DDPR_feedback_0327s		
	Name	Viv Smith-Campbell
	Organisation	
	Email	[redacted]
	Response Date	Aug 23 22 12:49:35 pm
	Notes	VSC
Q1	Select the chapter you want to provide feedback on	
	General Residential Zone	
Q2	In general, to what extent do you support the contents of this chapter?	
	Neutral	
Q3	Objective/Policy/Rule/Standard reference:	
	GRZ-S8 Design for safe streets	
Q4	Feedback/Comments	
	I strongly oppose this standard. While the work on "design for safe streets" is laudable, it is not appropriate to include it as a standard for determining the category of resource consent required for a house. It is not justified to make the resource consent process more complicated and more expensive for houses based on one very specific aspect, that in all circumstances can not be guaranteed to achieve an outcome of less crime. To make property owners have to apply for a restricted discretionary consent for non-compliance with this standard is not justified at all. At Lake Ōhau Village, this standard would require many property owners to trade off views and sun into the house, in order to comply with this standard. Is the crime rate so high at Lake Ōhau Village to justify these types of changes and the additional cost if this standard can't be met? I doubt it. You are asking property owners to potentially trade off the use of passive solar gain into the habitable rooms of their houses, because they have to put a habitable room or kitchen facing the street. This is like going back to the 1950s when all the houses where built to face the street, with no regard to getting light and sun into the house. Do the areas with these 1950s houses have a lower crime rate? Are the purported benefits from this standard more important than warm and dry houses with a lower carbon footprint? When all of New Zealand faces a shortage of good quality houses, is it justified to require this standard to have to be met? what cost benefit analysis has been done for Waitaki District to prove this standard is justified in all circumstances? What alternative ways have been considered to achieve "safe streets"? is it the role of the district plan to make this streets safer? Please remove this standard from the GRZ as it will contribute to worse outcomes for property owners (in terms of siting a house on a site to make best use of the site) and increase the cost of building houses while resulting in a very uncertain outcome in relation to safer streets in the Waitaki district.	
Q5	Objective/Policy/Rule/Standard reference:	
	Mention of design guidelines for Lake Ōhau Village	
Q6	Feedback/Comments	
	The standards in the GRZ are in effect set the design guidelines for the Lake Ōhau Village. Standards for height of building, setbacks, building coverage and outdoor living space define how residential use can be undertaken on sections in the Village. These are the building blocks for any design standards as they define the bulk and location on a site. In recent years, the boundary setbacks have been applied as the minimum requirement in all circumstances, so new houses have been build right up to the setback - i.e. 1.6m from the boundary - this means houses are now very close together - where the intention for an "alpine" village was for smaller buildings with generous separation between them. I don't see how design guidelines will assist with retaining a distinctive "alpine village" character for Lake Ōhau Village when the fundamental DP requirements are the same for every residential site within the Waitaki District.	

	Going for uniformity with one GRZ for the whole district is administratively simpler, but it doesn't recognise the distinctive character of different places in the district. It is a shame this has been lost for Lake Ōhau Village - and I see nothing in the draft DP that shows Council is interested in remedying this.
Q7	Objective/Policy/Rule/Standard reference:
Q8	Feedback/Comments
Q9	Objective/Policy/Rule/Standard reference:
Q10	Feedback/Comments
Q11	supporting documents?
	0
Q12	If you need more space, or have any other general comments, please leave them here

DDPR_feedback_0328s		
	Name	Viv Smith-Campbell
	Organisation	
	Email	[redacted]
	Response Date	Aug 23 22 12:53:26 pm
	Notes	VSC
Q1	Select the chapter you want to provide feedback on	
	Settlement Zone	
Q2	In general, to what extent do you support the contents of this chapter?	
	Neutral	
Q3	Objective/Policy/Rule/Standard reference:	
	SETZ-S7 Design for safer streets	
Q4	Feedback/Comments	
	As per my feedback on the inclusion of this standard in GRZ - I strongly oppose this standard. Please see the reasons for this in my feedback on GRZ. I believe there is even less justification for this standard in the SETZ - why is there attention being given to one random standard for "crime" when other aspects of development, such as for warm and dry homes are not included? Please remove this standard from the SETZ zone.	
Q5	Objective/Policy/Rule/Standard reference:	
Q6	Feedback/Comments	
Q7	Objective/Policy/Rule/Standard reference:	
Q8	Feedback/Comments	
Q9	Objective/Policy/Rule/Standard reference:	
Q10	Feedback/Comments	
Q11	supporting documents?	
	0	
Q12	If you need more space, or have any other general comments, please leave them here	

DDPR_feedback_0330s		
	Name	Viv Smith-Campbell
	Organisation	
	Email	[redacted]
	Response Date	Aug 23 22 02:49:52 pm
	Notes	VSC
Q1	Select the chapter you want to provide feedback on	
	Activities on the Surface of Water	
Q2	In general, to what extent do you support the contents of this chapter?	
	Strongly oppose	
Q3	Objective/Policy/Rule/Standard reference:	
	Whole ASW chapter	
Q4	Feedback/Comments	
	The chapter treats all waterbodies in Waitaki District the same - except for some very small carve outs in ASW-R1. There is no apparent consideration of the different values of different waterbodies and therefore what uses would be appropriate. For example, use of vessels for accommodation may not be an issue in the large hydro lakes, but is a very big issue for a small waterbody such as Lake Middleton. This whole chapter is weak and needs a major overhaul to be fit for purpose. The regional Navigation Safety Bylaw specifically does not cover environmental matters, only navigation safety matters. This was a specific change made to the regulations to avoid overlap between the safety aspects and Council's RMA responsibilities for environmental considerations about the use of the surface of water. The Safety Bylaw should therefore not be used as a proxy for when the use of motorised and powered vessel use is appropriate in terms of environmental considerations, i.e. just because in a navigation sense it is appropriate to uplift the speed limit, this does not make it appropriate from an environmental perspective. This judgement has to be made on the impact of these vessels on the environment they will be operating in. Before the change to the Navigation regulations, the Hopkins river was recognised as having significant natural values and use by motorised vessels was restricted during the braided river bird breeding season. This restriction was removed only because the navigation regulations no longer allowed ECan to include environmental considerations when setting the bylaw. The values being protected by the previous bylaw have not gone away - in fact, the values have come under even more threat from activities in the riverbed and on the water since the removal of the seasonal restriction on vessel use. A season restriction on motorised vessel use on the whole of the Hopkins River should be included. DOC can advise on the critical times of year when disturbance of ground nesting birds should be avoided. Lake Middleton is a very special small lake, recognised as such in the ECan regional plans. The water quality of Lake Middleton is declining (ECan reports to UWWZ committee). Under this chapter, motorised vessel use of the lake is not restricted for any environmental reasons, even though the values of the lake are very high. Vessels (as many as could fit on the lake) are able to be used for accommodation on the lake for recreational activities. The definition of "recreational activities" in the draft DP - "includes the sale of food and beverage for consumption on the site provided it is ancillary to the recreational activity" - so, this appears to mean people can stay on boats in the lake and also sell food and beverage. There is no restriction on how many days they can stay on the boat on the lake or how many vessels could do be there at any given time. This is not an activity that has occurred before on Lake Middleton, but that is not to say it might not be something that is attractive to some people in the future. It would be totally inappropriate to have this activity on Lake Middleton because of the impact on the natural values present at the Lake and its surrounds.	
Q5	Objective/Policy/Rule/Standard reference:	
Q6	Feedback/Comments	

Q7	Objective/Policy/Rule/Standard reference:
Q8	Feedback/Comments
Q9	Objective/Policy/Rule/Standard reference:
Q10	Feedback/Comments
Q11	supporting documents?
	0
Q12	If you need more space, or have any other general comments, please leave them here

DDPR_feedback_0331s		
	Name	Viv Smith-Campbell
	Organisation	
	Email	[redacted]
	Response Date	Aug 23 22 03:08:50 pm
	Notes	VSC
Q1	Select the chapter you want to provide feedback on	
	General Rural Zone	
Q2	In general, to what extent do you support the contents of this chapter?	
	Neutral	
Q3	Objective/Policy/Rule/Standard reference:	
	These comments relate to Lake Middleton being include in the General Rural Zone with no overlays to indicate its high environmental values.	
Q4	Feedback/Comments	
	Lake Middleton's high environment values have not been recognised in the draft DP. It has a note about environmental values - RLS013 - but I can't find what this refers to. As far as I understand the lake and its surrounds are just included in the general rural zone. I have included comments in the ASW chapter about Lake Middleton as well. The lake supports a rich variety of native animals and plants as detailed in the report about the Lake compiled by DOC staff for the Upper Waitaki Water Zone Committee. The Lake is recognised as being of high natural character worthy of a high level of protection in the CRPS and Waitaki Catchment Water Allocation Regional Plan - such as in Policy 2 of the Regional Plan: Policy 2 Cross-ref: Objective 1 By recognising that the following water bodies have a high natural character worthy of a high level of protection, because they are currently either in largely unmodified parts of the catchment; or contain rare or important species and habitat or habitat assemblages: a. tributaries of Lakes Tekapo, Pūkaki and Ōhau; b. mainstems and tributaries of Fork Stream, Irishman Creek and Mary Burn, upstream of the Braemar Road; c. mainstem and tributaries of the Twizel River, upstream of the Pūkaki Canal; d. wetlands with a moderate or higher significance throughout the catchment; e. Lakes Alexandrina, McGregor and Middleton and their tributaries and other lakes upstream of Lakes Tekapo, Pūkaki and Ōhau. Explanation This policy recognises that there are some parts of the catchment where the water bodies should be managed as far as possible to retain their high natural character and are, therefore, afforded a high level of protection in this Plan. This is consistent with provisions of the Canterbury Regional Policy Statement (Chapter 9 Policy 4) regarding the identification of any water bodies that should be sustained as far as possible in their natural state. The regional plan deals with these high natural character values in terms of water allocation, and the district plan should deal with these high natural character values in terms of land use including the use of the surface of the water of the Lake. This would provide for a comprehensive approach to the protection of the natural environmental values of Lake Middleton. Please include more comprehensive provisions in the District Plan to recognise and provide for its values, particularly the native bird species that rely on the lake for habitat.	
Q5	Objective/Policy/Rule/Standard reference:	
Q6	Feedback/Comments	

Q7	Objective/Policy/Rule/Standard reference:
Q8	Feedback/Comments
Q9	Objective/Policy/Rule/Standard reference:
Q10	Feedback/Comments
Q11	supporting documents?
	0
Q12	If you need more space, or have any other general comments, please leave them here

Lake Middleton Catchment Report

Intrinsic instream values of the Lake Middleton catchment

newzealand.govt.nz

Department of Conservation
Te Papa Atawhai

Lake Middleton Catchment Report

Intrinsic instream values of the Lake Middleton catchment

John Benn

June 2019

Cover photograph:
Looking north-east across Lake Middleton, from its western shore, to the Ben Ohau Range (Viv Smith-Campbell, 24.04.2017)

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Summary

This report summarises readily available literature relating to the Lake Middleton catchment[1]. The catchment is situated adjacent to the south-western shore of Lake Ohau, in the South Island's Mackenzie Basin. The focus of the report is on intrinsic instream (and terrestrial) values within the catchment, including those for habitats, species, landscapes and recreation. Hydrology, water quality, and sediments are also discussed, contributing to an overall account of Lake Middleton and its catchment. This report has been prepared as an information resource for both the Department of Conservation (DOC) and the general public.

Despite its small size, the catchment has numerous intrinsic values. The lake and its surrounds provide habitat for many indigenous species, with at least four fish, 27 birds, 26 plants (aquatic and terrestrial), 14 invertebrates (aquatic), lizards (individual species not identified), 66 algae/phytoplankton and four zooplankton species being recorded. Of these species, two fish, nine birds, one aquatic invertebrate and two plants have a conservation status threat ranking of *Threatened* or *At Risk*. Lizard species (*Threatened* or *At Risk*) are presumed to be present. Introduced animals (predators) and plant species (weeds), along with human activities, have had major impacts on indigenous species in the catchment.

Lake Middleton and its surrounds form an important component of the wider Mackenzie Basin landscape. This landscape is recognised for its outstanding and significant landscape values, on both regional and national scales. The lake is also, long-established as a popular recreational resource. Over the summer months, the lake and its surrounds are very popular for a variety of recreational activities; many of which are water-based and rely on good water quality.

The lake's water quality is generally suitable for contact recreation, although water quality has deteriorated, from being oligotrophic in 1969 to mesotrophic by 1996. Increased eutrophication associated with intensified farming and other potential contamination sources around the lake has been recognised as a problem since the early 1980s. Based on its 2017 LakeSPI assessment, Lake Middleton is in moderate ecological health. This has declined from its high ecological-health status in 2012.

Much of the upper catchment falls within the Ahuriri Conservation Park and is, thus, protected under the Conservation Act (1987). In the lower catchment, the Lake Middleton Recreation Reserve (lake and surrounding margins) is protected under the Reserves Act (1977), whilst a slither of land (Lake Ohau West Conservation Area) along the gravel barrier that forms the lake and adjacent to the Lake Ohau Road, is also protected under the Conservation Act (1987). These reserved areas are managed by DOC. The remainder of the catchment is in private ownership.

[1] Lake Middleton and its catchment, respectively, are also referred to as '*the lake*' and '*the catchment*', in this report.

Acknowledgements

Sjaan Bowie (Technical Advisor: Freshwater), Richard Clayton and Jane Gosden (Technical Advisors: Plants), Andrew Grant (Technical Advisor: Birds), and Susan Newell (Senior Solicitor: Corporate Services) from the Department of Conservation (Christchurch Office), proof-read and provided constructive comments on the manuscript. Viv Smith–Campbell (Management planner for DOC, Christchurch; Chairperson of the Ohau Conservation Trust and long-term resident of Lake Ohau Village) provided photographs and a considerable amount of information for this report.

Disclaimer

This report is a living document and hence, it is subject to frequent changes as new information becomes available and editorial updates are made[2]. The report is a summary of current, readily-available literature: It is not a critique of the accuracy or integrity of the original information. Therefore, the Department of Conservation takes no responsibility for the accuracy of this report, nor the findings and opinions expressed herein.

[2] Updated versions will be indicated by dates and version numbers on the title pages, and file names at the bottom of each page.

1. Introduction

This report summarises readily-available information (desk-top search) relating to the Lake Middleton catchment, in the South Island's Mackenzie Basin (Figure 1). The report focuses on intrinsic instream (and terrestrial) values within the catchment (habitats, biodiversity, recreation, landscape) although summaries of the catchment's physical values (hydrology, water quality, sediments) are also included, contributing to the overall account of the catchment. The earliest written record found for the lake was by Shortland (1851)[3] and the earliest survey map found was from 1860, by an anonymous author/draftsman (Appendix 1: Map 1).

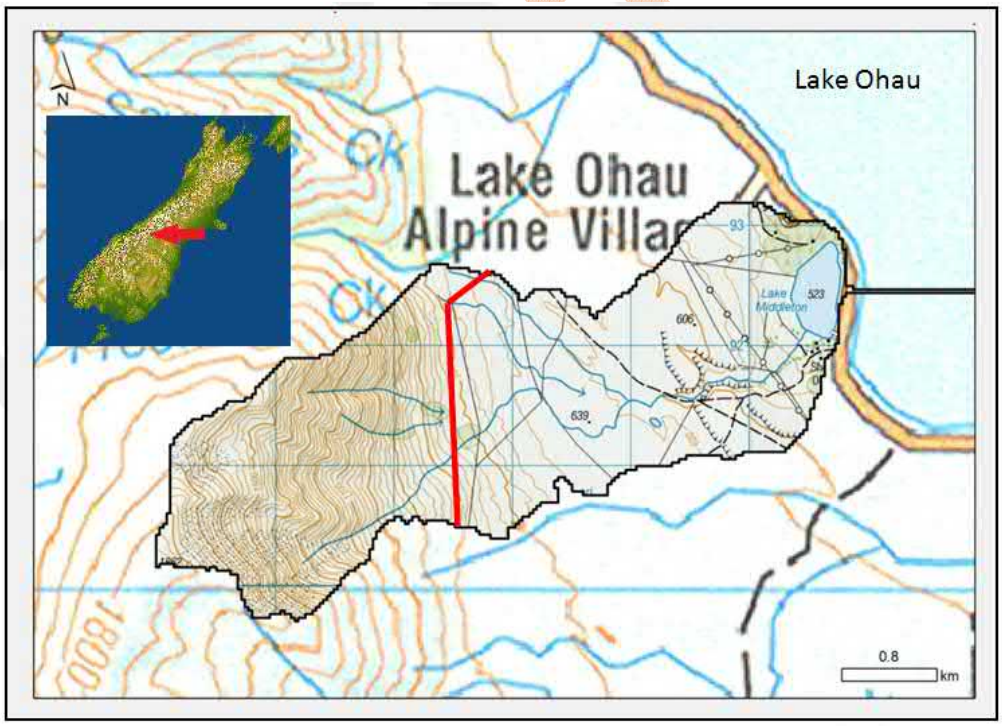

Figure 1. The Lake Middleton catchment. The catchment area upstream (left) of red line lies within the Ahuriri Conservation Park (Approximate boundary). See Figure 2 for lower catchment detail.

Lake Middleton is a small lake having a surface area of approximately 24 ha; a shoreline of just under two kilometres long and a catchment area of 1,025 ha. The lake is situated at 523 m above sea level, in glacial moraine, immediately adjacent to the south-western edge of Lake Ohau and south of

[3]Shortland's (1851) published account was based on his journeys in 1843. Shortland (p. 198) recorded the Māori names of lakes in the upper Waitaki catchment, provided to him by his guide, Huruhuru. Shortland stated that besides Pukaki; "*The names of the other lakes according to Huruhuru, are Takapo, Te kapuaruru, Ohou, Otetoto, Otauawhiti, and Whakapapa*". Vance (1965; p. 9) referenced Shortland's (1851) lake names and remarked: "*These lakes are now called Tekapo, Alexandrina, Ohau, McGregor, Middleton, and a lagoon at the southern end of Lake Ohau*".

Lake Ohau village (Figure 1). A gravel barrier, ranging in width from approximately 50 m to 130 m (DOC GIS analysis), separates Lake Middleton, along its eastern margin, from Lake Ohau. Much of the gravel barrier is legal road reserve in which lies Lake Ohau Road. The upper catchment area lies within the Ahuriri Conservation Park (Figure 1), whilst the lake and its shoreline margins are gazetted as a recreation reserve, vested in the Department of Conservation (Jones 2015). A slither of land, along the gravel barrier at the northern end of the lake, is gazetted as the Lake Ohau West Conservation Area (Figure 2). These three areas are managed by DOC. The remainder of the catchment is privately owned.

This report is intended for internal use by DOC, as an information resource for its planning and management purposes. It is also intended as a general public information resource.

Figure 2. Public conservation land in the lower Lake Middleton catchment: Lake Middleton Recreation Reserve (Darker blue) and Lake Ohau West Conservation Area (Bright green).

2. Methods

2.1 Literature search

A literature search was undertaken for information relating to Lake Middleton in scientific journals, technical papers, regional and district council reports and plans, consultant reports, newspapers and general history books held at DOC, Environment Canterbury (ECan), Waitaki District Council (WDC), universities and public libraries. The internet was also searched and personal communications with DOC staff were also used if information was credible, but not written (e.g., species sightings). All relevant literature was summarised under the following headings: habitat, biodiversity, physical, and recreation values. Literature was summarised in reverse chronological order, from the most recent to oldest reports. The literature search and summary were undertaken in a hierarchal manner. Priority was given to published scientific and technical reports, Government and local authority reports, consultant reports, newspaper reports, general history books, then personal communications. The literature summary is intended for bibliographic purposes only; it is not a critique of the literature. Thus, no assessment of integrity or factual content has been made. The literature search for this report ended in April 2019.

Each major section of the report that follows has been written to stand alone, beginning with a brief summary in italics. This allows for specific sections of interest to be read in context, without having to read the whole report. Hence, some repetition occurs between individual sections of the report.

2.2 Species list

Lists of all species identified in the Lake Middleton catchment were produced (appendices 2–9). The species lists contain scientific species names, common names and Māori names; conservation status (threat ranking), references and other relevant information, where appropriate or available. Species names are listed alphabetically within each threat ranking, descending from Nationally Critical to Introduced and Naturalised species. Species names, common names and threat rankings were based on the most recent information available, such as the latest DOC threat classification publications and websites of the New Zealand Plant Conservation Network and Landcare Research plant database. Māori names were derived from the above sources, as well as taonga species names listed in the Ngāi Tahu Claims Settlement Act (1998) and those agreed to by DOC and Te Rūnunga o Ngāi Tahu[4].

