Department of Conservation

Fonterra

Living Water:

Collation of Baseline Environmental Data for the Lake Ruatuna Catchment

KesselsEcology

SURVEY, ASSESSMENT AND RESTORATION

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EXECUTIVE SUMMARY

This report outlines and collates existing data about the Lake Ruatuna catchment as part of the Living Water Partnership peat lakes project. The report's purpose is to inform future decisions on lake and catchment management by collating existing data and identifying gaps that may need to be remedied. Catchment data will then be used for modelling and to assist in determining the most effective restoration actions for the ecosystem.

Data relating to the catchment soils, climate, hydrology, water quality, and biodiversity are summarised and presented.

The Ruatuna catchment has been significantly modified since the arrival of people in the area and especially since the broad-scale clearance of the land for farming and subsequent drainage of extensive areas of wetland. Indigenous vegetation in the catchment is restricted to the wetlands around Lake Ruatuna and these are heavily degraded and dominated by exotic species. Water quality in the lake has not been measured since 1997, but is almost certainly in a very poor state. The lake is almost entirely devoid of aquatic plants, partially as a result of poor water clarity.

Restoration work in the form of weed and pest control has begun at Ruatuna and the Living Water project will see this expanded considerably and will likely result in long-term improvements in water quality and land productivity.

A number of gaps in the data may need to be rectified during the course of the proposed restoration work in the catchment to give a solid base for management decisions. Most importantly, water quality data for the lake is now very old and no data are available at all for the drains in the catchment. Establishing a solid and accurate baseline of water quality data is essential so that the efficacy of restoration and management efforts can be assessed. It is recommended that a water quality monitoring programme is set up in partnership with Waikato Regional Council so that all protocols and results are consistent with and comparable to other lakes in the region which are already monitored. Information about the biodiversity of the catchment is somewhat sparse, especially for aquatic biodiversity. Undertaking an inventory of indigenous fish and invertebrates would be valuable but of particular importance is more accurate information on the pest fish populations in the lake. Pest fish adversely affect water quality both directly and indirectly through disturbance of the sediment and browsing of submerged macrophytes and will need to be managed if water quality is to be improved.

1 INTRODUCTION & SCOPE

1.1 The Living Water Partnership

The Living Water Partnership is a collaboration between the Department of Conservation (DOC) and Fonterra to protect and enhance sensitive water catchments beyond normal on-farm commitments. It recognises the importance of healthy waterways for their intrinsic natural value, biodiversity value and for the ecosystem services they provide. The partnership coordinates a $20 million community investment fund and is initially focusing on five key catchments or project areas across New Zealand. One of these project areas comprises the three peat lake catchments of Areare, Rotomanuka, and Ruatuna in the Waikato.

1.2 Scope

This report deals solely with the Lake Ruatuna catchment, outlining the information available for the catchment and summarising key data. Its purpose is to inform future decisions on lake and catchment management by collating existing data and identifying gaps that may need to be remedied. Catchment data will then be used for modelling and to assist in determining the most effective restoration actions for the ecosystem. Water quality, hydrology, biodiversity, climate and resource use are covered.

1.3 Data Availability

Unlike the nearby Rotomanuka catchment, there is very little published information available for the Ruatuna catchment. Water quality information is restricted to a few discrete sampling periods, the most recent of which was in 1997 (Thompson & Greenwood 1997). Waikato Regional Council (WRC) maintains an automated water temperature and lake level recorder at the jetty which has been recording daily mean temperature and water level since 2005. Ruatuna has been included in the LakeSPI programme and was last surveyed for submerged macrophytes in 2007 (Burton *et. al.* 2014). Climate data for the catchment or the adjacent Ohaupo village could not be found but the NIWA climate station at Hamilton Airport provides useful data for the catchment. Other data relevant to the catchment includes early inventory reports which detailed the invertebrate and plant life in and around the lakes (e.g. Chapman & Boubée 1977; Page 1988), a recent vegetation survey and restoration plan (Bycroft & Reeves 2013), and summary of information about all shallow lakes in the region produced by WRC (Dean-Spiers *et. al.* 2014).

2 CATCHMENT DESCRIPTION

The Ruatuna catchment is located just to the west of Ohaupo village approximately 14 km south of Hamilton city (Figure 1). It occupies an area of approximately 190 ha comprising low hills and flat peatland. Lake Ruatuna occupies an area of 13 ha in the southern part of the catchment a short way north of Ryburn Road. It is situated at the southern end of a small peat deposit which has now been drained and is intensively farmed. Beyond the flat peat land to the north, south and east are a series of low hills.

The lowest point in the catchment is at the Lake Ruatuna outlet which is set at 38.75 m relative to the Moturiki datum while the highest point is 80 m above datum approximately 500 m east of the lake. The Lake Ruatuna Wildlife Management Reserve is listed in Section 3.7.7 of the Waikato Regional Plan as a wetland to which certain restrictions relating to drainage apply.

The catchment is within the Waipa District and the Hamilton Ecological District.

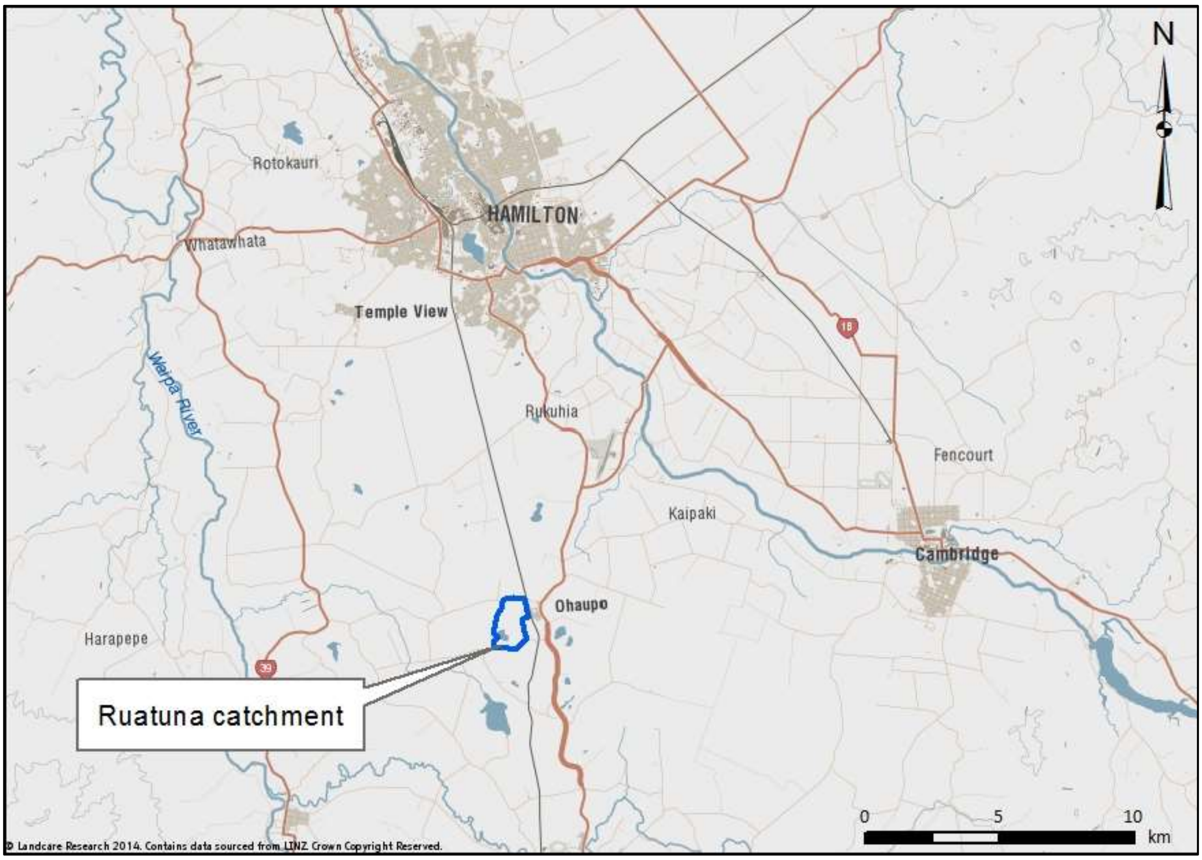

Figure 1: Location of the Ruatuna catchment.

2.1 Catchment Land Cover and Use

Pastoral farming is the dominant land use of the Ruatuna catchment with more than 85% of the catchment in pasture. Dairy farms make up almost all of the pasture area although there are several small lifestyle and residential properties as well. Lake Ruatuna and another small pond make up 7% of the catchment area while the wetlands, including willow-dominated deciduous hardwoods, make up a further 3.2%. The remaining area is in orchards, residential houses, and roads (Table 1).

Table 1: Landcover Classes in the Ruatuna catchment. Based on LCDB4 (Landcare Research) but with alterations based on 2012 WRAPS aerial photography.

Landcover Class	Area (ha)	% of catchment
Broadleaved Indigenous Hardwoods	1.21	0.65%
Built-up Area (settlement)	2.60	1.39%
Deciduous Hardwoods	4.52	2.42%
Herbaceous Freshwater Vegetation	1.51	0.81%
High Producing Exotic Grassland	159.58	85.49%
Lake or Pond	13.09	7.01%
Orchard Vineyard and Other Perennial Crops	3.50	1.88%
Transport Infrastructure	0.67	0.36%
Grand Total	186.67	100.00%

2.2 Land Ownership

Lake Ruatuna and its immediate surrounds are owned by the crown and administered by DOC. This land was gazetted as a Wildlife Management Reserve under the Reserves Act

(1977) in 1983. It comprises 18.5 ha and 9.9% of the catchment area (Figure 9). Waipa District Council (WDC) owns a further area of Esplanade Reserve around the margins of the Wildlife Management Reserve as well as a Recreation Reserve between Ryburn Road and the southern shore of the lake. In total WDC administers 9.3 ha of land in the catchment (5%). Apart from a small area (1%) of road reserve the remaining land (156.8 ha, 84%) is privately owned.

