Lake Matiri assessment

NIWA Client Report: CHC2007-089
June 2007

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Prepared for

New Zealand Energy

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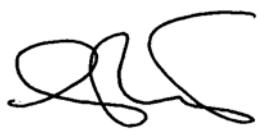

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Executive Summary

A hydro-electric power development has been proposed at the outlet of Lake Matiri, which will modify the existing regime of water level fluctuations in the lake. The new water regime will have a working range of 0.92 m and involve additional diurnal fluctuations compared with the existing regime. The lower 0.4 m of the working range is currently exposed mostly only during summer months of low rainfall years under the existing natural regime.

NZ Energy requested NIWA to: provide a description of the existing environment in Lake Matiri, assess effects of the new water regime on the environment, and recommend mitigation for any effects that would be more than minor. The focus of this report is specifically on effects of water level fluctuations. Other issues, such as fish passage through weirs and riparian effects, are considered in other studies. The scope of the study is specifically three groups of organisms likely to be affected by changes in water regime: submerged aquatic macrophytes, aquatic macroinvertebrates, and freshwater fish. For the invertebrates, particular attention was paid to the native freshwater mussel *Hyridella menzesii*, which is declining nationally. Fish passage issues associated with the weir are being considered in other reports and are only briefly commented on in this report.

Macrophyte, macroinvertebrate and fish populations were investigated at Lake Matiri on 3-4 May 2007. For macrophytes, divers swam perpendicular to shore along four transects recording plant species present, their depth ranges, cover and height data. Macroinvertebrates were studied on the same transects. Samples were collected from macrophyte beds, along shoreline edges and from sediments. A targeted population survey of the freshwater mussel *Hyridella* was also undertaken using a quantitative assessment method which provides depth/density data. Freshwater fish were assessed using a combination of fyke nets, Gee-minnow traps and electrofishing methods.

The main basin of the lake had a dense littoral fringe of submerged vegetation with only three submerged macrophytes recorded: water buttercup (*Ranunculus trichophyllus*), elodea (*Elodea canadensis*), and water milfoil (*Myriophyllum triphyllum*). The water milfoil was the only native species present and grew in the rarely exposed lower 'varial' zone. The other two species are widespread tall-growing aliens that have come to dominate the submerged vegetation since the last survey in 1980 when the vegetation was nearly all native.

Despite the low native biodiversity value of the submerged vegetation, the lake littoral margin is vegetated and provides valuable habitat for invertebrates, fish and some birds. Maintenance of submerged vegetation in Lake Matiri - even though it is mainly alien - is paramount as it is an important part of the lake ecosystem.

The proposal to develop the lake for hydro power does not involve lowering lake levels below the natural minimum, so impacts will not occur through exposure and desiccation of the shallow margins below this point. A weir is proposed at the natural mean lake level of 341 m.a.s.l., so levels above this would be spilt and higher water levels would follow the natural regime closely. This gives the scheme a working range of 0.92 m (between the natural minimum level and natural average level). Using this working range will alternately expose and submerse the varial zone on a more frequent basis than occurs naturally. The upper part of this zone is currently bare and the lower part of it has the native milfoil, a plant which has a degree of tolerance for fluctuating water levels. We cannot be certain, but do not expect significant change in the varial zone. It depends on the frequency and duration levels are kept in thelower half of the operating range. This could be monitored once the hydro weir is operating.

For about a third of the time water levels are expected to operate a higher (about 0.3 m is one estimate) than currently. This will reduce the quanta of light submerged plants will receive at depth, but will maintain shallow water species submersed for longer. However for about 26% of the time (when the lake is drawn down in anticipation of rain) the lake level will be lower than occurs naturally, producing the opposite effect. Overall an assessment of effects on submerged vegetation cannot be determined precisely and will vary from year to year, but the effect will be no more than minor, causing only a slight retraction in bottom limits of probably less than 0.2 m.

During the construction phase of the scheme, turbidity may be elevated in the lake within the locality of the outlet construction, and may impact locally on plants with reduced light levels. However, when the source of turbidity stops, submerged plant species are expected to recover within months. We recommend macrophyte surveys after weir construction to detect any effects and to allow water regimes to be modified if any effects are observed.

A diverse assemblage of macroinvertebrates was recorded from the lake, with the total taxa richness being somewhat higher than other South Island lakes. No species of conservation significance were recorded. Macrophyte beds provide a significant habitat for littoral macroinvertebrates and it is likely that the macroinvertebrate community has been modified since the post-1980 change in macrophyte species composition from native charophyte-dominated species to tall-growing exotic species. This is because other studies have shown that charophyte-dominated macrophyte beds support the most productive and diverse macroinvertebrate assemblages.

Mussels were recorded from all sites surveyed, with densities of up to 152/m^2 being recorded. It is highly likely that the increase in areal extent of macrophyte has impacted on the mussel populations, although comparison with previous collected data is not possible. Mean mussel densities of up to 59/m^2 are comparable to densities recorded from some Rotorua lakes. The individuals collected from Lake Matiri were confirmed as *Hyridella menziesii*. While being the most common species, it has recently been listed on the Department of Conservation's New Zealand Threat Classification System lists" (2004) as being in gradual decline. This classification recognises the apparent decline in populations observed, possibly as a consequence of degradation of habitat and water quality, although there is little empirical data to support these observations. On a global scale, freshwater mussels from the group to which *Hyridella* belongs (Unionids) are in decline. Members of this group are characterised by having a parasitic larval stage which uses a fish species as its host. It is likely in Lake Matiri that larval mussels parasitise koaro and/or upland bullies.

Potential effects on macroinvertebrate communities associated with the proposed operation include loss of habitat through lowered water levels and loss of macrophytes. Lake Matiri is characterised by highly variable lake levels, with daily changes in lake levels considerably greater than what is proposed. In addition, impacts on macrophytes are likely to be minor. Therefore the overall impacts on macroinvertebrate communities are likely to also be minor.

Potential impacts on mussel populations in Lake Matiri of the proposed operation are associated with loss of habitat through further extension of macrophyte beds (e.g. into shallow areas), desiccation and death resulting from increased extent and frequency of dry littoral zones, and reduction in fish host populations. Extension of macrophyte beds into the shallows is unlikely. Lake levels currently vary by considerably more than what is being proposed under the operating scheme, so increases in macrophyte colonisation are unlikely, particularly as overall mean lake levels will increase slightly. Any impacts on the fish host species will impact indirectly on mussels over a longer term, through recruitment failure. Such an impact would be difficult to detect for some time, as juvenile mussels are difficult to detect and adults are very long lived (up to 50 years). However, we do not expect any change in fish populations from this proposal (see below).

During the construction phase of the scheme, short term impacts associated with sedimentation should be minimised, but the use of sediment trap methods to prevent run-off of sediment to mussel beds. Some mortality from exposure during construction is likely, and we recommend mitigation involving maintaining water levels to prevent exposure for any periods longer than 7 days.

Fish species in the lake included four very common freshwater fish in New Zealand: upland bullies, longfin and shortfin eels, and koaro. Eels were present in low to moderate numbers compared with studies on other lakes, and were considerably lower in number than during the last fish assessment at the lake in 1980. This probably reflects the increase in commercial eel fishing pressure in the catchment over that time. Koaro were found mainly in the tributaries of the lake, but is likely that larval koaro rear in the lake as these koaro are known to be a land-locked population.

These species are all mobile with some climbing ability, and it is unlikely that the proposed change in lake water regime or lowering of level during construction will have a significant effect on them. The most important consideration is that during dry periods, the lake level should not remain at the natural minimum level of 340.018 m.a.s.l. for periods longer than the historical natural duration of the minimum level. The proposed water regime is also unlikely to be a sufficient change from the status quo to have any effect on the connectivity of fish habitat between lake and tributaries.

1. Introduction

New Zealand Energy Ltd requested NIWA to carry out an assessment of changes in water level fluctuation in Lake Matiri associated with the proposed Matiri hydroelectric scheme on habitat and biological values of the lake. Other issues, such as fish passage and riparian habitat, are considered in other reports and are not part of this study.

Water level fluctuation is a natural feature of all lakes. The extent of fluctuation is dependent mainly on rainfall patterns, area and depth of the lake, and shoreline slope. Seasonal and short-term fluctuations over days or weeks are typical, and may operate within ranges of as little as a few cm, to ranges of several metres in high rainfall catchments. Some lakes have little short-term variation relative to their seasonal variation, whereas in others short-term variability is the dominant feature (Riis and Hawes 2002). Water level fluctuation creates a number of distinct habitats for plants and animals. The area that is wetted and dried by the water level fluctuations is termed the ‘varial zone’ and has its own community that is tolerant of periodic immersion and exposure. Below the varial zone is the littoral community dominated by large aquatic plants visible to the naked eye, the aquatic macrophytes. The maximum depth of the littoral zone is the maximum depth of plant colonisation, which is a direct function of the depth to which sufficient light can penetrate for plant photosynthesis. Water level fluctuation can therefore affect this community because light penetrates more deeply on the littoral shore at lower water levels than higher water levels. Littoral zones in New Zealand lakes may reach as deeply as 40 m in very clear lakes such as Lake Wakatipu, but there may be almost no littoral development in very turbid lakes. The deep open water of the lake is termed the pelagic zone, and is least affected by water level fluctuations. In small lakes, very large fluctuations can affect nutrient cycling and availability and hence plants and animals in this zone, but in most lakes direct effects of water level fluctuations on the pelagic zone are small.

The extent to which human alteration of the water regime affects biological communities in lakes depends on the extent to which the regime is operated outside its natural range, the magnitude of the fluctuations, and the duration of periods of prolonged low levels (causing desiccation) and prolonged high levels (flooding). At one extreme, lakes such as Lake Hawea currently support very little littoral development because of daily fluctuations >2 m in their current operating regime. In other lakes such as L. Coleridge, there are more moderate fluctuations associated with generation that allow extensive littoral development.

In this assessment, our task was to address the effects of changes in the water regime associated with the proposed Matiri hydro scheme on three specific groups of organisms closely associated with the littoral zone: aquatic macrophytes, aquatic macroinvertebrates, and freshwater fish. For the invertebrates, we were asked to pay particular attention to freshwater mussels (*Hyridella* species), which the Department of Conservation lists as nationally declining (See Section 4.2.2).