[4] DOC. (2014). Internal file: DOCDM-1354803

3. Literature summary

3.1 Habitat values

Jarman (1987) identified Lake Middleton as a Site of Special Wildlife Interest (SSWI) within the Lake Ohau Shoreline Scrub Protected Natural Area (PNA). The lake provides good spawning habitat for brown trout (Salmo trutta) *and rainbow trout* (Oncorhynchus mykiss) *(e.g., Hughes 2013). Wildlife protection measures around Lake Middleton commenced in the early 1920s (Department of Lands and Survey 1985). As the upper reaches of the catchment are located within the Ahuriri Conservation Park (Figure 1), habitat values in this area are protected under the Conservation Act (1987). Habitats in the lower catchment (Lake Middleton Recreation Reserve and Lake Ohau West Conservation area) are protected respectively under the Reserves Act (1977) and the Conservation Act (1987).*

Hughes (2013) reported to the Central South Island Fish and Game Council (Fish and Game) and DOC on the fishery values of Lake Middleton. This report was produced in relation to restricted public access into the recreation reserve. The gravels of the main tributary stream entering Lake Middleton were noted as good spawning habitat for both brown trout and rainbow trout.

The Waitaki District Council's (2010) district plan identifies freshwater habitats in the Waitaki District and has objectives, policies and rules relating to them. Lake Middleton is described as a small lake '*With regard to freshwater and associated habitat and systems*' (p. 140). In general, the upper Waitaki lakes are noted as significant habitat for birds, fish and plants.

The Waitaki Catchment Water Allocation Board (2006), in the Waitaki Catchment Water Allocation Regional Plan, noted the natural values of rivers and lakes in the Waitaki River catchment. Objectives policies and rules to protect these values area provided. Lake Middleton was noted for its trout and bird habitats.

Jarman (1987) reported on wildlife and *Sites of Special Wildlife Interest* (SSWI) in the upper Waitaki River catchment, for the New Zealand Wildlife Service. Lake Middleton was described (p. 77) as: '*A small lake, separated from Lake Ohau by a road and a narrow strip of land*'. The lake had 100% open-water with a sloping shoreline on its north side. Lake Middleton was classed as a SSWI (No.77) within the Lake Ohau Shoreline Scrub PNA. The SSWI was categorised as: '*... a lake with potential*'. It was recommended that SSWIs with a '*potential*' rating should be protected from incompatible development, detrimental land uses, changes, or land modification. This should have been done through mechanisms in regional and district schemes and plans, as well as legislation such as the Wildlife

Act (1953), Reserves Act (1977) and the Queen Elizabeth II National Trust Act (1977).

The Conservation Act (1987) Part 4, Section (19) states that conservation parks shall be managed so: '*... that its natural and historic resources are protected ...*'. As the upper reaches of the Lake Middleton catchment are located within the Ahuriri Conservation Park (Figure 1), habitats, flora and fauna within this area are protected under the Conservation Act (1987).

The Department of Lands and Survey (1985) produced a management plan for the Lake Middleton Recreation Reserve, in which the history of wildlife protection in the broader area was described. Between 1929 and 1957, the Lake Ohau catchment, which included Lake Middleton, was a sanctuary for native and imported game species under the Animals Protection and Game Act (1921). From 1957, the area became a Wildlife Refuge under the Wildlife Act (1953). That schedule was changed in 1963 to include only Lake Ohau, Lake Middleton and a five-chain (just over 100 m) margin around their shores. Finally, the Wildlife Refuge status was revoked in 1969 because of the Canada goose (*Branta canadensis*) population on Lake Ohau.

The Reserves Act (1977) Part 3, Section 17 (2)(b) offers protection for wildlife in recreation reserves, such as the Lake Middleton Recreation Reserve. This section of the Act states:

> '*... where ... biological ... features or indigenous flora or fauna or wildlife are present on the reserve, those features or that flora or fauna or wildlife shall be managed and protected to the extent compatible with the principal or primary purpose of the reserve*'.

3.2 Biodiversity values

3.2.1 Fish

*Six fish species have been recorded in the Lake Middleton catchment. Four species are native; koaro (*Galaxias brevipinnis*), Canterbury galaxias (*Galaxias vulgaris*), common bully (*Gobiomorphus cotidianus*) and upland bully (*Gobiomorphus breviceps*). Koaro and Canterbury galaxias both have a conservation status of 'At Risk: Declining' (Dunn et al. 2018). Two introduced and naturalised species recorded in the lake are brown trout (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*). The trout fishery of Lake Middleton has been documented for well over 100 years in various newspapers (see below). Details of fish species recorded or presumed to be in the catchment, are presented in Appendix 2.*

The National Institute of Water and Atmospheric Research (NIWA 2019) administers the New Zealand Freshwater Fish Database. This database shows three species of fish were recorded in Lake Middleton in 1993 (caught in fyke nets). These were upland bully, brown trout and rainbow trout.

Hughes (2013) reported to the Central South Island Fish and Game Council (Fish and Game) and DOC on the fishery values of Lake Middleton. This report was produced in relation to restricted public access into the recreation reserve. It was noted that the lake had been a popular fishery for both brown trout and rainbow trout since the 1890s. The lake was noted for producing large numbers of small trout. The former Waitaki Valley Acclimatisation Society, and latterly, Fish and Game, had both trapped trout (methods not given) in the only tributary stream entering the lake, thus restricting the area of spawning gravels for both species of trout. This was an attempt to increase the numbers of successful brown trout redds, which were often disturbed by runs of rainbow trout, later in the season. Spawning adults that had been trapped were transported to stock some of Lake Ohau's tributary streams.

The Waitaki Catchment Water Allocation Board (2006) in the Waitaki Catchment Water Allocation Regional Plan, noted the natural values of rivers and lakes in the Waitaki River catchment. Objectives, policies and rules to protect these values are provided. Lake Middleton is noted for its trout fishery and habitat.

Hughes (2000) reported to Fish and Game on the brown trout fishery of Lake Middleton, after Fish and Game had destocked the lake of rainbow trout, which were out-competing brown trout. Rainbow trout were generally small and in average condition. This report was based on interviews with a random selection of anglers, undertaken over a five-day period during the 1999/2000 season. Results were inconclusive as to whether de-stocking the lake of rainbow trout had improved the overall condition and numbers of brown trout in the lake.

Jeppesen et al. (2000) examined the trophic structure in the pelagic[5] zone of 25 shallow New Zealand lakes and associated changes along nutrient and fish gradients. Lake Middleton was included in this investigation. Fish were obtained from overnight catches (18–19 hours) in multiple-mesh gill nets. Between two and six nets were used, depending on lake size (number of nets not given for Lake Middleton): half of them were set within 20–30 m of the shore and parallel to it, and the rest were set mid-lake and in the middle of the water column. Fish data[6] were expressed in catch (kg) per net, per night. For Lake Middleton, the total fish catch was just over 5.0 kg per net, per night. In terms of fish numbers caught and the proportional weight of the catch rainbow trout was, by far, the dominant species in the lake, making up approximately 98% of both counts. Brown trout made up the remainder of the catch. For all the lakes examined, trout stock (both numbers and weight) decreased significantly (negatively related) with increases in total nitrogen and total phosphorus, but was positively related to chlorophyll-*a*. It was concluded that fish may have a major influence on zooplankton community structure and biomass in New Zealand lakes, and that these effects may cascade to ciliates and phytoplankton, though

[5] Called "*the pelagial*" in Jeppesen et al. (2000).
[6] Read off coarse-scale graphs. Raw data not presented in Jeppesen et al. (2000).

apparently with a modest effect on these variables. The effect of fish on zooplankton was not restricted to lakes in which native species (or perch) dominated, but also extended to trout-dominated lakes (such as Lake Middleton).

Scott and Irvine (2000) reported on the competitive exclusion of brown trout by rainbow trout, in the tributaries of two New Zealand lakes; one of which was Lake Middleton. Spawning runs of both species were compared for timing, numbers and redd characteristics. Middleton Burn[7], the tributary stream of Lake Middleton, was found to be low in solutes, near neutral in pH and sediments ranged '*... from coarser gravels to finer gravels*' (See section 3.3.2, below, for further sediment descriptions). The spawning section for Middleton Burn was short, extending 500 m upstream from the lake, but the preferred area was approximately up to 300 m from the lake and 0.9 m wide, giving a spawning area of 270 m^2. Rainbow trout mainly spawned in September: Between 1994 and 1997, 800 trout were trapped in Middleton Burn, of which only 1.9% were brown trout. It was noted that up until 1961, both species were well represented in Lake Middleton, but competitive pressure for spawning space was the most likely explanation for the decline in brown trout.

Graynoth (1995) reported on the spawning migrations and reproduction of landlocked, sockeye salmon (*Oncorhynchus nerka*) in the Waitaki River catchment. He concluded that it would be difficult to establish new spawning runs of sockeye salmon in other New Zealand lakes because the species required stable, spring-fed, spawning-streams for successful reproduction and the juveniles also had tendencies to migrate downstream, out of the rearing lake. Lake Middleton was identified as a lake where sockeye salmon could become established and reach large sizes because it had no (or an intermittent) outlet.

Graynoth et al. (1986) investigated and reported on the diet of landlocked sockeye salmon, brown trout and rainbow trout in the Waitaki lakes. For this investigation, fish were caught in July and September 1975 in fine-mesh gill nets, then their stomach contents were examined. Of the fish caught, 14 rainbow trout were from the near-shore shallows of Lake Middleton. In order of abundance, molluscs, fish, then insects, made up the diet of trout in the lake. The fish component of the diet (39%) was composed of juvenile bullies (*Gobiomorphus* spp.). Diet data for the Lake Middleton trout are shown in Table 1, below.

[7] Middleton Burn is the name used by Scott & Irvine (2000). This creek is not officially named on any topographic maps or survey plans found.

Table 1. Lake Middleton rainbow trout diet (After Graynoth et al. 1986).

Rainbow trout				% of diet by volume		
Sample (No.)	Mean length (mm)	Mean weight (g)	Stomach fullness (%)	Molluscs	Insects	Fish
14	282	267	35	48	13	39

Davidson (1986) reported on the evolution of mountain-land recreation in New Zealand for the New Zealand '*Man and the Biosphere*' series, citing several historical reports. Lake Middleton was noted for its trout population and fishery. In 1891, the Waitaki Acclimatisation Society netted Lake Middleton and caught over 60 trout in two days. The average fish weight was 4.5 lb (2.0 kg); the largest being 6.5 lb (2.9 kg). In 1895, Douglas Matheson, the run-holder at Freehold Creek Station, wrote to the Waitaki Acclimatisation Society stating that Lake Middleton was over-stocked with trout. Around the same time, Thomas Middleton, the run-holder of Benmore Station, also noted the lake was over-stocked with trout and he dismissed a previously suggested idea, of cutting a channel through the gravel barrier (separating lakes Middleton and Ohau), to free the trout into Lake Ohau. This was because the continual drift of gravel along the Lake Ohau side of barrier under nor'west conditions, would constantly block any outlet.

The Department of Lands and Survey (1985) produced a management plan for the Lake Middleton Recreation Reserve. Native fish species described as likely to be present in the lake were koaro, Canterbury galaxias and common bully. The three native species were all a food source for the two introduced trout species (brown trout and rainbow trout).

Graynoth and Skrzynski (1973) reported on the Waitaki Valley trout and salmon fishery, based on angling results obtained between 1957 and 1967, collected by three angling-diary schemes. Lake Middleton was noted for an abundance of rainbow trout and brown trout. Based on data from 1962 only (only year with adequate records), 32 rainbow trout were caught, having an average length of 43.2 cm.

Boud and Eldon (1960) surveyed Lake Middleton to determine the lake's suitability as a nursery pond for trout. Both rainbow trout and brown trout were present in the lake. Adult fish grew up to 3 lb (1.3 kg) in weight and large shoals of fry were noted around the shores, particularly at the mouth of the creek which enters the lake. Bullies (*Gobiomophus* spp.) were the only native fish species noted. It was stated on p. 2 that:

> '*The creek flowing into the eastern end of Lake Middleton provides stable, well consolidated gravel and does not appear to be subject to severe flooding that could reduce spawning efficiency. There is also suitable spawning gravel in places around the lake shore and redds were observed there in 1959*'.

The liberation of trout fry was not recommended, as this would mean more competition for food supply for existing trout stock and there were sufficient spawning areas in the lake to sustain the trout population.

Newspaper articles from the 1890s refer to the trout fishery in Lake Middleton, including the size, number and condition of fish caught (Anon. 1895, 1897a, b, c.)[8].

3.2.2 Birds

*At least 43 bird species have been recorded on, or around Lake Middleton. Of these, 27 are native, with nine species having a conservation status of Threatened or At Risk (Robertson et al. 2017). Threatened species, ranked as Nationally Critical are the grey duck/pārera (*Anas superciliosa*), black-billed gull/tarāpuka (*Laruas bulleri*) and black stilt/kakī (*Himantopus novaezelandiae*). The black-fronted tern/tarapirohe (*Chlidonias albostriatus*) is ranked as Nationally Endangered and the Southern crested grebe[9]/kāmana (*Podiceps cristatus australis*) is ranked as Nationally Vulnerable. At Risk species are ranked as: Declining—New Zealand pipit/pihoihoi (*Anthus novaeseelandiae novaeseelandiae*) and South Island pied oystercatcher/torea (*Haematopus finschi*); Recovering—Eastern falcon/karearea (*Falco novaeseelandiae novaeseelandiae*) and Naturally Uncommon—black shag/kōau (*Phalacrocorax carbo novaehollandiae*). Details of bird species recorded at, or around Lake Middleton, are listed in Appendix 3.*

Smith-Campbell[10] (2019; Figure 3) has kept observation notes of birds in or around Lake Middleton for the last 30 years, with 36 species being identified. These are listed in Appendix 3, along with accompanying comments.

Figure 3. Southern crested grebe/kāmana, nesting in Lake Middleton on a raft placed by the Ohau Conservation Trust (Photograph: Warren Baker, Trustee, Ohau Conservation Trust, 23.09.2018).

[8] These newspaper articles are a sample selection only and have not been separated out, owing to their very similar content.

[9] Southern crested grebe was called Australasian crested grebe in most of the reports referred to. Southern crested grebe is the common name given in Robertson et al. (2017).

[10] Viv Smith-Campbell (DOC, Christchurch) is a long-term resident of Lake Ohau Village and is the Chairperson of the Ohau Conservation Trust.

Nelson (2018) listed casual species observations (with high/precise reliability, mainly from DOC staff) in the upper Waitaki catchment–Mackenzie basin area, over the last 10–15 years. At Lake Middleton, two observations of the Eastern falcon/kārearea were listed. On 14.12.2009, an Eastern falcon/kārearea was sitting in the pine trees on the lake's edge, calling to another in the distance. On 11.04.2017, an Eastern falcon/kārearea was observed flying past the scrub and pine trees around the lake edge, near Shelton Downs. On 26.02.2018, Southern crested grebes/kāmana (two adults and a chick) were observed on a raft, put in the lake by the Ohau Conservation Trust (OCT).

The Waitaki Catchment Water Allocation Board (2006) in the Waitaki Catchment Water Allocation Regional Plan, noted the natural values of rivers and lakes in the Waitaki River catchment. Objectives, policies and rules to protect these values are provided. Lake Middleton was recognised as an important bird habitat, with special mention being made of the Southern crested grebes/kāmana, on the lake.

Jensen and Snoyink (2005) reported on the distribution and numbers of Southern crested grebes/kāmana in New Zealand. Field counts were undertaken simultaneously throughout New Zealand on 24 January 2004 (during peak breeding season) by 81 observers. This simultaneous effort eliminated the possibility of double counting, associated with birds moving between lakes (including Lake Middleton). No Southern crested grebes/kāmana were recorded at the lake during this survey.

Daly (2004) produced an inventory of instream values for Canterbury's rivers, lakes and waterways based on a desktop study. The presence of black stilts/kakī was mentioned at Lake Middleton although it was noted that the species no longer bred there.

Pollock (2003) in *Classified Summarised Notes* recorded two Southern crested grebes/kāmana on Lake Middleton on 18 April 2000. Note that this is a duplication of O'Donnell's (2002) record below.

O'Donnell (2002) in *Classified Summarised Notes* recorded two Southern crested grebes/kāmana on Lake Middleton on 18 April 2000.

O'Donnell and West (1994) in *Classified Summarised Notes* recorded a Southern crested grebe/kāmana on Lake Middleton on the 7.7. 1991.

Jarman (1987: 77) reported on wildlife and Sites of Special Wildlife Interest (SSWI) in the upper Waitaki River catchment for the New Zealand Wildlife Service. Eleven bird species were recorded at Lake Middleton. These included *Threatened* and *At Risk* species such as grey duck/pārera, black-billed gull/tarāpuka and black shag/kōau. Grey warbler/riroriro (*Gerygone igata*) was the only species listed as breeding at the lake.

The Department of Lands and Survey (1985) in its management plan for the Lake Middleton Recreation Reserve, noted that although no bird surveys had been undertaken at the lake, most of the species recorded at Lake Ohau would most likely be found at Lake Middleton. These included both native and introduced species. Species with a current threat ranking included the grey duck/pārera and black shag/kōau.

Wayte (1891: p. 28) reported on a trip to the upper Waitaki Catchment. Lake Middleton '*... was chiefly remarkable for its numberless congregation of wild fowl, principally the beautiful paradise ducks*' (pūtakitaki, *Tadorna variegata*).

3.2.3 *Invertebrates (freshwater)*

*At least 14 freshwater invertebrate species have been recorded in the Lake Middleton catchment (Boud & Eldon 1960; Graynoth et al. 1986). The conservation status of the freshwater mussel/kākahi (*Echyridella menziesii*) is At Risk: Declining (Grainger et al. 2018). Invertebrates identified at Lake Middleton are listed in Appendix 4.*

Bowie (2011) collated observations and records of freshwater mussels/kākahi from sites in Canterbury (and some other South Island Sites). An observation made by DOC staff of freshwater mussels in Lake Middleton, on 11 December 2003, is listed.

Graynoth et al. (1986) investigated and reported on the diet of landlocked sockeye salmon, brown trout and rainbow trout in the Waitaki lakes. Fish were caught in July and September 1975 in fine-mesh gill nets, and their stomach contents were examined. Fourteen rainbow trout were caught in the nearshore-shallows of Lake Middleton. Invertebrates made up 61% of the trout diet, being composed of 48% molluscs (*Potamopyrgus antipodarum* and *Lymnaea* spp.) and 13% insects (species not given).

Boud and Eldon (1960) surveyed Lake Middleton to determine the lake's suitability as a nursery pond for trout. The survey included Surber sampling of bottom fauna around the lake's edge. Seven orders of invertebrates, representing at least 12 genera, were recorded. Non-biting midges (Chironomidae) were by far the most common invertebrates (57.1% of sample) followed by molluscs (25.9%). Details of Boud and Eldon's (1960) invertebrate survey are presented in Table 2, below.

Table 2. Invertebrates recorded in Lake Middleton (Boud & Eldon 1960).

Order	Tricoptera (caddisflies)	Ephemeroptera (mayflies)	Diptera (2-winged flies)	Colepotera (beetles)	Odonata (damselflies and dragonflies)	Annelida (worms)	Mollusca (snails etc)
Genera (percent of total)	Hydrobiosis 0.2% Hydroptera 0.2% Pycnocentrodes 2.1% Pseudonema 1.5%	Deliatidium 0.6%	Chironomidae 57.1%	Dyticidae 0.6%	Xanthagrion 0.7%	Tubificid 11.3%	*Potamopyrgus antipodarum* (aquatic snail) 25.9% *Sphaerium* sp. (pea clam)[11] 3.1% *Isidora* sp. (aquatic snail) 2.6%

3.2.4 *Lizards*

No specific lizard records were found for the Lake Middleton catchment, but skinks and geckos are presumed to be present, based on records from the Lake Ohau catchment (Appendix 5).

The Department of Lands and Survey (1985) in its management plan for the Lake Middleton Recreation Reserve identified animal species in the lake's catchment. Skinks (Scincidae) and geckos (Gekkonidae) were presumed to be present, although species were not named.

3.2.5 *Introduced wild mammals*

A variety of introduced wild mammals are found in the Lake Middleton catchment (Appendix 6). The Department of Lands and Survey (1985) states several of these are known to have caused a reduction in native bird populations in the area.

