Stop the leak, if possible. Shut off or remove all ignition sources.
Ventilate the space involved. Avoid generation of vapors.
Prevent waterway contamination. Construct a dike to prevent spreading.
Use non-sparking equipment to clean up spill.
Absorb, sweep up, place in appropriate containers for recovery or disposal.

6 ACCIDENTAL RELEASE MEASURES

Collect run-off water and transfer to drums or tanks for later disposal.
After removal, clean area with soap and water, collect rinsate. Remove from spill location.
Consult a regulatory specialist to determine appropriate state or local reporting requirements, for assistance in waste characterization and/or hazardous waste disposal and other requirements listed in pertinent environmental permits.

7 HANDLING AND STORAGE

Handling

Do not breathe vapor. Do not breathe mist.
Wash thoroughly after handling. Keep container closed.

Empty container may contain hazardous residues.
KEEP OUT OF REACH OF CHILDREN.

Use only with adequate ventilation.

Storage

Do not store in a manner where cross-contamination with pesticides, fertilizers, food or feed could occur.

8 EXPOSURE CONTROLS / PERSONAL PROTECTION

Engineering Controls

Investigate engineering techniques to reduce exposures. Provide ventilation if necessary to minimize exposure. Dilution ventilation is acceptable, but local mechanical exhaust ventilation preferred, if practical, at sources of air contamination such as open process equipment. Consult ACGIH ventilation manual or NFPA Standard 91 for design of exhaust systems.

Eye / Face Protection

Where there is potential for eye contact, wear chemical goggles and have eye flushing equipment immediately available.

Skin Protection

Minimize skin contamination by following good industrial hygiene practice. Wearing rubber gloves is recommended. Wash hands and contaminated skin thoroughly after handling.

Respiratory Protection

Where airborne exposure is likely, use NIOSH approved respiratory protection equipment appropriate to the material and/or its components. If exposures cannot be kept at a minimum with engineering controls, consult respirator manufacturer to determine appropriate type equipment for a given application. Observe respirator use limitations specified by NIOSH or the manufacturer. For emergency and other conditions where there may be a potential for significant exposure, use an approved full face positive-pressure, self-contained breathing apparatus or positive-pressure airline with auxiliary self-contained air supply. Respiratory protection programs must comply with 29 CFR § 1910.134.

Airborne Exposure Guidelines for Ingredients

The components of this product have no established Airborne Exposure Guidelines

-Only those components with exposure limits are printed in this section.
-Skin contact limits designated with a "Y" above have skin contact effect. Air sampling alone is insufficient to accurately quantitate exposure. Measures to prevent significant cutaneous absorption may be required.
-ACGIH Sensitizer designator with a value of "Y" above means that exposure to this material may cause allergic reactions.
-WEEL-AIHA Sensitizer designator with a value of "Y" above means that exposure to this material may cause allergic skin reactions.

9 PHYSICAL AND CHEMICAL PROPERTIES

Appearance/Odor	Yellow brown liquid, very faint chlorine odor.
pH	7.4 (nominal)
Specific Gravity	1.285 (H2O=1)
Vapor Pressure	negligible
Vapor Density	NE
Melting Point	NA
Freezing Point	NA
Boiling Point	>100 deg C
Solubility In Water	Miscible
Percent Volatile	59.7

10 STABILITY AND REACTIVITY

Stability

This material is chemically stable under normal and anticipated storage and handling conditions.

Hazardous Polymerization

Does not occur.

Incompatibility

Materials that react with water.

Hazardous Decomposition Products

Elevated temperatures may convert endothall to anhydride, a strong vesicant, causing blistering of eyes, mucous membranes, and skin.(*See section 16)

11 TOXICOLOGICAL INFORMATION

Toxicological Information

Data on this material and/or its components are summarized below.

Endothal-potassium
Although no allergic skin reactions were observed in guinea pigs following exposure to this material in water, allergic skin reactions were observed following exposure to this material in ethanol. Repeated application to the skin of rats produced severe skin irritation, liver and kidney effects considered to be secondary to irritation, and increased mortality. Long-term dietary administration produced no adverse effects in rats.

Single exposure (acute) studies indicate:
Oral - Moderately Toxic to Rats [LD50 99.5 mg/kg (Category II)]
Dermal - Slightly Toxic to Rabbits [LD50 2,000 mg/kg (Category III)]
Inhalation - Slightly Toxic to Rats [4-hr LC50 0.83 mg/l; aerosol (Category II)]
Eye Irritation - Causes irreversible eye damage in rabbits (Category I)
Skin Irritation - Non-irritating to Rabbits (Category IV)

Endothall
Intentional swallowing of 40 ml led to death within 12-hours. Skin allergy was observed in guinea pigs following repeated exposure. Repeated dietary administration (via gelatin capsules) produced vomiting, diarrhea,

11 TOXICOLOGICAL INFORMATION

sluggish movements, and liver, kidney and blood effects in dogs. Long-term dietary administration to rats and mice produced effects in the glandular stomach. High mortality rates and intestinal tumors considered to be secondary to the effects in the stomach were observed in mice. Long-term application to the skin of mice produced no tumors. No birth defects were observed in the offspring of rats exposed orally during pregnancy, even at dosages that produced adverse effects on the mothers. Skeletal anomalies were observed in the offspring of rabbits and mice exposed orally during pregnancy, but only at dosages that produced adverse effects in the mothers. No genetic changes were observed in tests using bacteria, animal cells or animals.

