CANTERBURY CONSERVANCY

Sumner Lakes Complex (56)

Location: 42°42'S, 172°13'E. In the Hurunui River catchment in inland North Canterbury, east of the main divide, South Island. Hawarden township (50 km southeast) is the nearest settlement. Lake Sumner, the largest lake, is 137 km by road and track northwest of Christchurch. Formed public roads end at Lake Taylor, 11 km south of Lake Sumner. The other lakes are accessible by either rough vehicle tracks or walking tracks. Within Sumner Ecological District
Area: c.1,870 ha.
Altitude: 523-676 m.
Overview: The Sumner Lakes Complex is made up of Lake Sumner, a deep, medium-sized oligotrophic lake; five small deep lakes, namely, Loch Katrine and lakes Marion, Taylor, Sheppard and Mason; and two shallow wetlands, Lake Mary and Raupo Pond. The smaller lakes are all within 10 km of Lake Sumner. During the Pleistocene, various lobes of a glacier carved the Hurunui Valley and several adjacent valleys and basins. The lakes occupy moraine-dammed troughs within the valleys. The complex is very similar to the Coleridge Lakes Complex in terms of physical character, origin and climate.
The Sumner Lakes, like the Coleridge Lakes, are used by Great Crested Grebes *Podiceps cristatus australis*, and also support large populations of Paradise Shelduck *Tadorna variegata* and the introduced Canada Goose *Branta canadensis*. Lake Sumner is the best example of a forested lake catchment in the eastern South Island. Lake Sumner Forest Park extends over part of the Lake Sumner and Lake Mason catchments. Lake Marion is partially protected as a Faunal Reserve. Most of the lakes are popular recreation sites, particularly for game-bird shooting, fishing, boating, camping and walking. There are no major threats to the lakes at present. In the 1970s, however, there were proposals for hydro-electric power development in the Hurunui River.
Physical features: Lake Sumner (1,080 ha, 134 m deep) is a cold oligotrophic lake in inland North Canterbury, formed approximately 18,000 years ago (Kenny & Hayward, 1993). It occupies a deep trough, 9.7 km long by 2.4 km wide, within the glacially-carved Hurunui River Valley. The upper Hurunui River enters the lake via a shingle delta and drains through a narrow, natural channel at the south eastern end of the lake.
The lake buffers stream flows in the lower river. Lake levels vary within a natural range of 3.5 m. The stony shoreline is subject to heavy wave action, as strong northwesterly winds funnel down the lake. Waters do not show temperature stratification. Lake Sumner is usually clear, with a low algal content (Livingston *et al.*, 1986b). Floods in the upper catchment cause minor discoloration in the lake.
Lake Marion (15 ha, depth not known) is an isolated and unmodified lake north of Lake Sumner. It is drained by Marion Stream, which feeds into Lake Sumner.
Loch Katrine (75 ha, 28 m deep) is one of the five smaller glacial lakes in the vicinity of Lake Sumner but outside the Hurunui valley. Loch Katrine lies within a steep-sided valley, dammed by moraine and alluvial fans. Minor streams feed into the lake. Drainage into Lake Sumner is via a narrow channel and low-lying swampland at the loch's northwestern end. Most of the lake is surrounded by steep shingle beaches. A small shingle spit creates an area of sheltered water in this usually windswept lake.
Lake Taylor (185 ha, 40.5 m deep) and Lake Sheppard (115 ha, 21 m deep) are south east of Loch Katrine, in the same glacial valley. A low hill separates lakes Taylor and Sheppard. They are moraine-dammed, and drain via Raupo Pond and Sisters Stream into the Hurunui River

below Lake Sumner. They are of similar physical character to Loch Katrine. Lake Taylor is the most accessible of all the Sumner Lakes.

Lake Mason (53 ha) is an isolated lake southwest of Loch Katrine, within the Hurunui River South Branch catchment. Two shingle spits have built out from opposite shores, dividing the lake into two basins. The north basin (35 ha) is 38.5 m deep, whereas the south basin (18 ha) is only 1.9 m deep.

Raupo Pond (13 ha) and Lake Mary (18 ha) occupy shallow depressions on moraine and outwash gravels beside Lake Sheppard.

Ecological features: The lakes are surrounded by steep hill sides covered in either mountain beech forest (*Nothofagus solandri* var. *cliffortioides*) or mosaics of fire-induced shrub, forest and tussock grassland. Forest is most extensive north of Lake Sumner. Around Lake Taylor, Lake Sheppard and Loch Katrine, outwash surfaces, moraines and alluvial fans have been farmed for over 100 years. Submerged aquatic vegetation in the Sumner Lakes Complex was surveyed in 1987, and described by de Winton *et al.* (1987). The report includes recommendations for management of aquatic plants. The aquatic vegetation is closely comparable with other inland South Island glacial lakes. Common species of shallow water are *Glossostigma submersum* and *Elatine gratioloides*. *Isoetes alpinus* dominates littoral margins. Charophyte diversity is high, with four species of *Chara* and four of *Nitella*. Two species, *Chara braunii* and *Nitella stuartii*, are uncommon species. Bryophytes are found down to 34 m depth. The introduced weed *Elodea canadensis* is widespread, except in Lake Marion, which has only native species. More undesirable weeds such as *Lagarosiphon major* are not yet present.

There has been relatively little research into water quality of the Hurunui Lakes (Bowden, 1977). Existing data do not concur in terms of trophic status of all the lakes. Seasonal variations and assessment criteria may account for some of the variation. The trophic status of each lake is discussed below. Results of chemical analyses are presented in Bowden (1977).

Lake Sumner possesses a diversity of habitats, *i.e.* braided river delta, lake margin swamplands, a large area of open water and extensive forest adjacent to the lake shore. The lake is classed as highly oligotrophic, as is typical of deep glacial lakes in New Zealand.

Lake Marion is of particular biological significance because it is free from introduced fish and completely enclosed by forest. The lake has been described as mildly mesotrophic and, alternatively, "dystrophic" and in a state very similar to lakes of Westland where brown humic material has leached from surrounding forest. (Dystrophic usually describes water that has deteriorated to a state of low productivity. However, some lakes rich in humic material may be highly productive (Jolly & Brown, 1975, cited in Bowden, 1977).

Loch Katrine is bounded by beech forest on one side, and tussock grassland on the other. The loch is variously classed as oligotrophic or mesotrophic.

Lake Taylor is surrounded by partly developed tussock pasture. The lake margin is heavily vegetated with New Zealand Flax *Phormium tenax*, Matagouri *Discaria toumatou* and Manuka *Leptospermum scoparium* (Lewis, 1983). This lake is classed as oligotrophic.

The margins of Lake Sheppard are dominated by Raupo *Typha orientalis*, New Zealand Flax and *Carex* species. Trophic status assessments vary between oligotrophic and mildly mesotrophic.

Lake Mason lies within a catchment dominated by mountain beech forest. The main part of this lake is highly oligotrophic, whereas the shallow area known as Little Lake Mason is mesotrophic.

Raupo Pond is a large area of open water, surrounded by raupo swamp with willow trees.

Lake Mary is a small area of open water is surrounded by an extensive flax and sedge swamp.

Land tenure: Lake beds are Crown land reserved from sale. Lakes and rivers in this area are lined with Crown land Section 58 (Land Act 1948) marginal strips. Other tenures are