The Ohau Conservation Trust (OCT 2017) produced a strategy for restoring biodiversity and natural heritage in the Lake Ohau basin, which includes Lake Middleton. Lake Ohau Village and its surrounds (including Lake Middleton) was identified as a priority area for an OCT predator control programme and various trapping and baiting methods were suggested for each predator species identified. Seven mammalian predators were identified, included cats (*Felix domesticus*), rats (*Rattus* spp.), mice (*Mus domesticus*), possums (*Trichosurus Vulpecula*), stoats (*Mustela erminea*), weasels (*Mustela nivalis*) and ferrets (*Mustela furo*).

[11] Sphariid bivalves were formally called Corneocylas in Boud and Eldon (1960).

The Department of Lands and Survey (1985), in its management plan for the Lake Middleton Recreation Reserve, identified eight wild mammal species in the Lake Middleton catchment. Rabbits (*Oryctolagus cuniculus*), were reported to be in plague proportions. It was stated (p. 14) that: *'It has been suggested that cats, and possibly rats may well have been responsible for the reduction of native birds even before the release of mustelids in the 1880s to control rabbit numbers'.*

3.2.6 Plants

At least 40 plant species have been recorded in the Lake Middleton catchment. The most detailed plant information found related to submerged flora, with relatively little information being found for riparian and terrestrial species. The lake's aquatic plant assemblage is composed of both native and exotic species (e.g., Department of Lands & Survey 1985; Champion et al. 2006; NIWA 2014, OCT 2017). Native aquatic species include milfoils, pondweeds, rushes etc., which are considered typical of a small montane lake. The most unusual aquatic plant is Isoetes alpina[12]*, a primitive plant (e.g., Scott 1958; Department of Lands & Survey 1985). Based on its 2017 Lake Submerged Plant Indicators (LakeSPI) assessment of 50%, (Land and Water, Aotearoa: LAWA 2019), the lake is classed as being in moderate ecological-health. This has deteriorated from its 2012 LakeSPI assessment (57%), of high ecological-health (de Winton & Burton 2017). The lakeshore terrestrial plant assemblage is similar to (and included in) that of the Lake Ohau shore, which is regionally significant and nationally important for its native vegetation (Head 2014, pers. comm.; OCT 2017). Two species have a conservation status of Threatened or At Risk (de Lange et al. 2018). Manuka (*Kunzea serotin*) is ranked as Threatened: Nationally vulnerable, whilst matagouri (*Discaria toumatou*) is ranked At Risk: Declining. Extensive areas of exotic trees and weeds are found around the lake's shoreline and aquatic weeds are present in the lake. Plant species identified at Lake Middleton are listed in Appendix 7.*

LAWA (2019) is an environmental data website, created by a partnership of New Zealand's regional councils, unitary authorities, Cawthron Institute, and the Ministry for the Environment. Data from these organisations and NIWA are presented. Using the LakeSPI data from de Winton and Burton (2017, see below), the overall ecological health of Lake Middleton was assessed as moderate (50%). This was based on a Native Condition Index ('*Good*' plants) of 77% and an Invasive Impact Index (introduced, exotic plants) of 68%.

Smith-Campbell's (2019) observation notes of birds around Lake Middleton (Appendix 3), included general vegetation observations. Large pines (*Pinus* spp.) were noted at the southern end of the lake and willows (*Salix* spp.)

[12] Called *Isoetes alpinus* by Scott (1958) and Department of Lands and Survey (1985). Called *I. alpina* by de Lange et al. 2018.

and larches (*Larix deciduas*) were along the eastern edge of the lake. Grasslands were present along the western shore.

de Winton and Burton (2017) assessed 18 Canterbury lakes (including Lake Middleton) for ECan and DOC, using Lake Submerged Plant Indicators (LakeSPI): General weed surveillance was also undertaken for Meridian Energy Ltd. LakeSPI is a bioassessment method, used to indicate the ecological condition of a lake. It is based on the degree of development by native submerged plants, plus the level of impact by exotic, invasive weeds. The LakeSPI Index ranges from 0% (heavily impacted lakes) to 100% (pristine, unimpacted lakes) and provides five categories of condition. In 2017, Lake Middleton had a LakeSPI Index of 50%, meaning it was at the lower margin of the high ecological condition category. No significant changes in LakeSPI Indices were detected between 2012 and 2017. *Elodea canadensis* was the only invasive weed to be recorded from Lake Middleton and this formed closed-canopy beds and extended to depths between 5.2 m and 5.5 m, usually occupying between 26 to 50% of the vegetated area at sites. Multiple surveys suggested *E. canadensis* was expanding over time, in terms of cover and depth range. *Elodea. canadensis* was now the deepest growing vegetation in Lake Middleton but despite its dominance, up to five native submerged plant communities were recorded, which contributed to a relatively high Native Condition Index in 2017 (as in 2012). de Winton and Burton (2017: p43) noted:

> *'Charophyte meadows (≥75% cover) were present shallower than the main elodea bed in 2017 to depths of between 2.9 and 4.3 m. These meadows were dominated by high covers of* Chara australis*, together with locally abundant* C. fibrosa *and* Nitella pseudoflabellata. *Low covers of a milfoil and a pondweed were associated with these meadows. Swards of quillwort (*Isoetes alpina*) were common in shallow water to 2.5 m depth, and accompanied in the upper part of the depth range by lower cover turf species'.*

The Ohau Conservation Trust (2017) produced a strategy for restoring biodiversity and natural heritage in the Lake Ohau basin, which included Lake Middleton. Numerous aquatic and terrestrial weeds were identified in and around Lake Middleton and various methods to control and/or eradicate these were noted. Aquatic weeds included willows, *Lagarosiphon major* and *Ceratophyllum demersum*. Terrestrial weeds around the lake margin reserve included pines, larch, cotoneaster (*Cotoneaster* spp.), broom (*Adropogon virginicus*), gorse (*Ulex europaeus*), briar rose (*Rosa rubiginosa*), silver birch (*Betula pendula*), Russell lupins (*Lupinus polyphyllus*) and hawkweeds (both *Hieracium and Pilosella* spp).

Kelly et al. (2014) modelled[13] nutrient loads into 27 high country lakes in Canterbury for the purpose of sustaining ecological values. Lake Middleton was included in this study. Modelling parameters included terrestrial vegetation cover and lake macrophytes. Table 3, below, shows

[13] CLUES model (Vollenweider modified). See section 3.3.1, below for explanation.

the percentage of terrestrial vegetation cover type in the Lake Middleton catchment, whilst Figure 4, below, shows the distribution of this vegetation within the catchment. Sixteen species of macrophytes were identified in the lake, but not named. Macrophytes were recorded to a depth of 4.6 m.

Table 3. Lake Middleton catchment. Vegetation cover as % of 1,012 ha catchment area (After Kelly et al. 2014).

Tussock/alpine grassland/scrub	Gravel /rock	Lake/pond	Exotic forest	High producing exotic grassland	Low producing grassland
36	4	3	7	31	18

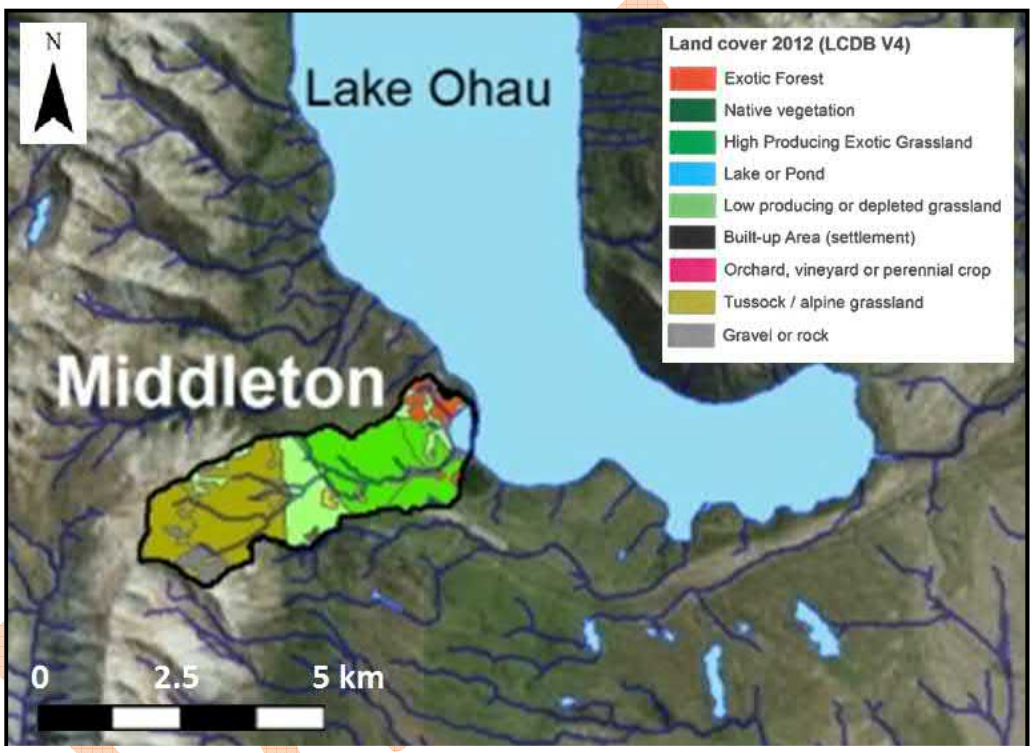

Figure 4. Lake Middleton catchment vegetation cover (After Kelly et al. 2014).

Head (2014, *pers. comm.*) stated that the native shoreline vegetation of Lake Ohau (including Lake Middleton) is of regional significance and national importance. This was largely because of its predominantly unmodified, natural state.

Champion et al. (2006) carried out a submerged vegetation survey of high-country lakes for ECan. Data from this survey were compared with historical records. Lake Middleton was surveyed on 7 April 2005. Lake condition assessment was based on the submerged vegetation, combining species richness, maximum depth colonised by vegetation and the impact of exotic species. The current distribution of the worst submerged weeds, assessment of potential impact on high-country lakes and the mechanisms and associated risks of weeds spreading, were evaluated. The lake was

previously surveyed in 1982 when 19 indigenous species were recorded (not named) along with the exotic species, *Elodea*. The dominant species in Lake Middleton in 1982 were *Isoetes alpina*, *Chara fibrosa* and *C. australis*. Vegetation extended to 5.5 m water depth. By 2005, the vegetation pattern had changed. *Elodea* dominated much of the lake from 1.1 m to the deepest part of the lake and it was estimated to occupy 63% of the submerged vegetation, compared to two per-cent in 1982. In the 0.7 m to 1.1 m depth range, 10 submerged indigenous species were identified, with *Isoetes alpina* being the dominant species. A *Lagarosiphon* sign was present at the access point. Lake Middleton was assessed to be at high–risk from the introduction of *Lagarosiphon* (and other exotic weeds) and the predicted impacts of introduced vegetation are also assessed as high. Management recommendations for lakes at high–risk from weed incursion included: a) survey and restrictions of boat use; b) education (e.g., signage); and, c) annual vegetation surveillance of the lakes.

Davidson (1986) reported on the evolution of mountain-land recreation in New Zealand for the New Zealand *Man and the Biosphere* series, citing numerous historical reports. Vegetation was described for various mountain areas. In the Ohau basin, conifers were used extensively as windbreaks around homesteads and a large stand of mixed-species conifers was found around the Avoca homestead at the northern end of Lake Middleton.

The Department of Lands and Survey (1985), in its management plan for the Lake Middleton Recreation Reserve, identified extensive weed banks in the deeper waters of the lake and pieces of aquatic macrophytes were found around the lakeshore. Macrophyte species included *Myriophyllum triphyllum*[14] (water milfoil), *Potamogeton cheesemanii* (red pondweed), *Lilaeopsis novae-zelandiae*, and the most unusual species, *Isoetes alpina* (alpine quillwort), a primitive plant. It was also noted (p. 12) that: '*There is a risk that more aggressive lake-weed species could be inadvertently introduced to the lake by boat owners*'. The northern end of the lakeshore was forested with lodgepole pine (*Pinus contorta*) and larch. Clearings among these trees and other open spaces around the lakeshore were vegetated with a mixture of introduced pasture grasses and native fescue tussock (*Festuca novae-zelandiae*). Some sweet briar, matagouri and *Coprosma* shrubs were present, especially along the Lake Ohau Road shoreline, and scattered willows were also present around the lakeshore.

Adcock (1984) produced the Wetlands of Ecological and Representative Importance (WERI) database and user guide for DOC. Lake Middleton was noted for being surrounded by larch trees on its northern side.

Espie et. al (1984) produced the Protected Natural Area Programme (PNAP) report the Mackenzie Ecological Region. The objective of the

[14] The Department of Lands and Survey also identified *Myriophyllum elatinoides*: This is now formally recognised as being the same as *M. triphyllum* (e.g., Johnson 2009: p. 206; New Zealand Plant Conservation Network 2014).

PNAP was to implement Section 3(1)(b) of the Reserves Act (1977) to ensure: *'... the reservation of representative samples of all classes of natural ecosystems and landscapes which in the aggregate originally gave New Zealand its recognisable character'*. Floral, faunal, geomorphological and landscape values for the Mackenzie Ecological Region were based on a variety of methods such as literature reviews, field work and sampling, as well as analysis of aerial photographs and maps. Lake Middleton was classified within the Omarama Ecological District: Lake Ohau Shoreline Scrub Unit. This unit was described as: '*A unique area of good quality shoreline scrub. It includes an area of dry matagouri/briar, small patches of thick manuka and an area of healthy, tall red tussock (*Chionochloa rubra subsp.)*.*' (p 77).

Alexander and Bould (1981), in their investigation on coastal reserves for Lake Ohau, commented on vegetation at Lake Middleton. On the Crown Reserve land at the northern end of the lake, stands of larch, willow and mixed-conifer species were present. On the western edge of the lake, tussock pasture was used for sheep grazing.

Boud and Eldon (1960) surveyed Lake Middleton to determine the lake's suitability as a nursery pond for trout. Extensive weed beds were observed in the deeper parts of the lake, but no species names were recorded.

Scott (1958) reported on a field trip by the Otago University Science Students Association to the Lake Ohau area, in May 1958. A brief description of plants in Lake Middleton was given. No emergent plants were seen in the lake but *Isoetes alpina* was found near the lake edges. Further out in the lake, pondweed *(Potamotgeton* sp[15].) water milfoil and two species of *Nitella*[16] were recorded.

3.2.7 *Algae and plankton*

Lake Middleton has a high diversity of algae, with over 60 species being recorded in the lake. These include toxic blue-green algae (cyanobacteria) such as Nostoc *sp. (Harland et al. 2014) and Aphanizomenon flos-aquae (e.g., Thomasson 1980; Department of Lands & Survey 1985). Algae and phytoplankton species recorded in Lake Middleton are listed in Appendix 8. Zooplankton species are recorded in Appendix 9.*

Harland et al. (2014) investigated cyanotoxin production in cyanobacterial strains, isolated from benthic freshwater mats dominated by cyanobacteria, in 10 water-bodies from Canterbury (including Lake Middleton). Twenty–seven strains were isolated and characterised using morphological and molecular phylogenetic characteristics. All 27 strains were screened for genes involved in the biosynthesis of common cyanotoxins. Positive results were confirmed and cyanotoxin concentrations were quantified

[15] Assumed red pondweed, *Potamogeton cheesemanii*

[16] *Nitella* spp. are algae. See Section 3.2.7. and Appendix 8, below.

using liquid chromatography–mass spectrometry. In Lake Middleton, *Nostoc* sp. was identified.

Jeppesen et al. (2000) examined the trophic structure in the pelagic zone of 25 shallow New Zealand lakes and associated changes along nutrient and fish gradients. Lake Middleton was included in this investigation. Sampling for zooplankton, phytoplankton, ciliates and heterotrophic nanoflagellates (HNF) was undertaken during January–February 1996. Depth-integrated plankton samples were taken, with a 3.3 litre Patalas sampler, at three stations along a transect parallel to the shore in the deepest part of the lakes. Sediment core-samples from the deepest part of the lake, or mid-lake position, were also collected and analysed for plankton (wet, dry and ash-free weights). In Lake Middleton, the dominant zooplankton were *Ceriodaphnia* spp. and Calanoids; recording just under 50% each of the total sample. The remaining few percent of zooplankton were composed of Rotifers. Approximate relative proportions[17] of zooplankton, ciliates and HNF in Lake Middleton were: zooplankton (dry weight) = 0.1 mgL^{-1}; ciliates (N°. of individuals) = 5.0 per mL^{-1}, and HNF (N°. of individuals) = less than 0.5 per μgL^{-1}. For all the lakes sampled, zooplankton biomass was positively related to increases in Total Phosphorus (TP) and Total Nitrogen (TN), and negatively related to increases in fish numbers. It was concluded that fish may have a major influence on zooplankton community structure, plus biomass and mean weight of cladocerans in New Zealand lakes, and that these effects may cascade to ciliates and phytoplankton, though apparently with a modest effect on these variables. The effect of fish on zooplankton was not restricted to lakes in which native fish species (or perch) dominated, but also extended to trout-dominated lakes (such as Lake Middleton).

Smith et al. (2000) surveyed *Syctonema* (cyanobacteria) and associated saxitoxins (neurotoxins) from the littotral zone of 34 high-use, recreational lakes in Canterbury, including Lake Middleton. Samples of metaphyton and periphyton were collected from the shores of the lakes, then analysed in the laboratory for saxitoxins using the Jellett rapid test for paralytic shellfish poisoning. Saxitoxin variants were identified in positive samples using high-performance liquid chromatography with fluorescence detection. Phylogeny was determined by using partial 16S rRNA gene sequences of laboratory-grown cultures. In Lake Middleton, two genera of cyanobacteria were identified. These were *Anabacenal trichomus* and *Scytonema* cf. *fritchii*. Saxitoxin was not found in any of the samples from Lake Middleton.

Pridmore and Etheridge (1987) reported on the distribution and population dynamics of planktonic cyanobacteria (blue-green algae) in New Zealand's inland waters. Based on the work of Thomasson (1980; see below), *Aphanizomenon flos-aquae* was reported in Lake Middleton. It was noted

[17] Read off coarse-scale graphs. Raw data not presented in Jeppesen et al. (2000).

that none of the blue-green algae species in New Zealand were endemic; most, if not all, were cosmopolitan.

The Department of Lands and Survey (1985) in its management plan for the Lake Middleton Recreation Reserve, noted over 60 species of free-floating algae in the lake. By comparison, only 15 species were found in Lake Ohau and only nine species were common to both. Lake Middleton's diverse algal species were more characteristic of a small pond rather than a lake. *Aphaniozomenon floa-aqaue*, a species of blue-green algae that forms blooms in nutrient-rich lakes, was found in Lake Middleton.

Cassie (1984a) revised the checklist of New Zealand's freshwater algae (excluding diatoms and charopphytes), based on a search of published literature. Thirty-four species were recorded in Lake Middleton (Appendix 8).

Cassie (1984b) revised the checklist of New Zealand's freshwater algae (excluding diatoms and charopphytes), based on a search of published literature. Thirty-four species were recorded in Lake Middleton (Appendix 8).

Alexander and Bould (1981), in their investigation on coastal of reserves for Lake Ohau, commented on algae in Lake Middleton. It was stated (p. 7) that algae species in Lake Middleton differed to those in Lake Ohau because of: '*... different environmental conditions in the water*'.

Thomasson (1980) reported on phytoplankton in nine oligotrophic lakes in the South Island, including Lake Middleton. Randomly selected plankton samples were collected from the lakes between March 29 and April 4 1969. Sixty-three species of phytoplankton were recorded from Lake Middleton (Appendix 8). It was noted that plankton species were more varied and abundant in Lake Middleton than they were in both Lake Ohau and Lake Pukaki. Plankton species in Lake Middleton were dominated by *Botryococcus braunii* and *Polyarthra vulgaris*.

Wood and Mason (1977) undertook a floristic study of New Zealand's Characeae. Brief descriptions and lists of specimens were given, along with distribution maps. Two species of Characeae were recorded in Lake Middleton. These were *Chara corallina* and *Nitella pseudoflabellata*.