3 SOILS

The Ruatuna catchment is located at the southern tip of the historical Rukuhia peat bog (Figure 3). The New Zealand Fundamental Soils Layer (NZFSL) maps show four different soil types within the catchment (Figure 4). The lake and surrounding flat land is situated on Typic Orthic Gley soil of the Horotiu-Te Kowhai complex (WRC 2015). These soils are poorly drained with compact subsoil. On hillslopes south of the lake the soils are Typic Orthic Granular soils of the Hamilton group which are well drained and erosion prone (NZFSL 2014; WRC 2015). The hillslopes of the eastern part of the catchment are Ohaupo Typic Orthic Allophanic soils which are well drained with low risk of erosion (NZFSL 2014; WRC 2015). The fourth soil type is Kaipaki peat which is situated in the northeast corner of the catchment (WRC 2015). This is classified as Mellow Mesic Organic soil of moderately decomposed peat (NZFSL 2014) and represents the southern extent of the historic Rukuhia peat bog. Another 'arm' of peat extends from the main Rukuhia bog to just west of the Ruatuna catchment. Davoren *et. al.* (1978) described the peat on the southern fringes of the Rukuhia bog as comprising sedge-derived peat around 2 m deep with a thin overlying horizon of mineralised peat. This is in contrast to the dome peat of the Rukuhia bog which is at least partially composed of the restiad rush *Empodisma minus* (Davoren *et. al.* 1978).

The peat deposit which surrounds the lake itself is not mapped in NZFSL data but was described by Thompson & Greenwood (1997). The peat generally increases in depth with distance from the lake from only a shallow surface layer < 0.5 m deep near the lake edge to more than 1.5 m deep near the edge of the deposit. The peat is deepest around 200 m north of the lake where it is up to 1.75 m deep and comprises a surface layer of oxidised peat over layers of clayey peat, marshy peat, and lake peat in descending order (Thompson & Greenwood 1997). The peat extends furthest from the lake edge to the north (around 250 m) while there is less than 130 m between the lake shore and the edge of the deposit on the east and south sides of the lake (Thompson & Greenwood 1997). Thompson & Greenwood (1997) also mapped a shallow peat deposit to the north of the lake contiguous with the deepest area and warned that this area was likely to become flooded as the peat shrinks and would need to be carefully managed. Thompson & Champion (1993) concluded that Ruatuna had never historically been connected with the Rukuhia bog, although it is now hydrologically linked to at least the southern extreme of the bog via the drain from the northeast of the catchment.

Each of the soils in the catchment has different characteristics which affect how they should be managed and how their management affects the lake. Characteristics relating to nutrient and water management are summarised in Table 2 below. Characteristics described for Kaipaki loamy peat are also likely to apply to the deposit of peat on which Ruatuna sits.

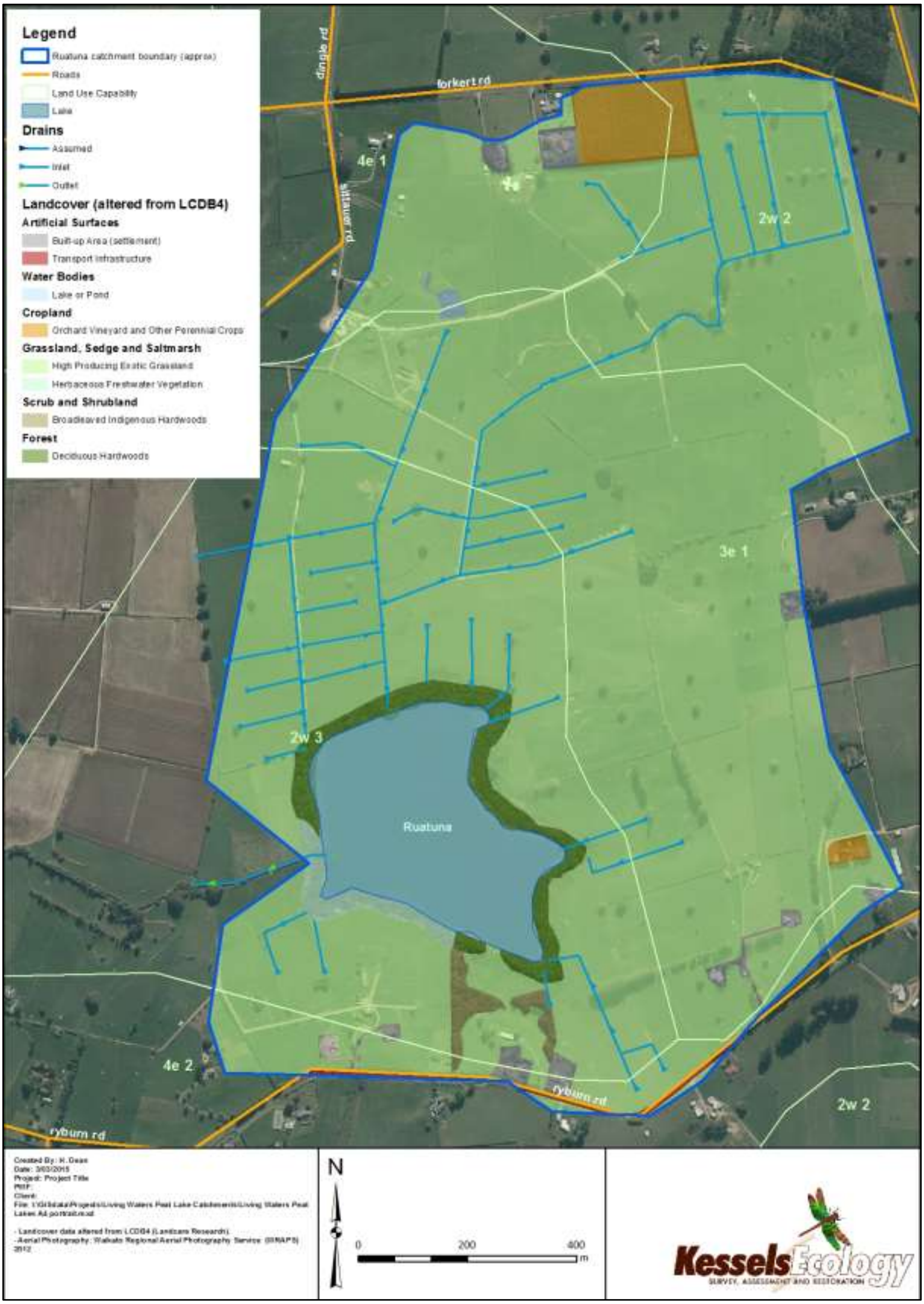

Figure 2: Landcover and drainage network of the Ruatuna catchment. Data based on LCDB4 with alterations based on WRAPS 2012.

Table 2: Nutrient and water management characteristics of soils in the Ruatuna catchment. Data from S-Map (Landcare Research and WRC).

	Kaipaki loamy peat	**Te Kowhai silt loam**	**Hamilton Silt Loam**	**Ohaupo Silt Loam**
Soil classification (NZSC)	Mellow Mesic Organic	Typic Orthic Gley	Typic Orthic Granular	Typic Orthic Allophanic
Area in catchment (ha)	26.41	69.86	8.61	84.81
% of catchment	13.9%	36.8%	4.5%	44.7%
Erodibility	Minimal	Slight	Minimal	Minimal
Structural vulnerability	Moderate	High	Low	Very low
Waterlogging vulnerability	High	High	Low	Very low
Drought vulnerability	Low	Low	High	Low
N leaching vulnerability	Very low	Very low	High	Low
P leaching vulnerability	Medium	Medium	---	---
Dairy effluent (FDE) risk category	C if >7°, otherwise B	C if >7°, otherwise B	C if >7°, otherwise D	C if >7°, otherwise D
Relative runoff Potential:				
0-3°	Medium	Low	Very low	Very low
4-7°	High	Medium	Low	Very low
8-15°	High	Medium	Medium	Very low
16-25°	Very High	High	Medium	Low
>25°	Very High	High	Medium	Low

3.1 Land Use Capability

The Land Use Capability (LUC) classification is a long-established system for assessing the suitability of land for various uses. The system uses data from the Land Resources Inventory to classify land into eight major classes: Class 1 land is highly versatile, with no limitations and suitable for arable cropping or intensive grazing while Class 8 land is unsuitable for any farming or forestry and is highly limited (Lynn *et. al.* 2009). The system also incorporates a land use subclass which provides information about the limitations of the land.

The areas of Te Kowhai silt loam and Kaipaki loamy peat are classed as 2w (Figure 4) indicating that they are highly suitable for arable cropping and intensive grazing with a high water table being the limiting factor (Lynn *et. al.* 2009). The northern and southern hilly areas which comprise Ohaupo silt loam and Hamilton silt loam respectively are classified as 4e land which is moderately suitable for grazing with erosion as the limiting factor (Lynn *et. al.* 2009). The remaining area of hillslope in the eastern part of the catchment is class 3e land which is well suited for grazing but erosion may be an issue (Lynn *et. al.* 1978).