unalienated Crown land (as at Raupo Pond), Crown Pastoral Lease (Lake Mary) and Crown Conservation area within Lake Sumner Forest Park (Lake Marion).
Most land surrounding Lake Sumner and Lake Mason is within Lake Sumner Forest Park managed by the Department of Conservation. Elsewhere, Crown Pastoral Lease tenure predominates. Other tenures include freehold title and legal road. There are camping reserves at Lake Taylor and Lake Sumner, and a Crown-owned Recreation Reserve at the southern end of Loch Katrine. There is no legal public access to Lake Mary or Lake Sheppard.
Conservation measures taken: Lake Marion is a "Faunistic Reserve" under the Freshwater Fisheries Regulations, 1951 (New Zealand Forest Service, 1979). This designation is to preserve the biological status of the lake waters by prohibiting introduction of any fish, other animal or plant. Lake Sumner Forest Park adjoins Lake Sumner and Lake Mason, but only Lake Marion is included in the park.
All lakes, except Lake Sheppard, were closed game areas up until 1977. The then North Canterbury Acclimatisation Society wanted to encourage breeding of the introduced Canada Goose *Branta canadensis*. However, protection was removed because of high goose numbers and the damage the geese caused to crops on local farms. Lake Marion was selected as a Project Aqua lake (part of an international biological research and protection programme). It was considered a representative and little-disturbed freshwater lake (Davis, 1984; Luther & Rzoska, 1971).
Conservation measures proposed: None.
Land use: The lakes are wildlife habitats. Recreation is the only other main use of the wetlands. Lake Sumner Forest Park is managed for its conservation values and for recreational use. Pastoral Lease land is used for extensive grazing of sheep and cattle. Human settlement in the upper Hurunui catchment is limited to a few isolated homesteads and an informal settlement of 40 huts and caravans at Loch Katrine. The Loch Katrine huts and Recreation Reserve are the subject of a recent draft management plan (Department of Conservation, 1993a). (See also New Zealand Forest Service, 1979).
Possible changes in land use: None known at the wetlands. Recreational use may increase gradually, but difficult access will probably limit growth. Intensification of pastoral farming and plantation forestry projects are potential land use changes in the catchment area. These changes may involve burning, application of seed and fertiliser, and alteration of the hydrology and landscape.
Disturbances and threats: Land development poses minor threats to water quality and landscape values. Water pollution remains a threat at Loch Katrine Recreation Reserve. Invasive water weeds, such as *Lagarosiphon major*, may be introduced accidentally by boat owners. Motor boats on Loch Katrine and Lake Sumner may disturb waterbirds.
In the 1970s, hydro-electric power development was proposed for the upper Hurunui River. The proposal did not go beyond the initial investigation stage. It is possible, however, that similar plans will resurface in the future. Lake levels and flow regimes may be affected.
Hydrological and biophysical values: Lake Sumner is the best example of a forested lake catchment in the eastern South Island. The lakes within this complex are classed as nationally important landforms; they are described as "extremely well defined landforms of scientific/educational and scenic value" by Kenny and Hayward (1993). The complex has excellent examples of lake features in a formerly glaciated environment.
Social and cultural values: The lakes are highly valued by the Maori people. The small lakes were along a traditional route between the east and west coasts. The complex is noted for its exceptional scenic beauty (Boffa Miskell and Lucas Associates, 1993).
Noteworthy fauna: Individual lakes within this complex are of moderate wildlife habitat value. Collectively, however, they are of high value because they support a small population of the nationally endangered Great Crested Grebe *Podiceps cristatus australis*, large numbers of

Paradise Shelduck *Tadorna variegata* (especially during the moulting period) and large numbers of the introduced Canada Goose *Branta canadensis*.

Lake Sumner is an important moulting area for Paradise Shelduck, and is one of few South Island lakes to contain resident populations of three introduced salmonid fish species, Brown Trout *Salmo trutta*, Rainbow Trout *S. gairdneri* and Quinnat Salmon *Oncorhynchus tshawytscha*. Lake Marion is of particular biological significance because it is free from introduced fish.

Loch Katrine is important for Paradise Shelduck and Grey Duck *Anas superciliosa*. Lake Sheppard supports Great Crested Grebe, Black Swan *Cygnus atratus*, New Zealand Scaup *Aythya novaeseelandiae* and often large numbers of Canada Geese. Lake Mason is moderately important as a habitat for Canada Goose and Paradise Shelduck. Raupo Pond and Lake Mary or important for Anatidae, especially for Black Swan, Mallard *Anas platyrhynchos* and Grey Duck.

Little is known of the native fish or invertebrate fauna of any of the Sumner Lakes.

Noteworthy flora: An aquatic fern, *Pilularia novae-zelandiae*, is found on the margins of Lake Sumner and Loch Katrine (de Winton *et al.*, 1987). The conservation status of this uncommon plant has not yet been determined. No details are available on noteworthy terrestrial flora.

Scientific research and facilities: Limited water quality sampling programmes were conducted in the summer of 1975/76; the results are presented in Bowden (1977). Long-term hydrological records are available for Lake Sumner and the Hurunui River (Bowden, 1977). There are no research facilities at the lakes.

Conservation education: None.

Recreation and tourism: No commercial tourism facilities are available. The lakes are popular recreation areas, especially for fishing, boating, camping and waterfowl hunting. Hurunui River, below Lake Sumner, is valued for kayaking. Recreational off-road driving is popular, and is a common way of gaining access to parts of the complex. Lake Sumner Forest Park is used by deer-hunters and walkers.

Management authority: The Department of Conservation has responsibility for the management of Lake Sumner Forest Park, Loch Katrine Recreation Reserve and wildlife. Day-to-day management is undertaken by the Department's Hanmer Field Centre. The North Canterbury Fish and Game Council manages sport fishing and game-bird hunting. Land Corporation Ltd. is responsible for the management of Pastoral Leases on behalf of the Crown. The Canterbury Regional Council has management and policy responsibilities for sustainable management of water, soil and other natural resources under the Resource Management Act 1991. Hurunui District Council has responsibility for resource consents and district planning.

Jurisdiction: Functional: Department of Conservation and North Canterbury Fish and Game Council. Territorial: Hurunui District Council and Canterbury Regional Council.

References: Boffa Miskell and Lucas Associates (1993); Bowden (1977); Canterbury Regional Council (in prep.); Davis (1984); Department of Conservation (1993a); de Winton *et al.* (1987); Kenny & Hayward (1993); Lewis (1983); Livingston *et al.* (1986b); Luther & Rzoska (1971); New Zealand Forest Service (1979).

Reasons for inclusion:

1a The Sumner Lakes Complex is a good example of lake system in a formerly glaciated environment, with extremely well defined landforms of scientific, educational and scenic value.

2b The lakes support a wide diversity of waterfowl, including the Great Crested Grebe *Podiceps cristatus australis*, an endangered species in New Zealand, and are thus of special value in maintaining the genetic and ecological diversity of the region.

3b The complex regularly supports substantial numbers of waterfowl, especially *Tadorna variegata* and *Branta canadensis*.

Source: John Andrew and Jenny Steven.

Waimakariri Lakes Complex (57)

Location: 43°06'S, 171°51'E at Lake Hawdon. In the upper catchment of the Waimakariri River in inland North Canterbury, northwest of Christchurch on the eastern side of the South Island. All but Lake Letitia are clustered within 5 km of the river, on the true right bank. Lake Letitia is between the Poulter and Esk Rivers on the true left bank of the Waimakariri River. Lake Pearson and Lake Grasmere are adjacent to State Highway 73. The other lakes are accessible by foot or along farm tracks, each less than one km from minor public roads. The lakes are situated within Cass Ecological District.

Area: 347 ha (water area for the six main lakes).

Altitude: 576-670 m.

Overview: A group of six small lakes and several tarns within the upper catchment of the Waimakariri River. Lakes Pearson, Grasmere, Sarah, Hawdon, Marymere and Letitia all occupy glacial hollows bounded by relic glacial deposits, ice-scoured slopes and/or alluvial fans. These lakes are linked together because of their common geomorphology and ecological character, and because they all support Great Crested Grebe *Podiceps cristatus australis*, an endangered species in New Zealand. The lakes range in size from 179 ha (Lake Pearson) to 20 ha (Lake Sarah). Despite being relatively small, some individual lakes support large populations of several species of Anatidae; together, they form a network of habitats for a variety of waterbirds.

Other wetlands, on old moraine surfaces in the Waimakariri Basin, are included in the complex but not described in detail. These are as follows: Remus Swamp, around a stream at Cass settlement, downstream from Lake Grasmere and Lake Sarah; Hawdon Swamp at the outlet of Lake Hawdon; Kettle Hole, a swampy tarn east of Lake Sarah; Blackwater Lake, a permanently wet tarn on elevated moraine east of Lake Hawdon; and Vagabonds Inn, a kettle hole tarn south of Marymere. The principal lakes are described separately below as Sites 57a-d.

Physical features: The lakes are within or surrounded by a diverse range of landforms. They share common geomorphic origins and are part of the same inter-montane basin (in this case, an irregularly shaped area rather than a single open plain).

Lobes of the Waimakariri Glacier advanced then retreated from this area several times during the Pleistocene. Relic glacial landforms include moraine, kettle holes, outwash surfaces, outwash channels, kame terraces, roche moutonees, carved bedrock slopes, fans formed while ice was still present, and former lake shorelines above the Waimakariri River. Since ablation of the ice, more alluvial fans have built out into the valleys. Fans at Lake Pearson, which almost divide the lake in two, and a very large fan between Lake Pearson and Lake Grasmere are classic examples of a common high country landform.

Lake water levels are highly stable and unmodified by dams or diversions. Inflow streams are small or non-existent, especially in kettle hole tarns. Outflows are narrow swampy streams or underground seepage. Further details are given in the individual site accounts (57a-d).

The upper Waimakariri Basin receives warm summers, strong, often persistent, northwesterly winds and cold frosty winters. Surface ice forms for short periods during winter, but because of local wind and shading patterns, it is rare for all lakes to freeze over completely.

Ecological features: Vegetation types are discussed in the individual site accounts. The complex includes a good range of wetland plant communities, many of which are recommended for protection (Shanks *et al.*, 1990). Lakes Pearson, Letitia, Sarah and Hawdon are oligotrophic lakes, typical of glacial high country lakes. The waters of Marymere and Lake Grasmere are tending towards mesotrophic status.