Scott (1958) compiled a report on a field trip by the Otago University Science Students Association to the Lake Ohau area in May 1958. Part of this field trip involved analysing the surface plankton of the lake (phytoplankton and zooplankton). A net was towed behind a dinghy, just below the water surface, for the length of the lake, to collect the plankton samples. Plankton identified and their relative abundance, derived from a total of 10 water samples of 0.5 mL each, are shown in Table 4, below. The total plankton density of 34, 000/L was considered low. The Cladocera included *Bosmina meridionalis* whilst Copepods consisted mainly of

Boeckella species. Two species of *Nitella* were also noted but species names were not given.

Table 4. Relative abundance of plankton in Lake Middleton (After Scott 1958).

Order/Species	Total number from 10 samples of 0.5 mL each	Type
Cladocera	145	crustacean
Copepoda	11	crustacean
Diatoms	8	phytoplankton
Volvox sp.	4	green algae
Ulothrix sp.	3	filamentous green algae

3.3 Physical values

3.3.1 Water (hydrology and water quality)

Lake Middleton is a small shallow lake, around 5.0 m deep, with no natural outlet (e.g., Department of Lands and Survey, 1985). Recorded lake water temperatures have ranged from freezing (O'Donnell & West 1994) to 17 °C Thomasson 1980). Between 1969 and 1996, the lake changed from being oligotrophic, with low levels of nutrients and algae (Thomasson 1980) to mesotrophic, with moderate levels of nutrient and algae (Jeppesen et al. 2000; ECan 2014a; Meredith 2014). Toxic blue-green algae have been recorded in the lake (e.g., Thomasson 1980; see section 3.2.7, above). In general, water quality is safe for contact recreation (e.g., Clarke 2015; Bolton-Ritchie & Arthur 2016).

The Land, Air, Water, Aotearoa website (LAWA 2019) records the Trophic Level Index (TLI) as a measure of nutrient status of lakes in New Zealand. The TLI in LAWA is calculated from data collected over the previous 12 months and is made up of four parameters; water clarity, chlorophyll content, phosphorus and total nitrogen. The most recent water quality data for Lake Middleton (2017), show the TLI at 3.31 (Level 3: Mesotrophic), which is average condition. Table 5, below, shows that between 2011 and 2017, TLI scores for the lake have ranged between 3.1 and 3.31 (all mesotrophic and average water quality

Table 5. Lake Middleton TLI scores 2011–2017 (After LAWA 2019).

Year	**TLI score**
2011	3.1
2012	3.23
2013	3.12
2017	3.31

The National Institute of Water and Atmospheric Research's LakeSPI website (NIWA 2019; see section 3.2.6 above for definition) provides basic hydrological information for Lake Middleton. The lake was described as a barrier lake, with an area of 0.23 km^2 and a maximum depth of 4.9 m, although submerged plants were recorded at 5.5 m depth[18].

ECan (2019) made Section 15B: Waitaki (Plan Change 5) of the Canterbury Land and Water Reginal Plan (ECan 2012) operative, on the 1 February 2019. Section 15B sets water quality outcomes and limits for water bodies in the Waitaki River catchment. Lake Middleton was identified as one of the smaller lakes in the Haldon sub-catchment of the Upper Waitaki Freshwater Management Unit '... *which are particularly vulnerable to nutrient enrichment*' (p. 1). Freshwater outcomes and water quality limits for Lake Middleton, defined in the plan, are shown in Table 6 and Table 7, respectively, (below).

Table 6. Freshwater outcomes for Lake Middleton (After ECan 2019).

Ecological Health Attribute	Dissolved Oxygen (minimum saturation %)	7.0% hypolimnion / 90% epilimnion
	Temperature (maximum °C)	19
	Lake Submerged Plant Index (LakeSPI) (minimum grade)	High
Eutrophication Attribute	Trophic Level Index (TLI) (maximum annual average)	3.6
Visual Quality Attribute	Colour	Natural colour of the lake is not degraded by more than 5 Munsell units
Human Health for Recreation Attribute	Cyanobacteria (either mm^3/L or cells/mL) (80^{th} percentile)	<0.5mm^3/L biovolume equivalent for all cyanobacteria or <500 cell/mL of total cyanobacteria
	Suitability for (Contact) Recreation Grade (SFRG)	Good-Fair
	Escherichia coli (*E. coli*/100 mL). Annual median	<260
	E. coli (E. coli/100 mL). 95^{th} percentile	<540
Tangata Whenua Attribute	Freshwater mahinga kai species sufficiently abundant for customary gathering, water quality is suitable for their safe harvesting and they are safe to eat.	

[18] Burton, *(pers. comm.* 18. 3. 2019) commented that: '*Our records show that this lake is 4.9 m in depth – not 4 m as it currently shows on the website. Plants were recorded at 5.5 m by our dive-team but this was likely a result of seasonal changes in water level at the time of the 2017 survey with vegetation extending across the bottom of the lake*'.

Table 7. Water quality limits for Lake Middleton (After ECan 2019).

TLI: Maximum annual average	3.6
Total Phosphorus (TP) concentration (mg/m^3): Annual median	<10
Total Nitrogen (TN) concentration (mg/m^3): Annual median	<160 (seasonally stratified)
Chlorophyll-a concentration (mg/m^3): Annual median	<2
Chlorophyll-a concentration (mg/m^3): Annual maximum	<10
Amoniacal nitrogen concentration $(mg/L)^2$: Annual median	<0.03
Amoniacal nitrogen concentration $(mg/L)^2$: Annual maximum	<0.05

Arthur et al. (2017) presented the results of ECan's recreational water quality monitoring programme for the 2016-2017 summer period. In this programme, ECan monitors key contact recreation sites for faecal bacteria (*E. coli* and enterococci), as well as benthic cyanobacteria cover and planktonic cyanobacteria. The northern end of Lake Middleton (the most popular part of the lake for swimming) was one of the sampling sites. Faecal bacteria indicate the increased risk of pathogen presence in waters. These pathogens are detrimental for human health. Benthic and planktonic cyanobacteria can produce neurotoxins that are also harmful to humans and other animals. The monitoring programme follows the national microbiological water quality guidelines for marine and freshwater recreational areas (Ministry for the Environment & Ministry of Health [MfE & MoH], 2003) and the interim national guidelines for cyanobacteria in recreational freshwaters (MfE & MoH, 2009). Freshwater sampling and benthic cyanobacteria cover surveys are conducted weekly, between mid-November and early-March, each year. Monthly water samples from selected lake sites are tested for phytoplankton throughout the year; monitoring frequency increases if alert and action trigger levels for cyanobacteria are exceeded. Based on the monitoring results found, a 'Suitability for (contact) Recreation Grade' (SFRG) is then determined. The SRFRG for Lake Middleton had improved from '*fair*' over the 2012-2014 period, to '*good*', over the 2014-2017 period. Thus, the recommended grade for the following 2017-2018 season was '*good*'.

The Ohau Conservation Trust (OCT 2017) produced a strategy for restoring biodiversity and natural heritage in the Lake Ohau basin (including Lake Middleton). Lake Middleton was described as a beach-barrier lake. General water quality observations made for the lake included that it (along with Ohau), '*... are somewhat rare in being semi-clear water glacial lakes that are not fully regulated and are subject to major variations in climate and weather of the basin*' (p. 4). Owing to land development around the lake, '*... water quality is showing signs of severe degradation from eutrophication ... The lake is in desperate need of measures to mitigate water quality degradation*' (p. 24). Key tasks to improve water quality in the lake included:

- Water quality monitoring;
- Riparian fencing on the western side to prevent stock encroachment on the lake shore and margins;

- Restoration of native wetland vegetation on the western shores for nutrient and sediment abatement;
- Fencing and restoration of riparian vegetation along the inflow stream on Shelton Downs Station for sediment and nutrient abatement;
- Willow thinning and replanting of native lake-edge trees, and
- Re-definition of camping areas to protect and lake-side vegetation.

Bolton-Richie and Arthur (2016) reported on water quality monitoring for contact recreation in Canterbury's freshwater and coastal water bodies, for the 2015–2016 summer season, using similar methods to those described by Arthur et al. (2017), above. For Lake Middleton, the SFRG had improved from '*fair*' over the 2011–2014 period, to '*good*' over the 2014–2016 period and based on these results, the recommended SFRG for the following 2016–2017 season, was '*good*'. This meant the site was satisfactory for swimming most of the time. Exceptions may follow periods of rainfall, as a potential source of faecal contamination was drainage from surrounding low-intensity rural use land.

Boulton-Ritchie and Robinson (2015) reported on water quality monitoring for contact recreation in Canterbury's freshwater and coastal water bodies, for the 2014–2015 summer season, using similar methods to those described by Arthur et al. (2017), above. For Lake Middleton, the SFRG had improved from '*fair*' over the 2010–2014 period, to '*good*' over the 2014–2015 season, and based these results, the recommended SFRG for the following 2015–2016 season, was '*good*'. This meant the site was satisfactory for swimming most of the time. Exceptions may follow periods of rainfall, as a potential source for faecal contamination was drainage from surrounding low-intensity rural use land.

Clarke (2015) reported on the state of water quality of lakes in the upper Waitaki River catchment, based on water samples and data collected by both ECan and NIWA. TLI, LakeSPI and SFRG were used to determine overall water quality of the lakes, including Lake Middleton. Two sites in Lake Middleton were sampled: Mid-lake, for the regional high-country lakes monitoring programme, and the eastern side of the northern end (main swimming area), for the regional contact recreational monitoring programme. Lake Middleton was mesotrophic and regularly failed to meet the Canterbury Land and Water Regional Plan's (ECan 2012) objective of TLI = 3. The average TLI for the lake, over five years from 2009 to 2014 (incorporating both ECan and NIWA data), was 3.6. Owing to the limited sampling history in the lake, it was not certain if the TLI results were a deviation from an historic state, driven by changes in surrounding land management practises. Nonetheless, compared to unpublished ECan results dating back to 1996–1997, it was likely that the lake has produced more algal biomass in recent times. Between the summers of 2008/09 and 2012/13, an increase in faecal contamination in the lake was detected and the SFRG changed from '*good*' (summer of 2009/10) to '*fair*' (summer of

2010/11). This is below the LWP (ECan 2012) desired objective of '*good*'. Possible contamination sources included the campground on the shores of the lake; increased construction of dwellings, or pastoral grazing near the western shore. The small catchment and inferred longer water residence time made the lake particularly susceptible to effects of eutrophication. From a single NIWA analysis, a LakeSPI result of 57 gave an overall lake condition score of '*high*', which met the objective of the LWP (ECan, 2012).

Kelly et al. (2014) modelled nutrient loads in 27 high country lakes in Canterbury, for the purpose of sustaining ecological values. Lake Middleton was included in this study. Estimates of nutrient loads (Total Nitrogen [TN] and Total Phosphorus [TP]) into the lakes were made using the national CLUES (Catchment Land Use for Environmental Sustainability) model. The model results were calibrated against existing water quality data and relationships were statistically improved by transforming nutrient loads with Vollenweider regression models. Nutrient loads were related to a range of ecological integrity indicators of the lakes, including the TLI and its components, water transparency and aquatic macrophytes communities. In general, good statistical relationships were observed between TN and TP loads calculated using the CLUES model and in-lake nutrient concentrations. However, Lake Middleton was one of the lakes that did not fit the TN and TP loading relationship for turbidity, falling above the regression line. This was: '*... possibly related to turbidity being influenced by non-algal related parameters such as suspended sediment*' (p. 35), although it was uncertain to what degree re-suspension affected water clarity. It was also stated that: '*Lake Middleton had a shallower macrophyte depth than would be expected from TN and TP loads, probably because of glacial suspended material affecting turbidity*' (p. 37). Catchment and hydrological data used by Kelly et al. (2014) for their modelling are shown in Table 8 and Table 9, respectively, below.

Table 8. Lake morphometric data, CLUES nutrient loads, and total nutrient concentrations and turbidity for Lake Middleton used in the nutrient loading modelling study. P = phosphorus, N = nitrogen (After Kelly et al. 2014).

Lake area (ha)	Max depth (m)	Residence time (y^{-1})	Catchment area (ha)	CLUES P-load (kg/ha/y)	CLUES N-load (kg/ha/y)	CLUES sediment load (T/ha/y)	Median in-lake total-N (mg/m^3)	Median in-lake total-P (mg/m^3)	Median in-lake turbidity (NTU)
23.5	4	0.0922	1011	73.4	3.2	2.0	354.5	14.5	1.33

Table 9. In-lake parameters used in regression modelling for Lake Middleton (After Kelly et al. 2014).

CLUES predicted TN inflow	CLUES predicted TP inflow	CLUES predicted sediment inflow	Chlorophyll-a	TLI	LakeSPI	Macrophyte depth	Macrophyte richness	Turbidity	TN	TP	Areal TN load	Areal TP load	Areal sediment load
mg/m^3	mg/m^3	g/m^3	mg/m^3	-	-	(m)	# species	NTU	mg/m^3	mg/m^3	kg/ha/y	kg/ha/y	T/ha/y
408.9	9.6	14.2	2.2	3.3	57	4.6	16	1.33	354.5	14.5	73.4	3.2	2.0

Environment Canterbury (2014a) produced a technical overview of the current status of the Upper Waitaki Water Zone, in relation to a public process of setting nutrient discharge limits for the zone. Based on the TLI, water quality in Lake Middleton was described as regularly failing to meet current plan objectives. Limited historical water sampling from the lake meant there was uncertainty if these TLI results were derived from an historic state, driven by changes in land-use management. Nonetheless, compared to samples taken in 1996-1997, it was likely the lake had become more productive in recent years. Between 2009 and 2014, the average TLI of Lake Middleton was 3.6. This compared to the proposed plan objective for the lake, of TLI = 3.0. Based on its LakeSPI result from March 2012 (see section 3.2.6, above), the overall condition of the lake was ranked as high, which corresponded with proposed plan objectives. Faecal contamination in the lake appeared to have increased in recent years, with possible contamination sources being the lakeshore campground, increased construction of dwellings, or pastoral grazing near the western shoreline. In 2012-2013, the 95 percentile for *E. Coli* was 375 mpn[19]/100 mL This fell short of proposed planning objectives for the SFRG quality.

Environment Canterbury (2014b) produced a technical overview of the Upper Waitaki Water Zone under Scenario 2(a, b, c)[20], in relation to a public process of setting nutrient discharge limits for the zone. *'Scenario 2 represents full utilisation of consented land-use in the catchment, with additional irrigation assumed in the zone representing "aspirational" development'* (ECan 2014b, p. 1). Under Scenario 2(a, b, c), significant increases in nitrogen and phosphorus loads were predicted for most of the lakes in the upper Waitaki catchment, including Lake Middleton (Figures 5

[19] mpn/100 ml = most probable number per 100 millilitres.

[20] Scenario 2a assumed small blocks of irrigation on large farms, with a combination of dairy support and sheep and beef land use. Scenario 2b assumed large blocks of irrigated dairy farms. Scenario 2c is similar to Scenario 2a, but located 80% of the additional irrigation in the Haldon Arm catchment of Lake Benmore.

& 6, below). In particular, Scenario 2c, estimated a large TLI increase for Lake Middleton from its current measured TLI of 3.6 to 4.1 (13% increase).

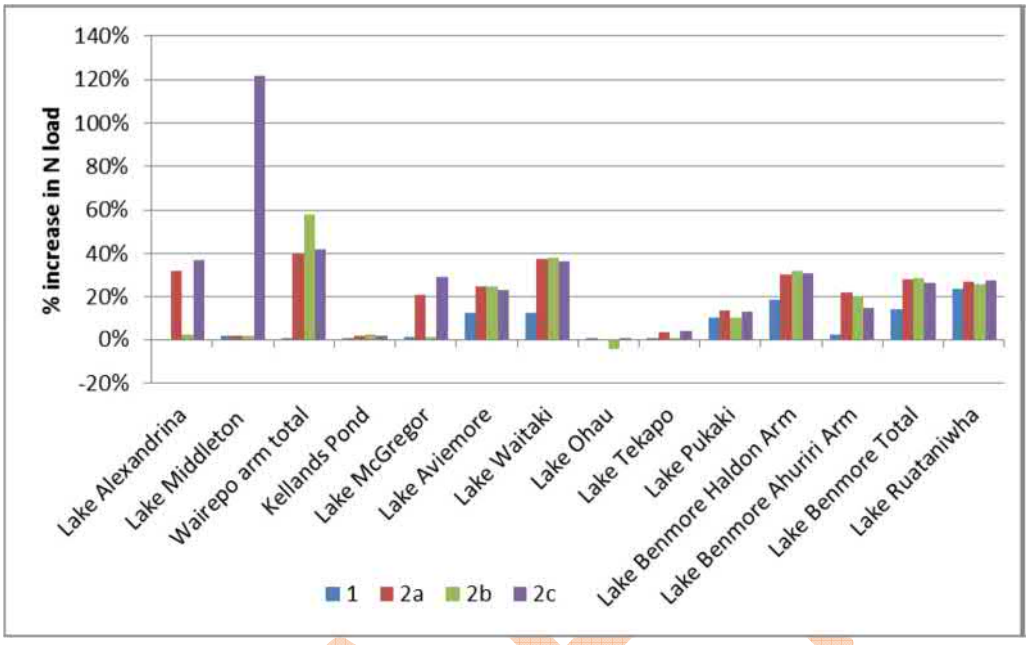

Figure 5. Modelled % increase (above current) in total Nitrogen load to lakes under Scenarios 1 and 2. Note the Lake Middleton increase of >120% under Scenario 2c (ECan 2014b).

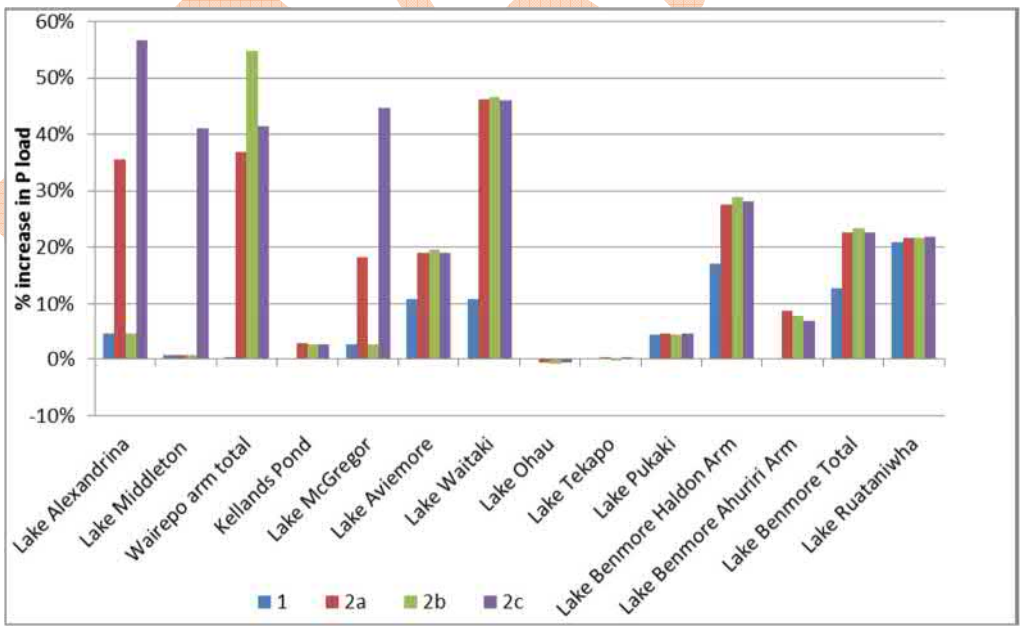

Figure 6. Modelled % increase (above current) in total Phosphorus load to lakes under Scenarios 1 and 2. Note the Lake Middleton increase of >40% under Scenario 2c (ECan 2014b).

Meredith (2014) provided unpublished data from ECan's water quality monitoring in Lake Middleton. This was part of ECan's programme to monitor water quality in lakes and waterways for contact recreation (amongst other parameters). Monitoring at Lake Middleton was

undertaken from December to April (inclusive), in both 2011/2012 and 2012/2013. Respective mean TLI scores of 3.52 and 3.6 were determined. These scores indicated the lake was in a mesotrophic state, having moderate levels of nutrients and algae.

The National Institute of Water and Atmospheric Research's website (NIWA 2014) provided information (collected in March 2012) on the submerged plants in Lake Middleton, which indicated the ecological health of the lake. This was based on LakeSPI (see Section 3.2.6, above). In this assessment, the surface area of the lake was given as 0.23 km^2 and water depths up to 4.8 m were recorded.

Sutherland-Downing et al. (2003) produced an inventory of recreational values for rivers and lakes of Canterbury, based on a desktop study. Lake Middleton was ranked as high value for water quality.