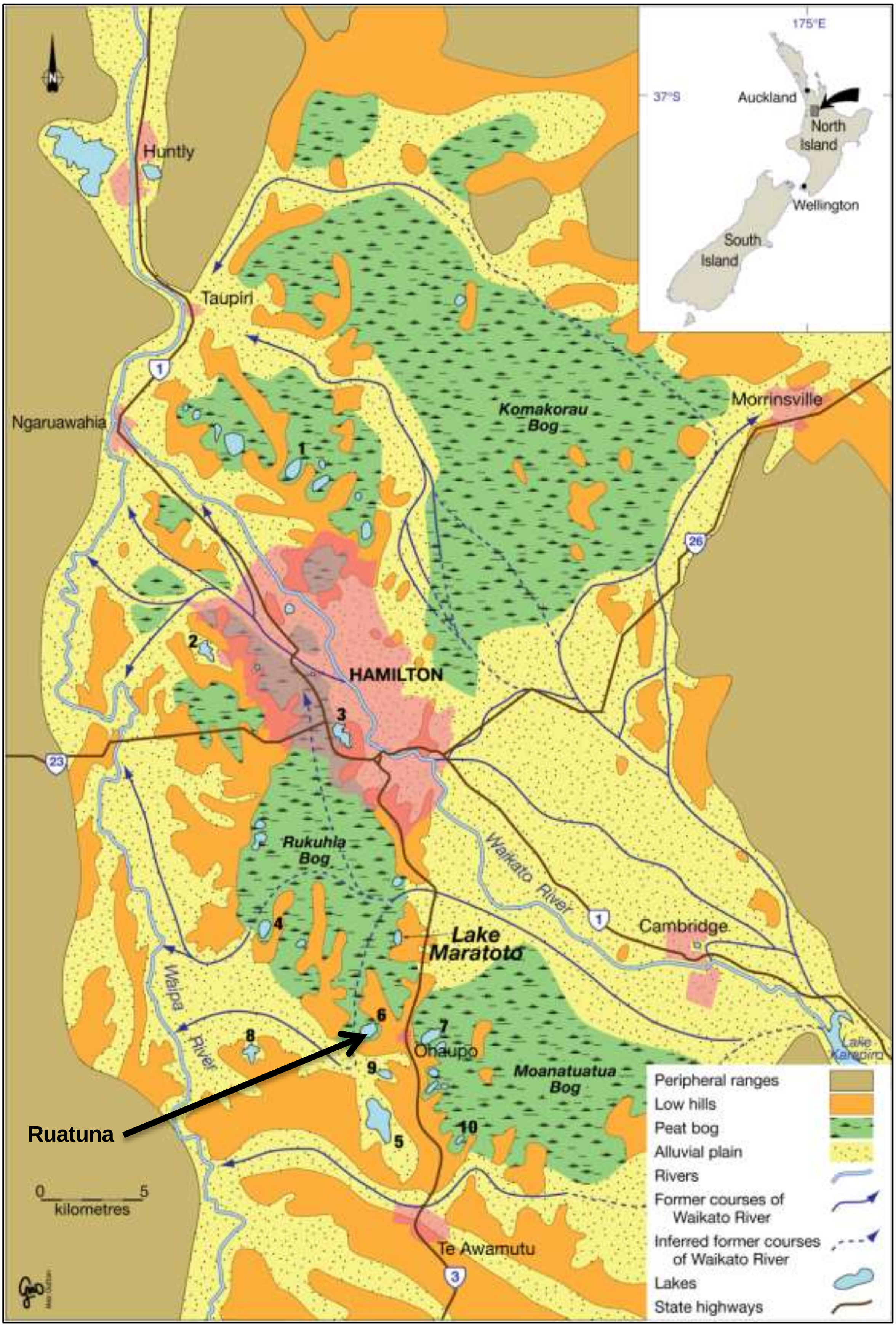

Figure 3: Landscape features of the Hamilton basin and the extent of peat bog soils. Ruatuna is located on the southern tip of the Rukuhia Bog. Figure by DJ Lowe (2010) after McGraw 2002.

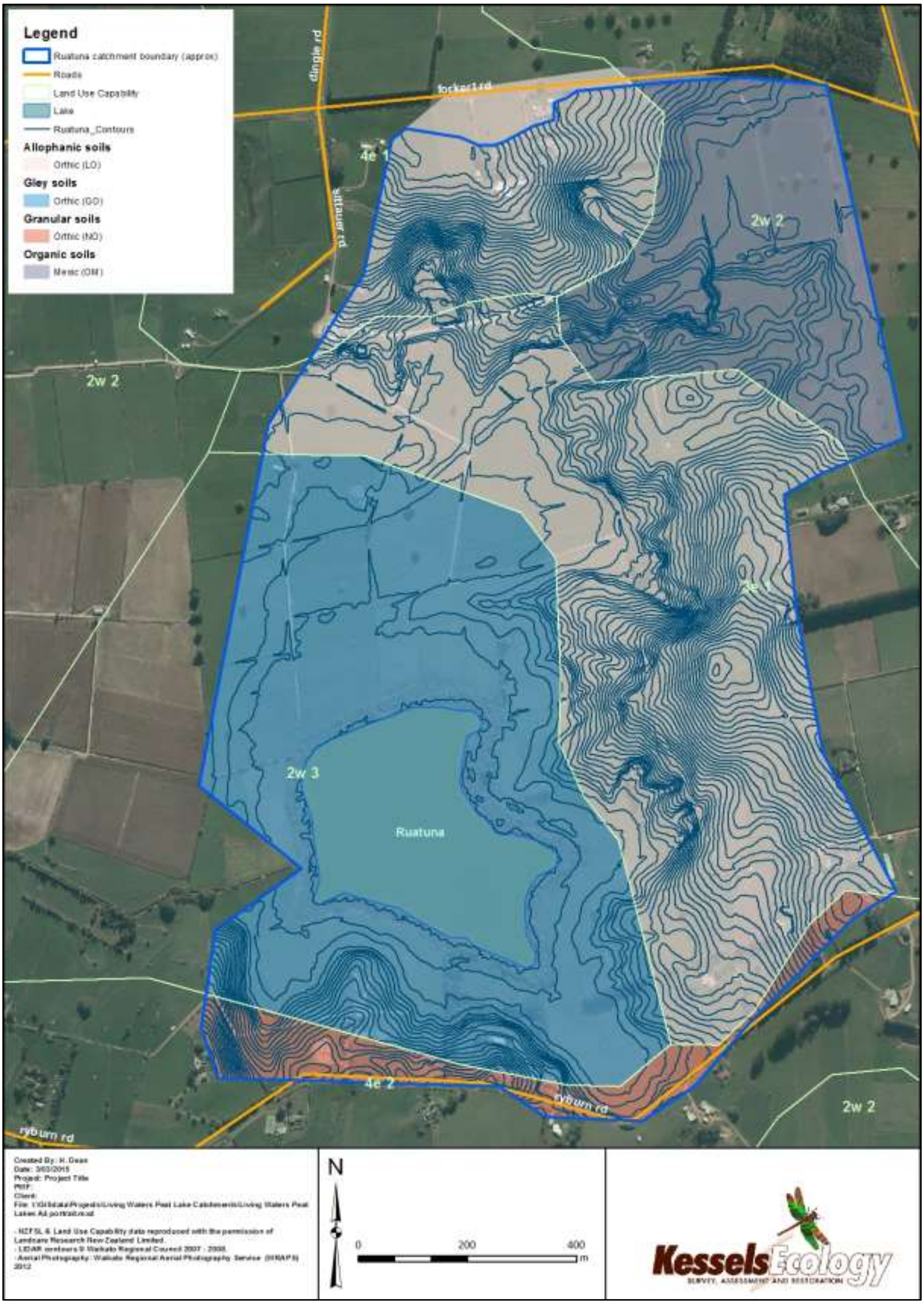

Figure 4: Soils, Land Use Capability and contour of the Ruatuna catchment.

4 CLIMATE

While no climate data is available specifically for the Ruatuna catchment, the Hamilton airport climate station provides relatively local data which may be sufficient for the purposes of the Living Water project. Key climate characteristics for the period 2009 - 2014 are summarised in Table 3. Mean annual air temperature ranged between 13.3 and 14.2°C during the period with a maximum summer temperatures of around 30°C and minimum winter temperatures of approximately -3.5°C. The number of frost days per year has varied considerably over the last six years, ranging between 11 in 2013 and 31 in 2009. Average annual rainfall for the five years from 2009 - 2013 was 1,247 mm. Summers can be very dry with water deficits in excess of 140 mm (CliFlo 2015).

Table 3: Climate data for Hamilton Airport between 2009 and 2014. Data from NIWAs CliFlo service.

	Mean Air Temp (°C)	Lowest Daily Mean Temp (°C)	Highest Daily Mean Temp (°C)	Extreme Maximum Air Temp (°C)	Extreme Minimum Air Temp (°C)	Number of frost days	Mean Of 9am Relative Humidity (%)	Total Rainfall (mm)
2009	13.3	2.3	25	29.8	-4.5	31	88	1088
2010	14.2	4.2	23.7	30.3	-3.3	13	87.2	1236
2011	14.1	3.1	23.7	30.3	-3.9	17	89	1539
2012	13.4	3	23	27	-3.6	24	88.2	1290
2013	14.2	4.2	22.5	30.7	-3.2	11	87.9	1086
2014	13.7	-	-	-	-	-	89.2	-

5 HYDROLOGY

5.1 Drainage

At least 7.84 km of drains feed into Lake Ruatuna. Many of these are shallow drains bordering individual paddocks which are likely to flow only during rain but larger drains are likely to flow for the majority of the time.

5.2 Streams

No natural streams occur within the Ruatuna catchment and historically the lake is likely to have had no natural inflows or channelled outflows. However, the contour of the land suggests that there may be gullies in the eastern and northern parts of the catchment that have overland flows during heavy rainfall.

Ruatuna now drains via a constructed channel on the western side of the lake into the Mangaotama Stream which flows westward into the Waipa River.

5.3 Lake

Waikato Regional Council records lake water levels using an automated station located at the jetty on the southern shore of the lake. Daily lake levels have been recorded since 2005 although there are one or two gaps in the data (Figure 5). The level of the lake is set by a weir on the outlet drain which is currently set at 38.75 m above Moturiki datum (Bycroft & Reeves 2013). The lake level is specified in the Waikato Regional plan as 38.61 m but the official level is to be altered to the current weir level in a future plan change (Dean-Spiers *et. al.* 2014).