Land tenure: The wetlands are mainly Crown land reserved from sale. Lake Grasmere is Crown land with overlying Wildlife Refuge status, and there is some University of Canterbury Endowment Lease land, especially at some of the tarns and swamps. The surrounding areas are a mixture of University of Canterbury Endowment Lease land, unalienated Crown Land (in Waimakariri river bed), Crown land held as Arthurs Pass National Park and Craigieburn Forest Park, Scenic Reserve (on the hill side above Lake Grasmere), legal road and Land Act 1948, section 58, marginal strips around most rivers and lakes.

Conservation measures taken: Lake Grasmere has Wildlife Refuge status overlying Recreation Reserve status. There is a 12 ha Scenic Reserve on the hill side above this lake.

Conservation measures proposed: Lake Sarah and Remus Swamp (but not all of Grasmere Stream nor Lake Grasmere) are included in a 940 ha "recommended area for protection" (RAP) as a result of assessment under a Protected Natural Areas Programme survey, conducted by the Department of Conservation (Shanks *et al.*, 1990). Other RAPs surround Lake Pearson (180 ha, covering the lake plus dry lands), Lake Letitia (50 ha), Vagabonds Inn (18 ha), Blackwater Lake (350 ha), Og Swamp (a 12 ha wetland beside the Waimakariri River) and Lake Hawdon (250 ha). Protection of these areas has yet to be negotiated with the landowners and lessees.

Land use: Primarily wildlife habitat. Recreation is a secondary and informal use of the wetlands. The principal form of land use in the surrounding areas is extensive pastoral farming of sheep, and sometimes cattle.

Possible changes in land use: See individual site accounts. Several properties near the main highway are being developed for tourist accommodation purposes. Farm development activities such as more irrigation, fencing, fertiliser application and forestry may pose threats to water quality.

Disturbances and threats: See individual site accounts. The main concerns are changes in water quality, disturbance of breeding Great Crested Grebes, further drainage and ploughing of Red Tussock *Chionochloa rubra* wetlands near Lake Hawdon, and stock damage to lake margin swamps.

Hydrological and biophysical values: The Waimakariri Lakes Complex includes very good examples of small high country lakes of glacial and fluvio-glacial origin, typical of the inland South Island of New Zealand. The complex also has good representative examples of many wetland types of Canterbury, *e.g.* Red Tussock *Chionochloa rubra* wetlands, turflands, and New Zealand Flax *Phormium tenax*, *Carex secta* and Raupo *Typha orientalis* swamps.

Social and cultural values: The lakes traditionally have been a source of food (mainly birds) for Maori people. Today the lakes are also valued because of their impressive scenic qualities and introduced sports fishery.

Noteworthy fauna: The lakes are used by a variety of waterbirds, including both native and introduced species. The complex is noted as one of the four key areas in New Zealand for the Great Crested Grebe *Podiceps cristatus australis* (other key areas are the Coleridge Lakes, Ashburton Lakes and Lakes Alexandrina and McGregor). The grebes are unevenly distributed among the lakes. The smaller lakes usually have very low numbers of grebes, perhaps just one pair. In contrast, over 20 grebes were counted on Lake Pearson in April 1994 (Department of Conservation, unpublished data). The grebes are thought to move about within the complex and also to shift to other catchments, *e.g.* the Coleridge Lakes Complex or Wairewa/Lake Forsyth, where they probably spend the winter.

The lakes also support large numbers of Anatidae. Lake Grasmere, a Wildlife Refuge, receives particularly heavy use during parts of the year, especially during the moulting season and the duck-hunting season. Notable species include Paradise Shelduck *Tadorna variegata*, New Zealand Shoveler *Anas rhynchotis variegata* and New Zealand Scaup *Aythya novaeseelandiae*. Other notable wetland birds include the Marsh Crake *Porzana pusilla affinis*. The Australasian Bittern *Botaurus poiciloptilus* has been recorded at Lake Pearson, which offers good habitat for this species, and may still occur there. Further details of waterbirds are given in the individual site accounts.

Noteworthy flora: The complex has good representative examples of many wetland types of Canterbury. No endangered species have been recorded from the wetlands, but several species are listed as regionally uncommon. See individual site accounts and Shanks *et al.* (1990).

Scientific research and facilities: The University of Canterbury (Christchurch) operates the Cass Field Station, adjacent to Remus Swamp. The base has accommodation and laboratory facilities for use during field trips. The Department of Conservation and the North Canterbury Fish and Game Council carry out regular bird counts on the Waimakariri Lakes. The distribution and breeding success of the Great Crested Grebes is of particular interest to the Department of Conservation. Introduced fish stocks in Lake Letitia and Lake Pearson have been the subject of numerous research projects.

Conservation education: The area is used for University of Canterbury field trips, usually those for botany students. There are no special programmes designed to help conserve the lakes.

Recreation and tourism: Lake Pearson and Lake Grasmere are close to State Highway No.73. Visitor activities include picnicking, fishing, camping and photography. Boating is allowed on Lake Pearson. The other lakes are further from the highway and receive only light use. Fishing is the most common activity. Lake Letitia receives few visitors and is closed to fishing.

Management authority: The Department of Conservation has responsibility for the management of Crown land and wildlife. Day-to-day management is undertaken by the Department's Waimakariri Field Centre. The North Canterbury Fish and Game Council manages sport fishing and game-bird hunting. The University of Canterbury is responsible for the management of University Endowment Leases. The Canterbury Regional Council has management and policy responsibilities for sustainable management of water, soil and other natural resources under the Resource Management Act 1991. Selwyn District Council has responsibility for resource consents and district planning.

Jurisdiction: Functional: Department of Conservation and North Canterbury Fish and Game Council. Territorial: Selwyn District Council and Canterbury Regional Council.

References: See individual site accounts and Shanks *et al.* (1990), which includes an extensive bibliography.

Reasons for inclusion:

1a The Waimakariri Lakes Complex includes very good examples of small high country lakes of glacial and fluvio-glacial origin, typical of the inland South Island of New Zealand.

2b The lakes support a wide diversity of waterfowl, including the Great Crested Grebe *Podiceps cristatus australis*, an endangered species in New Zealand, and are thus of special value in maintaining the genetic and ecological diversity of the region.

3b Lake Grasmere, one of the lakes in this complex, regularly supports substantial numbers of waterfowl.

Source: Jenny Steven.

———

Lake Grasmere and Lake Sarah (57a)

Location: 43°04'S, 171°46'E and 43°03'S, 171°46'E. Within Cass Basin in inland Canterbury, South Island. The site is 2.5 km southeast of Cass settlement near State Highway 73. The two lakes are approximately 7 km from Arthurs Pass National Park and 4 km from Craigieburn Forest Park.
Area: Lake Grasmere 67 ha, Lake Sarah 20 ha.
Altitude: Lake Grasmere 584 m, Lake Sarah 577 m.
Overview: Lake Grasmere, its swampy outlet Grasmere Stream, and Lake Sarah are part of the Waimakariri Lakes complex. These wetlands is part of a much larger area recommended for protection (Shanks *et al.*, 1990) and noted for its high representativeness, ecological viability and diversity. Both lakes are breeding sites for Great Crested Grebe *Podiceps cristatus australis*, and Lake Grasmere frequently supports large numbers of waterfowl, both of introduced and indigenous species. Large, relatively unmodified reed-beds of Raupo *Typha orientalis* provide valuable bird habitat. There is also a high diversity of plant species on the moraines, fans, hill slopes and stream channels surrounding the lakes.
Physical features: The site encompasses two small lakes, Grasmere and Sarah, their margins and swampland downstream of both lakes known as Remus Swamp. Lake Grasmere occupies a glacially-carved oblong hollow within a small catchment of pasture, tussockland and screes on alluvial fans and greywacke sandstone mountain slopes. The lake is bounded along its rocky northeastern margin by a hardrock hill slope; in the southeast, it is bounded by the extensive alluvial fan of Ribbonwood Stream and moraine deposits, and elsewhere by gently-sloping fans. The lake is fed by seepage from Ribbonwood Stream and surrounding fans and hill slopes. The outlet, Grasmere Stream, drains from the northwestern end of the lake. It flows via Cass River into the Waimakariri River. Lake Sarah is enclosed by moraine deposits on three sides and part of Cass alluvial fan on the west. The outlet stream joins Grasmere Stream south east of Cass. Fan development has impeded water flow from the lakes, creating, downstream, an extensive swamp with a stable, meandering channel. This swamp, adjacent to Cass settlement, is known as Remus Swamp.
Lake Grasmere (15 m deep) is a mesotrophic lake, with low nutrients, high alkalinity and conductivity, and high silica input from surrounding rocks. Lake Sarah (6.7 m deep) is oligotrophic to mesotrophic.
The lakes are within Cass Basin, an area which has warm summers and cold, frosty and often foggy winters. Strong northwesterly winds funnel through the basin. Both lakes freeze over occasionally. The waters of Lake Sarah are well mixed, whereas those of Lake Grasmere show temperature stratification at times during summer.
Ecological features: Grasmere Stream/Remus Swamp wetland is dominated by a large dense stand of Raupo *Typha orientalis*, the largest stand in Cass Ecological District (Shanks *et al.*, 1990). Raupo reed-beds also forms marginal stands around half of Lake Sarah's perimeter, providing valuable protection for waterbirds in what is often a windswept environment. New Zealand Flax *Phormium tenax* and a tall sedge tussock species, *Carex secta*, occur at both ends of Lake Grasmere. A large area of *Schoenus pauciflorus* sedge, to the north of Cass settlement, is divided by a railway line. The submerged flora of Lake Grasmere is dominated by the introduced *Elodea canadensis*. Other plants include the introduced *Ranunculus trichophyllus* and the indigenous milfoil *Myriophyllum propinquum*. Diatoms are prevalent in the plankton and Chironomidae (midges) dominate the benthos (Livingston *et al.*, 1986b). The biology of Lake Grasmere has been described in some detail by Stout (1975).
Hill slopes around Lake Sarah are covered by modified grasslands, with scattered shrubs of Matagouri *Discaria toumatou* and the uncommon *Coprosma intertexta*. Manuka *Leptospermum scoparium* shrubland occupies poorly-drained moraines south of Lake Sarah.