12 ECOLOGICAL INFORMATION

Ecotoxicological Information

Data on this material and/or its components are summarized below.
Endothal-potassium
This material is practically non-toxic to bluegill sunfish (LC50 316-501.2 mg/l), rainbow trout (LC50 107-528.7 mg/l), eastern oysters (LC50 117 mg/l), largemouth bass (LC50 130 mg/l), fiddler crab (LC50 752.4 mg/l) and sheepshead minnow (LC50 340 mg/l), and slightly toxic to mysid shrimp (LC50 79 mg/l) and smallmouth bass (LC50 47 mg/l). It is practically non-toxic to slightly toxic to Daphnia magna (EC50 72-319.5 mg/l) and no more than moderately toxic to freshwater blue-green algae (LC50 >4.8 mg/l), freshwater diatoms (LC50 >3.6 mg/l), freshwater green algae (LC50 >4.8 mg/l) and marine diatoms (LC50 >9.0 mg/l).

The 8-day LC50 for bobwhite quail and mallard ducklings is >5,000 ppm, the 21-day LD50 for mallard ducks is 344 mg/kg, the 14-day EC50 for duckweed is 0.84 mg/l and the 14-day LC50 for juvenile chinook salmon is 62.5 ppm.

Chemical Fate Information

Data on this material and/or its components are summarized below.

Endothal-potassium
This material is rapidly degraded in aqueous systems by the indigenous microbial population to CO_2 and other non-toxic natural products.

13 DISPOSAL CONSIDERATIONS

Waste Disposal

Pesticide wastes are acutely hazardous. Improper disposal of excess pesticide or rinsate is a violation of Federal law. If these wastes cannot be disposed of by use according to label instructions, contact your State Pesticide or Environmental Control Agency, or the Hazardous Waste representative at the nearest EPA Regional Office for guidance.

Cerexagri-Nisso LLC

AQUATHOL (R) K Aquatic Herbicide
Material Safety Data Sheet
Cerexagri-Nisso LLC

14 TRANSPORT INFORMATION

DOT Name	Pesticides, liquid, toxic, n.o.s.
DOT Technical Name	Endothall
DOT Hazard Class	6.1
UN Number	2902
DOT Packing Group	PG III
RQ	1000 lbs.
DOT Special Information	DOT HM215C= The Keep Away From Foodstuffs (KAFF) label is authorized until October 2003. During the transition period the KAFF or the Toxic label may be used. After October 2003 only the Toxic label is authorized.

15 REGULATORY INFORMATION

Hazard Categories Under Criteria of SARA Title III Rules (40 CFR Part 370)

Immediate (Acute) Health	Y	Fire	N
Delayed (Chronic) Health	N	Reactive	N
		Sudden Release of Pressure	N

Ingredient Related Regulatory Information:

SARA Reportable Quantities	CERCLA RQ	SARA TPQ
Endothal-potassium	NE	

SARA Title III, Section 313

This product does contain chemical(s) which are defined as toxic chemicals under and subject to the reporting requirements of, Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 and 40 CFR Part 372. See Section 2

Endothal-potassium

16 OTHER INFORMATION

Revision Information

Revision Date	05 JAN 2006	Revision Number 13
Supercedes Revision Dated	03-JAN-2006	

Revision Summary

Update section 1

Key

NE= Not Established NA= Not Applicable (R) = Registered Trademark

Miscellaneous

Proper PPE and vetnilation should be used when using high heat, such as welding or oxy-acetylene torch cutting, on machinery that may have endothal residue.

Aquathol (R) is a registered trademark of Cerexagri, Inc.

Cerexagri-Nisso LLC

AQUATHOL (R) K Aquatic Herbicide
Material Safety Data Sheet
Cerexagri-Nisso LLC

Cerexagri-Nisso LLC believes that the information and recommendations contained herein (including data and statements) are accurate as of the date hereof. NO WARRANTY OF FITNESS FOR ANY PARTICULAR PURPOSE, WARRANTY OF MERCHANTABILITY, OR ANY OTHER WARRANTY, EXPRESSED OR IMPLIED, IS MADE CONCERNING THE INFORMATION PROVIDED HEREIN. The information provided herein relates only to the specific product designated and may not be valid where such product is used in combination with any other materials or in any process. Further, since the conditions and methods of use are beyond the control of Cerexagri-Nisso LLC,Cerexagri-Nisso LLC expressly disclaims any and all liability as to any results obtained or arising from any use of the product or reliance on such information.

AQUATIC HABITAT MANAGEMENT

AQUATHOL® SUPER K

GRANULAR AQUATIC HERBICIDE

ACTIVE INGREDIENT:	
Dipotassium salt of endothall*	63.0%
OTHER INGREDIENTS:	37.0%
TOTAL	100.0%

*7-oxabicyclo [2.2.1]heptane-2,3-dicarboxylic acid equivalent 44.7%

KEEP OUT OF REACH OF CHILDREN

DANGER

FIRST AID:

IF IN EYES:
- Hold eye open and rinse slowly and gently with water for 15-20 minutes.
- Remove contact lenses, if present, after the first 5 minutes, then continue rinsing.
- Call a poison control center or doctor for treatment advice.