Jeppesen et al. (2000) examined the trophic structure in the pelagic zone of 25 shallow, New Zealand lakes and associated changes along nutrient and fish gradients. Lake Middleton was included in this investigation. Water samples for this investigation were gathered from the lakes in January–February 1996. The maximum depth of sampling stations at Lake Middleton was 4.5 m; this was approximately 80% of the maximum lake depth. The concentration of total phosphorus (TP) in lake water was determined as molybdate-reactive phosphorus following persulphate digestion, and the concentration of total nitrogen (TN) was determined as nitrite after potassium persulphate digestion. Chlorophyll-*a* (CHL-a) was determined spectrophotometrically, after ethanol extraction. Approximate concentrations[21] of TN, TP and CHL–a, in micrograms per litre (μgL^{-1}) were 0.4 μgL^{-1}, 10 μgL^{-1}, and 6μgL^{-1}, respectively. Lake Middleton was listed as a mesotrophic lake.

Scott and Irvine (2000) reported on the breeding competition between brown trout and rainbow trout, with one of their study sites being Middleton Burn, a small tributary stream which enters the south-western edge of Lake Middleton. The lake was described as having an area of 0.19 km^2; was at an altitude 517 m and Middleton Burn was the only tributary stream. There is no direct outlet to Lake Ohau. Water quality samples from Middleton Burn were taken in September 1997, from the shallowest water at four redd sites, located near the lake. Middleton Burn was described as generally low in solutes and near neutral with respect to pH. Water quality details for Middleton Burn are shown in Table 10, below.

[21] Read off coarse-scale graphs. Raw data not presented in Jeppesen et al. (2000).

Table 10. Water quality parameters in Middleton Burn (After Scott & Irvine 2000). Chemical samples taken in September 1997.

Water Quality Parameter	Mean Value (Range of Values)
Temperature (^{0}C)	7.5 (7.0 – 8.0)
Flow (m^3. s^{-1})	0.04 (0.03 – 0.06)
Width (m)	0.9 (0.4 – 1.4)
pH	7.7
Conductivity (mS. cm^{-1})	2.0
Phosphate (ug L^{-1})	2.91
Calcium (mg L^{-1})	3.5
Chloride (mg L^{-1})	1.02
Alkalinity (mg L^{-1}) HCO_3	16.7

Smith et al. (2000) surveyed *Syctonema* (cyanobacteria) and associated saxitoxins (neurotoxins) from the littotral zone of 34 high-use, recreational lakes in Canterbury, including Lake Middleton. Samples of metaphyton and periphyton were collected from the shores of the lakes, then analysed in the laboratory for saxitoxins using the Jellett rapid test for paralytic shellfish poisoning: Saxitoxin variants were identified in positive samples using high-performance liquid chromatography with fluorescence detection. Phylogeny was determined by using partial 16S rRNA gene sequences of laboratory-grown cultures. In Lake Middleton, two genera of cyanobacteria were identified. These were *Anabacenal trichomus* and *Scytonema* cf. *fritchii*. Saxitoxin was not found in any of the samples from Lake Middleton.

O'Donnell and West (1994) in classified summarised notes reported that Lake Middleton was: '*...covered in ice ...*' on 7.7. 1991. This observation was made during general bird observations of the area.

Davidson (1986) reported on the evolution of mountain-land recreation in New Zealand for the New Zealand *Man and the Biosphere* series, citing several historical reports. Lake Middleton was described as one of several *'lagoons'* in the low-lying terrain of the Lake Ohau shoreline. Measurements made by the Waitaki Acclimatisation Society in 1891, showed the lake to be approximately one mile (1609 m) long and up to half a mile (804 m) wide: soundings showed the lake deepened rapidly from the edge, to 20 ft (6.4 m) deep.

The Department of Lands and Survey (1985) commented on water quality at Lake Middleton, in its management plan for the Lake Middleton Recreation Reserve. The lake was described as small, shallow and cool; had no natural outlet, was in an area where warm summers and calm conditions prevailed, and evaporation rates were high. Based on the Lake Ohau Station rain-gauge, mean annual rainfall at the lake was moderate; estimated at being between 800 mm and 1,000 mm per year. Maximum rainfall occurred in the spring and autumn months, while minimum rainfall occurred in the summer and mid-winter months. The lake's water quality

was: '*... of a high standard*' (p. 22); being very clear (little turbidity) and had low levels of nutrients such as nitrogen and phosphorous. Nonetheless, it was stated (p. 12) that:

> *'If the catchment area is disturbed, increased sediments reaching the lake would provide a substrate for the spread of aquatic macrophytes. An increased level of nutrients reaching the lake could stimulate changes in the lake's algal flora which could in time, cause deterioration in water quality, and make the lake unattractive for recreation ... Special efforts may have to be taken to preserve the quality of water in such small lakes as Middleton'.*

Oil/petrol spills and introduced weeds from boating activities, along with buried rubbish and chemical toilet waste were also considered as threats to the lake's water quality (Appendix 10). The report referred to historical water quality data in the lake from Scott (1958; see below) and Flint (1983)[22]. The results of a water sample taken in September 1975 by Flint (1983) are shown in Table 11 below.

Table 11. Lake Middleton water quality, September 1975 (Flint 1983). Referred to in the Department of Lands and Survey (1985).

Max. water depth (m)	4.4
Water temperature range (^{0}C)	3.9—5.0
pH	7.4
nitrate (mgL^{-1})	0.03
total inorganic nitrogen (mgL^{-1})	0.218
total phosphate (mgL^{-1})	0006
soluble phosphate (mgL^{-1})	0.02

Alexander and Bould (1981) in their investigation of coastal reserves for Lake Ohau, commented on water quality in Lake Middleton. The lake was described as having a surface area of 24 ha, was approximately 4.5 m deep and was geomorphically part of Lake Ohau but separated from Ohau by a shingle bar, formed by strong northerly winds. Lake Middleton had no outlet and there was no natural channel between lakes Ohau and Middleton: Seepage through the shingle bar maintained similar water levels between the two lakes. It was noted (p. 27) that:

> '*The potential for accelerated eutrophication of Lake Middleton from intensified farming practices and increased recreational use should be scientifically assessed. Such a study should make recommendations to hold or decelerate the eutrophication* processes .... *The necessity for these measures is to ensure that the highest water quality is maintained to ensure varied recreation opportunity'.*

[22] Attempts to find Flint (1983) to include in this literature summary were unsuccessful.

Thomasson (1980) reported on phytoplankton in nine South Island lakes, including Lake Middleton. All the lakes were considered oligotrophic and summer surface-water temperatures ranged between 12–17°C.

Graynoth and Skryzynski (1973) reported on the trout and salmon fishery in the Waitaki Valley, based on angler survey records. They noted that Lake Middleton was a small, shallow lake, about eight hectares in area and separated from Lake Ohau by a shingle bar.

Boud and Eldon (1960) surveyed Lake Middleton to determine the lake's suitability as a nursery pond for trout. Physical parameters of the lake were noted. The lake was described as roughly circular, covering an area of approximately 15 to 20 acres (six to eight hectares). Lake depth around the shore was estimated to be eight to ten feet (2.4–3.0 m) deep with presumed deeper water, further from the shore (Note: no soundings were taken). A small creek flowed into the lake at the '*eastern*' end of the lake and this did not appear to be subject to severe flooding, based on the stable, consolidated nature of the stream-bed sediments.

Scott (1958) reported on a field trip by the Otago University Science Students Association to the Lake Ohau area in May 1958. Physical descriptions and water quality analyses of Lake Middleton were included. The lake was described as: '*... an embayment of Lake Ohau which has been cut off by a gravel bar*'[23]. Water quality in the lake was described as clear and the bottom could be seen from the deepest point in the lake. Approximate pH readings gave a constant value of 5.3 at the surface, bottom and edge of the lake. Water temperature readings taken across the lake at a depth of two feet (0.6 m), gave a constant value of 41 °F (5 °C), although variation occurred between sample Points 1 and 2 (Table 12, Figure 7; below). The temperature at Point 2 was lower because of the tributary stream entering the lake. Table 13, below, presents further water quality data from the lake, obtained in May 1958. The plant assemblages found in the lake (Section 3.2.6, above), were '*...typical of water where reducing conditions pertain*', and the low plankton density indicated that the lake '*... is not a very productive body of water*'.

Table 12. Lake Middleton water temperatures May 1958, at Points 1 & 2 (see Figure 7, below). After Scott (1958).

Depth Inches (mm)	Water temperature °F (°C) Point 1 400 ft (122 m) from lake edge	Point 2 200 ft (61 m) from edge, opposite stream inlet
2 (50.8)	41 (5)	—
6 (152.4)	41 (5)	39.5 (4.16)
12 (304.8)	41 (5)	39 (3.88)
24 (609.6)	41 (5)	39 (3.88)

[23] Scott (1958) report has no page numbers. The quotation was made in the section titled: Part III: Lake Middleton.

Table 13. Lake Middleton water quality data. Units in gms.L[1] (After Scott 1958).

Location	NH_3	NO_2	Si	$C1^-$	CO_2	O_2	PO_{3-4}	Fe^{3+}
Edge	—	—	4	10	0.85	0.008	trace	trace
Bottom	—	—	trace	20	10	0.014	trace	—
Surface	—	—	5	14	5.5	Not tested	—	—

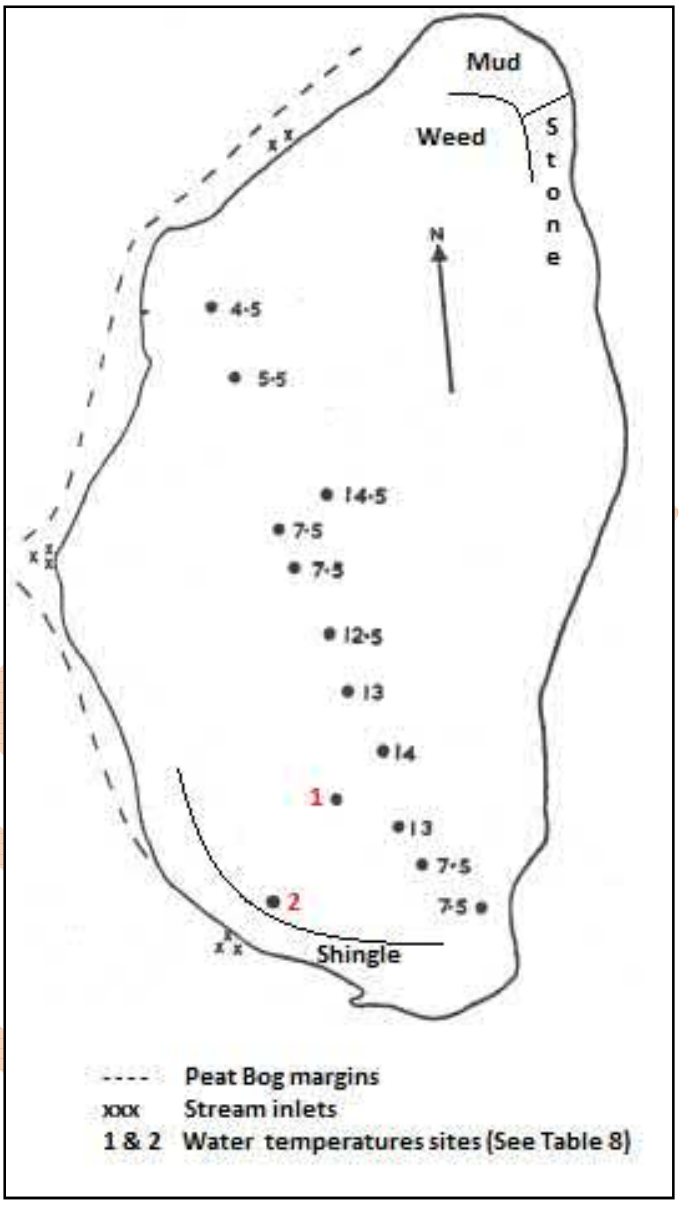

Figure 7. Lake Middleton, May 1958. Showing water depths (in feet) and bottom sediments. Lake length = 800 yards (732 m). Points 1 & 2 are water temperature measurement locations referred to in Tables 12 and 13, above (After Scott 1958).

Irwin (1975) produced a checklist of New Zealand lakes, based on a desktop study of topographic maps. For each lake, details of location, area, dimensions, altitude, and type were recorded. Details for lake Middleton are shown in Table 14, below.

Table 14. Lake Middleton data (after Irwin 1975).

Altitude (m)	Type	Area (km^2)	Max. Length (km)	Max. Width (km)	Major axis direction	Comment
517	Bar	02	0.8	0.4	North	Separated by 0.1 km strip of land from Lake Ohau and at the same level. A bar lake with associated shoreline

3.3.2 Sediments

No detailed sediment analysis of Lake Middleton's bed sediments has been undertaken but general observations show that the sediments are composed mainly of stones/gravel, with patches of sand and mud (e.g., Scott 1958; Boud & Eldon 1960; Figure 7, above). Kelly et al. (2014) calculated 2.0 tonnes/per hectare/per year of sediment entered the lake from its surrounding catchment. Streambed sediments of the tributary stream entering the lake are predominantly in the pebble gravel size-range (Scott & Irvine 2000; Figure 8, below). The gravel bar separating Lake Middleton from Lake Ohau is constantly replenished with drifting gravel on the Ohau side, especially under Nor'west conditions (e.g., Alexander & Boud 1981; Davidson 1986)

Kelly et al. (2014) modelled nutrient loads in 27 high country lakes in Canterbury, for the purpose of sustaining ecological values. Lake Middleton was included in this study. Estimates of nutrient loads (Total Nitrogen [TN], Total Phosphorus [TP] and sediment) into the lake were made using the national Catchment Land Use for Environmental Sustainability (CLUES) model. The annual sediment load into Lake Middleton from its surrounding catchment was calculated to be 2.0 tonnes/per hectare/per year. High turbidity levels in the lake were also noted and that: '*Lake Middleton had a shallower macrophyte depth than would be expected from TN and TP loads, probably because of glacial suspended material affecting turbidity*' (p. 37).

Scott and Irvine (2000) reported on the breeding competition between brown trout and rainbow trout, with one of their study sites being 'Middleton Burn', a small tributary stream which enters the south-western edge of Lake Middleton. Sediment samples from three representative trout redds in Middleton Burn were analysed for grain size, sorting and Fredle Index, using standards techniques. Figure 8 and Table 15, below, show that sediments in Middleton Burn ranged in size from coarse sand to cobble gravel, with the predominant sediment size being in the pebble gravel range.

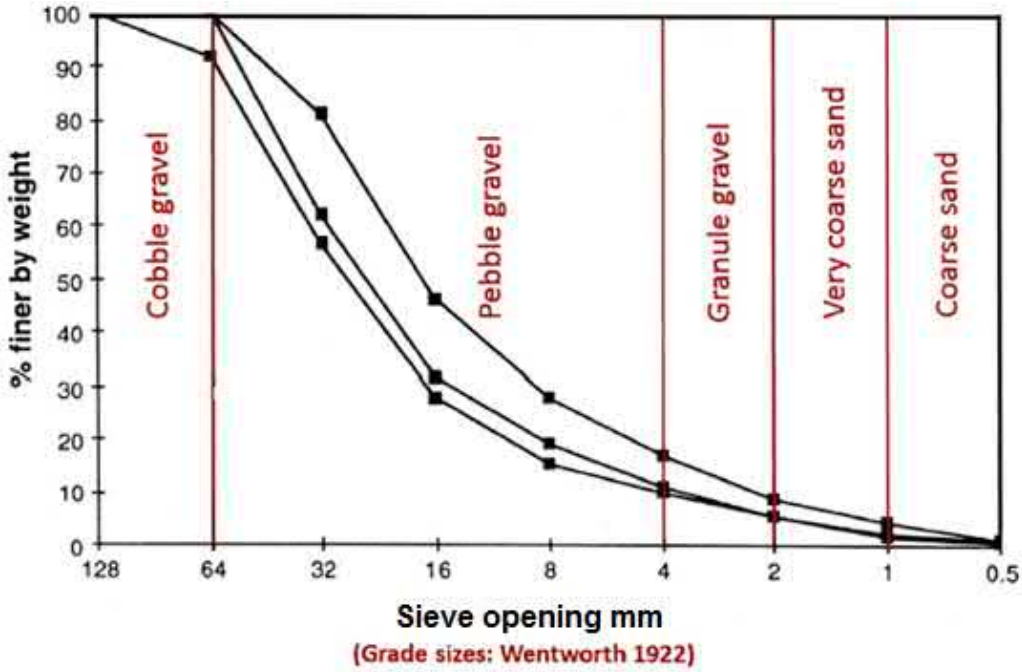

Figure 8. Cumulative frequency distribution of sediments in three representative redd samples from Middleton Burn, based on the Wentworth size and grade classes (After Scott & Irvine 2000). Note: Wentworth (1922) size & grade classes (in red) have been added to the graph for this report.

Table 15. Sediment analysis from samples collected in Middleton Burn, September 1997. Mean values (Standard Error). *n* = 11. (Scott & Irvine 2000).

Grain diameter d_g (mm)	14.9 (1.2)
Sorting S_0	1.9 (0.1)
Fredle index f_i	8.0 (0.8)
% <1.0 mm	3.2
Depth (m)	0.10 (0.01)
Velocity (m. s^{-1})	0.30 (0.02)

Davidson (1986) reported on the evolution of mountain-land recreation in New Zealand for the New Zealand *Man and the Biosphere* series, citing several historical reports. Davidson (1986) reported that around 1891, Thomas Middleton, the run-holder of Benmore Station, noted the gravel barrier separating lakes Middleton and Ohau was constantly replenished with gravel drifting along the Ohau shoreline, under nor'west conditions.

The Department of Lands and Survey (1985) commented on sediments at Lake Middleton in its management plan for the Lake Middleton Recreation Reserve. It was stated (p. 12) that: *'If the catchment area is disturbed, increased sediments reaching the lake would provide a substrate for the spread of aquatic macrophytes.*

Boud and Eldon (1960) surveyed Lake Middleton to determine the lake's suitability as a nursery pond for trout. Physical parameters of the lake were

noted. Lake Middleton was separated from Lake Ohau's southern shore by a consolidated, shingle bar approximately 50 yards (46 m) wide. Lake Middleton's bed '*... was composed mainly of stones and gravel and with occasional patches of sand*' (p. 1). The bed of the creek flowing into Lake Middleton was composed of '*... stable, well consolidated gravel, that does not appear subject to severe flooding*' (p. 2).

Scott (1958) reported on a field trip by the Otago University Science Students Association to the Lake Ohau area in May 1958. Sediments descriptions from the bed of Lake Middleton were included. The lake was described as: '*... an embayment of Lake Ohau which has been cut off by a gravel bar*'[24]. The bottom of the lake was mostly stony with some muddy areas. Some terrigenous bed material was present. The western margin of the lake was described as peat bog. (Figure 7, above).

3.3.3 Landscape and visual values

It is generally accepted that Lake Middleton and its immediate surrounds (e.g., Lake Ohau basin) have significant or outstanding landscape and visual values, on both regional and national scales. As the upper reaches of the lake's catchment are located within the Ahuriri Conservation Park (Figure 1), landscape values in this area are protected under the Conservation Act (1987). Landscape and visual values of the lake and its margins (recreation reserve) are protected under the Reserves Act (1977) and a small slither of this land, at the northern end of the lake, is gazetted under the Conservation Act (1987), as the Lake Ohau West Conservation Area (Figure 2, above).

Hughes (2013) reported to Fish and Game and DOC on the fishery values of Lake Middleton. This report was produced in relation to restricted public access into the recreation reserve. In this report, Lake Middleton was described as '*picturesque*'.

Boffa Miskell (2010) prepared a report reviewing the Canterbury landscape for ECan. It was stated (p. 142) that:

> '*The entire Mackenzie Basin ... has been identified as an Outstanding Natural Feature and Landscape. This landscape contains areas of exceptional legibility, aesthetic, transient, shared and recognised, very high natural science and high tangata whenua and historic landscape values*'.

The Waitaki Catchment Water Allocation Board (2006) in the Waitaki Catchment Water Allocation Regional Plan, noted the natural values of rivers and lakes in the Waitaki River catchment. Objectives, policies and rules to protect these values are provided. Lake Middleton was noted for '*High natural character*', and '*High landscape and visual amenity values*'. A

[24] Scott (1958) has no page numbers. The quotation was made in the section titled: Part III: Lake Middleton.

potential water allocation issue identified, was retaining the lake's high natural character state.