Other native species are New Zealand Flax, *Schoenus pauciflorus*, Tauhinu *Cassinia leptophylla*, Red Tussock *Chionochloa rubra* and *Hebe odora*. The small Scenic Reserve above Lake Grasmere (12 ha) is dominated by mountain beech forest *Nothofagus solandri* var. *cliffortioides*, extensive in the eastern South Island of New Zealand.

Land tenure: Lake Grasmere is Crown land held as Wildlife Refuge under the Wildlife Act 1953 and as Recreation Reserve, both of which are administered by the Department of Conservation. Other areas include leased pastoral land held under University of Canterbury Endowment Lease, Crown land held as Scenic Reserve, and legal road.

Conservation measures taken: Lake Grasmere was designated a Wildlife Refuge in 1968. This area was given the additional status of Recreation Reserve in 1970. Grasmere Scenic Reserve adjoins the lake and is included as part of the Wildlife Refuge. The hillside Scenic Reserve above Lake Grasmere is fenced to prevent access by domestic livestock access. There is an agreement between the lessee and owner (University of Canterbury) to minimise livestock damage in Remus Swamp and Lake Sarah.

Conservation measures proposed: Lake Sarah and Remus Swamp (but not all of Grasmere Stream nor Lake Grasmere) are included in a 940 ha "recommended area for protection" as a result of assessment under a Protected Natural Areas Programme survey (Shanks *et al.*, 1990). A scenic corridor concept has been developed for part of State Highway 73 and the Midland Railway route (Bennett & Lucas, 1992). Both lakes are part of that corridor. The study aims to guide land-use changes in this area, to ensure it is sympathetic with existing landscape characteristics.

Land use: The lakes and swampland are managed for conservation purposes. A track at the southern end of Lake Grasmere gives visitors access to the lake shore. Land around Lake Sarah and the swampland are used for extensive pastoral grazing. Approximately half of Lake Grasmere's margin adjoins intensively stocked and irrigated grassland.

Possible changes in land use: Agricultural development is expected to continue on irrigated land. There is potential for increased run-off of chemicals, fertiliser and sediment.

Disturbances and threats: Lake Grasmere is susceptible to nutrient enrichment from agricultural run-off. Lake Sarah is vulnerable to change in water quality because of its small size. The unfenced swamplands are at risk from trampling and grazing by livestock, particularly cattle. Gorse *Ulex europaeus*, Broom *Cytisus scoparius* and the willow *Salix fragilis*, common weeds in this locality, may spread into disturbed areas. Parts of Remus Swamp have been drained, and introduced grasses are dominant in places. Fire is a constant risk, especially with the seasonal accumulation of dry raupo leaves and proximity to railway operations. There have been culling operations on Lake Grasmere to reduce the population of the introduced Canada Goose *Branta canadensis*. Some high country land-owners object to the grazing and fowling of pasture by large numbers of geese at certain times of the year.

Hydrological and biophysical values: The lakes and swampland play a minor role in buffering flow into the Waimakariri River.

Social and cultural values: The wetlands are of value for scientific research including studies of long-term change. This value is enhanced by the proximity of the Cass Field Station research facilities. Both lakes are components of the Waimakariri Basin, a regionally significant inter-montane and basin landscape (Boffa Miskell and Lucas Associates, 1993). Lake Grasmere is a highly visible and attractive landscape feature on a major tourist route.

Noteworthy fauna: The lakes are very important habitat for waterfowl. Both are breeding areas for the Great Crested Grebe *Podiceps cristatus australis*, an endangered species in New Zealand. Lake Sarah typically supports one breeding pair, whereas five to eight birds may be found on Lake Grasmere. The grebes are known to move between the numerous lakes of the upper Waimakariri Basin. Lake Grasmere is also of particular significance because at certain times of the year it supports very large numbers of swans, geese and ducks (Anatidae), more

than any of the other lakes in the Waimakariri complex. The most abundant species are Black Swan *Cygnus atratus*, Canada Goose *Branta canadensis*, Paradise Shelduck *Tadorna variegata*, Mallard *Anas platyrhynchos*, Grey Duck *A. superciliosa* and New Zealand Scaup *Aythya novaeseelandiae*. Waterfowl occurring in smaller numbers include Black Shag *Phalacrocorax carbo*, Little Shag *P. melanoleucos*, White-faced Heron *Egretta novaehollandiae*, Grey Teal *Anas gracilis*, New Zealand Shoveler *A. rhynchotis variegata* and Southern Black-backed Gull *Larus dominicanus*. The Marsh Crake *Porzana pusilla affinis* occurs in the thick vegetation at Remus Swamp.

Noteworthy flora: No notable plants are associated with the wetlands. The uncommon *Coprosma intertexta* grows amongst small patches of shrubland on hill slopes and moraine.

Scientific research and facilities: The University of Canterbury (Christchurch) operates the Cass Field Station, adjacent to Remus Swamp. The base has accommodation and laboratory facilities for use during field trips. Numerous scientific research projects (including Ph.D studies) have been conducted in the locality; these are summarized in Burrows (1977) and Livingston *et al.* (1986b). The Department of Conservation and North Canterbury Fish and Game Council conduct regular waterbird counts at lakes within the Waimakariri Lakes complex. The distribution and breeding success of the Great Crested Grebe is of particular interest to the Department of Conservation.

Conservation education: Cass Field Station provides a base for scientific and environmental education. However, there are no known educational programmes focused upon the lakes and no permanent staff. There are no interpretation facilities at the lakes.

Recreation and tourism: The southern end of Lake Grasmere is easily accessible from State Highway 73 and is occasionally used by day visitors and campers for passive recreation, fishing and bird-watching. No facilities are provided. Lake Sarah is used by trout anglers, and is accessible by foot from a nearby road.

Management authority: See under account for lake complex (57).

Jurisdiction: See under account for lake complex (57).

References: Bennett & Lucas (1992); Boffa Miskell and Lucas Associates (1993); Burrows (1977); Livingston *et al.* (1986b); Shanks *et al.* (1990); Stout (1975).

Reasons for inclusion:

1a Lake Grasmere and Lake Sarah are part of the Waimakariri Lakes Complex, which constitutes a very good example of a group of small high country lakes of glacial and fluvio-glacial origin, typical of the inland South Island of New Zealand.

2b The lakes support a wide diversity of waterfowl, including the Great Crested Grebe *Podiceps cristatus australis*, an endangered species in New Zealand, and are thus of special value in maintaining the genetic and ecological diversity of the region.

3b Lake Grasmere regularly supports substantial numbers of waterfowl.

Source: John Andrew and Jenny Steven.

Lake Letitia (57b)

Location: 43°03'S, 171°57'E. Approximately 50 km southeast of Arthur's Pass and 60 km northwest of Sheffield, Central Canterbury, South Island. The lake is accessible via a secondary road linking Mount White station homestead with Provincial State Highway No.73 at Cass.

Area: c.8 ha.

Altitude: 589 m.

Overview: Lake Letitia is part of the Waimakariri Lakes Complex. The lake occupies an ice-excavated bedrock hollow, blocked by moraine deposit at the eastern end. It is bordered by mountain beech forest with willow trees along its north side, by raupo swamp at the western end and by fescue tussock grasslands on the south side, with native flax on the lake shore. There is one surface inflow, and there are numerous springs around the lake shore. The main outlet is at the western end via the raupo swamp to Letitia Stream. Lake Letitia is important habitat for the nationally endangered Great Crested Grebe *Podiceps cristatus australis*, and contains an introduced stock of hybrid Splake, in addition to eels, galaxiids and bullies.