Historical water level data for the lake and proposed changes for the hydropower scheme were provided by the client and are used in the assessment. Data for wet, average and dry years were provided, allowing responses to be determined for a range of rainfall and water level scenarios.

2. Site description and scenarios

Lake Matiri (0.70 km^2, 343 m.a.s.l – see Figure 1) is a young lake formed by a landslide ca. 300 years ago in the Matiri River catchment due north of Murchison (NZG 25 54 441E, 59 49 675 N). Maximum depth is ca. 30 m in a depression at the southern end of the lake, but most of the lake is <10 m deep. Water quality in the lake is high, consistent with a largely unmodified beech forest catchment. The water column is oligotrophic (little nutrient enrichment) with the algal biomass limited by nitrogen availability in particular. Like many lakes in beech catchments, L. Matiri has a naturally brown colour due to dissolved organic carbon (DOC) leaching from the forest. Such lakes are termed dystrophic – they can have moderate concentrations of total nitrogen and total phosphorus in the DOC, but very low amounts of phytoplankton algae in the water column. This is because the DOC-associated N and P are not available to algae and the DOC reduces light penetration into the water, limiting photosynthesis. DOC reduction of light penetration also means that the littoral zone in dystrophic lakes such as L. Matiri is much shallower than in other unpolluted lakes, because macrophytes cannot grow as deeply. Water clarity in Lake Matiri also fluctuates naturally due to suspended frequent sediment run-off during high rainfall events. High rainfall events also mean the lake has large natural water level fluctuations and a low residence time, with rapid vertical and horizontal mixing of the lake water during floods.

There have been relatively few previous studies on the biology of Lake Matiri. A broad limnological assessment was produced in 1980 by Bioresearches Ltd for assessing a proposed hydropower scheme at that time. In this assessment we refer frequently to Bioresearches (1980) to show how the lake has changed in the intervening 25+ years, and contrast current communities with those present in 1980 in assessing effects.

Historical water level information shows a highly dynamic water regime with a natural range of >2.5 m (see Appendix I). The hydrographs are characterised by frequent sudden flood events that are common at all times of the year, even in dry years. In low rainfall years, there can be periods of several weeks where the water level is below the mean lake level, but levels respond rapidly to rainfall events. These hydrological characteristics are consistent with the geomorphology of the catchment and rainfall patterns. Dynamic water levels, large water level ranges, and sudden large increases in water level are typical for landslide lakes with low residence times under high rainfall climates.

Effects of water level in the proposed scheme include effects due to the operational scenarios after construction and effects during the construction phase. The operational scenario involves superimposing an additional daily water level fluctuation over the natural variability in water level. The proposed daily fluctuations are small relative to the current water level range; the important issue to consider is that there would in effect be three operating scenarios for water level, depending on:

- In Scenario 1 of the proposed operating regime (inflows >7.5 cumecs) water levels will be little different from those occurring naturally because excess water is discharged over the weir. Scenario 1 is expected to be run for about 132 days (36%) in a year of average inflows being more frequent in winter when most rainfall occurs.

- In Scenario 2 (generator runs for part of each day drawing down water for generation from near the lake's natural mean level) water levels are likely to be generally higher than would occur naturally. The extent of this increase is not known, but is likely to be less than half a metre (Paul Troon New Zealand Energy, pers. comm.). Scenario 2 is expected to operate for about 138 days or 38% of an average year.

- In Scenario 3 (lake lowering in anticipation of forecasted rain events) may lower lake levels below what they would be naturally. This could occur throughout the year but is more likely in winter when most storms are forecast. It is expect to occur for 95 days in an average year equivalent to 26% of the time.

In addition, there will be a period of 2 – 3 weeks of water level modification during the construction of the weirs. The lake discharge consists of three outlets, each of which will have a weir constructed on it. Weir construction would occur during a period of naturally low levels. A coffer dam would be in place during construction of the first, largest weir, during which time the lake would discharge through its two smaller outlets and the coffer dam would hold the water level at close to its natural minimum. The two smaller weirs would be built subsequently, with the completed first weir lowering the water level ca. 0.5 m below the natural minimum for about 1 week during construction. The time required to return the water level above the natural minimum would depend on the flow. In an average summer with a low flow of 2 cumecs it would rise by 0.5 m over 2.5 days, at 4 cumecs this would take 1 day, and any rainfall events would shorten the time further.

3. Description of survey methodology

3.1. Aquatic macrophytes

The submerged vegetation in Lake Matiri was investigated on 4th May 2007. The water level at the time of the survey was close to 341.2 m.a.s.l. and vegetation depth data has been adjusted relative to the natural mean water level of 341 m.a.s.l.. The aquatic macrophytes were surveyed by divers using a method similar to Clayton (1983). The lake was sampled at four localities (Figure 1) and the profile locations were selected as representative of the underwater vegetation and the range of plant communities present in the lake based on Bioresearches (1980) and lake bathymetry. Figures 2–5 illustrate each site. The north end of the lake was not sampled as it is mostly de-vegetated due to the scouring effects of two inflows. Divers swam perpendicular to shore recording plant species present, their depth ranges, average and maximum heights and covers. Transects were continued to depths of ca. 6–8 m (Table 1), at which depth the lake bottom had flattened and there was little further increase in depth with distance from the shoreline. These transects were therefore representative of most of the lake area, which is < 10 m deep. The deeper hole at the southern end near the outlet is a small proportion of total lake area, is below the maximum macrophyte depth, and is unlikely to be impacted by the proposed water level regime.

Vegetation survey data was entered into the NIWA Freshwater Biodata Information System (FBIS) which stores and processes the data to tabular form as presented in the results section. Raw data can be viewed using spatial and textural searches at the web-site, fbis.niwa.co.nz. LakeSPI or 'Lake Submerged Plant Indicators' (Clayton & Edwards 2002; Clayton & Edwards 2006) information was also gathered. LakeSPI is an index that allows comparison of macrophyte communities and lake ecological condition, based on the proportions of native and exotic species and the maximum depths colonised by plants.

Additional data collected to enable a LakeSPI analysis, included the maximum depth of native and alien species with cover >10%, and the maximum depth of charophyte meadows with >75% cover. A sketch was also made of the profile relief and spatial distribution of vegetation with notes on height and cover. An echogram with GPS

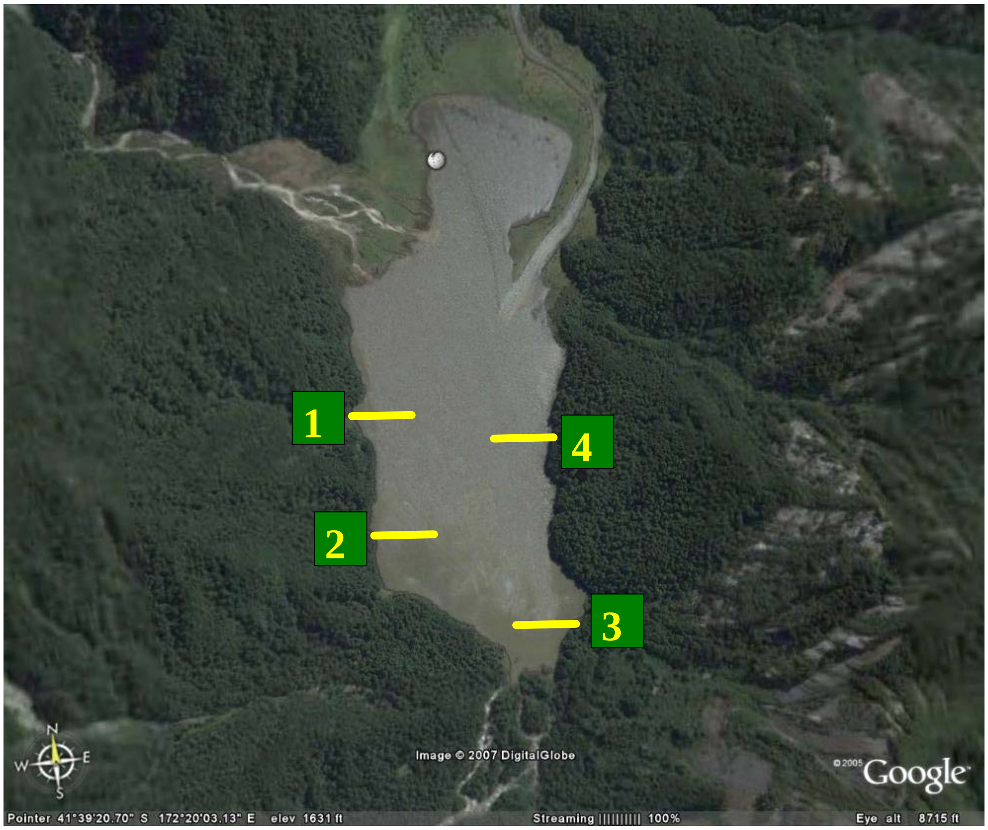

Figure 1: Aerial view of Lake Matiri showing location of the four macrophyte and invertebrate profiles sampled.

Figure 2: Site 1, near Department of Conservation hut, on western shore of lake

Figure 3: Site 2, south of Department of Conservation hut, on western shore of lake

Figure 4: Site 3 as seen from across the lake, on eastern shore of lake.

Figure 5: Site 4, approximately opposite the Department of Conservation hut, on eastern shore of lake.

Table 1: Location, substrate type and depth of diving transects for the four macrophyte and macroinvertebrate sampling sites at Lake Matiri

Site number	Equivalent Bioresearches (1980) site	Easting	Northing	Substrate	Max depth dived (m)
1	A	2454206	5949955	Firm mud	6.4
2	B	2454225	5949778	Soft mud	7.4
3	D	2454747	5949439	Soft mud at depth; firmer closer to shore	7.2
4	Between D and E	2454688	5949753	Soft mud at depth; firmer closer to shore	8.1

information embedded was made to record profiles and delineate the vegetation assisting percentages of vegetation categories (such as the relative abundance of the two invasive alien species) to be calculated.