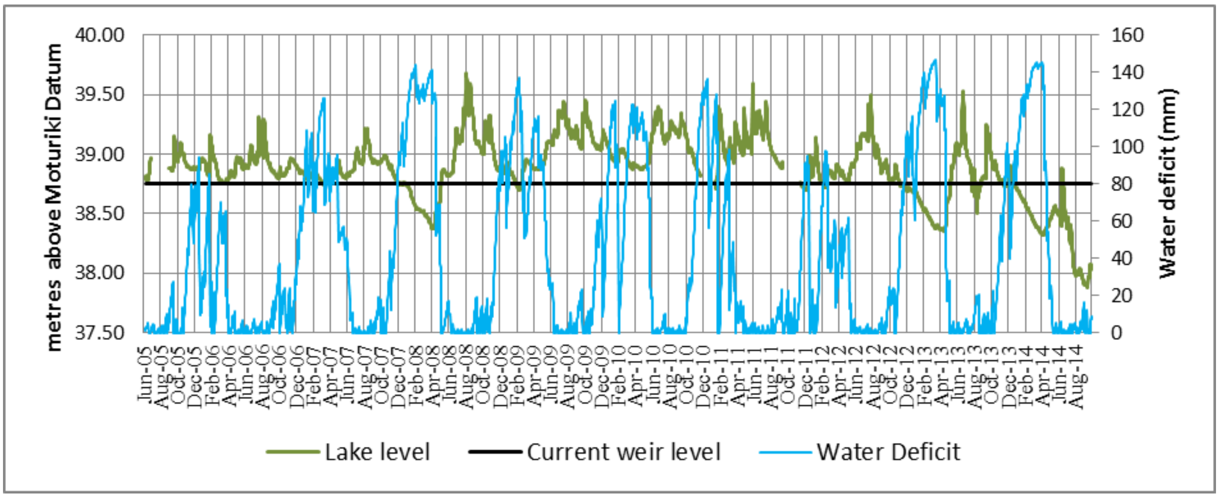

Figure 5: Daily water level in Lake Ruatuna, daily water deficit at Hamilton airport, and the current weir level. Level data from WRC and water deficit sourced from CliFlo with the permission of NIWA.

Short term fluctuations in lake level in response to rain can be as much as 0.5 m or more over several days (Figure 5, Figure 6) and fluctuations of more than 1 m can occur within six weeks or so (e.g. June - July 2013; Figure 5). As would be expected the lowest water levels occur in the summer months but there is considerable fluctuation throughout the year. Drought or dry conditions in 2008, 2013 and 2014 caused lake levels to fall well below the current weir level. However the lowest levels recorded were in spring 2014 when lake levels were below 38 m for the first time since 2005.

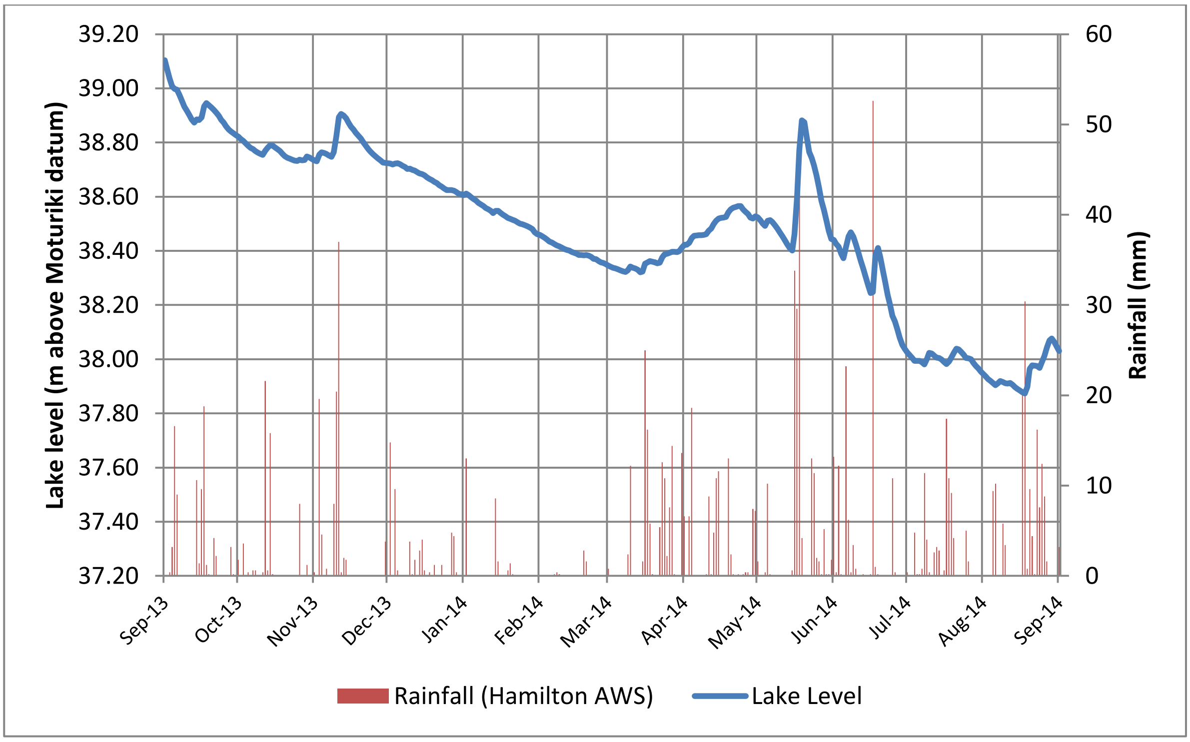

Figure 6: Daily lake level and rainfall at Hamilton Airport between September 2013 and September 2014. Lake level data courtesy of WRC, Rainfall data sourced from CliFlo with the permission of NIWA.

5.4 Groundwater

No information on the groundwater hydrology of the Ruatuna catchment appears to be available. However, the lake sits above and on the eastern edge of the Waipa aquifer. Waikato Regional Council are currently undertaking a programme of research to determine sustainable yields of aquifers for groundwater consent purposes during which more detailed information about the groundwater in the area is likely to be collected (Waikato Regional Plan).

6 BATHYMETRY

The bathymetry of Lake Ruatuna has recently been surveyed for the Department of Conservation by de Winton *et. al.* (2014) and the map from that survey is included as Figure 7. Lake Ruatuna had a maximum recorded depth of 2.41 m when surveyed in February 2014 (de Winton *et. al.* 2014). With fluctuations in water level the maximum depth during the period between September 2013 and September 2014 was between 1.53 m and 2.76 m (Figure 6). A maximum lake depth of 3.2 m was reported by Thompson & Greenwood (1997) which is within the maximum fluctuations in water level recorded by Waikato Regional Council: The maximum lake level recorded was 39.68 m on August 2nd 2008 (Figure 5) which equates to a maximum depth of 3.34 m.

The deepest part of the lake is at the southern end but a large part of the central bed is relatively flat with depths between 1.6 and 2m (de Winton *et. al.* 2014; Figure 7).

7 WATER QUALITY

Very little water quality information is available for the Ruatuna catchment but that data which is available is summarised in this section.

7.1 Trophic State

The Trophic Level Index (TLI) is a standard method for measuring the trophic status of lakes in New Zealand (Burns *et. al.* 2000). It provides a single indicator value based on information on the nutrient status of the lake and is an important indicator of water quality. TLI is calculated using measurements of Total Phosphorus (TP), Total Nitrogen (TN), chlorophyll α (chl a), and secchi depth (SD) and ranges in value from 0 (ultra microtrophic) to 7 (hypertrophic; Table 4) (Burns *et. al.* 2000).

Table 4: Values of TLI, TP, TN, SD, and Chl a in relation to trophic states (from Burns *et. al.* 2000).

Trophic State	TLI	Chlorophyll α (mg/m^3)	Secchi depth (m)	Total Phosphorus (mg/m^3)	Total Nitrogen (mg/m^3)
Ultra microtrophic	0 - 1	0.13 - 0.33	33 - 25	0.84 - 1.8	16 - 34
Microtrophic	1 - 2	0.33 - 0.82	25 - 15	1.8 - 4.1	34 - 73
Oligotrophic	2 - 3	0.82 - 2.0	15 - 7	4.1 - 9.0	73 - 157
Mesotrophic	3 - 4	2.0 - 5.0	7.0 - 2.8	9.0 - 20	157 - 337
Eutrophic	4 - 5	5.0 - 12	2.8 - 1.1	20 - 43	337 - 725
Supertrophic	5 - 6	12 - 31	1.1 - 0.4	43 - 96	725 - 1558
Hypertrophic	6 - 7	> 31	< 0.4	> 96	> 1558

Published water quality data for the Ruatuna catchment are limited to early inventory and water quality reports from 1977, 1982 and 1988, and a later one from 1997. These data are summarised in Table 5 and an approximate trophic state has been assigned based on the TLI threshold information provided by Burns *et. al.* (2000). All of these records indicate very poor water quality in the lake which was at least eutrophic in 1982 and was hypertrophic by 1988. Water clarity has remained very low since 1977 with secchi depths of less than 1 m throughout the period. Total phosphorus increased markedly between the 1982 and 1988 samples and nitrogen showed a large increase between 1988 and 1997. Although the most recent of these records is now 17 years old it is probable that the water quality of the lake is at least as poor as it was in 1997 - recent information confirms that at least water clarity remains very low (Burton *et. al.* 2014).