Physical features: Lake Letitia is a long, narrow lake formed as a result of past glacial advances. It is situated at the southern foot of Mount White (1,774 m), between the confluences of the Poulter and Esk Rivers with the Waimakariri River. The catchment area includes the small depression within which the lake is situated, plus parts of Lake Hill and the Sugarloaf which are situated to the south and east. The water level remains relatively stable throughout the year, possibly because of to the damming effect of the raupo swamp at the western end. The rocky shoreline limits soil development except near the outflow where organic soils occur. The outflow drains via a steep escarpment to the Esk River and is subterranean for some distance. The climate in the vicinity of the lake is continental, with warm summers, very cold winters and frequent periods of strong northwesterly winds. The lake is subject to periodic, partial ice cover in winter.

Ecological features: The swamp at the western end of the lake is dominated by Raupo *Typha orientalis*, and there are areas of willow *Salix fragilis* and New Zealand Flax *Phormium tenax* along the lake shore. Remnant beech forest (*Nothofagus* sp.) and fescue tussock grasslands are the dominant vegetation types bordering the lake. Aquatic plant species identified during a fisheries survey of the lake included *Elodea canadensis*, *Potamogeton ochreatus* and *Ranunculus fluitans* (Ross, 1984).

Land tenure: The bed of Lake Letitia is Crown land and is open to public recreational use. Land adjoining the lake comprises part of the Mount White station, substantially Crown leasehold pastoral run utilised for the farming of sheep and cattle.

Conservation measures taken: The lake was closed to recreational angling in the recent past (1987-1989) to allow natural recruitment of artificially-stocked, hybrid Splake *Salvelinus namaycush* x *S. fontinalis*, but is now open to licensed angling subject to special equipment and daily bag limit restrictions.

Conservation measures proposed: Lake Letitia was identified as a "Recommended Area for Protection" (RAP) during the 1987/1988 ecological survey of the Cass Ecological District for the Protected Natural Areas Programme.

Land use: The resident human population of the area is limited to the owner/manager of Mount White station, associated farm workers and their families. Occasional short-duration visits to the area by recreational anglers, hunters and trampers do not create any significant seasonal population increase. Some drainage work has been done in the paddock next to the lake outlet, and further work may be carried out in the future.

Possible changes in land use: No major changes are foreseen. The risk of adverse development impacts on the wetland values of Lake Letitia is considered minimal for the foreseeable future. However, the catchment is situated immediately adjacent to Mount White station homestead, and consequently some further land development may take place in the vicinity in the future. Such development could adversely impact on water quality in the lake over the longer term.

Disturbances and threats: Cattle and sheep have direct access to the lake shore and raupo swamp at the lake outlet, but have not degraded existing habitat values to date. Further spread of the willows would restrict angling opportunities in the long term, but would add to waterfowl habitat values by increasing nesting cover and shelter. Hybrid Splake have been

introduced into Lake Letitia by the North Canterbury Acclimatisation Society (now Fish and Game Council) to diversify opportunities for recreational angling. The Splake are not expected to have an adverse impact on other species of aquatic fauna resident in the lake.

Hydrological and biophysical values: The lake is believed to be the source of groundwater discharge from the southern faces of Mount White. There is very little seasonal variation in lake level, but discharge via the Letitia Stream is known to cease for varying periods.

Social and cultural values: Lake Letitia is remote from population centres and reasonably difficult of access. It is of minor importance to the occasional visiting angler.

Noteworthy fauna: Resident waterfowl at the lake include Great Crested Grebe *Podiceps cristatus australis*, Little Shag *Phalacrocorax melanoleucos*, Black Swan *Cygnus atratus*, Paradise Shelduck *Tadorna variegata*, Mallard *Anas platyrhynchos*, Grey Duck *A. superciliosa* and New Zealand Scaup *Aythya novaeseelandiae*. The Black Shag *Phalacrocorax carbo* is a regular visitor. Fish include Long-finned Eel *Anguilla dieffenbachii*, Short-finned Eel *A. australis*, Common Bully *Gobiomorphus cotidianus*, Upland Bully *G. breviceps*, galaxiids *Galaxias* spp. and Splake *Salvelinus namaycush* x *S. fontinalis*.

Noteworthy flora: None known.

Scientific research and facilities: A fisheries survey of the lake carried out in 1984 by field staff of the North Canterbury Acclimatisation Society has provided records on fish and aquatic plant species present. There are no facilities for scientific investigation at the lake, and the area is remote from the nearest available accommodation.

Conservation education: None to date. The remote location of the lake does not facilitate this type of use, and there are similar wetland habitats within the region which are more readily accessible and closer to the main population centres.

Recreation and tourism: Present use is minimal and limited to occasional short-term visits by recreational anglers and hunters. Potential use is similarly limited due to the remote location of the lake, and there are no plans for any type of development for this purpose.

Management Authority: The Department of Conservation has responsibility for the management of flora and fauna, with the Department's Waimakariri Field Centre responsible for day-to-day management. The Selwyn District Council has statutory responsibilities under the Resource Management Act 1991 for water resources and development proposals. The North Canterbury Fish and Game Council manages sport fishing and game-bird hunting.

Jurisdiction: Territorial: Selwyn District Council. Functional: Department of Conservation (Canterbury Conservancy) and North Canterbury Fish and Game Council.

References: Ross (1984); Shanks *et al.* (1990).

Reasons for inclusion:

1a Lake Letitia is part of the Waimakariri Lakes Complex, which constitutes a very good example of a group of small high country lakes of glacial and fluvio-glacial origin, typical of the inland South Island of New Zealand.

2b The lake supports a wide diversity of waterfowl, including the Great Crested Grebe *Podiceps cristatus australis*, an endangered species in New Zealand, and is thus of special value in maintaining the genetic and ecological diversity of the region.

Source: Dick Hutchinson and John Andrew.

Lake Pearson (57c)

Location: 43°07'S, 171°47'E. In a valley between Mount Manson at the northern end of the Craigieburn Range and Purple Hill, on the east side of the Arthur's Pass highway (Provincial

State Highway No.73), 32 km southeast of Arthur's Pass and 56 km northwest of Sheffield, Central Canterbury, South Island.
Area: 200 ha.
Altitude: 607 m.
Overview: Lake Pearson is part of the Waimakariri Lakes Complex. The debris fans of Ribbonwood Stream and Craigieburn Stream dam the lake to the north and south respectively. A small area of raupo swamp (*Typha orientalis*) at the northern end of the lake constitutes the only marginal wetland; elsewhere, surrounding grasslands border the gravel lake shore. Outflow to the Waimakariri River drainage is from the southern end of the lake, via Winding Creek. Lake Pearson is the most important of the Cass Lakes for the nationally endangered Great Crested Grebe *Podiceps cristatus australis*, and also supports a number of other rare and threatened birds.
Physical features: Formed as a result of past glacial actions, Lake Pearson is the largest of the group of lakes in the Cass district. It is partly bordered partly by intensively farmed land and a large fan off Purple Hill. A smaller and steeper fan of debris from Mount Manson almost bisects the lake, forming two distinct lake basins. The water level varies seasonally over a range of about 1.5 metres, with maximum water levels occurring during the spring thaws and minimum levels during the winter freeze-up. The principal inflow is the Craigieburn which discharges into the lake immediately beside the outlet. For much of the year, the flow in the lower reaches of this stream is subterranean. Recent gley soils of the Dobson soil formation are found in the swampy area at the northern end of the lake, but elsewhere around the lake, the soils are poorly developed and comprised mainly of the finer component from surrounding outwash fans. The lake surface is subject to varying degrees of ice cover during winter, when surface drainage from the lake can cease for extended periods (months). The climate in the area is continental, with very warm summers and temperatures in winter often dropping below 0^{o}C.
Ecological features: Extensive beds of *Elodea canadensis* have displaced the indigenous aquatic plant community over much of the lakes' littoral zone. The aquatic fern *Pilularia novae-zelandiae* is present in the lakeshore gravels. Fescue tussock grasslands border much of the lake shore, with patches of manuka shrubland and matagouri/sweet briar associations over the infilling fans on both sides of the lake. Some limited areas of rushes (species of *Juncus*, *Carex* and *Scirpus*) occupy portions of the shoreline at the southern and northern ends of the lake, and small stands of willow *Salix* spp. and poplar have become established at several locations, predominantly along the western shore. Land to the north and south of the lake has been developed for intensive farming, and alternates between cropping and grazing use.
Land tenure: The bed of Lake Pearson and a discontinuous Riparian Reserve strip around the lake shore is Crown land reserved from sale and is open to public recreational use. Lands adjoining the lake are included within three Crown pastoral "runs" (large farm holdings) which are utilised for the farming of sheep, cattle and deer. Two of these runs include areas of freehold (privately-owned) land on the valley floor bordering the northern and southern ends of the lake.
Conservation measures taken: None.
Conservation measures proposed: Lake Pearson was identified as a "Recommended Area for Protection" (RAP) during the 1987/88 ecological survey of the Cass Ecological District for the Protected Natural Areas Programme. The RAP covers 180 ha including the lake itself and some adjacent dry land.
Land use: The resident human population of the area is very small, and is limited primarily to farm workers and their families. Seasonal population increases are focused on winter skiing and a range of outdoor recreational activities during the summer and autumn months. Recreational angling, boating and game-bird hunting are the predominant activities focused on

the lake, of which angling is probably the most important, followed by boating. Camping and picnicking on the lake shore adjacent to the Provincial State Highway 73 are popular during the summer months. Areas of private land at the northern and southern ends of the lake are intensively developed for farming and cropping purposes.