LakeSPI data was entered into the NIWA LakeSPI database, and it calculated three ecological indices. The Native Condition Index provides a measure (score) of the diversity, quality and abundance of indigenous submerged vegetation. The Invasive Condition Index scores the impact by any of ten invasive alien plant species that may be present. A high Invasive Condition Index indicates large impacts by invasive alien plants. The LakeSPI Index integrates components from the previous indices, with additional ecological information. The specific features that are assessed to generate each score are detailed on the web-reporting pages (lakespi.niwa.co.nz). The indices are expressed as a percentage of their maximum potential score to enable direct comparisons between different types of lake. The LakeSPI Index provides a measure of how close a water body is to its potential or pristine state, and can if repeated over time be used to detect changes in lake condition over time or to make comparisons between lakes.

LakeSPI results presented in this report are also available on NIWA's web-reporting pages (lakespi.niwa.co.nz), where a report can be generated for any lake, summarising all available assessments.

3.2. Macroinvertebrates and mussels

Samples for determining the abundance and composition of the aquatic macroinvertebrate community in Lake Matiri were collected simultaneously with macrophyte surveys at the four sites. The focus of the sampling was on the littoral zone, as littoral zone habitats generally provide the most diverse macro-fauna in lakes, especially the invertebrates (Kelly and McDowall, 2004). At each site, a Wisconsin sample was taken by dragging the sampler through the depth profile of the macrophyte bed, a dip net sample was collected along the wadeable edge (taken from wood, macrophytes, and substrate), and a core of sediment was collected at the base of the macrophytes. Samples were composited in the lab to provide an overall description of macroinvertebrate biodiversity at each site. Macroinvertebrates were identified to genus where possible and enumerated to provide an estimate of relative abundance.

Mussel (*Hyridella sp*) populations at each site (Figures 2–5) were surveyed using a diver. Sites used were the same as those for the macroinvertebrate and macrophyte surveys and were similar in location to those surveyed in a previous report by Bioresearches (1980). The survey was conducted by the diver moving progressively shoreward along a transect line perpendicular to the shoreline from the greatest to the shallowest depth. At each meter of depth the number of freshwater mussels observed in a 0.25m^2 quadrat placed randomly on either side of the transect line were counted, with dominant substrate type(s) also being recorded. From these data a depth/abundance profile for each site was generated. As with the macrophyte data, depths are corrected to natural mean lake level. In order to provide a description of population size structure addition, approximately 20 mussels were collected from each site and shell width, depth and height measured.

Table 1 provides details of each site, including predominant substrate and the maximum depth dived during the mussel survey.

3.3. Fish

Fisheries surveys of the Matiri River, including sites near the outlet of Lake Matiri, were completed in April 2007 as part of a separate study (see Jowett 2007). During the field visit in May 2007 the lake level was quite high (approximately 1.5m above the level observed during April 2007). The high lake levels were caused by heavy rain in the catchment during the 24 hours prior to the survey. Although high water level did not compromise the catching efficiency of the traps and nets, it was necessary to avoid shorelines that had shallow profiles, as these were prone to overnight dewatering as the lake level dropped.

Fisheries surveys were confined to the lake itself, and several inlet tributaries, using the three following methods:

Fyke nets

Fyke nets, similar to those used by commercial eel fishers, were set at right angles to the shoreline of the lake, either near the confluence (inlet) of a tributary stream or on steeper profiled shorelines where water depth was great than 1.5 m within 10 m of the shore. Fyke nets are the most effective method of capturing eels in lakes and ponds, but because they are constructed with coarse mesh, only eels greater than about 350mm in length can be captured.

Gee minnow traps

Trap lines about 25 m long were set at right angles to the shore using an inflatable dinghy. Ten Gee minnow traps, each baited with bread and “Marmite” yeast extract, were attached to the line at 2 m intervals along the length of the line. Gee minnow traps are effective for catching bullies, small galaxiids and small eels.

Fyke nets and Gee minnow traps were set in three locations around the lake (Figure 6). At each site, three fyke nets and one line of Gee minnow traps was set and left overnight. The next day, each net and trap was retrieved, then captured fish were anaesthetised, identified and measured. All fish were returned to the lake.

Beach seining was attempted in Lake Matiri, but was abandoned due to the dense layer of plants present in the shallow margins of the lake.

Figure 6: Aerial photograph showing electrofishing survey sites and location of fish nets and traps during survey.

Electric fishing

Electric fishing was conducted in the small tributary by the Matiri Lake hut and in Bay Creek which is the major tributary that flows into Lake Matiri on the western shoreline. The main Matiri River flowing into the Lake at the North Eastern shoreline was not fished due to discolouration from rain. The Lake Matiri outlet had been surveyed during April 2007 as part of investigations on the Matiri River (Jowett 2007). At all sites, fish communities were sampled using a battery-operated backpack electric fishing machine (KAINGA EFM300) set on 300 or 400 volts and a pulse frequency of 100 Hz. The area fished at each site ranged from 15 to 30 m^2 and incorporated the entire range of habitats present in that reach. In riffles and runs with moderate flow, sampling was conducted by fishing downstream into a fine-mesh stop net that covered about 1 m width of stream. In areas of slow flow (sluggish runs and pools), sampling was generally in an upstream direction using a dip net to retrieve fish, and avoiding siltation that reduced visibility in the area being fished. The fish species captured were identified, lengths measured and fish were returned to the place of capture following completion of sampling at that site. The area fished was estimated (by pacing) at each site so that a coarse measure of the relative abundance of different fish species could be calculated.

4. Description of existing environment and significance

4.1. Submerged aquatic macrophytes

4.1.1. Survey results

The main basin of the lake had a dense littoral fringe of submerged vegetation (Figure 7). Only three submerged macrophytes were recorded. Two of these were alien species: water buttercup (*Ranunculus trichophyllus*, also referred to in New Zealand as *R. amphitricus*, *R.. aquatilis* and *R..fluitans*), and elodea (*Elodea canadensis*), also known as Canadian pondweed or oxygen weed. There was one native species, water milfoil (*Myriophyllum triphyllum*), which formed a shallow band around the lake with moderate cover (about 60%) of low-growing plants from 0.4 to 0.8 m water depth (Table 2 and Figure 8). In deeper water the water buttercup dominated to nearly 3 m deep with mostly a closed canopy of tall-growing plants (~2.5 m tall), and deeper still elodea became dominant with an equally complete cover of tall growths down to a water depth a little over 4 m.

4.1.2. Biodiversity value

The only native submerged macrophyte recorded was the nationally widespread and abundant plant, water milfoil, *Myriophyllum triphyllum* (previously referred to as *M. elatinoides*). This species can exhibit a wide plasticity in growth form from a minute compact amphibious turf-forming habit to tall-growing, partially emergent, high-density stands. In Lake Matiri the average height was 0.1 m with about a 50% cover on all profiles, which is a common growth form of this plant, particularly in the South Island (Figure 9). The depth range for this plant puts it between the mean low and natural mean level for the lake, indicating that it is exposed at times of low water levels, although low water levels (340.08 – 340.5 m a.s.l.) occur seldom and during summer months of low rainfall years (Appendix I). The milfoil is better adapted than the other species recorded in the survey to survive in this habitat and this probably explains why it persists only at this depth range.

Bioresearchers (1980) described a native-dominated submerged vegetation (species not identified) with *Myriophyllum*, *Potamogeton* and charophyte genera growing to 6 m water depth (datum not given). In May 2007 no potamogeton or charophytes were recorded and the profiles were dominated by the two alien species, which had displaced the previously abundant native vegetation with a tall, closed canopy. The first of these, water buttercup, is relatively common throughout New Zealand in streams, lakes and ponds, but is usually of low invasiveness in still water, and co-exists with native species. The only other record of it dominating lake vegetation to

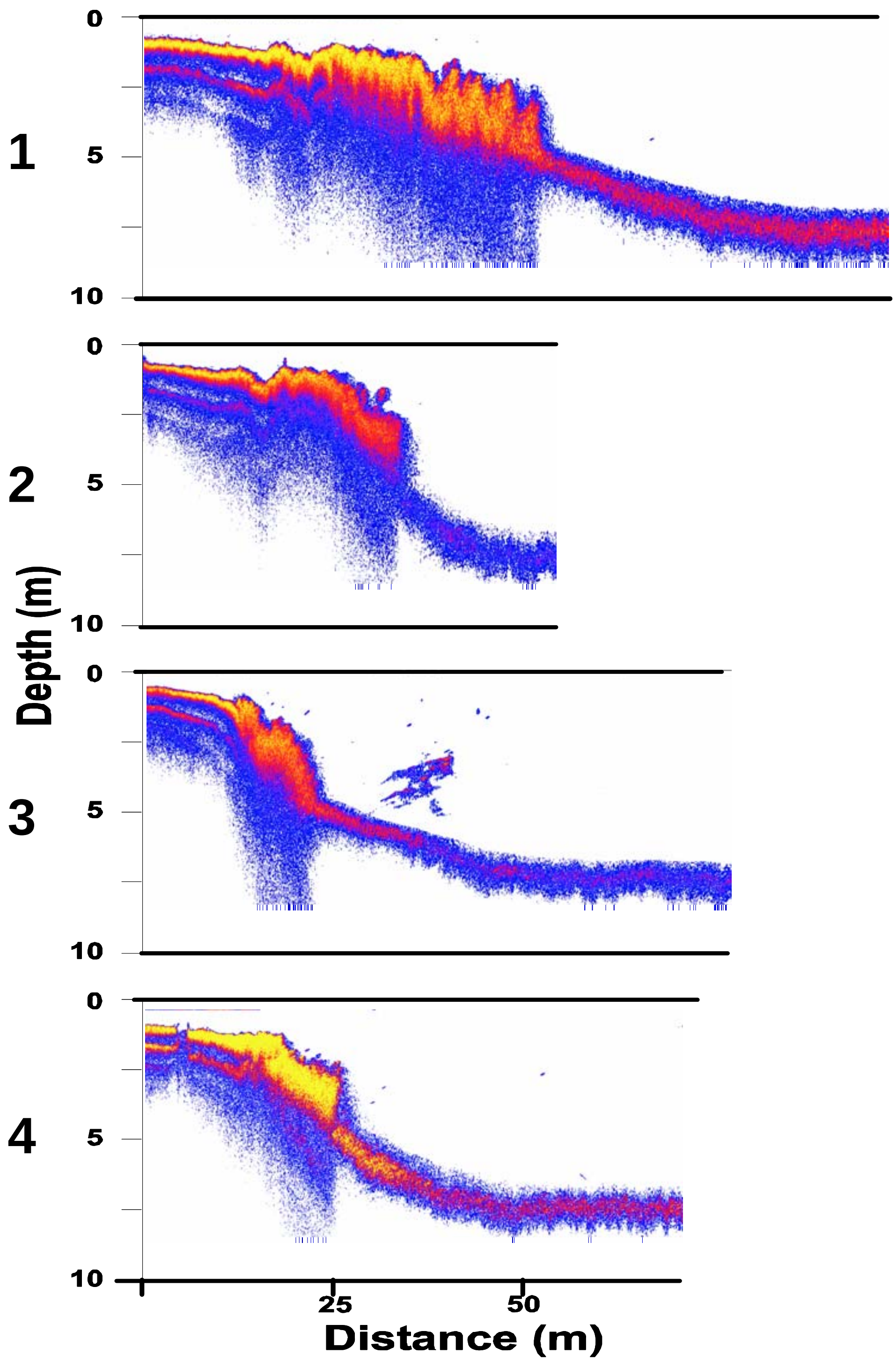

Figure 7: Echograms showing the four macrophyte profiles at sites 1 to 4 as located in Fig. 1 delineating the tall growing submerged vegetation (seen as yellow in 4 and red / yellow in the others).