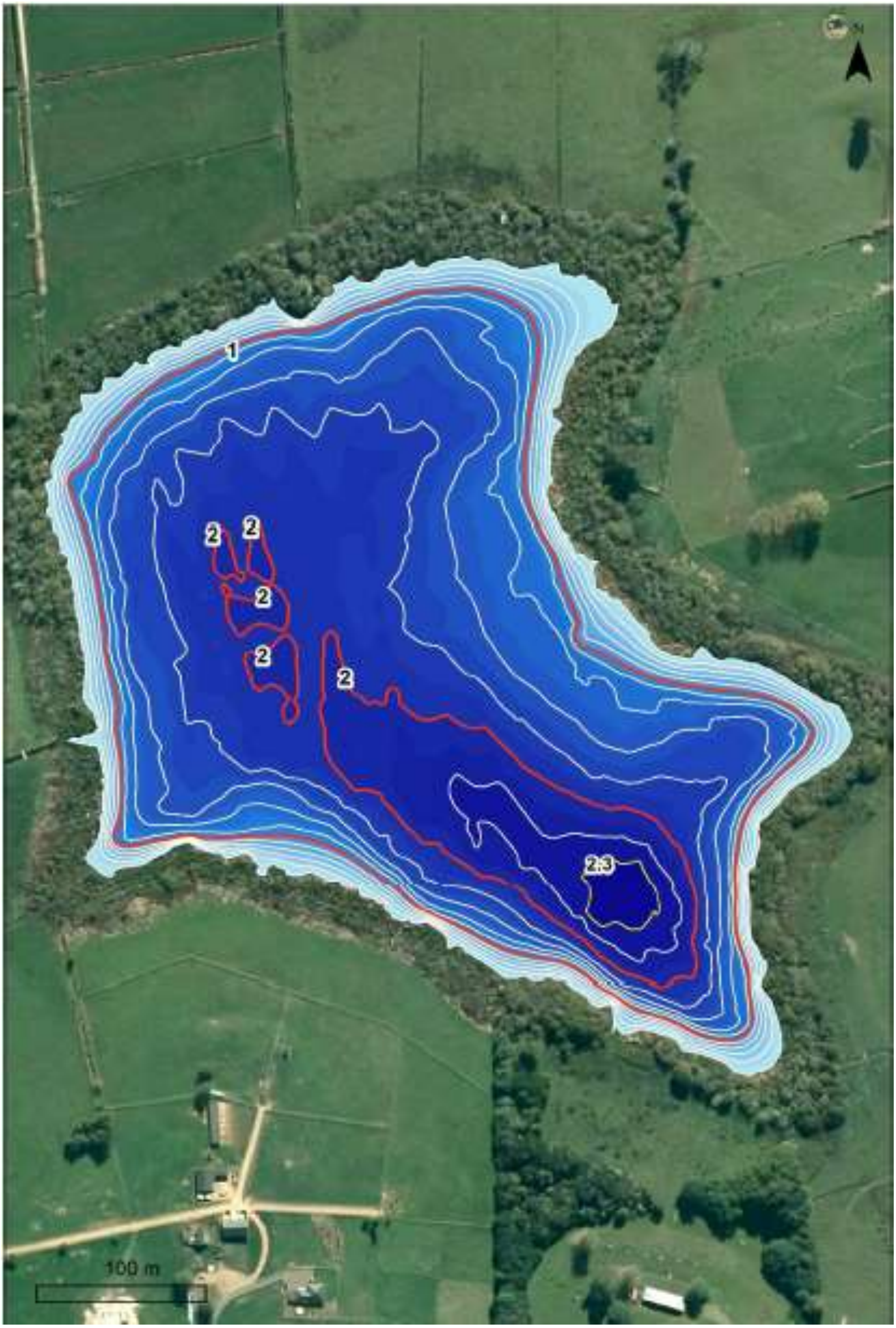

Figure 7: Bathymetry map of Lake Ruatuna showing 0.5m contours. Map by NIWA (2014), supplied by DOC.

Table 5: Water quality parameters for Lake Ruatuna.

Year	Location	Temp Range (°C)	DO Range ($g\ m^{-3}$)	Secchi Depth (m)	pH	SS ($g\ m^{-3}$)	TP ($mg\ m^{-3}$)	TN ($mg\ m^{-3}$)	Chl a ($mg\ m^{-3}$)	Estimated trophic state
1977[1]	-			0.49					28.7	Eutrophic - Supertrophic
1982[2]	Surface	20.5 - 25.0	5.8 - 12.9	0.7-1.0	6.55 - 7.62	2.3 - 27.9	21 - 78	--	7.9 - 35.6	Eutrophic - Supertrophic
	Bottom	20.4 - 23.8	0.4 - 11.0							
1988[3]		--	--	0.55	7.9	--	155	1860	142.3	Hypertrophic
1997[4]		--	--	~ 0.4	--	--	330	2868	--	Hypertrophic

The information available is not likely to be sufficient to serve as a baseline for future Living Water restoration and catchment management work and it is recommended that water quality monitoring is carried out prior to any further work being done in the catchment and at regular intervals during the course of the project.

7.2 Water Temperature

Waikato Regional Council collects water temperature data using an automated recorder which takes daily measurements. As expected the lake water temperature exhibits a seasonal fluctuation with summer temperatures reaching 20 - 25°C and winter temperatures dropping to 7 - 10°C. There appears to have been a steady drop in water temperature since 2008 despite air temperatures at least as warm and at least two drought events. The reason for this is not immediately obvious and could be investigated further.

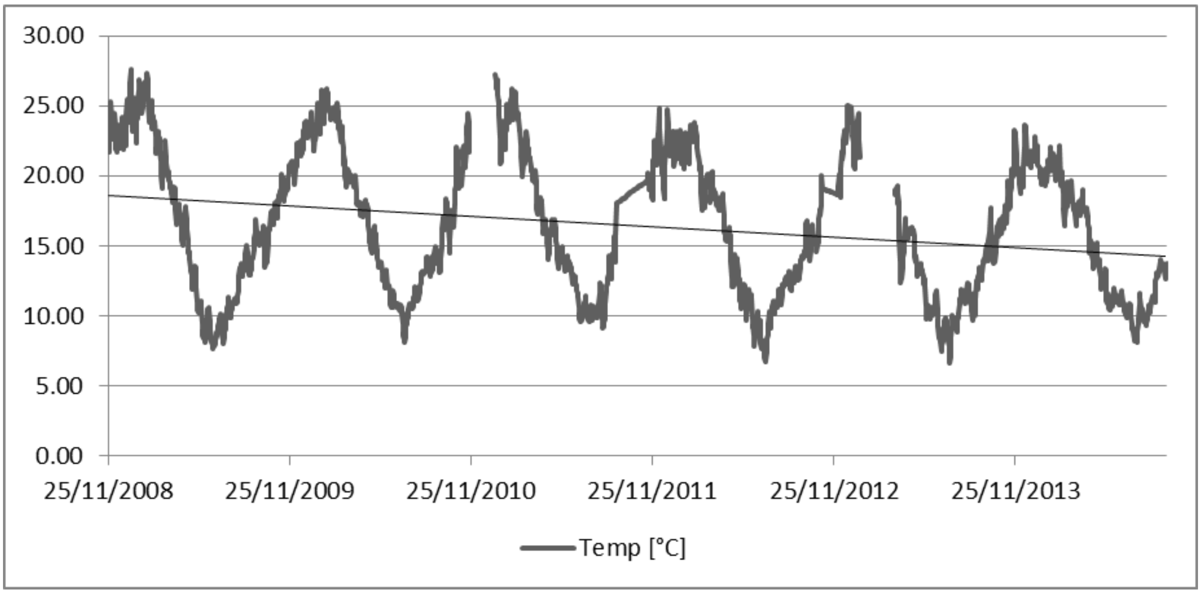

Figure 8: Daily water temperature readings for Ruatuna between November 2008 and September 2014. The trend is an OLS regression. Data from WRC.

[1] Chapman & Boubée 1977
[2] Town 1982
[3] Page 1988
[4] Thompson & Greenwood 1997

8 RESOURCE USE

Only three resource consents were active in the Ruatuna catchment at the end of 2014 and one other had been applied for. A landuse consent for a well is active at the southern end of the lake, the weir on the outlet drain is consented, and there is an active consent for the discharge of farm effluent to land at the northern end of the catchment (Figure 9). A consent application for a ground water take at the northern end of the catchment may now be active, and there are three additional consent applications for ground water takes just outside the catchment to the south which may have some effect on ground water levels.

9 BIODIVERSITY

This section outlines existing information about the biodiversity in the Ruatuna catchment. Data from a range of reports and databases have been collated.

9.1 Aquatic Biodiversity

9.1.1 Fish

The New Zealand Freshwater Fish Database (NZFFD) does not hold any records for Lake Ruatuna but several records are included for a drain site within the catchment which are labelled as being within the Mangaotama Stream. Earlier records from the Waipa peat lakes inventories are also available. Only common native and exotic species have been recorded in the catchment (Table 6). The Department of Conservation has recently completed a pest fish survey and results were being analysed at the time of writing.

Table 6: Fish species records from the Ruatuna catchment.

Common Name	Scientific name	**Threat status**[5]	**Location**	**Source**
Shortfin eel	*Anguilla australis*	Native: Not threatened	Drain/Mangaotama stream	NZFFD
Common bully	*Gobiomorphus cotidianus*	Native - Not threatened	Drain/Mangaotama stream	NZFFD
Gambusia	*Gambusia affinis*	Introduced and Naturalised	Drain/Mangaotama stream; Lake Ruatuna	NZFFD; Page 1988
Unidentified eel	*Anguilla sp.*	Native	Drain/Mangaotama stream	NZFFD
Unidentified bully	*Gobiomorphus sp.*	Native	Lake Ruatuna	Page 1988
Rudd	*Scardinius erythrophthalmus*	Introduced and Naturalised	Lake Ruatuna	Burton *et. al.* 2014
Goldfish	*Carassius auratus*	Introduced and Naturalised	Lake Ruatuna	Page 1988
Longfin eel	*Anguilla dieffenbachii*	Native: At Risk - Declining	Lake Ruatuna	Reeves et. al. 2011
Catfish	*Ameiurus nebulosus*	Introduced and Naturalised	Lake Ruatuna	Reeves et. al. 2011