Possible changes in land use: No major changes are foreseen at the lake itself. The catchment is located in an area which is heavily utilised for a wide variety of outdoor recreational activities, and is easily accessible from the city of Christchurch. The Craigieburn catchment is utilised for skiing, and together with several other ski fields which are situated in close proximity, could be subject to further development in the future. An accommodation lodge already established on Flockhill Station could be further developed and expanded in the future, and the land area bordering the southern end of Lake Pearson could again be targeted for development of an alpine-style village community in the future.

Disturbances and threats: Farming activities on the developed lands adjoining the lake are known to be the principal source of nutrient enrichment of the lake waters. This inflow of nutrients is expected to cause a progressive decline in water quality, in the absence of adequate protection of the riparian zone around the lake. Domestic livestock (cattle and sheep) have direct access to much of the lake shore and the swamp at the north end of the lake, and have damaged the natural vegetation and affected water quality. The resident eel population in Lake Pearson is periodically subjected to commercial harvest, and this has significantly reduced numbers of larger specimens. Introduced willows *Salix* spp. are well established at a number of localities around the western shoreline. (These trees provide important shelter and nesting habitat for Great Crested Grebe *Podiceps cristatus australis* and New Zealand Scaup *Aythya novaeseelandiae*).

Hydrological and biophysical values: Lake Pearson is the source of Winding Creek which is one of the major spawning tributaries for Quinnat Salmon *Oncorhynchus tschawytscha* which each year enter the Waimakariri River system from the south Pacific Ocean to spawn. It has an important smoothing effect on flood discharges down the Craigieburn, and also traps the bulk of the sediment discharge from that catchment, significantly enhancing the spawning and juvenile salmonid habitat values throughout the length of Winding Creek. The lake also ensures maintenance of the water table in the small wetland at its northern end.

Social and cultural values: While relatively remote from population centres, the lake is easily accessible via Provincial State Highway 73 from the city of Christchurch, and is of some regional importance for recreational angling, game-bird hunting, boating activities and camping. It is lightly exploited on a seasonal basis for each of these activities. The lake and surrounding area have high aesthetic significance due to their substantially unmodified state and spectacular alpine scenery.

Noteworthy fauna: Lake Pearson is the most important of the Cass group of lakes for the Great Crested Grebe *Podiceps cristatus australis*, with several pairs using the lake for breeding each year. Other resident waterfowl at the lake include Paradise Shelduck *Tadorna variegata*, Mallard *Anas platyrhynchos* (100-150), Grey Duck *A. superciliosa* (100-150), New Zealand Scaup *Aythya novaeseelandiae* and Spur-winged Plover *Vanellus miles*. A large flock of Canada Geese *Branta canadensis* (c.1,200-1,800) regularly visits the lake and feeds an adjacent developed farmlands. Australasian Bittern *Botaurus poiciloptilus* and Marsh Crake *Porzana pusilla affinis* have been recorded as occasional visitors.

Four species of introduced salmonids are resident in the lake, including the only population of Lake Trout *Salveliniis namaycush* established in New Zealand. Resident native fish species include two species of galaxiids *Galaxias* spp., two species of bully *Gobiomorphus* spp. and the Long-finned Eel *Anguilla dieffenbachii*.

Noteworthy flora: The endemic aquatic fern *Pilularia novae-zelandiae* is present in the lakeshore gravels. Overhanging growth from a number of the older, more mature willow trees

Salix spp. on the western shore of the lake is utilised by Great Crested Grebes for incorporation of nest platforms during the breeding season.
Scientific research and facilities: The bathometry of Lake Pearson has been mapped by Irwin (1970). Flain (1971 & 1987) has reported details of lake trout specimens taken from the lake, while McDowall and Richardson (1986) provided site records for other fish species present. Staff of the Department of Conservation's Waimakariri Field Centre carry out regular surveys of wildlife. The University of Christchurch (Ilam) maintains a field station at Cass, approximately 12 km west of Lake Pearson, and accommodation is also available at Flock Hill Lodge which is immediately adjacent to the southern end of the lake.
Conservation education: None at present. The remoteness of the lake from major educational institutions would limit such use.
Recreation and tourism: Recreational use is currently very limited, most visitors being short-stay campers, anglers or boating enthusiasts, with peak activity occurring around the opening of the fishing season or during the summer holiday period. Three permanent cabins situated around the lake shore are utilised principally by anglers. Lake Pearson has recently (1987) been unsuccessfully targeted for development of an alpine-style tourist village complex.
Management Authority: The Department of Conservation has responsibility for the management of fauna and flora, with the Department's Waimakariri Field Centre responsible for day-to-day management. The Selwyn District Council has statutory responsibilities under the Resource Management Act 1991 for water resources and development proposals. The North Canterbury Fish and Game Council manages sport fishing and game-bird hunting.
Jurisdiction: Territorial: Selwyn District Council. Functional: Department of Conservation (Canterbury Conservancy) and North Canterbury Fish and Game Council.
References: Flain (1971, 1987); Given (1989); Hutchinson (1981); Irwin (1970); McDowall & Richardson (1986); Parry (1948); Percival (1948, 1949). **Reasons for inclusion:**

1a Lake Pearson is part of the Waimakariri Lakes Complex, which constitutes a very good example of a group of small high country lakes of glacial and fluvio-glacial origin, typical of the inland South Island of New Zealand. Lake Pearson is an excellent example of a lake formed by fans.

2a The lake supports a substantial population of the threatened aquatic fern *Pilularia novae-zelandiae*.

2b The lake is the most important habitat in the Cass district for the Great Crested Grebe *Podiceps cristatus australis*, an endangered species in New Zealand, and is thus of special value in maintaining the genetic and ecological diversity of the region.

Source: Dick Hutchinson and John Andrew.

Lake Hawdon and Marymere (57d)

Location: 43°06'S, 171°51'E. 11 km southeast of Cass settlement in the upper Waimakariri Catchment of inland Canterbury, South Island. The lakes are accessible by rough private tracks across farmland, approximately 10 km along a secondary road off State Highway No.73.
Area: Lake Hawdon, 30 ha; Marymere, 23 ha.
Altitude: Lake Hawdon, 576 m; Marymere 616 m.
Overview: Lake Hawdon and Marymere are two small lakes of glacial origin in the upper reaches of Slovens Stream, a tributary of Broken River. The lakes are part of the Waimakariri

Lakes Complex, a series of small glacially formed lakes and swamps which drain, ultimately, into the Waimakariri River. Land around the two lakes is used for extensive pastoral farming. Disturbance at the lakes is minimal as they are not visible from the road, there are no buildings nearby, and trout fishing pressure is seasonal and never heavy. For their small size, the lakes support large numbers of waterbirds. The lakes are used regularly by the nationally endangered Great Crested Grebe *Podiceps cristatus australis*. The swamp at the outlet of Lake Hawdon is the largest remaining area of Red Tussock *Chionochloa rubra* in Cass Ecological District, It is also one of the two largest and most diverse wetlands in the district (Shanks *et al.*, 1990). The unprotected tussockland community is under threat from drainage and damage by cattle. The lakes and swamp have been recommended for formal protection.

Physical features: Slovens Stream valley was excavated during the last glaciation by a major lobe of the now non-existent Waimakariri glacier. The lakes occupy depressions in a large deposit of ablation moraine and ice-gouged bedrock along the valley margin. Both lakes are bounded to the west by hardrock and scree covered slopes of Purple Hill. Marymere is a large kettle hole lake, its roughly circular shape being typical of this origin. The lake is only 2 m deep, has gravel beaches and no obvious outlet. A smaller, more steeply sided kettle hole, which is inundated seasonally, is situated between Marymere and Lake Hawdon. Lake Hawdon sits at a lower elevation, effectively downstream of Marymere. This lake is larger, oblong in shape and 4 m deep. It occupies a glacially excavated rock hollow. The lake is considered to be a remnant of a former, more extensive lake, or of several ice marginal lakes (Gage, 1959).