Table 2: Submerged macrophyte data summary recorded from four representative profiles from Lake Matiri, 4th May 2007. *Cover values were assessed for a 2m by 2m area using six categories: 1 = 0-5%; 2 = 6-25%; 3 = 26-50%; 4 = 51-75%; 5 = 76-95%; 6 = 96-100%. ++ denotes native species. Depths are relative to 341 m.a.s.l., the natural mean water level.

Species	Minimum depth (m)	Maximum depth (m)	Maximum height (m)	Average height (m)	Maximum cover*	Median average cover*
Elodea canadensis	1.5	4.7	2.2	1.5	6	5/6
Myriophyllum triphyllum	0.4	0.8	0.2	0.1	5	4
++*Ranunculus trichophyllus*	0.4	4.1	2.2	1.4	6	6

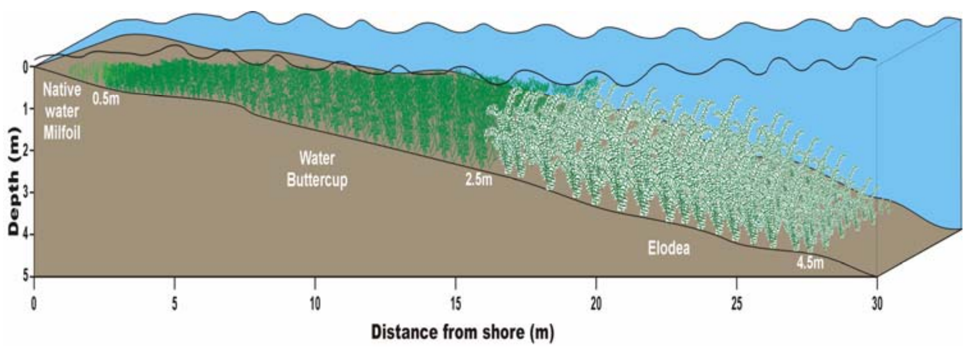

Figure 8: Stylised profile of Lake Matiri's submerged vegetation, showing an alien-dominated submerged vegetation comprised of a band of elodea below water buttercup, with the native milfoil the only indigenous component, restricted to shallow water only**.**

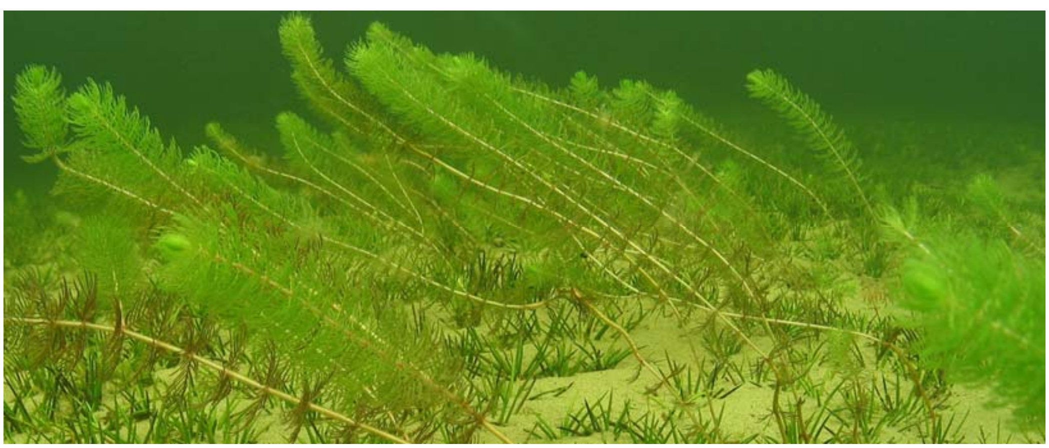

Figure 9: *Myriophyllum triphyllum* (water milfoil) of similar architecture, height and cover to the plants seen in Lake Matiri, photographed in Lake Hauroko. The other plant visible in the photograph is *Isoetes alpinus*, which is not present in Lake Matiri.

the extent seen in Lake Matiri was in 1980 in Lake Johnson, a small lake situated near Queenstown (Dr John Clayton, NIWA, pers. comm.). The water buttercup may have been a relatively new introduction to Lake Matiri in 1980, as Bioresearchers (1980) recorded it as sparsely distributed, and it did not feature in their profiles at the same locations used in this study. The second alien species was elodea, which dominated the deeper portions of each profile but was not recorded by Bioresearchers in 1980. This plant was actively spread throughout New Zealand (from pre-1900 to c. 1975) on the incorrect assumption that it enhanced trout fisheries. It is now common throughout New Zealand in lakes, ponds and streams, but is declining in abundance as more aggressive alien species (lagarosiphon, egeria and hornwort) displace it. We do not know how long elodea has been in Lake Matiri; it could be a very recent introduction (in the last 3 years) and may still have potential to displace much of the water buttercup. Since 1980 elodea has displaced the charophyte vegetation and bottom limits appear to have retracted by over one metre.

Overall the low native biodiversity values for the lake are reflected in the LakeSPI indices. The Native Condition Index is only 11% of the potential or pre-impacted state (Figure 10) it would have received in 1980. The high Invasive Condition Index (78%) is driving this and contributing to the very low Lake SPI Index of only 9%.

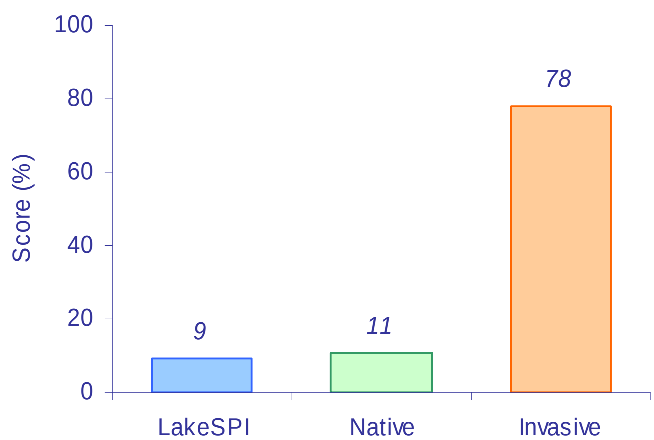

Figure 10: LakeSPI Index as % of potential score, Native Condition Index, and Invasive Condition Index (from left to right). The very low Lake SPI index largely reflects the high impact of invasive alien species on native biodiversity.

4.1.3. Habitat value

Despite the low native biodiversity value of the submerged vegetation regionally and nationally, the lake littoral margin is vegetated from 0.4 m to more than 4 m and provides valuable habitat for invertebrates, fish and some birds. Maintenance of submerged vegetation is therefore critical, even though it is mainly alien-dominated, as it is an important part of the lake ecosystem.

4.2. Macroinvertebrate community and freshwater mussels

4.2.1. Macroinvertebrates

Survey results

A total of 19 taxa (types of macroinvertebrates) was recorded from Lake Matiri and included representatives of Trichoptera (caddisflies), Oligochaeta (Worms), Odonata (dragonflies and damselflies), Molluscs (snails, clams and mussels), Hemiptera (true bugs), Diptera (true flies) and Coleoptera (beetles). Numerically, the common and widespread snail *Potamopygus antipodarum* dominated, with other snails (*Physa sp* and *Gyraulus sp*) also being common (Figure 11). Weatherhead and James (2001) reported a significant positive correlation between macrophyte biomass and snails, presumably reflecting the greater surface area available for growth of epiphyton (on which they feed). The water boatmen *Anisops sp* was also relatively common, along with the pea clam *Sphaerium novaezelandiae* and the fly *Chironomous* sp.

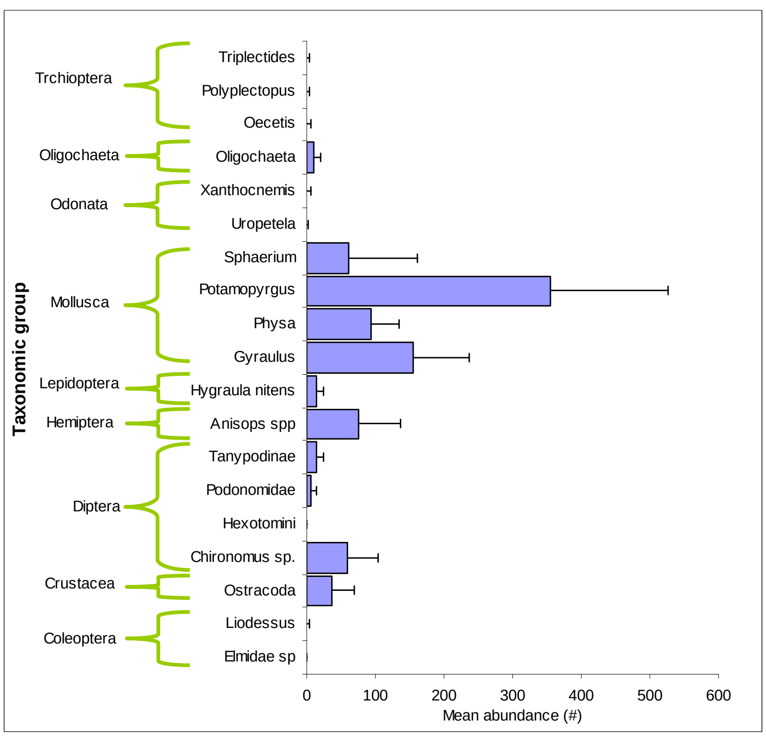

Figure 11: Mean abundance of macroinvertebrates recorded from 4 sites in Lake Matiri (combined sites and sampling methods) (± 1 standard deviation).