Daly (2004) produced an inventory of instream values for Canterbury's rivers, lakes and waterways based on a desktop study. In this report (p. 62), it was stated that:

> '*The Mackenzie Basin landscape including its lakes is the most outstanding feature in the Canterbury Region. Lakes, rivers, streams and tarns provide an important component to the landscape*'.

Sutherland-Downing et al. (2003) produced an inventory of recreational values for rivers and lakes of Canterbury based on a desktop study. Lake Middleton was ranked as '*High*' value for scenic appeal and '*Moderate–High*' value for sight-seeing.

The Conservation Act (1987) Part 4, Section 19 states that conservation parks shall be managed so: '*... that its natural ... resources are protected ...*'. As the upper reaches of the Lake Middleton catchment are located within the Ahuriri Conservation Park (Figure 1), landscapes, landforms and geological features within this area are protected under the Conservation Act.

3.4 Recreation values

Lake Middleton and its immediate surrounds are gazetted as a recreation reserve (Figure 2, above), under the Reserves Act (1977). Recreational activities undertaken at the lake include angling, camping, walking, swimming, picnicking, barbequing, boating and jet-skiing (e.g., Sutherland-Downing et al. 2003; Figure 9). Lake Middleton has been popular for trout angling for 125 years (e.g., Anon 1895) and for many years over the summer months, has been a popular camping site.

Figure 9. The northern end of Lake Middleton showing multiple recreational activities being pursued: Camping, mountain-biking, boating and paddle-boarding (Photograph: Viv Smith-Campbell, January 2018).

Jones (2015) documented the legal change of management of Lake Middleton Recreation Reserve, from the cancellation of vesting of the reserve in the Waitaki District, to vesting it back to DOC. Jones (2015) provided historical details of the recreation reserve, its various gazette notices, recreation and conservation values. The changing status of the lake, over time, is shown in the maps of Appendix 1.

Hughes (2013) reported to Fish and Game and DOC on the fishery values of Lake Middleton. This report was produced in relation to restricted public access into the recreation reserve and recent land-ownership issues. It was noted that the lake had been a popular fishery since the 1890s and that it had: '*... always been a highly prized and patronised fishery*' (p. 1). The lake was considered a small, but locally important fishery and was also very popular with campers, boaters and day-trippers. It was a safe waterbody for many different users.

The Waitaki District Council's (2010) district plan mentions recreational activities on the surface of water bodies and has policies and rules relating to them. The plan (p. 25) states: '*Lake Middleton is a small lake popular for water skiing and is frequently used for recreation and camping during the summer months*.' The lake was one of the few places identified in the district where recreational conflict occurred, as jet-skis can be a problem for other users of the lake.

The Waitaki Catchment Water Allocation Board (2006) in the Waitaki Catchment Water Allocation Regional Plan, noted the natural values of rivers and lakes in the Waitaki River catchment. Objectives, policies and rules to protect these values are provided. Recreation values identified at Lake Middleton included fishing, water fowl hunting and visual amenity values.

Daly (2004) produced an inventory of instream values for Canterbury's rivers, lakes and waterways, based on a desktop study. It was stated (p. 62) that: '*Lake Middleton is a small lake, popular for water skiing, and camping in summer*'.

O' Neill and Pfluger (2003) reported on tourism and recreation activities in the Waitaki River catchment, based on the collation and presentation of existing studies. Fishing activity at Lake Middleton, as described by Bushe (2003) and Kent (1998; see below) was noted, and data from national angler surveys in 1994/6 and 2001/02 for the lake were presented (Table 16, below). The Department of Conservation's (Twizel) Recreation Programme Manager stated that Lake Middleton gets a lot of use and gets very full, over the summer months.

Table 16. Estimated usage (angler-days ± 1 standard error) at Lake Middleton. After O'Neill & Pfluger (2003).

2001/02							1994/96 Total
Oct - Nov	Dec -Jan	Feb- Mar	Apr-May	Jun-Jul	Aug-Sep	Total	
-	20±20	30±30	-	-	-	40±30	880±350

Bushe (2003: p. 215) produced a guide to trout fishing in the South Island, covering 115 fishing spots. Details focussed on location, access, and fishing methods (lures, flies, best times etc). Lake Middleton was *'... used for recreational purposes and although it holds a small stock of trout it is not worth the effort of fishing.'*

Sutherland-Downing et al. (2003) produced an inventory of recreational values for rivers and lakes of Canterbury, based on a desktop study. Recreation values for Lake Middleton generally ranked as *'Moderate–High'*. The lake had *'Moderate–High'* value for sight-seeing, walking, picnicking, barbequing, camping, swimming, paddling, wading, boating, jet-skiing, water-skiing, sailing and board-sailing. The lake had '*Moderate*' value for trout fishing and '*Low*' value for bird-watching. Good camping facilities on the lake margins were easily accessible.

Kent (1998) produced a guide to trout fishing in the South Island and described Lake Middleton as: *'This small lake contains small brown and rainbow trout, but the lake is often disturbed by water-skiers and swimmers, and there's better fishing in waters close by.'* (p. 157).

Jarman (1987) reported on wildlife and '*Sites of Special Wildlife Interest*' (SSWI) in the upper Waitaki River catchment and adjacent areas for the New Zealand Wildlife Service. It was noted (p. 77) that Lake Middleton was: '*... used extensively for recreation (fishing, boating, camping, picnicking etc)*'.

The Conservation Act (1987) Part 4 Section (19) states that conservation parks shall be managed so as to: *'... to facilitate public recreation and enjoyment*'. As the upper reaches of the Lake Middleton catchment are located within the Ahuriri Conservation Park (Figure 1), recreation values in this area are protected under the Conservation Act.

Davidson (1986) reported on the evolution of mountain-land recreation in New Zealand for the New Zealand *Man and the Biosphere* series, citing a number of historical reports. Lake Middleton was noted as locally important for fishing, picnicking, camping, swimming, boating and water-skiing. The first record of water-skiing on the lake was in the 1950s. Power-boats were acknowledged as a danger to swimmers in the lake. Because of its popularity for the recreation activities mentioned, the lake and its surrounds were a closed-game area (no shooting/hunting allowed).

The Department of Lands and Survey (1985) summarised the history and recreational use and values of Lake Middleton, in its management plan for the Lake Middleton Recreation Reserve. In 1969, an area of land around and to the north of the lake, was separated out from the Shelton Downs Pastoral Lease, for the purpose of formalising its use as a camping and recreation reserve. In 1980, the lake bed, a 20 m strip around the lakeshore and seven hectares of land to the north of the lake were gazetted as the '*Lake Middleton Recreation Reserve*'. In 1982 an additional 20 m strip around the lakeshore was gazetted. Even before the recreation reserve was gazetted, the land to the north of the lake had been popular with campers, with numbers increasing on a yearly basis. Each year over the Christmas–January period, the lake was: *'... subject to intense recreational use from growing numbers of campers'* (p. 15), who used the camping ground at the northern end of the lake. The lake was used for fishing, swimming, power-boating, water-skiing, and rabbit shooting around the margins. A small number of day visitors also used the reserve.

Adcock (1984) produced the Wetlands of Ecological and Representative Importance (WERI) database and user guide for DOC. In this database, Lake Middleton was noted as a recreation reserve used extensively for water sports and passive recreation. The high recreation use was also noted as being disruptive to water fowl on the lake.

Alexander and Bould (1981), investigated coastal reserves for Lake Ohau and commented on recreation use at Lake Middleton. The lake was noted for a number of boat-launching sites, its easy off-road parking and informal camping sites, especially on Crown Reserve land at the northern end of the lake, amongst the exotic trees. Shallow lakes, such as Lake Middleton, were more popular with swimmers, boaters and anglers, than the deep, glacial-fed lakes in the Mackenzie Basin. It was recommended that seven hectares of Crown Reserve land at the northern end of the lake should be formally gazetted as a recreation reserve. Public access issues were also noted. At the northern end of the lake there was a 40 m wide public reserve, but there was no indication of the change of status between private and public land, as five fences ran radially into the lake. It was suggested (p. 27) that: '*The run owner should be compelled to erect suitable stiles over these fences and erect suitable public reserve notices supplied by the Department of Lands and Survey'*.

Tane and Patterson (1978) assessed changing land-use (and vegetation cover) in the Waitaki Basin, based on field surveys and a search of historical records. Several campsites were noted around Lake Ohau: '*The most popular are around Lake Middleton, a smaller warm lake close to Lake Ohau's western shores*' (p. 8).

The Reserves Act (1977) Part 3, Section 17 (1) states the purposes of a recreation reserve are for providing areas of recreation and sporting activities, physical welfare and enjoyment of the public, and protection of the natural environment, amongst other things. Because of such matters

and the general popularity of Lake Middleton, the Lake Middleton Recreation Reserve was gazetted in 1980, under the Reserves Act.

Graynoth and Skrzynski (1973) reported on the Waitaki Valley trout and salmon fishery, based on angling results collected by three angling diary schemes between 1957 and 1967. Adequate data for Lake Middleton was obtained from 1962 only. Based on the 1962 data, the lake was very popular with anglers, despite its small size: 32 rainbow trout were caught, having an average length of 43.2 cm. The catch rate was high (0.71 fish per hour) and most fish were caught on minnows, which was twice as successful as spoon fishing.

Anon. (1895, 1897a, b, c)[25] show that Lake Middleton has been used for recreational angling for at least 125 years. As far back as the 1890s, the trout fishery of the lake was recognised, with numerous newspaper reports commenting on fishing trips to the lake and the number and good condition of the fish that were caught.

4. Conclusion

A literature review has shown that the Lake Middleton catchment has many intrinsic, instream (and terrestrial) values, based on the number of indigenous species found there, its outstanding/significant landscape, and recreational importance. These values are under increasing risk from a variety of threats, including introduced mammalian predators, aquatic and terrestrial weeds (habitat competition), and human activities.

Several measures have been developed to protect these values. Various organisations/agencies have undertaken environmental monitoring and reporting, to determine trends in such things as water quality, species presence etc. Regional and territorial authorities have recognised Lake Middleton's values and the importance of protecting them, through objectives, rules and policies in statutory, regional and district plans, whilst other organisations and community groups have developed management plans and strategies to protect and enhance the natural and recreational values of the lake and its surrounds.

Relatively little (or no) literature was found for the Lake Middleton catchment in relation to native fish (most information related to the trout fishery), detailed bird surveys (most information was from casual observations); lizards (no specific information); terrestrial invertebrates (none found), native terrestrial plants (most information related to introduced species), detailed recreation use (limited angler surveys only) and lake-bed sediments (general observations only).

[25] These newspaper articles are a sample only and have not been separated out, owing to their similar content.

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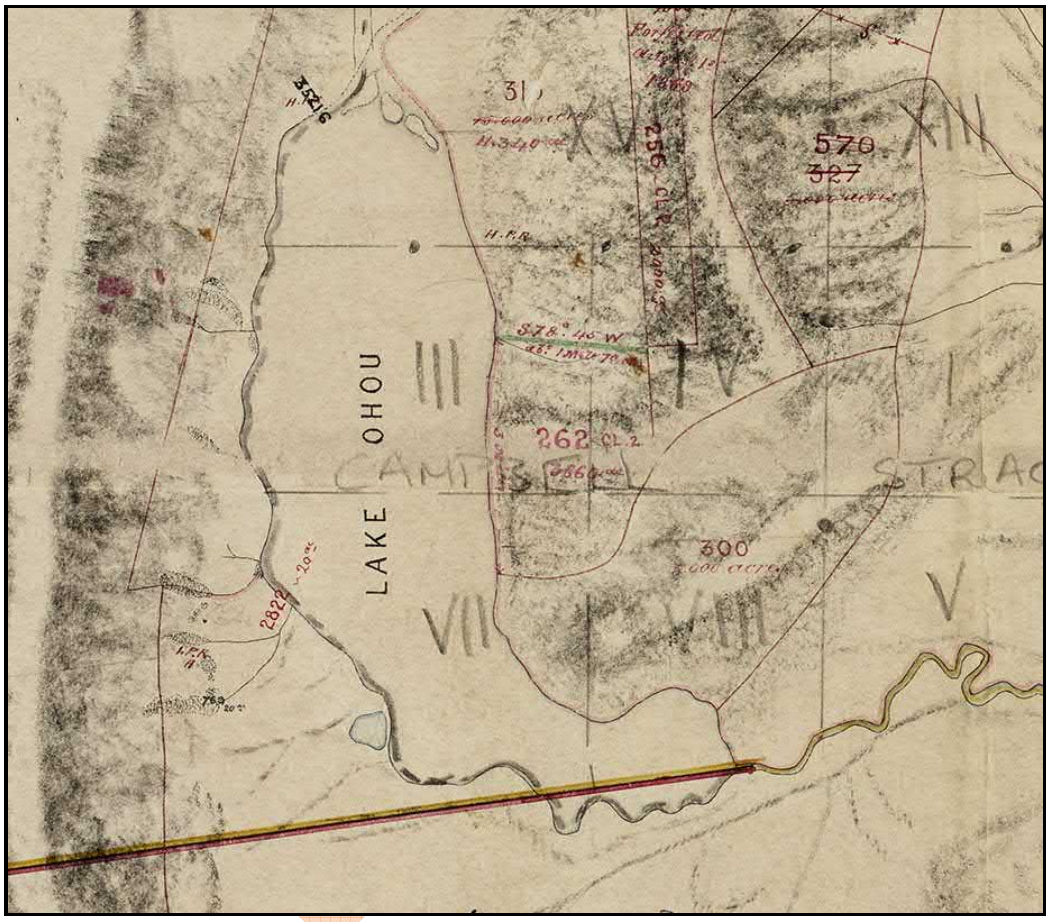
Watt, J.D. 1915. S.O. 244. Plan of part of Benmore (Runs 725 and 556): Section I, Bk. II & Section I Bk. VI. (Note: Survey date – Map release date was 1917, uncertain who by).

6. Appendices

Appendix 1.

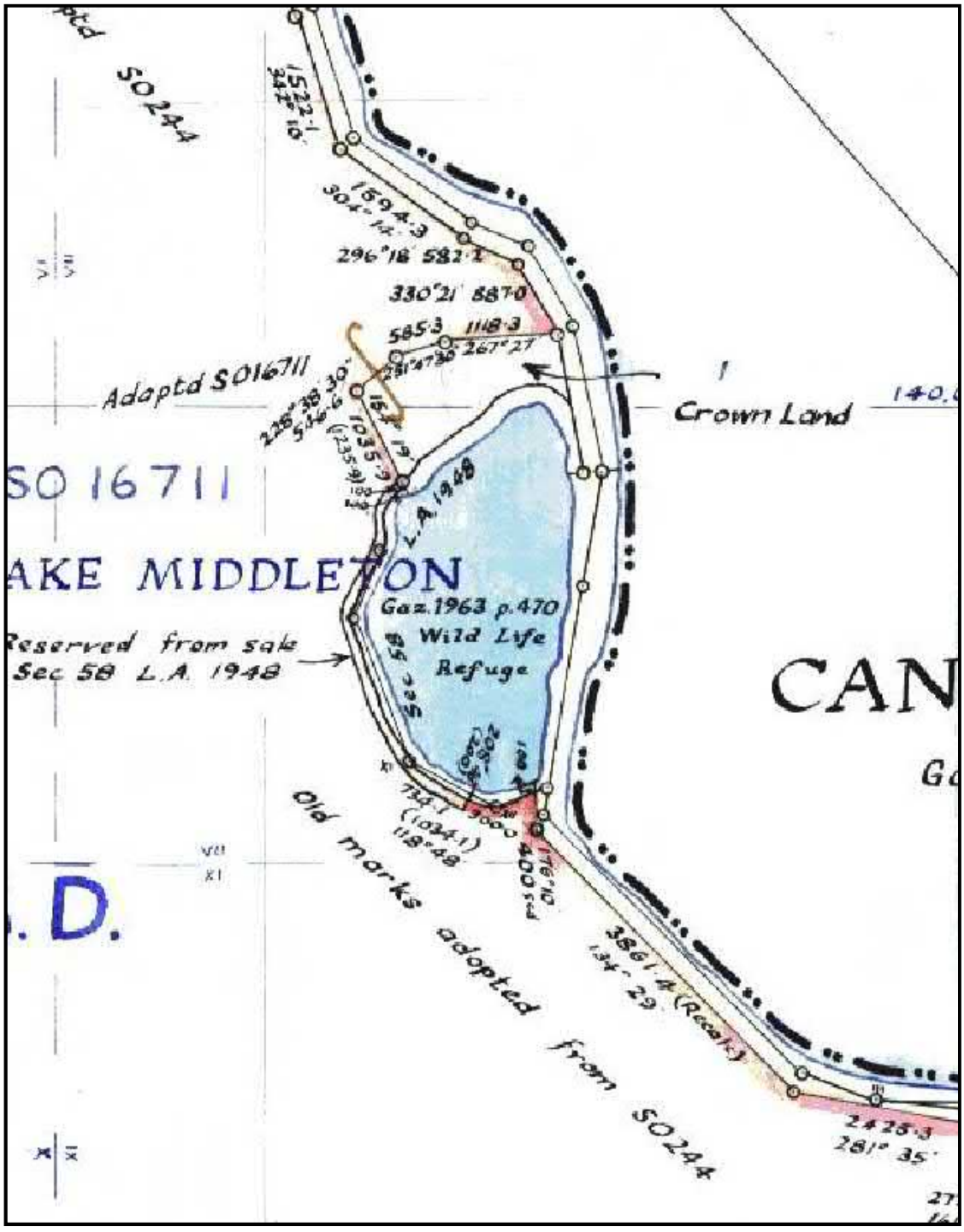
Sections of selected historical maps of the Lake Middleton, showing the lake's changing legal status over time.

Map 1. (Anon. 1860). Map of the country between the Rivers Rangitata and Waitangi. Earliest survey map found, showing Lake Middleton (un-named, to the left of Lake Ohau).

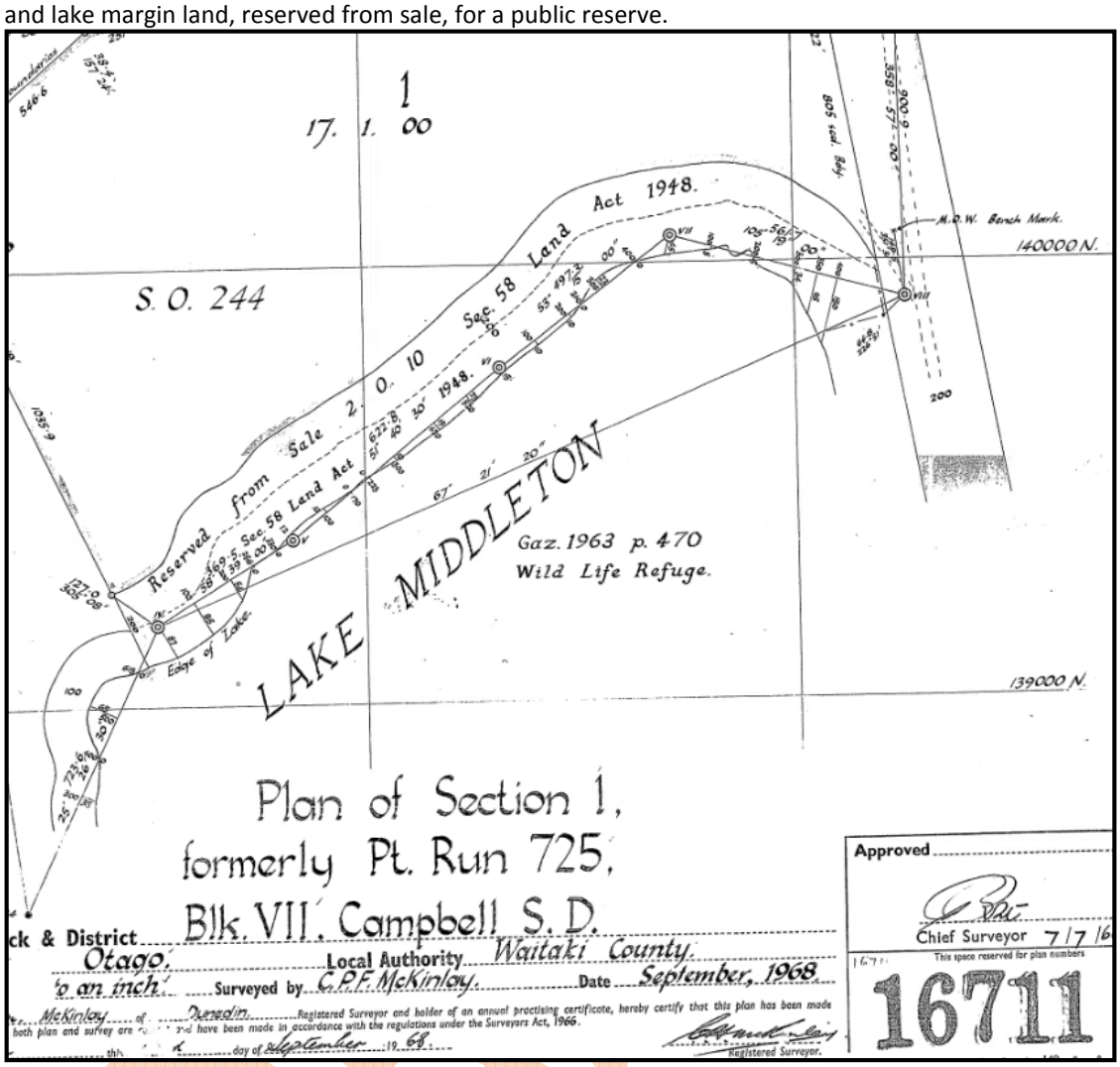


Map 2: S.O. 244.Water (1917). General map of Lake Middleton area.