On three sides, Lake Hawdon is bounded by hardrock or shattered colluvial and morainic rock deposits covered in high country yellow brown earth soils. The lake drains via an artificially aligned stream to the northwest, through fine swampy alluvium with gley soils. This drainage pattern is typical of the reversal after glacial retreat. Natural drainage of the swamp has been modified by the deepened and realigned channel at Lake Hawdon's outlet. A large drain near the road and railway contributes to drying out of the wetland.Both lakes are subject to minor fluctuations in level and occasional surface freezing.

The local climate is semi-continental, with warm to hot summers and severe frosts during winter. Strong winds from the northwest funnel down Slovens Stream valley. Lake Hawdon, in particular, is exposed to these winds.

Ecological features: Both lakes are open water bodies, with submerged aquatic plants growing in fine sediment around their margins. Raupo *Typha orientalis* reed-beds, in a band on the northern margin of Lake Hawdon, grades into *Carex* spp. and bog rush *Schoenus pauciflorus* sedgeland, then into the extensive Red Tussock *Chionochloa rubra* swamp of Slovens Stream. Some New Zealand Flax *Phormium tenax* is present on the western margin of this lake. Marymere has no marginal swamp. Instead, the gravel shores support patches of turf dominated by *Limosella lineata*, *Carex gaudichaudiana*, *Agrostis muscosa*, *Galium perpusillum* and *Pratia perpusilla*. Turflands also occur on the north bank of Lake Hawdon and in a strongly zoned pattern around the small kettle hole tarn. Lake Hawdon is an oligotrophic lake. Marymere, with its smaller size and shallow waters, is tending towards mesotrophic status.

Away from the lake shores, vegetation is typical of that found on well drained slopes throughout the upper Waimakariri catchment, *i.e.* modified short tussock grassland, with patches of shrubs, particularly Matagouri *Discaria toumatou*. Remnant mountain beech forest (*Nothofagus solandri* var. *cliffortioides*) survives on the western margin of Marymere. Fire has been the main agent of change on dry land surrounding the lakes.

Land tenure: The lakes are held as Crown land. The Red Tussock swamp is University of Canterbury Endowment Land, leased for pastoral farming.

Surrounding areas are University of Canterbury Endowment Lease land and legal road.

Conservation measures taken: None.
Conservation measures proposed: Following an assessment by Shanks *et al.* (1990), an area of 250 ha, including both lakes and a large tongue of swampland northwest of Lake Hawdon, was recommended for protection under the Protected Natural Areas Programme.
Land use: The lakes are managed by the Department of Conservation and the North Canterbury Fish and Game Council for conservation purposes and for recreational fishing. Recreational use of the lakes is limited to fly-fishing for trout. Visitor numbers are low and seasonal. Land around the lake is used for extensive grazing of sheep and, sometimes, cattle. The pasture is modified but uncultivated native grassland. It is likely to have been burnt and fertilised in the past. Human settlement in Slovens Stream valley is limited to one farm homestead, one of three large leased properties in the Cass and Craigieburn area.
Possible changes in land use: None known. Swamp drainage for agricultural purposes is a possibility, given the lack of formal protection.
Disturbances and threats: Construction of more drainage ditches in the Lake Hawdon Swamp would have serious repercussions for the hydrology and ecology of the area. Drier areas of Red Tussock adjacent to Lake Hawdon Swamp have recently been ploughed, highlighting the leaseholder's desire to expand agricultural land in Slovens Stream valley. Given the stony substrate and steep slopes, it is unlikely that the hill slopes will be developed intensively, although fertiliser run-off may occur in the future. The relatively small catchment area will minimise the risk of eutrophication from this source. There was an informal proposal, several years ago, to break down a small waterfall in lower Slovens Stream in order to allow salmon to spawn in this catchment.
Hydrological and biophysical values: The lakes and swamp play a minor role in moderating stream flows within the Waimakariri catchment. The lakes are of considerable ecological value because of their relatively unmodified character. The kettle holes, glacially carved lake and Red Tussock swamp are highly representative of wetland habitats of Cass Ecological District. The communities are moderately diverse. Viability is considered to be high, provided further drainage does not occur (Shanks *et al.*, 1990).
Social and cultural values: Lake Hawdon was used in the past by Maori people as a seasonal food collecting area, and Marymere's resources were probably also tapped. Lake Hawdon and Marymere are remote from population centres and little known, particularly because of their location down a "no exit" unsealed road. Amongst the small number of anglers who fish the upper Waimakariri Lakes, this area is highly valued, particularly because of its isolation.
Noteworthy fauna: The lakes support one or two pairs of the nationally endangered Great Crested Grebe *Podiceps cristatus australis*. Relative to their small sizes, the lakes support high numbers of Anatidae and other waterfowl. Common species include Black Shag *Phalacrocorax carbo*, Canada Goose *Branta canadensis*, Paradise shelduck *Tadorna variegata*, Mallard *Anas platyrhynchos*, Grey Duck *A. superciliosa* and New Zealand Scaup *Aythya novaeseelandiae*. Bird usage of Lake Hawdon Swamp has not been studied, but because of its considerable extent and dense cover, it is expected to be a valuable habitat for breeding birds.
Little is known about the native fish or aquatic invertebrates of the lakes.
Noteworthy flora: A small stand of *Baumea rubiginosa* on the shore of Lake Hawdon is the only known occurrence of this sedge species in Cass Ecological District. Two turfland species found at the kettle hole tarn, *Selliera radicans* and *Triglochin striatum*, have not been seen elsewhere in the district. These plants are usually found in coastal sites. *Carex enysii* and a *Cardamine* sp. also occur in the turfland. These plants are uncommon elsewhere in the district.
Scientific research and facilities: The site is 11 km away from the University of Canterbury Cass Field Station, which has research facilities and accommodation. Despite this proximity, the site has not been the focus of research.

Conservation education: None at present. Other more accessible lakes are likely to be chosen for educational activities before this site.
Recreation and tourism: Visitor use of the area is limited to occasional day-use of the lakes for trout fishing. The fishing season and regulations are controlled by the North Canterbury Fish and Game Council. There are no plans for development of facilities at the lake. Guided fishing tours may increase numbers of visitors slightly.
Management authority: The Department of Conservation has responsibility for the management of Crown land, flora and fauna. The Department's Waimakariri Field Centre is responsible for day-to-day management. The University of Canterbury is responsible for the management of University Endowment leasehold land. The Selwyn District Council has statutory responsibilities under the Resource Management Act 1991 for water resource management and approval of development proposals. The Canterbury Regional Council has a range of responsibilities with respect to the management of natural resources and land use policy under the Resource Management Act 1991. The North Canterbury Fish and Game Council manages sport fishing and game-bird hunting.
Jurisdiction: Functional: Department of Conservation and North Canterbury Fish and Game Council. Territorial: Selwyn District Council and Canterbury Regional Council.
References: Gage (1959); Shanks *et al.* (1990).
Reasons for inclusion:

1a Lake Hawdon and Marymere are part of the Waimakariri Lakes Complex, which constitutes a very good example of a group of small high country lakes of glacial and fluvio-glacial origin, typical of the inland South Island of New Zealand. The Red Tussock *Chionochloa rubra* swamp at Lake Hawdon is of considerable significance because it is a little modified and extensive example of a plant community that was once much more extensive in the upper Waimakariri area.

2b The lakes support one or two pairs of Great Crested Grebe *Podiceps cristatus australis*, an endangered species in New Zealand, as well as a number of plants which are rare elsewhere in the region; it is thus of special value in maintaining the genetic and ecological diversity of the region.

Source: John Andrew and Jenny Steven.

Coleridge Lakes Complex (58)

Location: 43°18'S, 171°31'E. On the true left bank of the upper Rakaia River catchment in inland Canterbury, approximately 40 km north of Methven township, west-northwest of Christchurch, South Island. Within Coleridge Ecological District.
Area: c.3,614 ha (surface water area).
Altitude: 507-841 m.
Overview: The Coleridge Lake Complex includes the following lakes and wetlands: Lake Coleridge and its lagoons; Lake Lyndon; the Ryton Lakes, namely, Henrietta, Selfe, Evelyn, Ida, Catherine (also known as Lake Monck) and Georgina, and their associated wetlands Moss Burn, Idaburn and Mt Hennah swamps; and numerous groups of dry, seasonally-wet or permanently inundated tarns in the general vicinity, *e.g.* Red Lakes, and tarns below Mt Barker, on the Clay Range, on Coleridge Downs south of the lake, and on the summit of Mt Georgina, a total of 93 tarns (Glenny *et al.*, 1987). Lake Coleridge, Lake Lyndon and the Ryton Lakes are described in greater detail as Sites 58a-c below.

All the lakes are of glacial origin. During the Pleistocene ice advances, tongues of the now insignificant Rakaia, Wilberforce and other glaciers carved steep-sided valleys and troughs. During the Holocene, the landforms have been modified by rivers, fans and wave action, creating a wide variety of wetland habitats.