[5] Goodman *et. al.* 2014

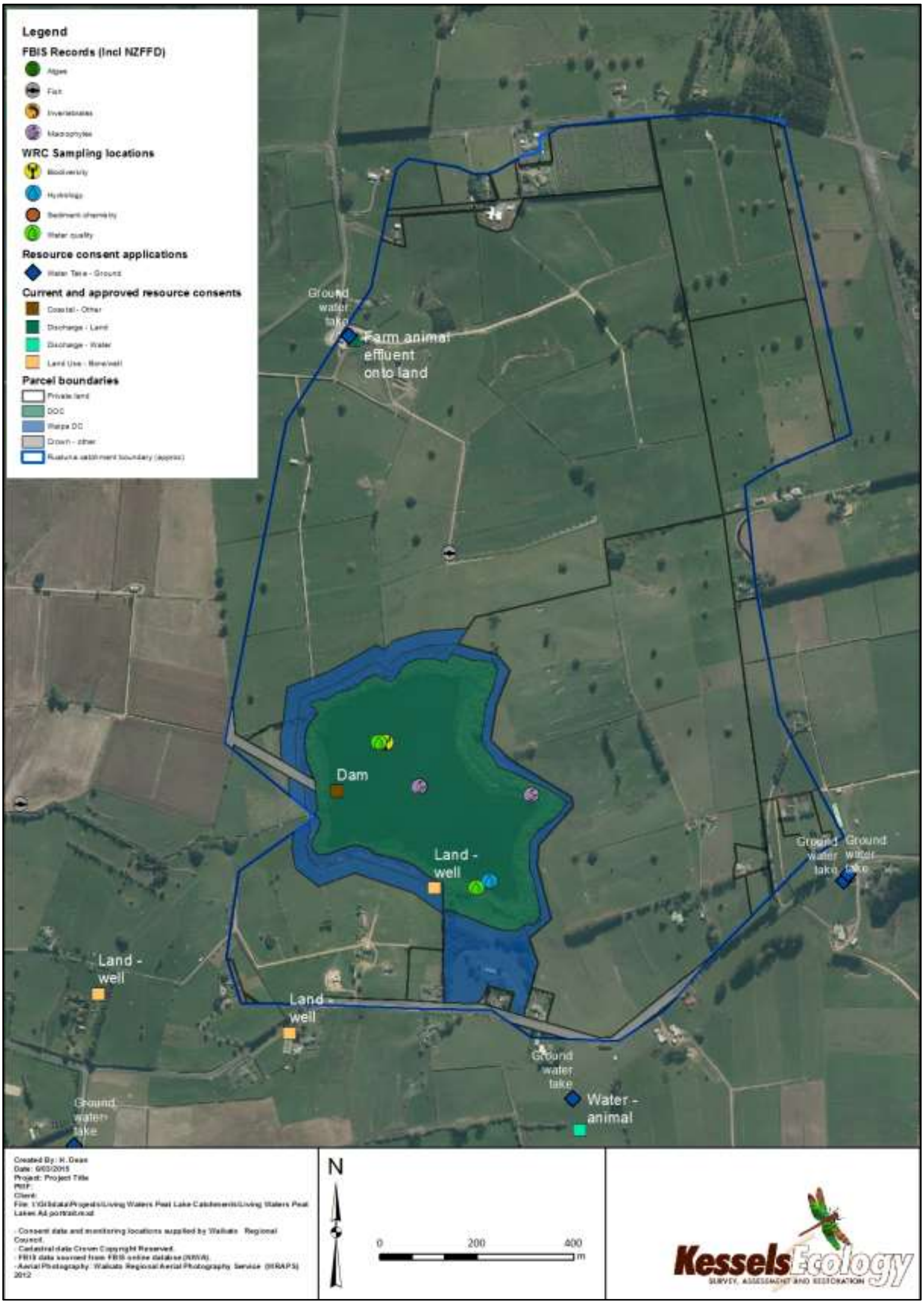

Figure 9: Land ownership, **r**esource consents and **l**ocation of existing data held by WRC and in the NIWA FBIS database.

9.1.2 Invertebrates

The invertebrate fauna of Lake Ruatuna has not been surveyed since 1988 when a resource inventory for the Waipa peat lakes was completed (Page 1988). Littoral invertebrates representing 13 groups were recorded along with four groups of benthic invertebrates (Table 7; Page 1988). A previous inventory in 1977 recorded four littoral invertebrates and the same four benthic invertebrates as the 1987-88 study (Page 1988; Chapman & Boubée 1977). Burton *et. al.* 2014 noted the presence of quantities of empty freshwater mussel shells (*Echyridella menziesii*) on the lake bed during their 2007 survey indicating that a population of this species was living in Ruatuna until relatively recently.

Table 7: Invertebrate species recorded in Lake Ruatuna during the 1987-88 inventory (from Page 1988).

Littoral	
Name (Order, Family, Genus, or common)	**% of sample**
Planarian	3.1
Nematoda	1.2
Prostoma	1.2
Oligochaeta	26.3
Cladocera	6.6
Copepoda	12.9
Chironomidae	24.4
Damselflies	0.3
Anisops	0.05
Sigara	0.1
Microvelia	16.5
Mite	0.9
Lymnaea	0.16
Benthic	
Name **(Order, Family, Genus, or common)**	**Number**
Oligochaeta	18
Horny-cased caddis	1
Chironomidae	10
Mite	1

9.1.3 Flora

The lake supports a range of emergent macrophyte species such as raupō (*Typha orientalis*), *Machaerina articulata*, kuta (*Eleocharis sphacelata*) and pūrua grass (*Bolboschoenus fluviatilis*) along with several exotic species (Bycroft & Reeves 2013).

Chapman & Boubée (1977) detailed the algal species present within the water column of Ruatuna which comprised a total of 21 species. This was one of the highest numbers of species of the 24 Waipa lakes they surveyed.

9.1.4 Lake Submerged Plant Indicators (SPI)

Lake SPI uses the extent and diversity of submerged native and exotic plants to provide an indicator of lake health (Clayton & Edwards 2006). Historical data for the 1800s and data from more recent reports has been used to assess SPI and more recently dedicated surveys for submerged plants have been undertaken in a range of Waikato Lakes (Burton *et. al.* 2014).

Lake Ruatuna has been almost completely de-vegetated since at least the 1970s and SPI scores have been zero since 1977 (Burton *et. al* . 2014). Chapman and Boubée (1977) did not report any submerged macrophyte species from the lake and in their 1991 survey and Champion *et. al.* (1993) reported *Nitella hookeri* from only one area. A survey by NIWA scientists as part of the LakeSPI programme found the lake to be completely de-vegetated in 2007 (Burton *et. al.* 2014).

Table 8: Lake SPI scores for Lake Ruatuna. Data from Burton *et. al.* 2014.

Year	LakeSPI Index (%)	Native Condition Index (%)	Invasive Impact Index (%)
1800s	94	87	0
1977	0	0	0
1991	0	0	0
2007	0	0	0

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9.2 Terrestrial biodiversity

9.2.1 Flora

The marginal vegetation of Lake Ruatuna was mapped by Champion *et. al.* (1993) from a 1989 survey and again in 2012 by Bycroft & Reeves (2013). The vegetation map from Bycroft & Reeves (2013) is included as Figure 10. In 1989 the lake marginal wetlands were dominated by grey willow (*Salix cinerea*) carr, with patches of harakeke (*Phormium tenax*) and raupō. Large beds of emergent kuta were present at the northern end of the lake and scattered around the margins and these were noted to be yellowing and dying in places (Champion *et. al.* 1993). In 2012 grey willow was still the dominant species of the marginal wetlands and the cover of kuta had apparently diminished considerably, with primrose willow (*Ludwigia peploides var. montevidensis*) and water pepper (*Persicaria hydropiper*) becoming dominant in the areas previously dominated by kuta (Bycroft & Reeves 2013). A total of 29 indigenous and 44 adventive vascular plant species were recorded in the 2012 survey, none of which are considered rare, at risk or threatened (Bycroft & Reeves 2013).

9.2.2 Fauna

Birds utilising Lake Ruatuna and the surrounding area have been recorded on a number of occasions. A compilation of past bird records is included in Table 9. Two Threatened and four At Risk species have been recorded and are likely to all still utilise habitat within the catchment. Caspian tern (*Hydroprogne caspia;* Threatened - Nationally Vulnerable) has been recorded in the nearby Rotomanuka catchment (Dean 2014) and are likely to also visit Ruatuna from time to time.