IF SWALLOWED:
- Call a poison control center or doctor immediately for treatment advice.
- Have person sip a glass of water if able to swallow. Do not induce vomiting unless told by a poison control center or doctor. Do not give anything by mouth to an unconscious person.

IF ON SKIN:
- Take off contaminated clothing.
- Rinse skin immediately with plenty of water for 15-20 minutes.
- Call a poison control center or doctor for treatment advice.

HOT LINE NUMBER: Have the product container or label with you when calling a poison control center or doctor, or going for treatment. You may also contact (303) 623-5716 for emergency medical treatment information.

NOTE TO PHYSICIAN: Probable mucosal damage may contraindicate the use of gastric lavage.

See back panel for additional Precautionary Statements.

EPA Registration No. 4581-388-82695 EPA Establishment No. 62171-MS-003

Net Weight ______________

Sold by:
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Cerexagri-Nisso LLC

Taihoro Nukurangi

PRECAUTIONARY STATEMENTS

HAZARDS TO HUMANS (AND DOMESTIC ANIMALS)

DANGER

CORROSIVE. CAUSES IRREVERSIBLE EYE DAMAGE. MAY BE FATAL IF SWALLOWED. HARMFUL IF ABSORBED THROUGH THE SKIN. Do not get in eyes, on skin or on clothing. Wear protective eyewear (goggles or face shield). Wash thoroughly with soap and water after handling and before eating, drinking or using tobacco. Remove contaminated clothing and wash before reuse.

ENVIRONMENTAL HAZARDS

Avoid contact with or drift to other crops or plants as injury may result.

Do not use water from treated areas for irrigation, for agricultural sprays on food crops or for domestic purposes within 7 days of treatment.

Not for use in brackish or salt water.

GENERAL INFORMATION

AQUATHOL SUPER K is a granular aquatic herbicide for use in ponds and lakes which, under field test conditions has shown to be effective against a broad range of aquatic plants with a margin of safety to fish. Dosage rates indicated for the applications of AQUATHOL SUPER K are measured in "Parts Per Million" (ppm). 1ppm as a dosage rate means that there would be 1 part of AQUATHOL SUPER K's active ingredient in 1,000,000 parts of water. Only 0.5 to 5 ppm are generally required for aquatic weed control, whereas some fish species are tolerant to approximately 100 ppm or over. For best results treat areas of one acre or more and/or margins of at least 100 feet in large bodies of water.

Thoroughly clean application equipment immediately after use.

DIRECTIONS FOR USE

It is a violation of Federal law to use this product in a manner inconsistent with its labeling.

HOW TO APPLY:

AQUATHOL SUPER K is a contact herbicide, consequently, do not apply before weeds are present. Treat as early as possible after weeds are present and are actively growing. If an entire pond is treated at one time, or if the dissolved oxygen level is low at the time of application, decay of weeds may remove enough oxygen from the water causing fish to suffocate. Water containing very heavy vegetation should be treated in sections to prevent suffocation of fish. Sections should be treated 5-7 days apart.

Carefully measure size and depth of area to be treated and determine proper amount of AQUATHOL SUPER K to apply. For best results apply when water is quiescent and/or flows are minimal.

Apply AQUATHOL SUPER K as evenly as possible over treated areas. A cyclone spreader is useful for this purpose. In instances where the nuisance weed(s) to be controlled is an exposed surface problem (i.e., some of the broad-leaved pond weeds) coverage is important.

Necessary approval and/or permits should be obtained in states where required.

HOW TO DETERMINE DOSAGE RATE (Active Ingredient)

AQUATHOL SUPER K is recommended for the control of the following aquatic weeds at the rates indicated. Since AQUATHOL SUPER K's active ingredient is water soluble and tends to diffuse from the treated area, select the dosage rate applicable to the area to be treated. Use the lower rate in each range when the growth is young and growing and/or where the weed stand is not heavy. Marginal treatments of large bodies of water require highest rates as indicated.