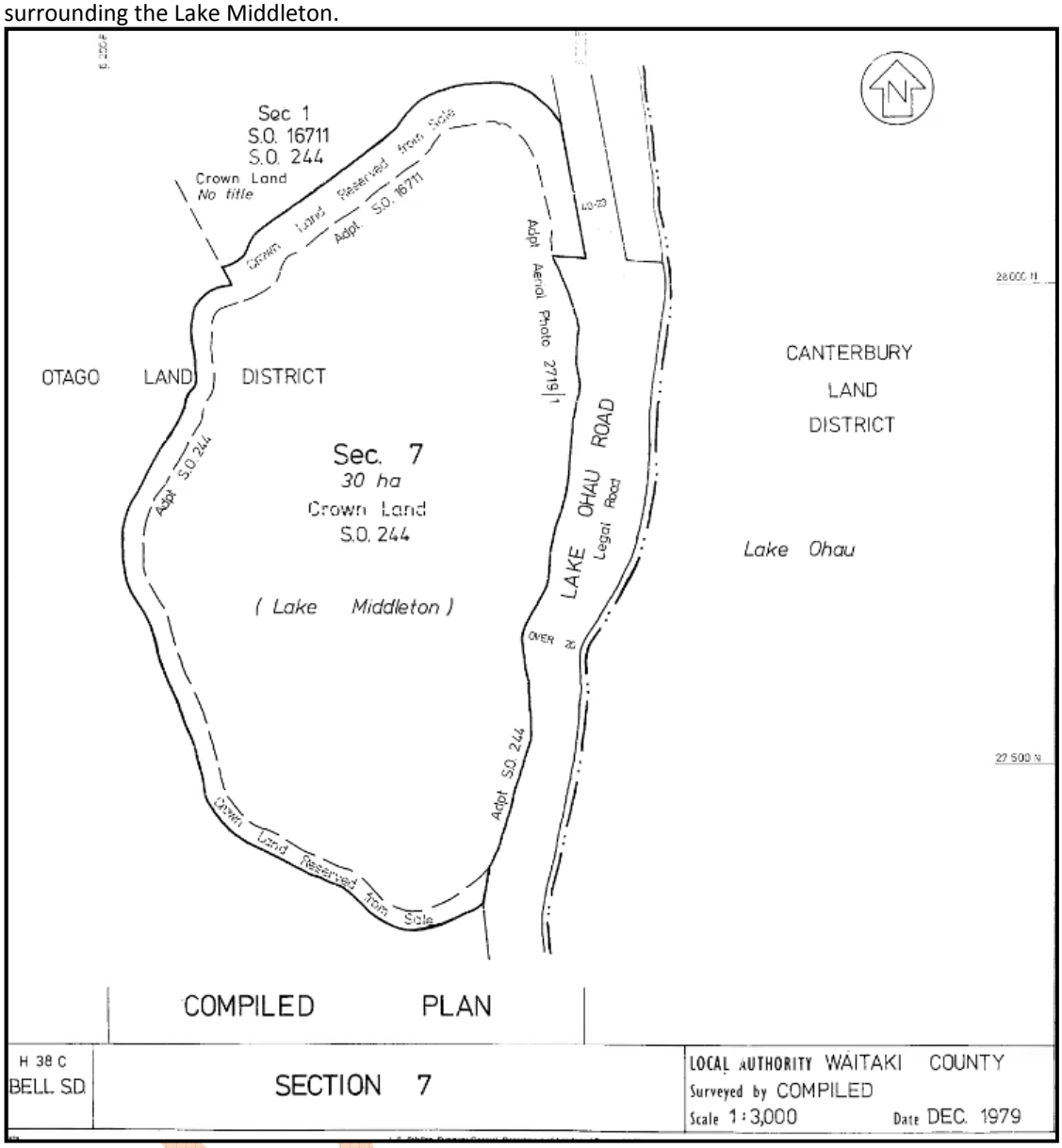
Map 3: S.O. 16836. Adams (1969). Showing Lake Middleton gazetted as a Wildlife Refuge.



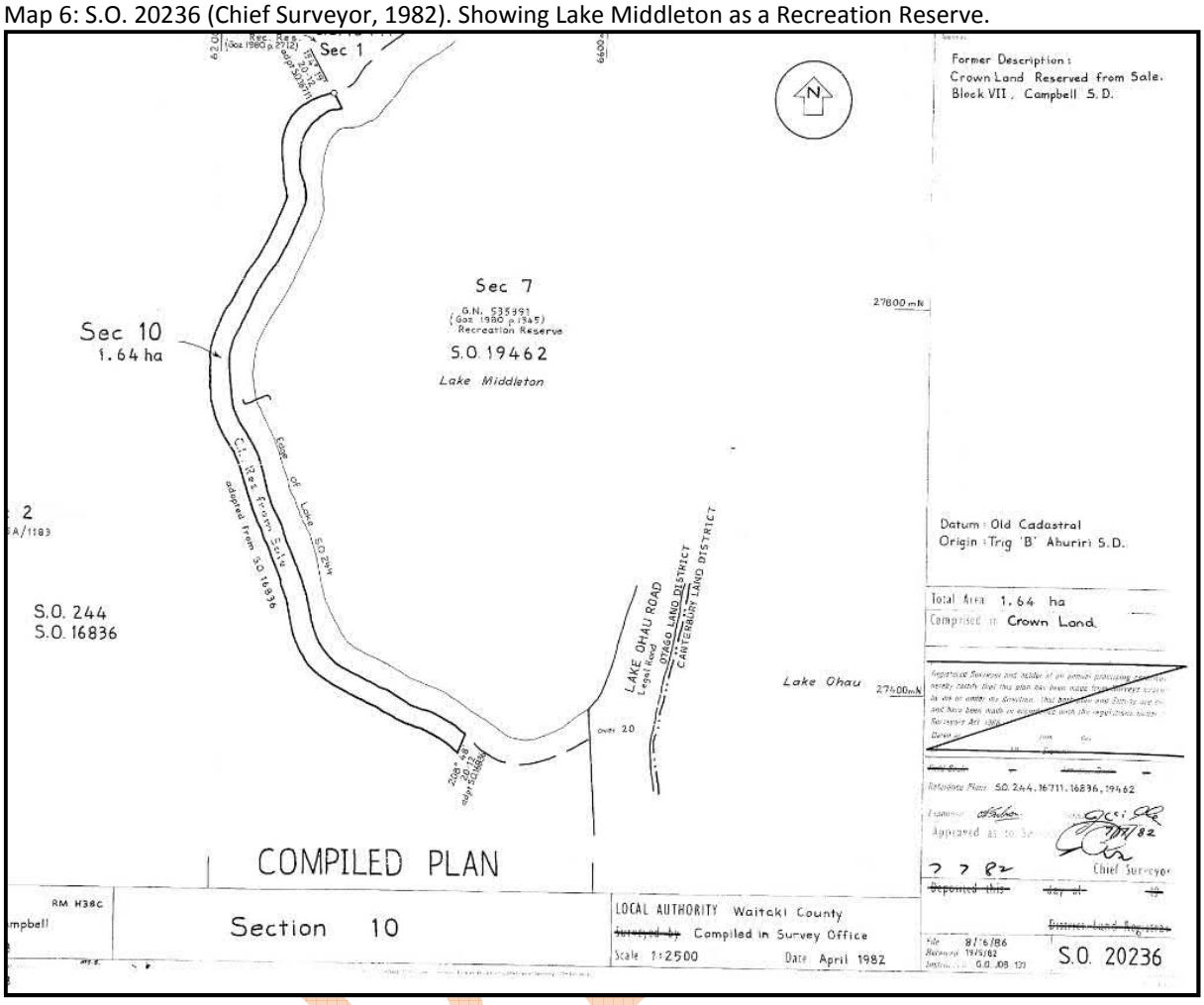
Map 4: S.O. 16711 (Chief Surveyor 1969). Showing the northern end of Lake Middleton wildlife refuge and lake margin land, reserved from sale, for a public reserve.



Map 5: S.O. 19462 (Deputy Chief Surveyor, 1980). Showing the publicly reserved land and legal road surrounding the Lake Middleton.



Map 6: S.O. 20236 (Chief Surveyor, 1982). Showing Lake Middleton as a Recreation Reserve.



Appendix 2

Fish species identified in the Lake Middleton catchment. Species names and conservation status from Dunn et al. (2018). Māori names from DOC and Ngāi Tahu (accessed May 2013). New Zealand Freshwater Fish Data Base (NIWA 2019) accessed 20.4.2019.

Species name	Common name	Conservation status	References
Galaxias brevipinnis	koaro	Declining	DLS 1985
Galaxias vulgaris	Canterbury galaxias	Declining	DLS 1985
Gobiomorphus breviceps	upland bully	Not threatened	NIWA 2019
Gobiomorphus cotidianus	common bully	Not threatened	DLS 1985
Gobiomorphus spp.	bullies	-	Boud & Eldon 1960; Graynoth et al. 1986
Oncorhynchus mykiss	rainbow trout	Introduced & naturalised	Anon. 1895, 1897a, b, c; Boud & Eldon 1960; Graynoth & Skrzynski 1973; DLS 1985; Graynoth et al. 1986; Jeppesen et al. 2000; Hughes 2000, 2013; NIWA 2019; Scott & Irvine 2000
Salmo trutta	brown trout	Introduced & naturalised	Anon. 1895, 1897a, b, c; Boud & Eldon 1960; Graynoth & Skrzynski 1973; DLS 1985; Jeppesen et al. 2000; Hughes 2000, 2013; NIWA 2019; Scott & Irvine 2000

Notes: DLS = Department of Lands and Survey. NIWA = National Institute of Water and Atmospheric Research. Davidson 1986 & the Waitaki Catchment Water Allocation Board (20006) both refer to '*the trout fishery*' in lake Middleton but which species is not defined.

Appendix 3

Birds recorded at (or around) Lake Middleton. Species names and conservation status and from Robertson et al. (2018).

Species name	Common name	Māori name	Conservation status	References	Smith-Campbell (2019) Observations	
					Occurrence	Comments
Anas superciliosa	grey duck	pārera	Nationally critical	*DLS 1985; Jarman 1987		
Laruas bulleri	black-billed gull	tarāpuka	Nationally critical	Jarman 1987		
Himantopus novaezelandiae	black stilt	kakī	Nationally critical	Daly 2004		
Chlidonias albostriatus	black-fronted tern	tarapirohe	Nationally endangered	Smith-Campbell 2019	Seasonal visitor – spring & summer	
Podiceps cristatus australis	southern crested grebe	kāmana	Nationally vulnerable	O'Donnell 2002; Pollock 2003; O'Donnell & West 1994; **WCWAB 2006; Smith-Campbell 2019	Resident pair breeding on lake. Occasional visits by others.	Bred successfully twice a year for the last 2 years on a floating raft installed by the OCT. 5 chicks fledged.
Anthus novaeseelandiae novaeseelandiae	New Zealand pipit	pihoihoi	Declining	Smith-Campbell 2019	Most likely – seen and heard on western shore grasslands.	
Haematopus finschi	South Island pied oyster catcher	torea	Declining	Smith-Campbell 2019	Seasonal visitor	Seen feeding around the lake edge
Falco novaeseelandiae novaeseelandiae	Eastern falcon	kārearea	Recovering	Smith Campbell 2019	Regularly seen around the lake	Regular visitors around Lake Ohau Village & Lake Middleton
Phalacrocorax carbo novaehollandiae	black shag	kōau	Naturally uncommon	DLS 1985; Smith-Campbell 2019	Resident and possibly breeding	Often seen in large pine trees at the end of the lake
Acanthisitta chloris chloris	South Island rifleman	titipounamu	Not threatened	Smith-Campbell 2019	Resident & breeding	Significant population in willows & larch along eastern edge of lake
Anthornis melanura melanura	bellbird	korimako	Not threatened	DLS 1985; Jarman 1987; Smith-Campbell 2019	Resident & likely breeding	Significant population around lake and Lake Ohau Village

Aythya novaeseelandiae	New Zealand scaup	pāpango	Not threatened	Smith-Campbell 2019	Resident & probably breeding	Large population over autumn and winter when lake isn't used much by motor boats
Chrysococcyx lucidus lucidus	shining cuckoo	pīpīwharauroa	Not threatened	Smith-Campbell 2019	Heard	
Cygnus atratus	black swan	-	Not threatened	DLS 1985; Smith-Campbell 2019	Seasonal visitor – has bred at the lake in 2018/19	
Circus approximans	swamp harrier	kāhu	Not threatened	DLS 1985; Jarman 1987; Smith-Campbell 2019	Regularly seen around the lake	
Egretta novaehollandiae	white-faced heron	matuku-moana	Not threatened	DLS 1985; Jarman 1987; Smith-Campbell 2019;	Resident	Regularly seen feeding around the lake edge
Gerygone igata	grey warbler	riroriro	Not threatened	DLS 1985; Jarman 1987; Snith-Campbell 2019	Resident & breeding	
Hemiphaga novaeseelandiae	New Zealand pigeon	kererū	Not threatenened	Smith Campbell 2019	Very occasional visitor	Resident population north of lodge, along Lake Ohau – visiting birds seen a Lake Middleton
Himantopus himantopus leucocephalus	pied stilt	poaka	Not threatened	Smith-Campbell 2019	Seasonal visitor	Seen feeding around the lake edge
Larus dominicanus	Southern black-backed gull	kororo	Not threatened	DLS 1985; Jarman 1987		
Petroica macrocephala macrocephala	yellow-breasted tomtit	mirmiro	Not threatened	Smith-Campbell 2019	Occasionally seen	
Phalacrocorax melanoleucos brevirostris	little shag	kōau	Not threatened	Smith-Campbell 2019	Resident & possibly breeding	Often seen in large pine trees at south end of lake
Prosthemadera novaeseelandiae novaeseelandiae	tui	tūī	Not threatened	Smith Campbell 2019	Very occasional visitor	Seen around the village and at the lake occasionally (often in winter)
Rhipidura fuliginosa fuliginosa	South Island fantail	pīwakawaka	Not threatened	Smith-Campbell 2019	Resident & breeding	Significant population
Tadorna variegata	paradise shelduck	pūtakitaki	Not threatened	Wayte 1891; DLS 1985; Jarman 1987; Smith-Campbell 2019	Resident and usually a breeding pair on the lake	Juveniles often in and around the lake

Vanellus miles novaehollandiae	spur-winged plover	-	Not threatened	DLS 198; Smith-Campbell 2019	Seasonal visitor	
Zosteros lateralis lateralis	silvereye	tauhou	Not threatened	Jarman 1987; Smith-Campbell 2019	Resident & probably breeding	Significant population
Alauda arvensis	skylark		Introduced & Naturalised	Smith-Campbell 2019	Heard & seen on western shore grasslands	
Alectoris chukar	chukor	-	Introduced & Naturalised	DLS 1985		
Anas platyrhynchos	mallard	-	Introduced & Naturalised	Jarman 1987; Smith-Campbell 2019	Resident & breeding	
Carduelis carduelis	goldfinch	-	Introduced & Naturalised	DLS 1985; Smith-Campbell 2019	Seen	
Carduelis chloris	greenfinch	-	Introduced & Naturalised	Smith-Campbell 2019	Occasionally seen	
Columba livia	rock pigeon	-	Introduced & Naturalised	DLS 1985		
Branta canadensis	Canada goose	-	Introduced & Naturalised	DLS 1985; Jarman 1987; Smith-Campbell 2019	Seasonal visitor	Often large flocks visit the lake then move on
Carduelis flammea	redpoll	-	Introduced & Naturalised	DLS 1985		
Emberiza cirlus	cirl bunting	-	Introduced & Naturalised	Smith-Campbell 2019	Seen	
Emberiza citrinella	yellowhammer	-	Introduced & Naturalised	DLS 1985; Smith-Campbell 2019	Seen	
Fringilla coelebs	chaffinch	-	Introduced & Naturalised	DLS 1985; Smith-Campbell 2019	Common	
Gymnorhina tibicen	Australian magpie	-	Introduced & Naturalised	DLS 1985; Smith-Campbell 2019	Common	Until 5 years ago, were uncommon but a significant population is now present all the way up Lake Ohau & the Hopkins Valley.
Passer domesticus	house sparrow	-	Introduced & Naturalised	DLS 1985; Smith-Campbell 2019	Common	

Prunella modularis	dunnock	-	Introduced & Naturalised	DLS 1985; Smith-Campbell 2019	Common
Turdus merlula	blackbird	-	Introduced & Naturalised	DLS1985; Smith-Campbell 2019	Common
Turdus philomelos	song thrush	-	Introduced & Naturalised	DLS 1985; Smith-Campbell 2019	Common

Note: *DLS = Department of Lands and Survey; **WCWAB = Waitaki Catchment Water Allocation Board

Appendix 4

Freshwater invertebrates recorded at/near Lake Middleton (Boud and Eldon 1960). Species names from Boud & Eldon (1960) & Grainger et al. (2018). Conservation status from Grainger et al. (2018).

Species name	Common name	Māori name	Conservation status	References
Echyridella menziesii	Freshwater mussel	kākahi	Declining	Bowie 2011
Potamopyrgus antipodarum	snail	-	Not threatened	Boud & Eldon 1960
Glyptophysa (Isodora) sp.	snail	-	-	Boud & Eldon 1960
Lymnaea spp.	snail	-	-	Boud & Eldon 1960
Chiromidae	two-winged fly	-	-	Boud & Eldon 1960
Dyticidae	beetle	-	-	Boud & Eldon 1960
Deliatidium spp.	mayfly	-	-	Boud & Eldon 1960
Hydrobiosis spp.	caddisfly	-	-	Boud & Eldon 1960
Hydroptera spp	caddisfly	-	-	Boud & Eldon 1960
Pycnocentrodes spp.	caddisfly	-	-	Boud & Eldon 1960
Triplectides (Pseudonema) spp.	caddisfly	-	-	Boud & Eldon 1960
Sphaerium spp.	pea clam	-	-	Boud & Eldon 1960
Tubificid	worm	-	-	Boud & Eldon 1960
Xanthocnemis (Xanthoagrion)	damselfly/dragonfly	-	-	Boud & Eldon 1960

Note: Names in brackets are original names used by Boud & Eldon (1960).

Appendix 5

Lizards presumed to be in the Lake Middleton catchment. Department of Lands and Survey (DLS 1985). Species un-named, therefore conservation status is unknown.

Scientific name	Common name	References
Scincidae	Skinks	DLS 1985
Gekkonidae	Geckos	DLS 1985

Appendix 6

Introduced and naturalised wild mammals in the Lake Middleton catchment. Department of Lands and Survey (DLS 1985) and Ohau Conservation Trust (OCT 2017).

Scientific name	Common name	References
Erinaceus europaeus	hedgehog	DLS 1985
Oryctolagus cuniculus	rabbit	DLS 1985
Felix domesticus	cat	DLS 1985; OCT 2017
Mustela ermina	stoat	DLS 1985; OCT 2017
Mustela nivalis	weasel	DLS 1985; OCT 2017
Mustlela furo	ferret	DLS 1985; OCT 2017
Rattus spp.	rat	DLS 1985; OCT 2017
Trichosurus vulpecula	possum	DLS 1985; OCT 2017

Appendix 7

Plants recorded in/around Lake Middleton. Conservation status and scientific names from de Lange et al. (2018), the New Zealand Plant Conservation Network website (Accessed 5 April 2019), and Landcare Research – New Zealand Plants website (Accessed April 2019).