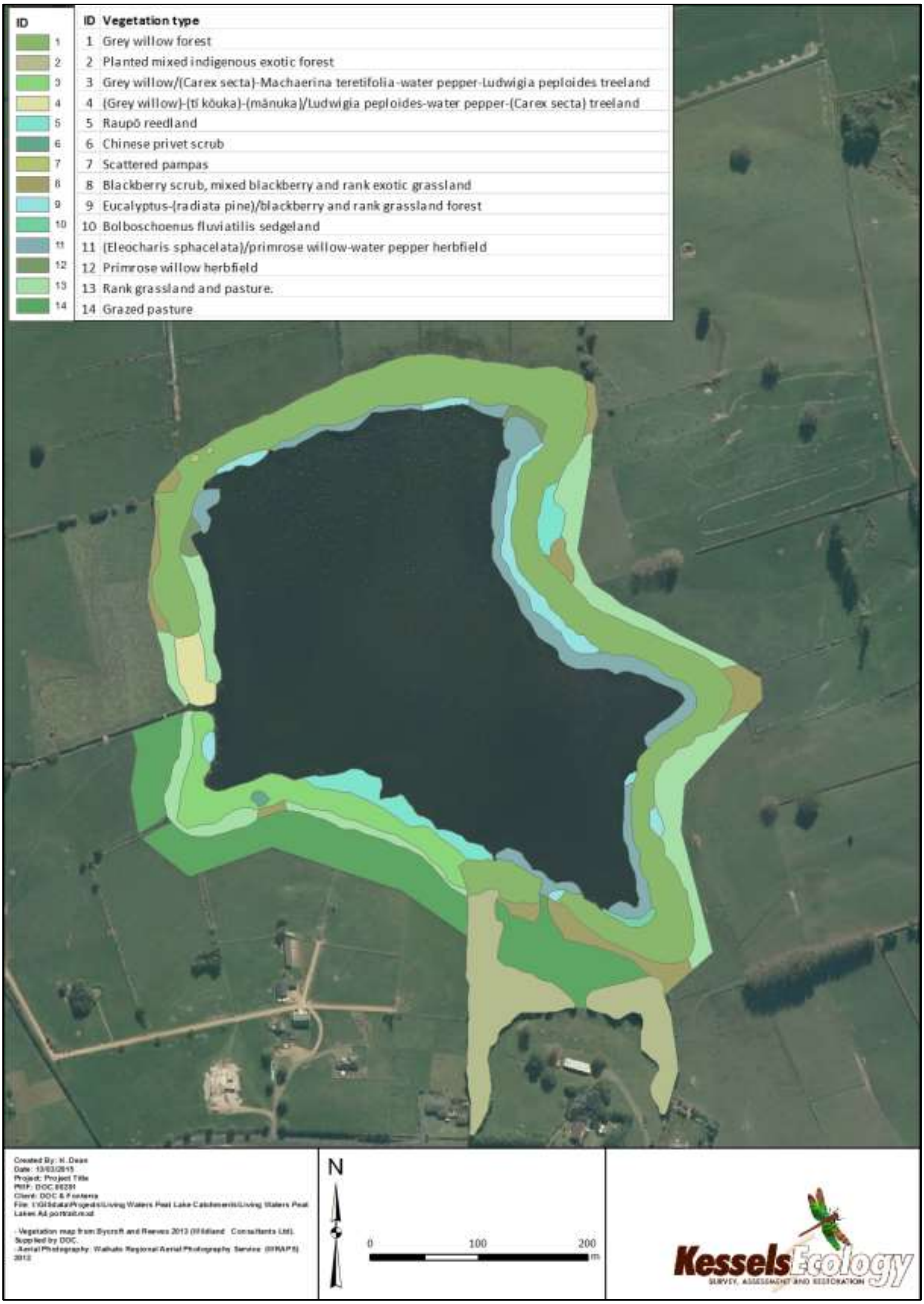

Figure 10: Vegetation types of the land surrounding Lake Ruatuna. Data from Bycroft & Reeves 2013 (Wildland Consultants Ltd), supplied by DOC.

Table 9: Records of birds from the Lake Ruatuna catchment.

Common Name	Specific name	Threat status	Notes (see Source)	Source
Australian magpie	*Gymnorhina tibicen*	Introduced and naturalised		Bycroft & Reeves 2013
Black swan	*Cygnus atratus*	Not threatened	Common	Bycroft & Reeves 2013
Blackbird	*Turdus merula merula*	Introduced and naturalised	Common	Bycroft & Reeves 2013
Eurasian skylark	*Alauda arvensis*	Introduced and naturalised	Common	Bycroft & Reeves 2013
Fantail	*Rhipidura fuliginosa placabilis*	Not threatened	Common	Bycroft & Reeves 2013
Goldfinch	*Carduelis carduelis*	Introduced and naturalised	Common	Bycroft & Reeves 2013
Grey warbler	*Gerygone igata*	Not threatened	Common	Bycroft & Reeves 2013
Kahu, harrier hawk	*Circus approximans*	Not threatened	Occasional	Bycroft & Reeves 2013
Kawau, black shag	*Phalacrocorax carbo novaehollandiae*	At Risk - Naturally uncommon	11 seen (2012)	Bycroft & Reeves 2013
Kawau paka, Little shag	*Phalacrocorax melanoleucos brevirostris*	Not threatened	1 seen (2012)	Bycroft & Reeves 2013
Kawau tūi, little black shag	*Phalacrocorax sulcirostris*	At Risk - Naturally uncommon		Reeves et. al. 2011
Kotare, sacred kingfisher	*Todiramphus sanctus vagans*	Not threatened	Common	Bycroft & Reeves 2013
Marsh crake	*Porzana pusilla affinis*	At Risk - Relict	1 heard 2013	Cheyne 2013
Mallard	*Anas platyrhynchos*	Introduced and naturalised	Common	Bycroft & Reeves 2013
Matuku hūrepo, Australasian bittern	*Botaurus poiciloptilus*	Threatened - Nationally Endangered	Unclear whether present or only likely to be present	Reeves et. al. 2011
Paradise shelduck	*Tadorna variegata*	Not threatened	Common	Bycroft & Reeves 2013
Pukeko	*Porphyrio melanotus melanotus*	Not threatened	Common	Bycroft & Reeves 2013
Pūweto, spotless crake	*Porzana tabuensis tabuensis*	At risk - Relict	Recorded 1985	Reeves et. al. 2011
Silvereye	*Zosterops lateralis lateralis*	Not threatened	Common	Bycroft & Reeves 2013
Skylark	*Alauda arvensis*	Introduced and naturalised	Common	Bycroft & Reeves 2013
Spur-winged plover	*Vanellus miles novaehollandiae*	Not threatened	Common	Bycroft & Reeves 2013
Taratimoho, New Zealand dabchick	*Poliocephalus rufopectus*	Threatened - Nationally Vulnerable		Reeves et. al. 2011
Welcome swallow	*Hirundo neoxena neoxena*	Not threatened	Common	Bycroft & Reeves 2013

Long-tailed bats (*Chalinolobus tuberculatus*) have been recorded at Lake Rotopiko about 3 km to the southeast (G. Kessels *pers. comm*). Bats may also be present in the Ruatuna area and a survey could be done to establish whether they utilise the area or not. Long-tailed bats are a Nationally Vulnerable species (O'Donnell *et. al.* 2013).

A number of pest mammals are also likely to be present in the catchment including Norway rats (*Rattus norvegicus*) ship rats (*Rattus rattus*), mice (*Mus musculus*), stoats (*Mustela erminea*), ferrets (*M. furo*), weasels (*M. nivalis*), cats (*Felis domesticus*), possums (*Trichosurus vulpecula*), and hedgehogs (*Erinaceus europaeus*). The Lake Ruatuna users group have undertaken pest control in the past and the Waipa Peat Lakes Accord group is in the process of investigating the possibility of establishing a more coordinated predator control programme (Paula Reeves *pers. comm.* 9/12/2014).

10 ECOLOGICAL SIGNIFICANCE

Lake Ruatuna has been ranked as 28th in the list of significant lakes of the Waikato (Reeves et al 2011). The wetlands surrounding the lake have been ranked as Regionally Significant by WRC and Waipa District Council (Deichmann & Kessels 2012) in accordance with Waikato Regional Policy Statement criteria for determining significance. The lake represents a small area of what was once a more extensive peat wetland. Prior to European settlement the Hamilton basin and Hamilton Ecological District featured extensive peat bogs including the large Komakorau, Moanatuatua, and Rukuhia bogs (Figure 3). It is estimated that less than 2% of the pre-1940 wetland vegetation now remains in the Ecological District and only around 10% of the total area remains in any form of indigenous vegetation (Leathwick *et. al.* 1995).

The entire Ruatuna catchment is classified as Acutely Threatened under the LENZ Threatened Environments Classification (Figure 11) which is a reflection of the scarcity of indigenous ecosystems in lowland areas and on peat soils in particular.

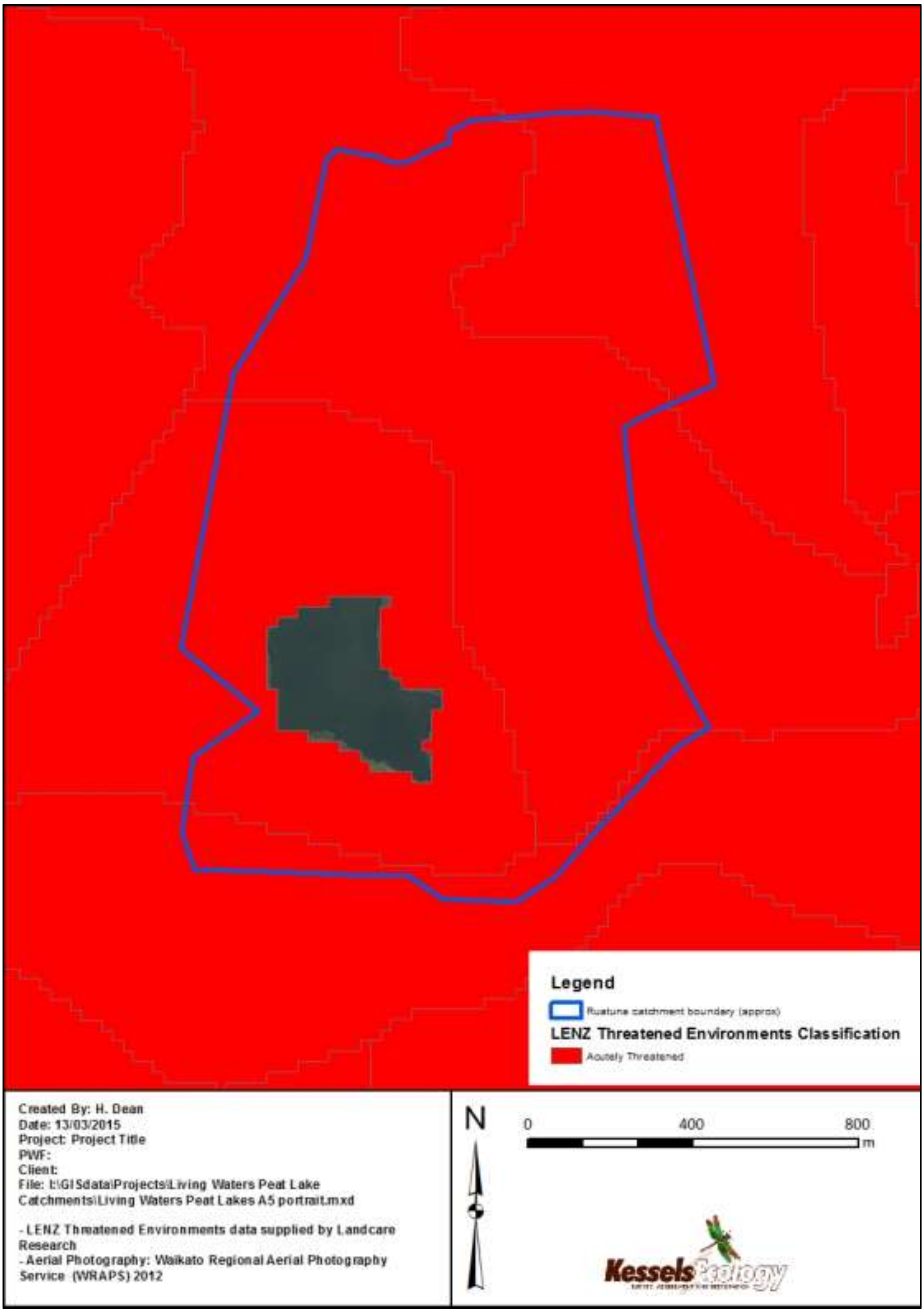

Figure 11: Ruatuna catchment showing LENZ Threatened Environments.