WEEDS CONTROLLED AND AQUATHOL SUPER K DOSAGE RATE CHART

Aquatic Weed	RATES: Entire Pond/Lake or Large Area Treatment	Lbs. per Acre Ft.	Spot or Lake Margin Treatment	Lbs. per Acre Ft.
Bur Reed, Sparganium spp.	3.0-4.0 ppm	13.2-17.6 lbs.	4.0-5.0 ppm	17.6-22.0 lbs.
Coontail, Ceratophyllum spp.	1.0-2.0 ppm	4.4-8.8 lbs.	2.0-3.0 ppm	8.8-13.2 lbs.
Horned Pondweed, Zannichellia palustris	1.0-2.0 ppm	4.4-8.8 lbs.	2.0-3.0 ppm	8.8-13.2 lbs.
Hydrilla, Hydrilla verticillata	2.0-3.0 ppm	8.8-13.2 lbs.	3.0-4.0 ppm	13.2-17.6 lbs.
Hygrophila, Hygrophila polysperma	4.0-5.0 ppm	17.6-22.0 lbs.	5.0 ppm	22.0 lbs.
Milfoil, Myriophyllum spp.	2.0-3.0 ppm	8.8-13.2 lbs.	3.0-4.0 ppm	13.2-17.6 lbs.
Naiad, Najas spp.	1.0-3.0 ppm	4.4-13.2 lbs.	2.0-4.0 ppm	8.8-17.6 lbs.
Pondweed, Potamogeton spp.	0.5-3.0 ppm	2.2-13.2 lbs.	1.5-4.0 ppm	6.6-17.6 lbs.
Including:				
American, P. nodosus	2.0-3.0 ppm	8.8-13.2 lbs.	3.0-4.0 ppm	13.2-17.6 lbs.
Largeleaf (Bass Weed), P. amplifolius	2.0-3.0 ppm	8.8-13.2 lbs.	3.0-4.0 ppm	13.2-17.6 lbs.
Curlyleaf, P. crispus	0.5-1.5 ppm	2.2-6.6 lbs.	1.5-3.0 ppm	6.6-13.2 lbs.
Flatstem, P. zosteriformis	2.0-3.0 ppm	8.8-13.2 lbs.	3.0-4.0 ppm	13.2-17.6 lbs.
Floating-leaf, P. natans	1.0-2.0 ppm	4.4-8.8 lbs.	2.0-3.0 ppm	8.8-13.2 lbs.
Illinois, P. Illinoensis	1.5-2.5 ppm	6.6-11.0 lbs.	2.5-3.5 ppm	11.0-15.4 lbs.
Narrowleaf, P. pusillus	1.0-2.0 ppm	4.4-8.8 lbs.	2.0-3.0 ppm	8.8-13.2 lbs.
Slender, P. filiformis	2.0-3.0 ppm	8.8-13.2 lbs.	3.0-4.0 ppm	13.2-17.6 lbs.
Sago, P. pectinatus	1.0-2.0 ppm	4.4-8.8 lbs.	2.0-3.0 ppm	8.8-13.2 lbs.
Variable Leaf, P. diversifolius	1.0-2.0 ppm	4.4-8.8 lbs.	2.0-3.0 ppm	8.8-13.2 lbs.
Parrot Feather, Myriophyllum aquaticum	2.0-3.0 ppm	8.8-13.2 lbs.	3.0-4.0 ppm	13.2-17.6 lbs.
Water Stargrass, Heteranthera spp.	2.0-3.0 ppm	8.8-13.2 lbs.	3.0-4.0 ppm	13.2-17.6 lbs.

APPROXIMATE POUNDS OF AQUATHOL SUPER K FOR ONE ACRE* TREATMENT DOSAGE IN POUNDS FOR VARIOUS CONCENTRATIONS IN PPM

DEPTH	0.5 ppm	1.0 ppm	1.5 ppm	2.0 ppm	3.0 ppm	4.0 ppm	5.0 ppm
1 Ft. Deep	2.2 lbs.	4.4 lbs.	6.6 lbs.	8.8 lbs.	13.2 lbs.	17.6 lbs.	22 lbs.
2 Ft. Deep	4.4 lbs.	8.8 lbs.	13.2 lbs.	17.6 lbs.	26.4 lbs.	35.2 lbs.	44 lbs.
3 Ft. Deep	6.6 lbs.	13.2 lbs.	19.8 lbs.	26.4 lbs.	39.6 lbs.	52.8 lbs.	66 lbs.
4 Ft. Deep	8.8 lbs.	17.6 lbs.	26.4 lbs.	35.2 lbs.	52.8 lbs.	70.4 lbs.	88 lbs.
5 Ft. Deep	11 lbs.	22 lbs.	33 lbs.	44 lbs.	66 lbs.	88 lbs.	110 lbs.

*One acre equals approximately 208' x 208'

Where the area being treated is greater than those listed in the charts, proceed as follows:

a. Compute the approximate surface acreage

b. Determine the average depth

c. Multiply a. by b. to determine total number of acre/feet

d. Multiply the pounds required at the 1 foot depth under the rate to be used by the number of acre/feet to determine the total quantity to be used.

APPROXIMATE POUNDS OF AQUATHOL SUPER K FOR 1000 SQUARE FEET TREATMENT DOSAGE IN POUNDS FOR VARIOUS CONCENTRATIONS IN PPM

DEPTH	0.5 ppm	1.0 ppm	1.5 ppm	2.0 ppm	3.0 ppm	4.0 ppm	5.0 ppm
1 Ft. Deep	0.05 lbs.	0.1 lbs.	0.15 lbs.	0.2 lbs.	0.3 lbs.	0.4 lbs.	0.5 lbs.
2 Ft. Deep	0.1 lbs.	0.2 lbs.	0.3 lbs.	0.4 lbs.	0.6 lbs.	0.8 lbs.	1.0 lbs.
3 Ft. Deep	0.15 lbs.	0.3 lbs.	0.45 lbs.	0.6 lbs.	0.9 lbs.	1.2 lbs.	1.5 lbs.
4 Ft. Deep	0.2 lbs.	0.4 lbs.	0.6 lbs.	0.8 lbs.	1.2 lbs.	1.6 lbs.	2.0 lbs.
5 Ft. Deep	0.25 lbs.	0.5 lbs.	0.75 lbs.	1.0 lbs.	1.5 lbs.	2.0 lbs.	2.5 lbs.