Some variation in composition was observed between sites (Figure 12). While *Potamopyrgus* and other molluscs dominated all sites, the pea clam *Sphaerium* was particularly common at Site 4, while waterboatmen were more common at Sites 1 and 3. Also, Ostracods (micro-crustacea) were absent from Site 1.

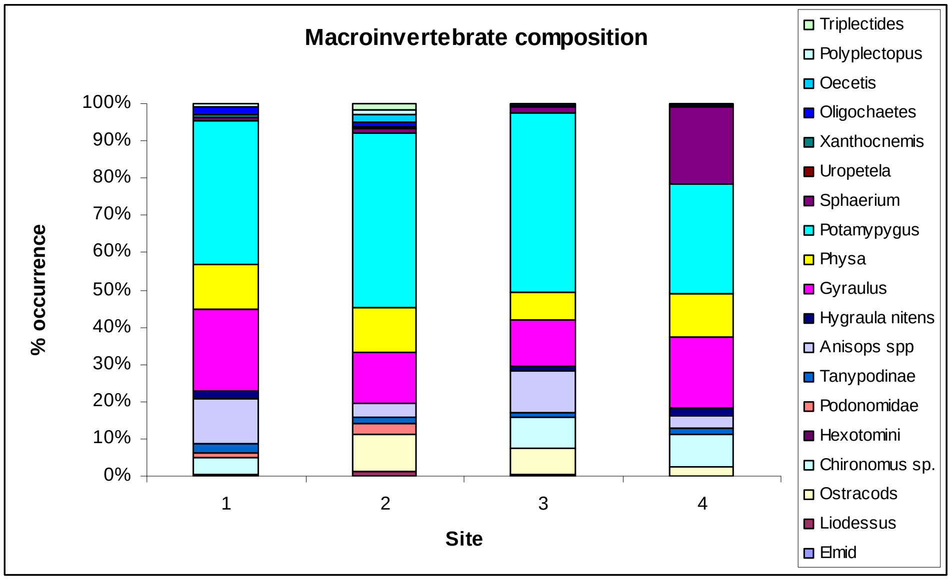

Figure 12: Macroinvertebrate composition (based on relative abundance) at each of 4 sites in Lake Matiri (combined sampling methods).

Biodiversity value

None of the taxa recorded is considered to be of particular conservation significance and most are common and widespread. The lepidopteran *Hygaula nitens* is exclusively associated with its host plant *Elodea canadensis* and is likely to be a recent resident of the lake, given that this macrophyte species was not recorded from the lake in 1980.

Comparison with data collected by Bioresearches (1980) is not possible, as their lake survey involved the use of only limited sampling methods (dredge). In addition, the substantial increase in macrophyte surface area since 1980 due to the alien invasion has most likely increased the available habitat for lake invertebrates (Kelly and McDowall 2004).

In New Zealand lakes, littoral invertebrate faunas consist mainly of a variety of larval insects, molluscs, annelids, crustaceans and mites, with about 10-25 species observed in most lakes (Kelly and McDowall, 2004). Timms (1982) surveyed 20 South Island lakes and found a total of 50 benthic and littoral taxa, with an average number of species of 12.4 per lake. The number of taxa recorded in Lake Matiri is therefore higher than that expected for other South Island lakes and indicates a thriving community, probably because of the high through-flow. The distributions and productivity of littoral invertebrate communities is of course related to physical, chemical and biological variables, with the latter two appearing to be more important in many cases (Kelly and McDowall, 2004).

Habitat value

Depending on the characteristics of the lake, littoral invertebrates may be found along rocky shorelines, among macrophytes, and associated with the sediments beyond the macrophyte beds (Weatherhead and James 2001). Invertebrate species associated with macrophytes are generally recognised to be the most diverse and productive component of the lake fauna (Winterbourn and Lewis, 1975). Macrophytes play a critical role in providing habitat for macroinvertebrates, which was reflected in our survey (Appendix II). Biggs and Malthus (1982) found that there were differences in species composition depending on macrophyte species, but that native charophyte species were the most productive habitats for littoral macroinvertebrates. The rocky shorelines of lakes (edge habitat) tend to be dominated by larval insect taxa, which are subject to wave action as well as fluctuations in lake levels (Kelly and McDowall 2004).

4.2.2. Freshwater mussels

Survey results

Mussels were found at all sites surveyed. Site 4 recorded the greatest density (Table 3). This observation is consistent with Bioresearches (1980), in which a dense mussel bed was noted at the location of this site. Some differences in densities were noted at Sites 1 and 2 in comparison to the Bioresearches (1980) report. This may reflect differences in actual site locations (analogous sites were identified on the basis of position on a map rather than GPS coordinates) and sampling method (diver observation versus dredge). Also, our results reflect mean numbers along the transect line. It is not evident at what depth mussels were sampled in the Bioresearches (1980) report. In other lakes, mean densities ranging from 5/m^2 in Lake Ngapouri (Happy, 2006) to 160/m^2 in Lake Rotokawau (James, 1987) have been recorded. Mussel densities in Lake Matiri are similar to those recorded from some Rotorua lakes (e.g. Lake Rotorua – 62.1/m^2, Lake Rotoiti – 73.8/m^2). Maximum densities of up to 615/m^2 have been recorded from Lake Rotoiti (Happy 2006).

Table 3: Numbers of mussels recorded along each transect line (#/m^2).

Site #	Mean #/m^2 along transect	Maximum #/m^2 recorded along transect line	Maximum depth dived	#/m^2 recorded in Bioresearches (1980) for equivalent site
1	8.00	24	6.4	70
2	13.00	32	7.4	0
3	36.57	104	7.2	40
4	59.00	152	8.1	Not surveyed

Mussel density varied with depth at each of the sites (Figure 13). Mussels were recorded in high densities in <1.0 m depth at Site 4. In general, mussel density decreased considerably within macrophyte beds. On most transects mussels were present to the maximum depth dived and hence are likely to occur over most of the lake area.

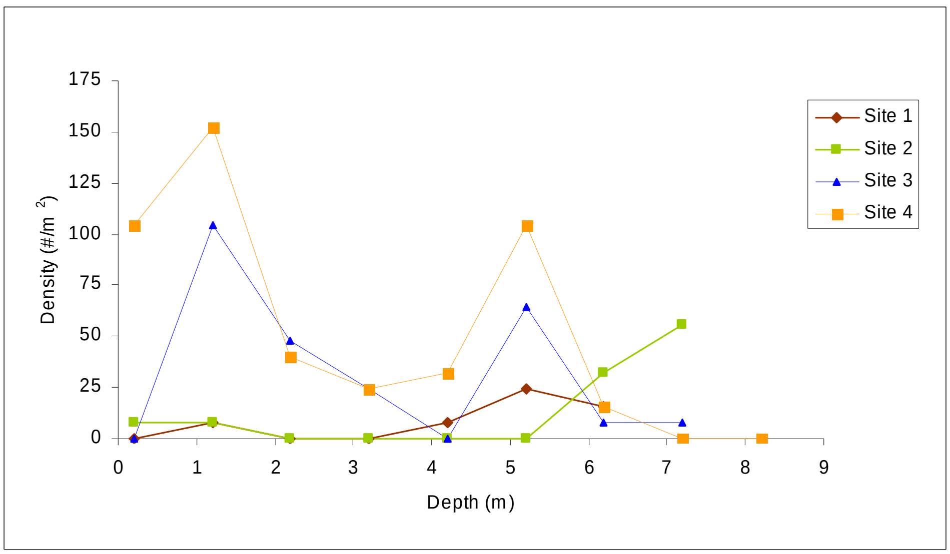

Figure 13: Depth profiles for mussels collected from 4 sites in Lake Matiri. Depths corrected to natural mean water level.

Significance

The freshwater mussel family Hyriidae is represented in New Zealand by two genera and three species or sub-species: *Hyridella menziesii*, *Hyridella aucklandica*, and *Cucumerunio websteri/Cucumerunio websteri delli*. *H. menziesii* is common and widespread throughout New Zealand, in habitats ranging from small, fast-flowing streams to lakes. In contrast, *H. aucklandica* and *C. websteri* are restricted to the northern North Island near Auckland, and are little known (Walker et al. 2001). Recent evidence indicates that other species may also be present, including *H. onekaka*, which is currently known only from the northern part of the South Island (Fenwick and Marshall 2006). *H. menziesii* is known to show strong variation in shell form (Walker et al. 2001). The adult has a very variable growth form and this causes confusion in separating the New Zealand species.

Specimens of mussels collected from Lake Matiri were formally identified as *Hyridella menziesii* by Bruce Marshall, Collection Manager Mollusca at Te Papa Museum and were lodged in the National Collection Database (registration #M.273899, 10 May 2007).

Adults are long-lived (over 50+ years in Lake Waipori (South Island), with a mean age of 20-25 years) (Grimmond 1968) and reasonably hardy, so that residual adult populations may be present but do not necessarily indicate viable, self-sustaining populations. Mussels of more than 100 mm length have been recorded in New Zealand (Ogilvie 1993) and ages reported for large individuals range from 13 years (61mm) in Lake Taupo (James 1985) to 33 years (84 mm) in lakes on the Waikato River (Roper and Hickey 1994). This species lacks a byssal thread commonly found in other mussel species as a mechanism of attachment to the substrate; instead it partially buries itself into soft sediment.

Mussels collected from Lake Matiri were particularly large (up to 106mm in length) (Figure 14), with a minimum length of 57 mm. While every attempt was made to collect as wide a range of individuals as possible, poor visibility limited our capacity. A search for juveniles (<10 mm length) was attempted by sieving sediments in the shallows (1 mm mesh size) but failed to locate any. This size class can be difficult to detect without intensive sampling, so our results may not necessarily indicate a lack of individuals. It is not possible to age these mussel populations at this stage. Large individuals of *H. menziesii* dominate population studies and it is rare to find juvenile mussels (Grimmond 1968; James, 1985; Roper and Hickey 1994). It is possible that juvenile mussels occur in a different habitat from the adults and undergo a migration as they develop. For example, Grimmond (1968) found juvenile mussels near the mouths of inflowing rivers.