Species	Common name	Māori name	Conservation status	References
Kunzea serotine	mānuka	manuka	Nationally vulnerable	Espie et al. 1984
Discaria toumatou	matagouri	tūmatakuru	Declining	Espie et al. 1984
*Chara australis**	stonewort		Not threatened	Champion et al. 2006; de Winton & Burton 2017
*Chara fibrosa**	stonewort		Not threatened	Champion et al. 2006; de Winton & Burton 2017
Chionochloa rubra subsp.	red tussock	haumata	Not threatened	Espie et al. 1984
Corokia cotoneaster	wire-netting bush	korokio	Not threatened	Head (2017, pers. comm).
*Elatine gratioloides**	-	-	Not threatened	Champion et al. 2006
*Eleocharis pussila**	-	-	Not threatened	Champion et al. 2006
Festuca novae-zelandiae	fescue tussock	-	Not threatened	DLS 1985
*Glossostigma diandrum**[26]	mudmat	-	Not threatened	Champion et al. 2006; de Winton & Burton 2017
*Isoetes alpina**	alpine quillwort	-	Not threatened	Scott 1958; Espie et al. 1984; DLS 1985; Champion et. 2006; NIWA 2014; de Winton & Burton 2017
*Lilaeopsis novae-zelandiae**	-		Not threatened	DLS 1985
*Lilaeopsis ruthiana**	-	-	Not threatened	Champion et al. 2006; de Winton & Burton 2017
*Limosella lineata**	mudwort	-	Not threatened	Champion et al. 2006
*Myriophyllum pedunculatum**	-	-	Not threatened	Champion et al. 2006
*Myriophyllum propinquum**	common water milfoil		Not threatened	Champion et al. 2006; de Winton & Burton 2017
*Myriophyllum triphyllum**	water milfoil	-	Not threatened	Espie et al. 1984; DLS 1985; NIWA 2014; de Winton & Burton 2017
*Myriophyllum votchii**	-	-	Not threatened	Champion et al. 2006
*Nitella hookeri**	stonewort	-	Not threatened	Champion et al. 2006
*Nitella hyaline**	stonewort	-	Not threatened	Champion et al. 2006

[26] Called *Glossostigma submersum* in Chapman et al. 2006.

*Nitella pseudoflabellata**	stonewort	-	Not threatened	Champion et al. 2006; de Winton & Burton 2017
*Pilularia novae-hollandiae**	pilwort	-	Not threatened	Champion et al. 2006
*Potamogeton cheesemanii**	red pondweed	-	Not threatened	Scott 1958; Espie et al. 1984; DLS 1985; Champion et al. 2006; NIWA 2014; de Winton & Burton 2017
*Ranunculus limosella**	mud buttercup	-	Not threatened	de Winton & Burton 2017
*Utricularia dichotoma**[27]	-	-	Not threatened	Champion et al. 2006
Coprosma spp.	coprosma	karamū	?	DLS 1985
Adropogon virginicus	broom	-	Introduced & naturalised	OCT 2017
Betula pendula	silver birch	-	Introduced & naturalised	OCT 2017
Ceratophyllum demersum	hornwort	-	Introduced & naturalised	OCT 2017
Cotoneaster spp.	cotoneaster	-	Introduced & naturalised	OCT 2017
*Elodea canadensis**	Canadian pondweed	-	Introduced &naturalised	Champion et al. 2006; de Winton & Burton 2017
Hieracuim lepidulum	hawkweed	-	Introduced & Naturalised	OCT 2017
*Lagarosiphon major**	lagarosiphon	-	Introduced & naturalised	Champion et al. 2006; OCT 2017
Larix deciduas	larch	-	Introduced & naturalised	Adcock 1984; Espie et al. 1984; OCT 2017; Smith-Campbell 2019
Lupinus polyphyllus	Russell lupin	-	Introduced & naturalised	OCT 2017
Pilosella spp.	hawkweed	-	Introduced & naturalised	OCT 2017
Pinus contorta	lodgepole pine	-	Introduced & naturalised	Espie et al. 1984
Pinus spp.		-	Introduced & naturalised	OCT 2017; Smith-Campbell 2019
*Ranunculus trichophyllus**	Water buttercup	-	Introduced & naturalised	Champion et al. 2006
Rosa rubiginosa	(sweet) briar	-	Introduced & naturalised	Espie et al. 1984; OCT 2017
Salix spp.	willow	-	Introduced & naturalised	Espie et al. 1984; O**CT** 2017; Smith Campbell 2019
Sorbus aucuparia subsp. *aucuparia*	rowan	-	Introduced & naturalised	OCT 2017
Ulex europaeus	gorse	-	Introduced & naturalised	OCT 2017

Notes: Species marked with * are submerged plant species. DLS = Dept. of Land & Survey. OCT = Ohau Conservation Trust.

[27] Called *Utricularia monanthos* in Champion et al. 2006.

Appendix 8

Algae and phytoplankton species recorded in Lake Middleton. Conservation status unknown.

Species	References
Actinotaenium diplosporum	Thomasson 1980; Cassie 1984b
Actinotaenium globosum	Thomasson 1980; Cassie 1984b
Anabaena sipoides	Cassie 1984a
Ankistrodesmus gracilis	Thomasson 1980; Cassie 1984a
Ankistroesmus viridis	Cassie 1984a
Aphanizomenon flos-aquae	Thomasson 1980; Cassie 1984a; DLS 1985; Pridmore & Etheridge 1987
Astasia acus	Cassie 1984b
Asterionella formosa	Thomasson 1980
Bambusina brebissonii	Cassie 1984b
Botryococcus braunii	Thomasson 1980; Cassie 1984a
Chara corallina	Wood & Mason 1977
Closterium attenuatium	Cassie 1984b
Cosmarium bioculatum	Cassie 1984b
Cosmarium contractum var. *ellipsoideum*	Thomasson 1980; Cassie 1984b
Cosmarium contractum var. *retusum*	Thomasson 1980; Cassie 1984b
Cosmarium perfissum	Thomasson 1980; Cassie 1984b
Cosmocladium constrictum	Thomasson 1980; Cassie 1984b
Dictyosphaerium pulchellum	Thomasson 1980; Cassie 1984a
Eudorina elegans	Thomasson 1980; Cassie 1984a
Gomphosphaeria lacustris	Thomasson 1980; Cassie 1984a
Gonatozygon monotaenium	Thomasson 1980; Cassie 1984b
Gonium pectorale	Thomasson 1980; Cassie 1984a
Kirchneriella contorta	Thomasson 1980; Cassie 1984a
Kirchneriella lunaris var. *Bohlin*	Thomasson 1980; Cassie 1984a
Micractimum pusillum	Cassie 1984a
Monoraphidium dybowskii	Thomasson 1980; Cassie 1984a
Monoraphidium minutum	Thomasson 1980; Cassie 1984a
Mycrocystis aeruginosa	Cassie 1984a
Mycrocystis elachista	Thomasson 1980; Cassie 1984a
Nephrocytium agarihianum	Thomasson 1980; Cassie 1984a
*Nitella pseudoflabellata**	Wood & Mason 1977; DLS 1985
Nitella spp	DLS 1985; Scott 1958
Nostoc sp.	Harland et al. 2014
Oonephris obesa	Thomasson 1980; Cassie 1984a
Pandorina morum	Thomasson 1980; Cassie 1984a
Peridinium willei	Thomasson 1980; Cassie 1984b
Paulschulzia tenera	Thomasson 1980; Cassie 1984a
Pseudostaurastrum enorme	Thomasson 1980; Cassie 1984b
Scenedesmus platydiscus	Cassie 1984a
Sphaerocystis schroeteri	Cassie 1984a
Spondylosium planum	Thomasson 1980; Cassie 1984b
Staurastrum anatinum f. Denticum-paraoxum	Thomasson 1980; Cassie 1984b
Staurastrum avicula	Thomasson 1980; Cassie 1984b
Staurastrum disputatum var. extensum	Thomasson 1980; Cassie 1984b
Staurastrum evacatum	Thomasson 1980; Cassie 1984b
Staurastum floriferum	Thomasson 1980; Cassie 1984b
Staurastum furcatum	Thomasson 1980; Cassie 1984b
Staurastum limneticium	Thomasson 1980; Cassie 1984b
Staurastum longibrachiatum	Cassie 1984b
Staurastum magnifurcatum	Thomasson 1980; Cassie 1984b
Staurastum muticum	Thomasson 1980; Cassie 1984b
Staurastum orbiculare	Cassie 1984b
Staurastum planktonicum	Cassie 1984b
Staurastum smithii	Thomasson 1980; Cassie 1984b
Staurastum sonthalianum	Thomasson 1980; Cassie 1984b
Staurastum subgracillimum	Thomasson 1980
Staurastum trihedrale	Cassie 1984b
Staurastum victoriense	Thomasson 1980; Cassie 1984b
Staurodesmus dickiei	Thomasson 1980; Cassie 1984b
Staurodesmus leptodermus	Thomasson 1980; Cassie 1984b
Staurodesmus mamillatus	Thomasson 1980; Cassie 1984b
Staurodesmus obsoletus var. punctulatus	Thomasson 1980; Cassie 1984b
Staurodesmus triangularis	Thomasson 1980; Cassie 1984b
Trachelomonas volvocina	Thomasson 1980; Cassie 1984a
Volvox sp.	Scott 1958

Westella botryoides	Thomasson 1980; Cassie 1984a
Willea irregularis	Thomasson 1980; Cassie 1984a
Ulothrix sp.	Scott 1958

Notes: Scott 1958 and DLS (1985) noted two *Nitella* species (not named). Scott (1958) recorded diatoms, but species were not named.

Appendix 9

Zooplankton recorded in Lake Middleton. Conservation status unknown.

Species (or Phylum)	Common name	Reference
Bosmina meridionelis	water flea	Scott 1958; Jeppesen et al. 2000
Ceriodapnia sp.	water flea	Jeppesen et al. 2000
Boeckella spp.	—	Scott 1958; Jeppesen et al. 2000
Rotifera (Phylum)	wheel animals	Jeppesen et al. 2000

Appendix 10

Lake Middleton water quality (Department of Lands and Survey 1985).

Water Quality

Water quality in Lake Middleton is, at present, of a high standard and provides a habitat capable of supporting healthy fish and wildlife. However because it is small, shallow and lacks a defined outlet, Lake Middleton is vulnerable to change especially in sediment and nutrient inputs. If the catchment area is disturbed, increased sediments reaching the lake could increase the area of substrate suitable for the growth of aquatic macrophytes and give rise to a lake weed problem. Changes in pastoral management practices and an intensification of adjacent land use or other activities which result in an increased nutrient level could, in time, stimulate changes in the lake's algal flora as has happened at Lake Hayes, near Queenstown. The high summer temperatures and evaporation rates, and the frequent calm conditions characteristic of the area could contribute to the formation of algal blooms that would make the lake unattractive for recreation, and place its biological values at risk.

Buried rubbish, emptying of chemical toilets in the reserve and the use of detergents in the lake could all give rise to increased nutrient levels in Lake Middleton. There is also concern that effluent, or its products, from the Shelton Downs Village Development does not find its way into Lake Middleton's catchment.

Power and other boating on Lake Middleton poses a threat to water quality in two ways. Firstly, there is a risk of a major petrol or oil spillage, either by careless handling or by accident, especially with the large number of power boats using the lake over Christmas and New Year. Secondly, there is a risk that aggressive water weed species such as Lagarosiphon could be inadvertently introduced to Lake Middleton from other lake systems, on boats or equipment.

Policy To preserve the present high standard of water quality in Lake Middleton to maintain a healthy habitat for fish and wildlife and safeguard the lake as a recreational asset.

DDPR_feedback_0332s		
	Name	Viv Smith-Campbell
	Organisation	
	Email	[redacted]
	Response Date	Aug 23 22 03:22:36 pm
	Notes	VSC
Q1	Select the chapter you want to provide feedback on	
	Appendices & Schedules	
Q2	In general, to what extent do you support the contents of this chapter?	
	Neutral	
Q3	Objective/Policy/Rule/Standard reference:	
	SNA schedule	
Q4	Feedback/Comments	
	The SNA schedule does not include areas of public conservation land. This gives a completely false impression on where there is significant natural areas within the district. If the public conservation land has not been surveyed, at least written in the plan or shown on the maps, these areas should be noted as likely being SNAs. It is important for those using the district plan to understand that SNAs on private land are often part of a much bigger area extending onto public conservation land.	
Q5	Objective/Policy/Rule/Standard reference:	
	Additional SNA - Lake Ōhau Road reserve	
Q6	Feedback/Comments	
	The schedule of SNAs includes SNAs 5 & 6 covering road reserve at Lake Waitaki. These SNAs are noted as containing threatened broom species. There are several areas along the Lake Ōhau Road adjacent to the protected private land on Ohau Downs Station (near the wetlands in the moraines) and adjacent to Shelton Downs property, that contain coral broom and other native plants. These areas would fall within the SNA criteria. The main threat to these areas is the council staff and contractors who undertake "roadside vegetation clearance" activities....some of the areas where cleared last year by contractors but some where saved when we went and stopped the contractor and got an agreement for the clearing not to occur where there was coral broom. One area of coral broom can be found at these coordinates: SE boundary of area - 1351503 E 5089477 N SW boundary of area - 1351391 E 5089482 N These areas should be investigated and included as SNAs. The relationship between council operational/asset activities and the SNAs should be clarified. Why should the council routinely clear SNAs when others are not allowed to. These areas on the road side are not impeding the use of the road or likely to a safety issue.	
Q7	Objective/Policy/Rule/Standard reference:	
Q8	Feedback/Comments	
Q9	Objective/Policy/Rule/Standard reference:	
Q10	Feedback/Comments	
Q11	supporting documents?	

	0
Q12	If you need more space, or have any other general comments, please leave them here

DDPR_feedback_0333s		
	Name	Viv Smith-Campbell
	Organisation	
	Email	[redacted]
	Response Date	Aug 23 22 03:40:53 pm
	Notes	VSC
Q1	Select the chapter you want to provide feedback on	
	Subdivision	
Q2	In general, to what extent do you support the contents of this chapter?	
	Neutral	
Q3	Objective/Policy/Rule/Standard reference:	
	SUB-S1 - General Residential Zone - 300m2 net site area	
Q4	Feedback/Comments	
	I do not support this small subdivision standard at Lake Ōhau Village. The sites in the Village are generally small - 600 -700m2 generally. Allowing subdivision (through a controlled activity) to the small size is not in character with the "alpine village" objective. With the new provision that allows for an up to 80m2 secondary unit on a site within the Village, the amount of buildings provided for has already increased. This level of subdivision would severely impact on the Village's character. It would also lead to pressure on services (water, sewage and stormwater) for the Village as they were not designed for the potential increase of households using them. Because the number of sections in the Village is limited and no expansion of the Village is provided for (which I completely support), there could be increasing demand for subdivision of existing sites. A 300m2 site in Oamaru is probably OK, but it is not at Lake Ōhau Village. Any larger sites in the Village are generally because they connect to services in different ways - ie. they were created after the services for the Village where put in place. The ability to subdivide any sections within the Lake Ōhau Village should be a discretionary activity.	
Q5	Objective/Policy/Rule/Standard reference:	
Q6	Feedback/Comments	
Q7	Objective/Policy/Rule/Standard reference:	
Q8	Feedback/Comments	
Q9	Objective/Policy/Rule/Standard reference:	
Q10	Feedback/Comments	
Q11	supporting documents?	
	0	
Q12	If you need more space, or have any other general comments, please leave them here	

DDPR_feedback_0335s		
	Name	Viv Smith-Campbell
	Organisation	
	Email	[redacted]
	Response Date	Aug 24 22 10:46:41 am
	Notes	VSC
Q1	Select the chapter you want to provide feedback on	
	Activities on the Surface of Water	
Q2	In general, to what extent do you support the contents of this chapter?	
	Strongly oppose	
Q3	Objective/Policy/Rule/Standard reference:	
	Lake Middleton	
Q4	Feedback/Comments	
	This is further to my other comments about how the use of the surface of Lake Middleton is not adequately controlled in the draft district plan. With high natural values in and around Lake Middleton, it is inappropriate for motorised vessel use to dominate the lake. Lake Middleton is small (around 24 ha), shallow and doesn't have a defined outlet. It is a rain feed lake (not glacial), 1 of only 2 rain feed lakes in the whole Waitaki Catchment and the only one in the Waitaki District (Lake Alexandrina is the other lake of this type). This makes it very vulnerable to change. The use of motorised vessels (particularly power boats) is the main threat to the wellbeing of the wildlife and fisheries values at Lake Middleton. This intensive use of the small lake by high powered boats affects habitat in a number of ways, including: i. noise ii. disturbance of bottom sediments iii. displacement and mixing of naturally occurring thermally stratified layers iv. risk of oil or petrol spills (careless handling or accidents) At present motorised vessels use most of the lake, apart from a very small area set aside for swimming and non-motorised vessel use. The area set aside now contains large deposits of sediment and is effectively being filled in and becoming a wetland. This is a very undesirable area for swimming and other water activities as the water quickly becomes full of suspended sediment as soon as the bottom of the lake is disturbed. The release of this sediment also effects the rest of the lake with sediment laden water being moved around the lake with the water mixing by motorised vessels. For the protection of the natural values at Lake Middleton a much larger area of the lake should be free from use by motorised vessels (and over time, I believe motorised vessel use on Lake Middleton should cease). We know about the impacts of this use on the important natural values, but no one seems prepared to change the uses causing it - probably because of the fear of the reaction by those that have been used to using the area for motorised boating. There are plenty of other suitable places for motorised boating that doesn't have the effects on natural character and natural values, as the use at Lake Middleton does. There is strong statutory support for protecting Lake Middleton. The Canterbury RPS has several objectives and policies that are relevant, including Objs 7.2.1 "Sustainable management of fresh water" and 7.2.3 "Protection of intrinsic value of waterbodies and their riparian zones", Policies 7.3.1 "Adverse effects of activities on the natural character of fresh water" (implementing section 6(a) RMA) and 7.3.3 "Enhancing fresh water environments and biodiversity". The Waitaki Catchment Water Allocation Regional Plan identifies Lake Middleton as having a "high natural character" worthy of a high level of protection in Policy 2. The provisions of these higher level RMA documents do not appear to have been considered in terms of how Lake Middleton is zoned and the provisions in the draft District Plan in relation to the use of the surface water of the lake.	

	Lake Middleton should be identified as a significant natural area and the uses provided for should be consistent with the protection of its natural values. I have previously supplied a report prepared by DOC about the natural values present at Lake Middleton.
Q5	Objective/Policy/Rule/Standard reference:
Q6	Feedback/Comments
Q7	Objective/Policy/Rule/Standard reference:
Q8	Feedback/Comments
Q9	Objective/Policy/Rule/Standard reference:
Q10	Feedback/Comments
Q11	supporting documents?
	0
Q12	If you need more space, or have any other general comments, please leave them here

DDPR_feedback_0346s		
	Name	Viv Smith-Campbell
	Organisation	
	Email	[redacted]
	Response Date	Aug 25 22 11:01:55 am
	Notes	VSC
Q1	Select the chapter you want to provide feedback on	
	Light	
Q2	In general, to what extent do you support the contents of this chapter?	
	Strongly support	
Q3	Objective/Policy/Rule/Standard reference:	
	All of the Light provisions	
Q4	Feedback/Comments	
	I very strongly support these provisions to avoid and reduce the effect of artificial light on the environment and people. Recognising the impact of artificial light on our natural environment is important so it is great to see SNA, Significant Features and Outstanding Landscapes etc included in the definition of Light sensitive environments. I strongly support the residential zone and the rural scenic overlay at Lake Ōhau being included in the definition of Light sensitive environments. These areas are just across Lake Ōhau from the Mackenzie basin Dark Sky Reserve - so it is important and appropriate to include these provisions to ensure our night sky is protected as well. Thank you for listening to community feedback about this issue, that has been given over a number of years.
Q5	Objective/Policy/Rule/Standard reference:	
Q6	Feedback/Comments	
Q7	Objective/Policy/Rule/Standard reference:	
Q8	Feedback/Comments	
Q9	Objective/Policy/Rule/Standard reference:	
Q10	Feedback/Comments	
Q11	supporting documents?	
	0	
Q12	If you need more space, or have any other general comments, please leave them here	