Where the depth is greater than 5 feet, multiply the depth by the appropriate rate for 1 ft. depth to determine the amount of product required per 1000 square feet.

STORAGE AND DISPOSAL

Do not contaminate water, food or feed by storage or disposal.

Pesticide Storage Instructions: Store in the original container, preferably in a locked storage area. Do not store in a manner where cross-contamination with other pesticides, fertilizers, food or feed could occur. If spilled during storage or handling sweep up spillage and dispose of in accordance with the Pesticide Disposal Instructions listed below.

Pesticide Disposal Instructions: Pesticide wastes are acutely hazardous. Improper disposal of excess pesticide or rinsate is a violation of Federal law. If these wastes cannot be disposed of by use according to label instructions, contact your State Pesticide or Environmental Control Agency, or the Hazardous Waste representative at the nearest EPA Regional Office for guidance.

Container Disposal Instructions: Triple rinse (or equivalent). Then offer for recycling or reconditioning, or puncture and dispose of in a sanitary landfill, or by incineration, or, if allowed by state and local authorities, by burning. If burned, stay out of smoke.

EMERGENCY TELEPHONE NUMBERS:

CHEMTREC: (800) 424-9300

MEDICAL: (303) 623-5716 Rocky Mountain Poison Control Center

CONDITIONS OF SALE AND LIMITATION OF WARRANTY AND LIABILITY

The Directions for Use of this product must be followed carefully. It is impossible to eliminate all risks inherently associated with the use of this product. Crop injury, ineffectiveness or other unintended consequences may result because of such factors as manner of use or application, weather or crop conditions, presence of other materials, resistant strains or other influencing factors in the use of the product. To the extent consistent with applicable law, all such risks shall be assumed by Buyer and User, and Buyer and User agree to hold Cerexagri-Nisso LLC, Manufacturer and Seller harmless for any claims relating to such factors. TO THE EXTENT CONSISTENT WITH APPLICABLE LAW, CEREXAGRI-NISSO LLC AND MANUFACTURER MAKE NO WARRANTIES OF MERCHANTABILITY OR OF FITNESS FOR PARTICULAR PURPOSE NOR ANY OTHER EXPRESS OR IMPLIED WARRANTY EXCEPT AS STATED ON THIS LABEL.

To the extent consistent with applicable law, Cerexagri-Nisso LLC, Manufacturer or Seller shall not be liable for any incidental, consequential or special damages resulting from the use or handling of this product. TO THE EXTENT CONSISTENT WITH APPLICABLE LAW, THE EXCLUSIVE REMEDY OF THE USER OR BUYER, AND THE EXCLUSIVE LIABILITY OF CEREXAGRI-NISSO LLC, MANUFACTURER AND SELLER FOR ANY AND ALL CLAIMS, LOSSES, INJURIES OR DAMAGES (INCLUDING CLAIMS BASED ON BREACH OF WARRANTY, CONTRACT, NEGLIGENCE, TORT, STRICT LIABILITY OR OTHERWISE) RESULTING FROM THE USE OR HANDLING OF THIS PRODUCT, SHALL BE THE RETURN OF THE PURCHASE PRICE OF THE PRODUCT OR, AT THE ELECTION OF CEREXAGRI-NISSO LLC, MANUFACTURER OR SELLER, THE REPLACEMENT OF THE PRODUCT.

Cerexagri-Nisso LLC, Manufacturer and Seller offer this product, subject to the foregoing conditions of sale and limitations of warranty and of liability, which may not be modified except by written agreement signed by a duly authorized representative of Cerexagri-Nisso LLC.

Aquathol is a registered trademark of Cerexagri, Inc.

4581-388-82695(101906-1924) Made and Printed in U.S.A.

Cerexagri-Nisso LLC

AQUATHOL (R) SUPER K
Material Safety Data Sheet

Cerexagri-Nisso LLC

1 PRODUCT AND COMPANY IDENTIFICATION

Pre-Harvest Division
Cerexagri-Nisso LLC
630 Freedom Business Center, Suite 402
King of Prussia, PA 19406

EMERGENCY PHONE NUMBERS:
Chemtrec: (800) 424-9300 (24hrs) or (703) 527-3887
Medical: Rocky Mountain Poison Control Center
(866) 767-5089 (24Hrs)

Information Telephone Numbers	Phone Number	Available Hrs
R&D Technical Service	610-878-6100	8:00am to 5:00pm EST
Customer Service	1-800-438-6071	8:00am - 5:00 pm EST

Product Name	AQUATHOL (R) SUPER K
Product Synonym(s)	
Chemical Family	Dicarboxylic acid
Chemical Formula	C8H8O5K2
Chemical Name	Dipotassium endothall
EPA Reg Num	4581-388-82695
Product Use	Aquatic herbicide

2 COMPOSITION / INFORMATION ON INGREDIENTS

Ingredient Name	CAS RegistryNumber	Typical Wt. %	OSHA
Endothal-potassium	2164-07-0	63.0 %	Y
2-Propenamide, polymer with potassium	31212-13-2	27.5%	Y

The substance(s) marked with a "Y" in the OSHA column, are identified as hazardous chemicals according to the criteria of the OSHA Hazard Communication Standard (29 CFR 1910.1200)

3 HAZARDS IDENTIFICATION

Emergency Overview
Beige granular material, odorless.
KEEP OUT OF REACH OF CHILDREN.
DANGER!
Causes irreversible eye damage
MAY BE FATAL IF SWALLOWED.
HARMFUL IF ABSORBED THROUGH SKIN.