Mussels from Lake Matiri also showed evidence of shell erosion (Figure 14). Such erosion is a common feature present in most (but not all) other mussel populations throughout New Zealand and may be the result of a variety of environmental factors (Roper and Hickey 1994; N. Phillips, unpublished data, May 2007).

Figure 14: Mussels (*Hyridella menziesii*) from Lake Matiri. Arrows indicate shell erosion.

Hyridella menziesii is listed as being in gradual decline on the Department of Conservation's "New Zealand Threat Classification System lists" for 2005 (Hitchmore et al. 2005). This listing was determined largely on the basis of observed declines in populations in some areas of New Zealand (B. Marshall, May 2007). Such changes appear to be associated with land use modifications and increases in pollution (B. Marshall, May 2007). In addition, there is evidence to suggest that at least some populations are not self-sustaining, with only old individuals (>50 years) now being recorded (B. Marshall, May 2007). While such observations are largely not founded on empirical data, they must nevertheless be given weight in consideration of the value of the populations found in Lake Matiri. In addition, unionids (the group to which *H. menziesii* belongs and which is characterised by a parasitic larval phase) are in decline worldwide (Walker et al. 2001; Burlakova and Karatayev 2007). Factors causing their decline include habitat destruction, such as alteration to hydrologic regime, increased water level fluctuations and accumulation of sediment, along with interrupted life cycle and dispersal and introduction of alien species (Burlakova and Karatayev 2007). There is no reason to assume that New Zealand freshwater mussels would be any less susceptible to such effects.

The value of the population of mussels in Lake Matiri is difficult to assess given the very limited data on population structure/size of mussels throughout New Zealand. Given the data that is available, we conclude that the Lake Matiri mussels are certainly no less important than any other population in New Zealand, as they have similar abundance and distribution to the most well-documented populations. The large size of these mussels means that this probably an old population but it is not possible to say at present whether this is a viable population or how sustainable it is. Given all these unknown factors, a precautionary approach should be taken in the management of this population.

4.3. Fish

4.3.1. Survey results

During the surveys conducted in May 2007, a total of 92 fish, comprising four native species, was captured. The numbers, size range, and catch per unit effort are summarised in Table 4, and the following sections summarise the results by species:

Table 4: Numbers, size range, and catch per unit effort (CPUE) of fish caught during the May 2007 surveys, by method. CPUE is expressed as the total number of each species caught divided by the number of nets or traps used, or, for electrofishing, as the number of fish per 100m^2 surveyed.

	Upland bully	Longfin eel	Shortfin eel	Koaro
Method	N, size range, CPUE	N, size range, CPUE	N, size range, CPUE	N, size range, CPUE
Fyke net	-	20,410-910 mm, 2.2	14, 570-820 mm, 1.57	-
Gee minnow trap	36, 44-83, 1.20	1, 320mm, 0.03	-	-
Electrofishing	13, 40-70, 28.89	-	-	8, 40-120, 17.78
Total	49, 40-83 mm	21, 320-910 mm	14, 570-820 mm	8, 40-120 mm

Upland bully (*Gobiomorphus breviceps*)

Upland bullies were caught in Gee minnow traps set in the lake, and by electrofishing in the lake tributaries. Traps close to shore, and set amongst the submerged grasses, captured the greatest number of this species. In the tributaries, upland bullies were electrofished from the cobble and gravel substrates of the lower reaches near the lake.

Longfin eel (*Anguilla dieffenbachia*) and shortfin eel (*A. australis*).

Eels were mostly caught by fyke netting, and the proportion of longfin and shortfin caught in each net probably reflected the vegetation and cover at each net site – where nets were set amongst dense overhead vegetation, the cover provided better conditions for foraging shortfin eels.

Koaro (*Galaxias brevipinnis*)

All of the koaro caught during this survey were captured by electrofishing in tributary streams.

The numbers of eels recorded indicate that a low to moderate population of eels are present in Lake Matiri. The CPUE (catch per unit effort) of both eel species for all the fyke nets was 3.7 eels per net/night, which is consistent with an average CPUE of 2.2 per net/night in Lake Rotoiti by Jellyman (1995). Little other comparative data for small inland lake systems is available. It is not possible to make an accurate assessment of the of the size and age structure of the eel population in the Lake Matiri catchment without a more extensive study over several nights, which ideally would be undertaken in the spring/ summer months when eels are more active and susceptible to capture. Shortfin eels comprised more than a third of the eels caught in the lake during this survey, which was a little unexpected as longfin eels tend to be the predominate species in high-country river catchments. The proportion of shortfins in the catch during the May 2007 survey probably does not accurately reflect the actual eel species composition in the lake, as the survey coincided with elevated lake levels that can trigger an increase in shortfin eel foraging activity in lake margins, thus increasing the capture rate. A study by Jellyman (1991) in Lake Pounui (lower North Island) showed that during elevated lake levels, the catch rate of shortfin eels increased significantly.

Bioresearches (1980) stated that the catches of eels from their surveys indicated that a very large population of longfin eels was present, although there is no abundance data to support this statement. It is known that the Matiri system currently has pressure from commercial eel fisherman as commercial fykes with up to 8 eels were noted by NIWA staff on two occasions in April in the lower Matiri (below the West branch confluence). It is also possible that there has been some pressure from commercial eel fishing in the lake itself since 1980.

The koaro recorded during this study were all caught in the tributaries, although during the April 2007 investigation, two juveniles (0+ or young of the year) and one adult were captured by Gee-minnow trapping and electric fishing just below the lake outlet. No koaro have ever been recorded from the lake itself (Bioresearches 1979; Mitchell 2004; this survey). However a small school of galaxiids were seen by the lake outlet in this study, and we assume these were juvenile koaro. In this case Lake Matiri provides rearing habitat for larval koaro that have resulted from spawning in the tributaries around the lake. It is not known how long the juveniles reside in the lake or the importance of the lake for koaro adults.

The population of koaro in the Lake Matiri catchment was found to be 100% laucustrine (land locked) according to the fin ray counts and otolith microstructure analysis undertaken by Mitchell (2004). It is possible though that diadromous (sea migratory) koaro could also occur, as access to the lake is suitable for this climbing species.

4.3.2. Significance

All of the four fish species recorded from the Lake Matiri catchment have been commonly recorded throughout the South Island according to the NIWA Freshwater Fish Database (FFDB). The upland bully is a non-diadromous inland species, often occurring in prolific numbers in some lake margins or during the summer months in some Canterbury gravel bed rivers.

The diadromous longfin eel has a current national status of “threatened in gradual decline” (Hitchmough et al. 2007).The main concerns for the survival of this species are based on the evidence that the population structure of longfins is changing due to the pressures of commercial fishing and land-use, consequently the numbers of migrant females are becoming less (Jellyman 2007 in press). Despite commercial fishing pressure, this species is still one of the most commonly occurring on the NIWA FFDB records. Shortfin eels are also widespread, mainly around coastal areas , and often favouring the silty margins of low elevation waterways (McDowall 2000); this species is also an excellent climber and can penetrate some distance inland.

Koaro is mainly diadromous, but many populations become landlocked in sub-montane lakes far inland. Koaro are excellent climbers and are often found in creeks above seemingly impassable water falls (McDowall 2000).

5. Assessment of effects

5.1. Submerged aquatic macrophytes

The distribution of aquatic macrophytes in a lake is determined by the availability of suitable substrate and the depth range over which they grow is determined primarily by time of exposure to air at the shallow depth limit and by the availability of light at the deep limit.

Thus lower water levels could impact on the submerged plants by reducing the upper depth limit due to exposure to air, but may be compensated for by encouraging a subsequent extension of the bottom limits with increased light penetration i.e., the same band width of vegetation remains but it is just lower down the profile.

The upper depth limits of macrophytes in Lake Matiri are currently determined by the natural minimum water level (340.1 m.a.s.l.). This level exposes the milfoil, but this plant can survive in an amphibious environment. At times water levels do drop a little below this as there is seepage through the natural dam. The proposal to develop the lake for hydro power does not involve lowering lake levels below the natural minimum, but Appendix I indicates that the natural minimum is rarely reached and low water levels are mostly 0.4 m above the natural minimum. Water milfoil is present in this depth zone and impacts will occur through exposure and desiccation of the shallow margins if levels frequently get near the low end of the operating level.

If water levels under the proposed hydro scheme are on average increased during daylight hours then less light will penetrate the depths of the lake at a time when plants are photosynthesising and the lower macrophyte bottom limit will retract accordingly.

A weir is proposed at the natural mean lake level of 341 m.a.s.l., so levels above this would be spilt and higher water levels would follow the natural regime closely. The weir height limits the amount of control over water levels and gives the scheme a working range of 0.92 m (between the natural minimum level and natural average level). Using this working range will alternately expose and submerse the varial zone. These fluctuations will be more frequent than currently occur naturally. This zone in some hydro-lakes (such as Lake Aratiatia) has significant areas of an amphibious turf where ground water seepage and sediment characteristics are favourable. However there were no areas of low growing amphibious turf noted in Lake Matiri surveys within the natural varial zone. This will continue if other factors such as shade and substrate suitability are currently limiting development of this plant community. At present the native milfoil occupies the lower part of the natural inter-tidal zone. It survives here as it is likely the only habitat in the lake where it can out-compete the obligate submersed alien species, water buttercup and elodea. We do not expect a significant change in this zone of the lake given the water levels proposed. The milfoil could be impacted if water levels were often in the lower half of the working range as these levels rarely occur naturally.

Regarding the lower macrophyte depth limits:

- In Scenario 1 of the proposed operating regime (inflows >7.5 cumecs) water levels will be little different from those occurring naturally because excess water is discharged over the weir. Scenario 1 is expected to be run for about 132 days (36%) in a year of average inflows being more frequently in winter when most rainfall occurs.