11 MANAGEMENT

The Ruatuna Wildlife Management Reserve is managed by the Department of Conservation and the adjoining Esplanade and Recreation Reserves are managed by the Waipa District Council. A lake users group is also active at the lake. The lake is completely fenced and has been for some time.

This section briefly outlines recent management work in the catchment relevant to the project.

11.1 Nutrient Management

For most peat lake catchments, including Ruatuna, the management of nutrients and the inputs from surrounding farmland is the single most important aspect for maintaining and improving the quality of aquatic habitat and water quality in the catchment. No ‘discharge to water’ consents are active within the catchment, indicating that any dairy effluent is discharged to land. However nutrient runoff and leaching from farmland is still an issue and should be managed carefully if water quality is to be restored. Measures for reducing nutrients transport into lakes include reduced or more targeted fertiliser application on pasture, riparian fencing and planting, silt traps and infiltration wetlands. Infiltration wetlands and silt traps in drains entering the lake trap sediment and nutrients before they enter the lake. Silt traps are proposed for installation at Ruatuna by WRC (Dean-Spiers *et. al.* 2014).

11.2 Department of Conservation

The Department of Conservation administers the Wildlife Management Reserve around Ruatuna. DOC has undertaken willow control work and recently had a bathymetry survey completed (Dean-Spiers *et. al.* 2014). A vegetation survey and restoration plan for the lake margins was also completed in 2013 (Bycroft & Reeves 2013).

11.3 Waipa District Council

Waipa DC owns esplanade reserve land around the lake and is heavily involved in the lake management and protection through the Waipa Peat Lakes Accord. The Waipa Peat Lakes Accord group have recently been discussing establishing a coordinated predator control programme at several lakes in the Ohaupo area including Ruatuna (Paula Reeves *pers. comm.* 9/12/2014).

11.4 Lake Users and Landowners

A Ruatuna users group was established in 2013 to undertake restoration work at the lake (Dean-Spiers 2013) which is likely to include weed and pest control. A number of the drains in the catchment have been fenced off by landowners although the proportion of fenced versus unfenced drains is not known.

12 KNOWLEDGE GAPS

This section provides an outline of gaps in the data which may need to be filled in order to efficiently manage the catchment and restoration work within it. Other data gaps may be revealed as restoration work progresses. Recent data for the Ruatuna catchment is relatively scarce, especially when compared to the nearby Rotomanuka catchment. The following are areas which should be addressed as part of the Living Water project.

12.1 Catchment Extent and Hydrology

The exact extent of the catchment is not known and is especially confused in the northern and north-eastern parts where water appears to have been artificially drained into the catchment from an area which would otherwise drain to the east or north. Undertaking a simple survey during heavy rain would at least establish the surface catchment area but more detailed survey would be required to establish ground water flow directions. The quantity of water entering the lake through drains is also important information.

12.2 Soils

Effective management of the peatlands requires an accurate knowledge of the location and depth of the peat deposits as well as the state of their deterioration and shrinkage. The current soil map may be sufficient but a more detailed one would be beneficial.

12.3 Water Quality

Water quality data for the lake is now very old and no data are available for the drains in the catchment. Establishing a solid and accurate baseline of water quality data is essential so that the efficacy of restoration and management efforts can be assessed. It is recommended that a water quality monitoring programme is set up in partnership with WRC so that all protocols and results are consistent with and comparable to other lakes in the region which are already monitored.

12.4 Climate

Climate data available for the site includes the data used here which come from the Hamilton Airport Automated Weather Station and data from a privately owned weather station at Blueberry Country approximately 5.5 km to the south-east. While these data can provide a general picture of the climate in the catchment it may be useful to set up a dedicated climate station within the catchment. Rainfall data would be particularly useful if catchment water flows are to be modelled for nutrient management purposes.

12.5 Biodiversity

Information about the biodiversity of the catchment is somewhat sparse, especially for aquatic biodiversity. Undertaking an inventory of indigenous fish and invertebrates would be valuable and of particular importance will be the information gained from the recent pest fish survey of the lake. Pest fish adversely affect water quality both directly and indirectly through disturbance of the sediment and browsing of submerged macrophytes and will need to be managed if water quality is to be improved. Information about bats, birds, and terrestrial invertebrates could also be improved through dedicated survey and monitoring programmes which would assist with the management of the biodiversity values of the catchment.

13 SUMMARY

A summary of the state of key environmental data is included in Table 10 along with a statement about the trend in each attribute and potential restoration actions that may be required to improve the state of that attribute. In many cases the data available was not sufficient to show a clear trend but an assessment of the likely trend has been made based on information from other lakes and our own experience.

Most environmental attributes have deteriorated since the catchment was cleared and settled. Like most of the other shallow lakes in the region the water quality in Lake Ruatuna is very poor and there has been a deterioration in peat soils and changes in hydrology. Exotic plants and animals now dominate but a range of indigenous species are still present and restoration of the ecosystem is a very worthwhile venture.

Table 10: Current state, trend, and potential restoration actions for key environmental attributes in the Ruatuna catchment.

Attribute	Current State	Trend	Potential Restoration Actions
Soils	Peat soils occur in the northeast part of the catchment and around Lake Ruatuna. The remaining areas are mineral soils.	Unknown. Peat soils generally deteriorate when not carefully managed.	Maintenance of water level is important for maintaining peat and reducing shrinkage. If drains need to be cleaned they should be widened rather than deepened. Consideration should be given to fencing and retiring permanently wet areas which are prone to pugging.
Land use/cover	The catchment is currently more than 85% pasture, and less than 2% remains in indigenous vegetation.	N/A	Increasing the indigenous cover would benefit wildlife native plants and may provide ecosystem services such as buffering and filtering. However, the economic viability of the land is of prime importance and vegetation restoration may be restricted to riparian planting and the wetlands around the lake.
Climate	Average annual rainfall in the district is around 1.2 m. Average annual temperatures range between 13 and 14.2°C and number of frost days varies considerably.	N/A	N/A
Hydrology	Around 7.8 km of artificial drains feed Lake Ruatuna. Historically there would have been no permanent waterways in the catchment and the lake had no permanent outlet. Minimum lake level is set by a WRC-controlled weir to 38.75 m asl.	Historically there had been a significant decline in the state of hydrological processes because of drainage works in the catchment and peat shrinkage. The current trend is not known but it is likely to be stable.	Maintenance of both lake and ground water levels is important. Drainage works should be limited to maintenance of existing drains and this should be by herbicide application rather than mechanical cleaning where possible.

Attribute	Current State	Trend	Potential Restoration Actions
Water Quality	Very little information available. The lake was hypertrophic in 1997 and is probably hypertrophic or worse today. Hypertrophic means that there are very high levels of nutrients in the water, likely high levels of phytoplankton, and very low water clarity. This state is toxic to many aquatic organisms.	Unknown. Likely to be stable or deteriorating. There was a clear downward trend in water quality during the 1980s and 1990s.	Restoration of water quality in shallow lakes is very difficult and requires a range of remediation measures. Dealing with the sources of the problem may involve fencing and planting of drains and permanently wet areas and better management of effluent disposal (timing, location). Infiltration wetlands which filter water-soluble and sediment-bound nutrients from the drains before they reach the lake have been shown to be effective. Nutrients stored in lake sediments can also be a significant problem and methods such as dredging or application of flocculants which bind nutrients and prevent their release from the sediment may be required.
Lake SPI	Lake SPI uses the abundance and type of submerged water plants (macrophytes) as an indicator of the ecological health of the lake. Lake Ruatuna has been devegetated (<10% submerged macrophyte cover, indicating very poor ecological health) since as early as 1977.	Stable but cannot deteriorate further.	Water quality parameters (particularly water clarity) need to improve before water plants can establish. Pest fish will also be preventing macrophytes from establishing and a sustained control programme will need to be established.
Aquatic Biodiversity	Three native and four exotic pest fish species have been recorded from Ruatuna. Freshwater mussels were present until relatively recently.	Unknown but likely to be declining. I.e. becoming more dominated by exotic species or species adapted to degraded habitat.	Restoration of healthy aquatic communities will require an improvement in water quality and a reduction in pest fish numbers with sustained control.

Attribute	Current State	Trend	Potential Restoration Actions
Terrestrial Biodiversity	The vegetation in the catchment is dominated by exotic pasture and the wetlands around Ruatuna are dominated by willow and other exotics. However at least 29 indigenous plant species have been recorded from the wetlands. Seventeen native bird species including six threatened or at risk species have been recorded from the catchment.	Likely to be deteriorating.	Restoration of indigenous vegetation communities will require a considerable weed control effort and replanting of appropriate species in wetlands and along major drains. Pest animal control is planned for the lake margins which will benefit birds and other fauna utilising the area. Retirement and planting of drain margins and permanently wet areas on farmland will improve habitat for fauna and flora. Additional survey of both terrestrial and aquatic biodiversity would aid management decisions.

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