Do not get in eyes, on skin or on clothing.
Avoid breathing dust.

Potential Health Effects

Inhalation and skin contact are expected to be the primary routes of occupational exposure to this material. Based on single exposure animal tests, it is considered to be moderately toxic if swallowed, no more than slightly toxic if absorbed through skin, severely irritating to eyes and slightly irritating to skin.

4 FIRST AID MEASURES

IF IN EYES,
-Hold eye open and rinse slowly and gently with water for 15-20 minutes. Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye.
-Call a poison control center or doctor for treatment advice.

IF ON SKIN, immediately wash with cool/cold water. If irritation develops, immediately obtain medical attention.

IF SWALLOWED,
-Call a poison control center or doctor immediately for treatment advice.
-Have person sip a glass of water if able to swallow.
-Do not induce vomiting unless told to do so by a poison control center or doctor.
-Do not give anything by mouth to an unconscious person.

IF INHALED,
-Move person to fresh air.
-If person is not breathing, call 911 or an ambulance, then give artificial respiration, preferably mouth-to-mouth if possible.
-Call a poison control center or doctor for further treatment advice.

5 FIRE FIGHTING MEASURES

Fire and Explosive Properties

Auto-Ignition Temperature	NE	
Flash Point	NE	Flash Point Method
Flammable Limits- Upper	NE	
Lower	NE	

Extinguishing Media

Use water spray, carbon dioxide, foam or dry chemical.

Fire Fighting Instructions

Fire fighters and others who may be exposed to products of combustion should wear full fire fighting turn out gear (full Bunker Gear) and self-contained breathing apparatus (pressure demand NIOSH approved or equivalent). Fire fighting equipment should be thoroughly decontaminated after use.

Fire and Explosion Hazards

None known.

6 ACCIDENTAL RELEASE MEASURES

In Case of Spill or Leak

Contain spill. Sweep or scoop up and remove to suitable container. Flush with water. Prevent spilled product from entering sewers or natural water. Consult a regulatory specialist to determine appropriate state or local reporting requirements, for assistance in waste characterization and/or hazardous waste disposal and other requirements listed in pertinent environmental permits.

7 HANDLING AND STORAGE

7 HANDLING AND STORAGE

Handling

Do not breathe dust. Avoid contact with eyes, skin and clothing.
Wash thoroughly after handling. Keep container closed.
Empty container may contain hazardous residues.
KEEP OUT OF REACH OF CHILDREN.

Storage

Do not store in a manner where cross-contamination with pesticides, fertilizers, food or feed could occur.

8 EXPOSURE CONTROLS / PERSONAL PROTECTION

Engineering Controls

Investigate engineering techniques to reduce exposures. Provide ventilation if necessary to minimize exposure. Dilution ventilation is acceptable, but local mechanical exhaust ventilation preferred, if practical, at sources of air contamination such as open process equipment. Consult ACGIH ventilation manual or NFPA Standard 91 for design of exhaust systems.

Eye / Face Protection

Where there is potential for eye contact, wear chemical goggles and have eye flushing equipment immediately available.

Skin Protection

Minimize skin contamination by following good industrial hygiene practice. Wearing rubber gloves is recommended. Wash hands and contaminated skin thoroughly after handling.

Respiratory Protection

Where airborne exposure is likely, use NIOSH approved respiratory protection equipment appropriate to the material and/or its components. If exposures cannot be kept at a minimum with engineering controls, consult respirator manufacturer to determine appropriate type equipment for a given application. Observe respirator use limitations specified by NIOSH or the manufacturer. For emergency and other conditions where there may be a potential for significant exposure, use an approved full face positive-pressure, self-contained breathing apparatus or positive-pressure airline with auxiliary self-contained air supply. Respiratory protection programs must comply with 29 CFR § 1910.134.

Airborne Exposure Guidelines for Ingredients

The components of this product have no established Airborne Exposure Guidelines

-Only those components with exposure limits are printed in this section.
-Skin contact limits designated with a "Y" above have skin contact effect. Air sampling alone is insufficient to accurately quantitate exposure. Measures to prevent significant cutaneous absorption may be required.
-ACGIH Sensitizer designator with a value of "Y" above means that exposure to this material may cause allergic reactions.
-WEEL-AIHA Sensitizer designator with a value of "Y" above means that exposure to this material may cause allergic skin reactions.

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9 PHYSICAL AND CHEMICAL PROPERTIES

Appearance/Odor	Beige granular material, odorless.
pH	6.9 (1% aqueous soln)
Specific Gravity	0.607 g/cm3
Vapor Pressure	Negligible
Vapor Density	N/A
Melting Point	N/A
Freezing Point	N/A
Boiling Point	N/A
Solubility In Water	>65 g/100ml
Evaporation Rate	N/A
Percent Volatile	N/A

10 STABILITY AND REACTIVITY

Stability

This material is chemically stable under normal and anticipated storage and handling conditions.

Hazardous Polymerization

Does not occur.

Incompatibility

None known.