- In Scenario 2 (generator runs for part of each day drawing down water for generation from near the lake's natural mean level) water levels are likely to be generally higher than would occur naturally. The extent of this increase is not known, but is likely to be less than half a metre (Paul Troon New Zealand Energy, pers. comm.). This will reduce light to macrophytes and cause macrophyte depth limits to retract slightly (by less than 0.2 m). Scenario 2 is expected to operate for about 138 days or 38% of an average year.

- In Scenario 3 (lake lowering in anticipation of forecasted rain events) may lower lake levels below what they would be naturally. This could occur throughout the year but is more likely in winter when most storms are forecast. It is expect to occur for 95 days in an average year equivalent to 26% of the time. In this scenario light availability at depth in the lake will increase and would favour an extension in the depth range of the macrophytes as opposed to Scenario 2.

Overall our opinion is that the proposed changes in water level will have no more than a minor potential effect on macrophytes by causing a slight retraction in bottom limits of perhaps 0.2 m, under one of the three scenarios. It will have no effect on native biodiversity of aquatic macrophytes but will marginally decrease elodea abundance (the deeper growing alien macrophyte) and have minor flow-on effects for plant-associated invertebrates associated with these deeper weed beds.

Elevated levels of turbidity affect macrophyte depth limits, so if Lake Matiri becomes more turbid then its depth limits will reduce. The construction phase may cause transient turbidity locally within the lake. It is unlikely to spread up the lake as the predominant flow is out of the lake at the proposed construction site. When the source of turbidity stops, macrophytes are expected to recover within months.

Any future invasion of this lake by other alien weed species will have a much greater impact than the water level regime proposed. The likelihood of further introductions will increase as access to the lake becomes easier with construction of an access road. Potential new alien species of significant threat include lagarosiphon and hornwort. These species pose a greater weed nuisance than those species already present. Hornwort could also affect hydro-generation capacity by blocking intakes.

The lowering of water level during the construction phase would result in exposure of large areas of the native *Myriophyllum triphyllum*, but this is unlikely to have any long-term impacts. It is a highly amphibious species and tolerant to exposure periods of weeks, and is also a prolific seed producer so would almost certainly recover quickly if there was some mortality. Once the weirs were complete and the water level raised, it would regain its competitive advantage over the alien species in the shallow zone.

5.2. Macroinvertebrates and mussels

5.2.1. Macroinvertebrates

The potential effects of the change in water level regime on the resident macroinvertebrate community would largely be associated with:

1. *Any loss of habitat area in the shallows as a consequence of lowered water levels* – Large water level fluctuations nearly always cause major declines in the abundance of littoral zone invertebrates, through instability of the environment (variability in the wet/dry regime), as well as loss of macrophytes (which provide important habitat) and increased predation pressure (Richardson et al. 2002). In Lake Taupo, James et al. (unpublished report) found that littoral invertebrates were able to recolonise the shallow littoral zone during a single spring and summer, with the exception of years where fluctuations were of sufficient magnitude to damage macrophyte beds found deeper in the littoral zone. The natural water level fluctuations in Lake Matiri are considerable (Appendix I), with a typical range in any year of over 2m and which can vary on a daily basis by almost as much (Appendix I). The biotic communities are therefore likely to be well-adapted to the natural variability and the proposed scenarios are unlikely to expose the biota to lake level variation regimes that are significantly different from natural.

2. *Loss of macrophytes* – Macrophyte beds provide an important habitat for macroinvertebrates in lakes. The macrophyte studies in this report indicated that the potential negative effects of the proposed operational regime, under any of the 3 scenarios, would be no more than minor. Consequently it is predicted that effects on macroinvertebrate communities will be similarly minimal.

The construction phase would have little impact on macroinvertebrates given their association with the deeper-growing macrophytes, except if sedimentation was an issue (see following mussel section, Section 5.2.2).

5.2.2. Mussels

A number of physical factors influence the density of mussels (James 1985; James et al. 1998). Sediment type and stability has been suggested as a dominant factor, but bed slope, water level fluctuations and wave action, temperature (associated with depth), oxygen availability and presence of toxins are also important (James et al. 1998). Presence of macrophyte beds is also known to limit available habitat (James 1985).

The potential effects of water level changes on the resident mussel populations would be associated with:

1. *Any loss of habitat area in the shallow littoral zones through future spread of macrophytes* (ie extension of upper range of macrophyte beds): Mussels were recorded from depths of <1.0m in the current survey at sites where macrophytes were absent. It is quite likely that the recent (ie post-1980) invasion of Lake Matiri by alien macrophytes has negatively impacted on the mussel population, although it is not possible to confirm this empirically as the Bioresearches (1980) data were not collected using a similar method and are not of sufficient detail to allow comparison. Burlakova and Karatayev (2007) reported a negative correlation between both mussel density and biomass and percentage macrophyte coverage in a North American lake. Macrophyte beds may impact on mussel populations by:

    - Presenting a barrier to colonisation by out-competing for lake bed habitat.
    - Restricting water movement.
    - Causing nocturnal dissolved oxygen depletion and inducing high diurnal pH.
    - Interfering with food delivery.
    - Modifying sediments within and adjacent to the macrophyte bed, through the accumulation of fine sediments and decaying macrophyte material.

    Macrophyte data from this study indicated that any further extension of macrophytes into the < 0.5 m depth range is unlikely under any proposed operation scenario. Thus the potential impacts on mussels from loss of habitat associated with macrophyte invasion is likely to also be minimal.

2. *Desiccation and death as a consequence of fluctuating water levels increasing the extent and frequency of dry littoral areas*: Water level variability results in areas that periodically dry out, resulting in aerial exposure of mussels in shallow areas. Mussels may be able to mitigate exposure effects to some extent in the shallows by burrowing into the sediment if has not been dewatered or by moving into deeper parts of the lake (Tucker et al, 1997). In addition, the effects of aerial exposure are reduced by increasing humidity and rainfall, so that the cumulative effects of multiple factors needs to be considered when assessing the potential

impacts of drawdown (Waller et al, 1995). It has been suggested that lakes with large water level variations are likely to support mussels only in the deeper regions (Ogilvie, 1993). However, mussels were found in depths of <1.0 m in some parts of Lake Matiri, a lake known to have large water level fluctuations (see Appendix I). The proposed scenarios are unlikely to expose the mussels to lake level variation regimes that are significantly different from natural, although the average lake level will increase somewhat (P. Troon, pers. comm., May 2007)

3. *Reduction in host fish populations* - The life cycle of mussels is complicated and involves a parasitic larval stage on a host fish. The sexes are separate, eggs of the female are laid into the space above her gills and are fertilised by sperm ejected into the open water by the male and then drawn in with the water current generated by the female. Spawning occurs in summer. Larvae are brooded in the mantle cavity of the female, developing into tiny (3mm) larvae known as glochidia. After being released from the females in spring, the glochidia attach themselves to the pectoral fins, head, and mouth of eels (Hine 1978) and small native fish – Koaro (*Galaxias brevipennis)* and Giant Bully (*Gobiomorphus gobioides*) (Percival 1931) and Common Bully (*G. cotidianus*) or toitoi (DS Roper and CW Hickey, unpublished data), using a tooth on the shell. They drop off later to develop further independently. Figure 15 summarises the status of current knowledge of the biology of mussels.

   Availability of a suitable fish host is of paramount importance for successful development of the glochidia (see description of life cycle below) and therefore for the maintenance of self-sustaining populations. Loss of fish host has led to the extinction of freshwater mussel species (Hanson and Locke 2001). Koaro, upland bullies and both short and long-finned eels were recorded from tributaries of or within Lake Matiri in this study. Recent experiments indicate that koaro are the most suitable host fish for *Hyridella menziesii*, with common bullies being less effective and eels proving least effective (C. Hickey, unpublished data, May 2007). Koaro are therefore likely to be an important host fish for mussels in Lake Matiri, along with upland bullies, even though they may only be occasional visitors into the lake.

The construction phase may result in an increase in suspended material locally within the lake. Such material could have some localised impact on benthic invertebrates and mussels, through smothering effects, but is likely to be transient and affect small areas as the discharge is directed out of the lake. The existing lake bed is highly silty, and the lake frequently carries high suspended sediment loads in rainfall events, indicating some ability of the biota to cope with in-lake sediment. Excess sediment run-off into the lake from construction activities would however be likely to affect mussels, given their filter-feeding habit.

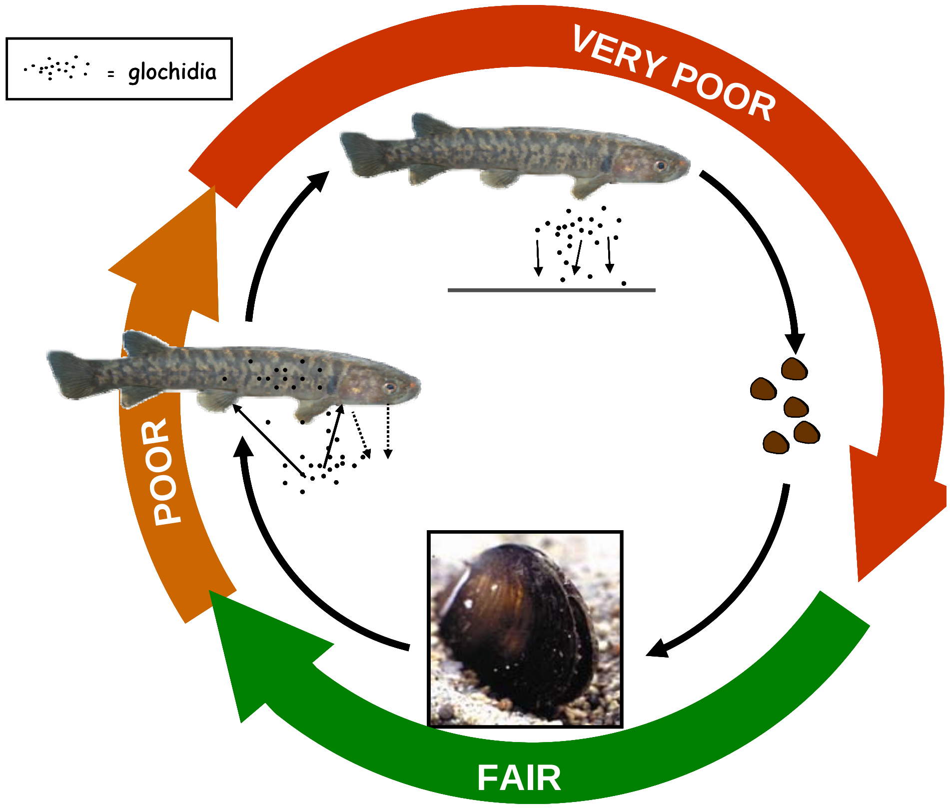

Figure 15: Current status of knowledge on different stages of the mussel life cycle.