Hazardous Decomposition Products

Elevated temperatures convert endothall to anhydride, a strong vessicant, causing blisters of eyes, mucous membranes, and skin.

11 TOXICOLOGICAL INFORMATION

Toxicological Information

Data on this material and/or its components are summarized below.
Single exposure (acute) studies indicate:
Oral - Moderately Toxic to Rats (LD50 98 mg/kg)
Dermal - No More than Slightly Toxic to Rabbits (LD50 >2,000 mg/kg)
Eye Irritation - Severely Irritating to Rabbits
Skin Irritation - Slightly Irritating to Rabbits
No skin allergy was observed in guinea pigs following repeated exposure.

Endothal-potassium (technical active ingredient)
Although no allergic skin reactions were observed in guinea pigs following exposure to this material in water, allergic skin reactions were observed following exposure to this material in ethanol. Repeated application to the skin of rats produced severe skin irritation, liver and kidney effects considered to be secondary to irritation, and increased mortality. Long-term dietary administration produced no adverse effects in rats.

12 ECOLOGICAL INFORMATION

12 ECOLOGICAL INFORMATION

Ecotoxicological Information

Data on this material and/or its components are summarized below.
Endothal-potassium (technical active ingredient)
This material is practically non-toxic to bluegill sunfish (LC50 316-501.2 mg/l), rainbow trout (LC50 107-528.7 mg/l), eastern oysters (LC50 117 mg/l), largemouth bass (LC50 130 mg/l), fiddler crab (LC50 752.4 mg/l) and sheepshead minnow (LC50 340 mg/l), and slightly toxic to mysid shrimp (LC50 79 mg/l) and smallmouth bass (LC50 47 mg/l). It is practically non-toxic to slightly toxic to Daphnia magna (EC50 72-319.5 mg/l) and no more than moderately toxic to freshwater blue-green algae (LC50 >4.8 mg/l), freshwater diatoms (LC50 >3.6 mg/l), freshwater green algae (LC50 >4.8 mg/l) and marine diatoms (LC50 >9.0 mg/l).

The 8-day LC50 for bobwhite quail and mallard ducklings is >5,000 ppm, the 21-day LD50 for mallard ducks is 344 mg/kg, the 14-day EC50 for duckweed is 0.84 mg/l and the 14-day LC50 for juvenile chinook salmon is 62.5 ppm.

Endothall
This material is slightly toxic to bluegill sunfish (96-hr LC50 77 mg/l), rainbow trout (96-hr LC50 49 mg/l), Daphnia magna (48-hr LC50 92 mg/l), eastern oysters (96-hr LC50 54 mg/l), mysid shrimp (96-hr LC50 39 mg/l) and fiddler crab (96-hr LC50 85.1 mg/l). It is practically non-toxic to sheepshead minnow (96-hr LC50 110 mg/l) and common mummichog (96-hr LC50 213.9 mg/l).

This material has an 8-day LC50 of >5,000 ppm (bobwhite quail and mallard ducklings), a 21-day LD50 of 111 mg/kg (mallard ducks), a 30-day MATC of 19 mg/l (fathead minnows) and a 21-day MATC of 6.7 mg/l (Daphnia magna). No adverse effects were observed in mallard ducks and bobwhite quail following repeated (20-weeks) administration in the diet.

Chemical Fate Information

Data on this material and/or its components are summarized below.
Endothal-potassium (technical active ingredient)
This material is rapidly degraded in aqeuous systems by the indigenous microbial population to CO2 and other non-toxic natural products.

13 DISPOSAL CONSIDERATIONS

Waste Disposal

Pesticide wastes are acutely hazardous. Improper disposal of excess pesticide or rinsate is a violation of Federal law. If these wastes cannot be disposed of by use according to label instructions, contact your State Pesticide or Environmental Control Agency, or the Hazardous Waste representative at the nearest EPA Regional Office for guidance.

14 TRANSPORT INFORMATION

DOT Name	Pesticides, solid, toxic, n.o.s.
DOT Technical Name	Endothall
DOT Hazard Class	6.1
UN Number	2588
DOT Packing Group	PG III
RQ	1,000 POUNDS

15 REGULATORY INFORMATION

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Hazard Categories Under Criteria of SARA Title III Rules (40 CFR Part 370)

Immediate (Acute) Health	Y	Fire	N
Delayed (Chronic) Health	N	Reactive	N
		Sudden Release of Pressure	N

Ingredient Related Regulatory Information:

SARA Reportable Quantities	CERCLA RQ	SARA TPQ
Endothal-potassium	NE	
2-Propenamide, polymer with potassium	NE	

SARA Title III, Section 313
This product does contain chemical(s) which are defined as toxic chemicals under and subject to the reporting requirements of, Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 and 40 CFR Part 372. See Section 2
Endothal-potassium

16 OTHER INFORMATION

Revision Information

Revision Date	05 JAN 2006	Revision Number 11
Supercedes Revision Dated	03-JAN-2006	

Revision Summary
Update section 1

Key
NE= Not Established NA= Not Applicable (R) = Registered Trademark

Miscellaneous
Aquathol (R) is a registered trademark of Cerexagri, Inc.

Cerexagri-Nisso LLC believes that the information and recommendations contained herein (including data and statements) are accurate as of the date hereof. NO WARRANTY OF FITNESS FOR ANY PARTICULAR PURPOSE, WARRANTY OF MERCHANTABILITY, OR ANY OTHER WARRANTY, EXPRESSED OR IMPLIED, IS MADE CONCERNING THE INFORMATION PROVIDED HEREIN. The information provided herein relates only to the specific product designated and may not be valid where such product is used in combination with any other materials or in any process. Further, since the conditions and methods of use are beyond the control of Cerexagri-Nisso LLC,Cerexagri-Nisso LLC expressly disclaims any and all liability as to any results obtained or arising from any use of the product or reliance on such information.

9.3 Appendix 3: Rule 10 of the HBRC Resource Management Plan (2006) – Widespread Application of Agrichemicals

Activity	Classification	Conditions/Standards/ Terms
The discharge of contaminants into air or onto land, or into water, arising from the use or disposal of any agrichemical, except is provided for by Rule 9.	Permitted	a. The discharge shall be undertaken in a manner which does not exceed any rate, or contravene any other requirement, specified in the agrichemical manufacturer's instructions. b. The discharge shall be undertaken in accordance with all mandatory requirements set out in Sections 2, 5 and 6 of the New Zealand Standard for the Management of Agrichemicals (NZS 8409:2004). c. For the ground based application of agrichemicals the following qualifications shall be held at all times: i. Every commercial user shall hold a qualification that meets the requirements of Schedule XI for commercial user or be under direct supervision of a person holding the qualification. ii. Every contractor shall be a GROWSAFE® Registered Chemical Applicator. iii. Every employee of a contractor shall hold or be under training for a valid qualification that meets the requirements of Schedule XI for contractor employees. d. Every pilot undertaking the aerial application of agrichemicals shall hold a GROWSAFE® Pilot Agrichemical Rating Certificate. e. The discharge shall not result in any agrichemical being deposited on any roof or other structure used as a catchment for water supply other than in compliance with condition (f). f. Where the discharge is onto land or onto water for the purpose of eradicating, modifying or controlling unwanted aquatic plants: i. Only agrichemicals approved for aquatic use by the Environmental Risk Management Authority may be used. ii. The applications shall not exceed the quantity and concentration required for that purpose. iii. The discharge shall not include disposal to water of any agrichemical. iv. The discharger shall notify: -every person taking water for domestic supply within 1 km downstream of the proposed discharge, and -every holder of a resource consent for the taking of water for public water supply purposes downstream of the proposed discharge at least 1 week before commencing the discharge. g. For aerial discharges, all reasonable measures shall be taken to prevent any discharge of agrichemicals within 20 m of: i. any continually flowing river which has a bed width of 3 m or more, and ii. any lake or wetland. h. Aerial and ground based discharges shall be notified by the property owner, manager or contractor in accordance with the following requirements: i. Where the application is on private land, occurs on any land within 50 m of an adjacent property twice in any 12 month period, and occurs in circumstances where spray

		drift beyond the property boundary cannot be avoided, a property spray plan shall be prepared at the beginning of each year, or spray season, in accordance with Appendix M4 of the New Zealand Standard for the Management of Agrichemicals (NZS 8409:2004). The plan shall be given upon request to the owner or occupier of any adjacent property, or to a Council officer. ii. Where the application is on private land, signs shall be used to clearly indicate the use of any agrichemicals: – within 10m of public land where there is a shelter belt giving effective protection between the application and the public land, or – within 30m of public land where there is no shelter belt giving effective protection between the application and the public land. iii. Where the application is on public land notification shall be given in newspapers or by door-to-door advice to land occupiers adjacent to the intended application at the beginning of the spray season, not more than six months prior to application and in any case not less than one month prior to application; and signs shall be used to clearly indicate the agrichemical use. iv. Where the application may affect bee keeping, prior notification shall be given to the affected parties.
ADVISORY NOTES: 1. Non-compliance with rules – If Rule 10 cannot be complied with, then the activity is a restricted discretionary activity under Rule 30, or a discretionary activity under Rule 52, whichever is relevant. 2. Vertebrate toxic agents are covered under the Hazardous Substances and New Organisms Act 1996 and under the Agricultural Compounds and Veterinary Medicines Act 1997. 3. Rule 10, condition (h) - For the avoidance of doubt, the notification requirements set out in condition h(i) do not apply to discharges of agrichemicals where there is never any spray drift beyond the property boundary. 4. Rule 10 does not cover the disposal of agrichemical containers. 5. Agrichemical spray drift hazard – Table Y1 from the New Zealand Standard for the Management of Agrichemicals (NZS 8409:2004) includes a guidance chart for assessing agrichemical spray drift hazard. Dischargers should note that adequate notification of those who may be at risk enables them to take precautionary action which can reduce the potential effects of spray drift.		

9.4 Appendix 4: GROSAFE® aquatic use registered chemical applicators with the capability to carry out aquatic weed control from a boat.

Names are sourced from the GROSAFE® website (www. growsafe.co.nz).

Name	Address
G Angel, Aqua-Ag Air Boat Services	121 Otonga Rd, Rotorua

There are many other people listed on the GROSAFE website as aquatic use registered chemical applicators however as far as we know none of them have the capability to dispense herbicide as recommended in the operational plan.