Prolonged exposure during the construction phase could well lead to negative impacts on mussels in the shallows. Mussels were common in the upper 1 m of the lake where the exposure would occur. At present, levels do occasionally fall as low as those proposed for the construction activity for periods of ca. 7 days, so exposures of this duration are probably not deleterious, but it is unknown how much longer mussels could survive. Large numbers of mussels do occur > 1 m depth, so it is possible that the effect on the total lake population would be minor, but as the greatest mortality would be expected in areas like our Sites 3 and 4 where mussel numbers are highest, we predict that significant mortality could occur.

5.3. Freshwater Fish

The proposed daily lake level fluctuation of around 200mm is not considered to be an issue for the short or long term survival of the fish species found in the upper Matiri catchment and lake. However, under a regulated regime it is desirable that during dry periods the lake level does not remain at the natural minimum level of 340.018 m.a.s.l. for periods longer than the historical natural duration of the minimum level, in order to maintain linkage to tribuatries. The fish species present in the lake are often associated with both flowing and still water habitats, and are all adapted to cope with sudden changes in flow associated with catchment run-off. When the margins of rivers and streams suddenly change with flow variation, fish such as koaro, upland bullies and juvenile eels are well adapted to move with the lateral shift in marginal habitat (Jowett and Richardson 1994). Similar behaviour was observed for fish species found in the margins of the Waitaki river (South Canterbury) when sampling was conducted during changes in discharge (I. Jowett pers. comm.)

The connectivity of smaller tributaries to the lake, during the proposed lake level regime that coincides with extended dry periods, is also not likely to be an issue for the fish species present in the upper Matiri catchment. It is widely known that many fish species prefer to migrate during the periods of elevated flows. Even small trickles of water in these tributaries during the dry summer months would still provide enough water for fish such as small eels and koaro to access. Eels are particularly adept at climbing wetted surfaces and crossing damp land when the habitat they occupy becomes unattractive. Adult upland bullies from the lake may be restricted in reaching the tributary spawning areas at these times, but would spawn in the lake margins if access was prevented. The downstream passage of larval uplands and koaro into the lake is also unlikely to be impeded. An observation of the tributary deltas and lake edge also appeared compact and silty enough to support a surface flow under most flow conditions. Populations of landlocked koaro exist in catchments where the lower reaches have periodically become disconnected from a lake, e.g. Lake Chalice, another earthquake dam lake. Given the climbing ability of eels and koaro, and the generalist spawning behaviour of bullies, we also do not expect any adverse effects on these species during the construction phase.

Barriers to fish passage due to the weir construction were not part of this study; this issue is most likely to have effects on fish populations and require mitigation. The provision of a suitable fish passage facility for elver (juvenile eels) and koaro access into Lake Matiri is important for the long term sustainability of this catchment's diadromous native fish population. A separate report on fish passage is being produced to assess these effects.

6. Mitigation

From water level scenarios, impacts on macrophytes are expected to be no more than minor so no mitigation is proposed. However, the possibility of localised impacts would suggest that monitoring along the existing profiles after the station is commissioned would be desirable. This would also allow any changes due to the water level regime to also be considered. The monitoring should involve a repeat of the four profiles after the scheme has been operational for at least three months and there should also be a summer survey. This would be enough to identify if there have been any impacts; a review could then be made of how these have occurred and what mitigation of the water regime would be needed to reverse these.

Based on consideration of the proposed water level regimes under each scenario, it is likely that impacts on macroinvertebrates will be minor so no mitigation is proposed. Short term impacts associated with increased sedimentation during construction should be minimised, by use of sediment traps, ponding and filtering. This applies also to mussels.

While it is unlikely that any direct impacts on the freshwater mussel populations will result from the proposed operation of a weir on Lake Matiri, indirect and longer term impacts are likely if a reduction in koaro or upland bully populations occurs as these species are hosts to the mussel larvae. Therefore appropriate mitigation needs to be undertaken to ensure the long-term viability of these fish populations, both within the lake and associated tributaries. In addition, short term impacts associated with increased sedimentation during construction should be minimised.

We have identified that, during the construction phase, some mortality of mussels is likely due to exposure and that these effects could be significant given the large numbers of mussels in shallow water. We recommend that timing of the construction phase and water level management during the construction phases should ensure that this shallow zone not be exposed for periods of greater than 7 days.

In order to maintain the current eel population of either eel species the following factors need to be considered:

- Good elver access is provided into Lake Matiri via a suitable fish pass at the lake outlet.

- Appropriate provisions are made for the downstream migrating adults eg a plunge pool as outlined in Mitchell (2004).

- A sufficient residual flow in the Matiri River below the impoundment (Jowett 2007)

- An appropriate barrier e.g. a 25 mm grill and trash cleaner to prevent larger eels (especially migrants) from entering the intake structure or becoming trapped.

- A series of observations followed, if necessary, by a manual trap and transfer operation at, (1) the outflow of the power scheme, and (2) the pool below lake outlet.

7. Acknowledgements

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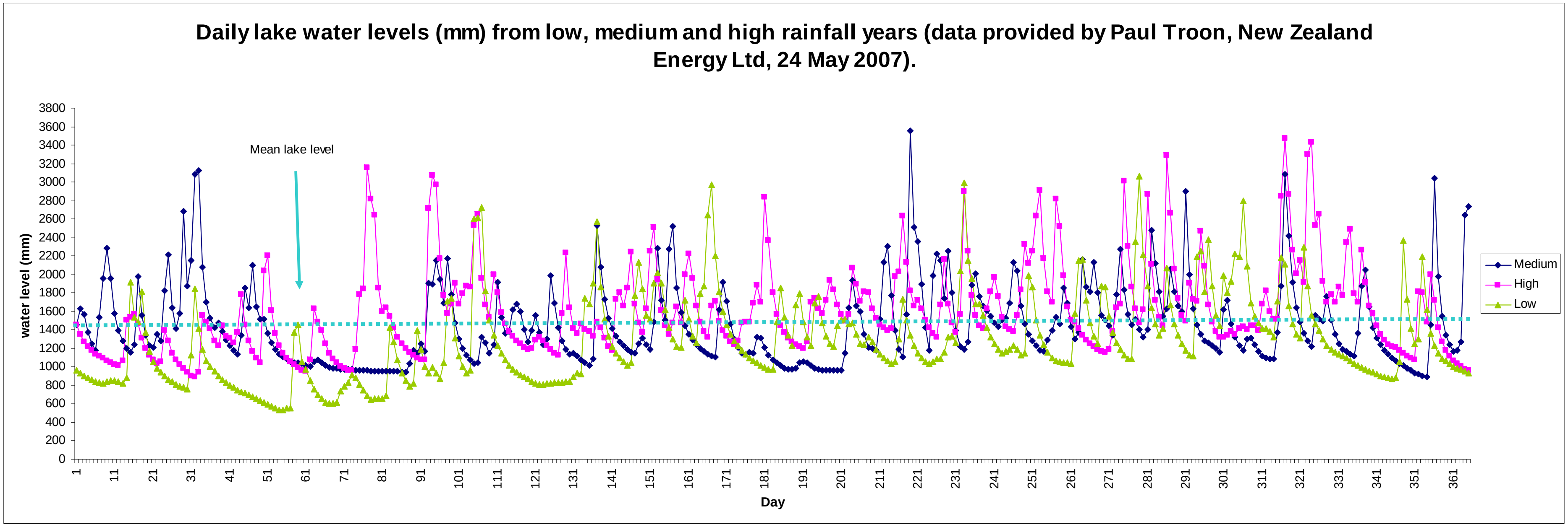
Appendix 1: Plots showing daily lake water levels (mm) and variation in daily lake water levels (mm) from low, medium and high rainfall years



Appendix 2: Macroinvertebrate data

	Sample type	Sweep and Wisconsin samples combined				Sediment samples				Combined samples			
Order	Taxon/Site	Site 1	Site 2	Site 3*	Site 4	Site 1	Site 2	Site 3	Site 4	Site 1	Site 2	Site 3	Site 4
Coleoptera	Elmidae	0	0	0	0	0	0	0	1	0	0	0	1
Coleoptera	Liodessus	0	4	3	0	0	0	0	0	0	4	3	0
Crustacea	Ostracoda	3	7	6	7	1	25	77	19	4	32	83	26
Diptera	*Chironomus* sp.	45	0	96	90	2	0	3	0	47	0	99	90
Diptera	Hexotomini	1	0	0	0	0	0	0	0	1	0	0	0
Diptera	Podonomidae	15	10	0	0	0	0	0	0	15	10	0	0
Diptera	Tanypodinae	25	0	13	11	2	5	1	3	27	5	14	14
Hemiptera	Anisops spp	127	12	128	35	0	0	0	0	127	12	128	35
Lepidoptera	Hygraula nitens	23	0	13	21	0	0	0	0	23	0	13	21
Mollusca	Gyraulus sp	234	44	145	197	0	0	0	0	234	44	145	197
Mollusca	Physa sp	127	37	90	123	0	1	0	0	127	38	90	123
Mollusca	Potamypygus antipodarum	411	151	556	305	1	0	0	0	412	151	556	305
Mollusca	Sphaerium novaezelandiae	9	5	20	212	0	0	0	0	9	5	20	212
Odonata	Uropetela sp	0	0	0	3	0	0	0	0	0	0	0	3
Odonata	Xanthocnemis sp	6	0	2	3	0	1	0	0	6	1	2	3
Oligochaeta	Oligochaeta	19	1	5	2	7	3	1	1	26	4	6	3
Trichoptera	*Oecetis sp*	0	6	2	0	0	1	0	1	0	7	2	1
Trichoptera	*Polyplectopus sp*	5	4	0	0	0	0	0	0	5	4	0	0
Trichoptera	*Triplectides sp*	2	4	1	0	0	1	0	0	2	5	1	0
Number of taxa		13	9	12	12	5	5	4	4	13	11	12	13

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