The complex includes the most important wetlands of the Coleridge Ecological District (Shanks *et al.* 1990), and the complex possesses typical examples of most of the district's wetland types. Plant diversity is high. A considerable number of the nationally endangered Great Crested Grebe *Podiceps cristatus australis* use the lakes. The birds breed at most of the lakes, and move about between the various water bodies during the course of the year. (The exact pattern of these movements is not yet known.) The wetlands are also used by large numbers of other waterfowl and wetland birds, and species diversity is high. In all, the lakes provide "outstanding habitat for birds" (Shanks *et al.* 1990).

Although Lake Coleridge has very different hydrologic characteristics because of its depth and large volume, it is grouped with the Ryton Lakes because of the common glacial origin, physical proximity in the same ecological district, and because of the movement of birds, especially the Great Crested Grebe *Podiceps cristatus australis*, between the lakes. Lake Lyndon is physically isolated from the rest of the complex, but is included because it too is used by Great Crested Grebes. It also has a significant area of turfland. The unnamed tarns are also relic glacial features with a diverse turfland flora. These tarns do not support Great Crested Grebes.

Lake Coleridge is subject to fluctuations in water level because of hydro-electric power generation. The other wetlands are highly natural, although they are set within fire-induced scrub and tussock grasslands. Despite past development proposals, there are few immediate threats to this wetland complex.

Physical features: Lake Coleridge is a large, deep, oligotrophic lake with shallow lagoon wetlands, bounded by steep hill sides. The Ryton Lakes are much smaller and shallower than Coleridge, but they have very similar glacial origins. They occupy the floor of glacially carved valleys. Drainage has been modified by subsequent alluvial processes. The lakes flow into Ryton River which in turn feeds Lake Coleridge. Lake Lyndon is a medium-sized oligotrophic lake. The landscapes around the Coleridge Lakes are expansive and relatively barren. Natural features predominate. Further details are given in the individual site accounts.

Ecological features: The geomorphology, vegetation, birdlife, aquatic invertebrates and water chemistry of the Coleridge Lakes Complex and additional local tarns and swamps have been surveyed in detail by Glenny *et al.* (1987) and Shanks *et al.* (1990). Details are given in the individual site accounts.

The climate around Lake Coleridge is typical of inland Canterbury. Summers are very warm to hot, with low humidity, while winters are cold, with frequent severe frosts. The shallow lakes occasionally freeze over. Strong northwesterly winds are characteristic of the area.

Land tenure: The beds of the lakes and most lake margins are Crown land. Lake Ida is on Crown Conservation area. Lakes Selfe, Evelyn and Catherine are Crown land with an overlying Wildlife Refuge status, under the Wildlife Act 1953. Lake Coleridge is Crown land reserved for the generation of electricity. Swamplands are on freehold land, *i.e.* privately owned, and on leased University of Canterbury Endowment Land. Surrounding areas include University of Canterbury Endowment Land, Crown land held under Pastoral Lease, Legal road and freehold land.

Conservation measures taken: There are no fully protected areas. Lakes Selfe, Evelyn and Catherine are Wildlife Refuges, protected under the Wildlife Act 1953. This status prohibits disturbance to wildlife, but does not protect wetland habitat or control land use within the wider catchment of a wetland. Lake Coleridge and the Rakaia River tributaries, excluding the Wilberforce River and its tributaries, are given partial protection under the Rakaia River

National Water Conservation Order, gazetted in 1988. The object of the order is to retain the water quantity and rate of flow in a natural state and to prevent loss of water quality (Shanks *et al.*, 1990). Wildlife and vegetation are not protected directly.

Conservation measures proposed: The Protected Natural Areas Programme survey by Shanks *et al.* (1990) recommends protection of 1,550 ha around the Ryton Lakes (Coleridge RAP 22), 3,290 ha at Lake Coleridge, including its shoreline and Peninsula Island (Coleridge RAP 31 and 19), and Lake Lyndon, plus several large areas of hill slope, gorge and upland tarn surfaces on land within the Coleridge catchment. The Department of Conservation is in the process of following up these recommendations. A report by Glenny *et al.* (1987) also recommends protection of wetlands on University of Canterbury Endowment Land. Scenic Reserve and Wildlife Refuge status is suggested for Lakes Evelyn, Henrietta and Catherine. Lake Selfe, Hennah Stream, Mt Hennah Swamp, Moss Burn, Simois Stream and Mt Barker Tarns are also recommended for protection. Lake Lyndon Recreation Area is being assessed in a plan to enhance its ecological, landscape and amenity values.

Land use: The lakes are used primarily for nature conservation purposes. There are few permanent residents in the vicinity as there are few farms (stations) in the area. During summer (also part of the fishing season), visitor numbers increase. There is some informal camping and use of fishing huts at Lake Selfe (no huts), the northern end of Lake Coleridge, Ryton River Mouth and Coleridge Peninsula. Lake Ida is the base for a winter sports club; there are several buildings, but usage is low. Lake Coleridge is used for hydro-electric power generation.

Extensive pastoral farming of sheep, cattle and deer is the predominant land use in the Coleridge Catchment. Some hill slopes and summits have been retired from grazing or have controlled livestock numbers under Soil and Water Conservation Plans. A road through the area provides access to a ski-field.

Possible changes in land use: A major tourist resort development on Ryton Station was proposed and assessed between 1987 and 1989. The proposal included a golf course near Moss Burn, resort accommodation near the shore of Lake Coleridge and a new ski-field in the adjacent Craigieburn Range. The proposal was put into abeyance because of financial uncertainty. It is possible that pastoral land development will involve increased use of fertilisers, with subsequent eutrophication of the small lakes of the Coleridge Catchment.

Disturbances and threats: Grazing of wetland margins is an existing threat to the unfenced wetlands. Cattle are particularly destructive to vegetation around the margins of the wetlands. Increased run-off of fertiliser is a risk associated with land development in the surrounding hills. Lake Coleridge is subject to increased sedimentation when inflow from the Harper Diversion channel occurs during floods. Fluctuations in lake level at Lake Coleridge pose a variety of risks to wildlife, especially to birds which nest on the water line. Positive, negative and unknown impacts will be assessed in the near future as New Zealand Electricity Corporations's water rights are due for renewal. Lakes Henrietta, Selfe and Evelyn are beside a little-used secondary road. There is likely to be some disturbance of waterfowl by a major increase in visitor traffic and camping at Lake Selfe.

Hydrological and biophysical values: The lakes and tarns are excellent examples of relic glacial landforms. Post glacial landforms, such as fans which dam Lake Catherine, are also of interest. Lake Coleridge is a storage lake for hydro-electric power generation.

Social and cultural values: The area is valued by Maori people because of traditional food resources and historical significance. Maori have always held water and natural resources in high spiritual regard.

Noteworthy fauna: The Coleridge Lakes Complex is one of the few strongholds of the Great Crested Grebe *Podiceps cristatus australis* in New Zealand.

Noteworthy flora: Several swamp and turfland species found in this complex are uncommon in Canterbury. See individual site accounts for more details.

Scientific research and facilities: The Coleridge Lakes Complex is not the focus of scientific research, and there are no facilities for this purpose. The report by Glenny *et al.* (1987), however, suggests that the University of Canterbury should develop a field station in the area. The Department of Conservation conducts regular bird counts on Coleridge and Waimakariri Lakes. In particular, the Department hopes to gain a better understanding of population dynamics and seasonal movements of the Great Crested Grebes.
Conservation education: Because of its remote location, this area is not used for conservation education programmes.
Recreation and tourism: Angling and picnicking are the main activities, but visitor numbers are low at present, and there are few facilities. Freehold land tenure around parts of Lake Coleridge restricts visitor access. A proposal for tourist resort development is not being pursued.
Management authority: The Department of Conservation has responsibility for the management of Crown land and wildlife. Day-to-day management is undertaken by the Department's Waimakariri Field Centre. The University of Canterbury is responsible for the management of University Endowment Leases. The Electricity Corporation of New Zealand is responsible for the management of the Lake Coleridge Power Scheme. Selwyn District Council has powers and responsibilities under the Resource Management Act 1991 for resource consents and district planning. Canterbury Regional Council has management and policy responsibilities under the Resource Management Act 1991 for the management of water, soil and other natural resources, flood control and pollution control. The North Canterbury Fish and Game Council manages sport fishing and game-bird hunting.
Jurisdiction: Functional: Electricity Corporation of New Zealand, Department of Conservation and North Canterbury Fish and Game Council. Territorial: Selwyn District Council and Canterbury Regional Council.
References: Glenny *et al.* (1987); Shanks *et al.* (1990).
Reasons for inclusion:

1a The Coleridge Lakes Complex is a good example of a group of small glacial lakes and tarns characteristic of the eastern high country of the South Island of New Zealand.

2a The lakes support a population of a globally threatened species of bird, the Australasian Bittern *Botaurus poiciloptilus*.

2b The lake, tarn and swamp habitats are of special value for maintaining the genetic and ecological diversity of the region. The wetlands support a wide variety of waterbirds, including the nationally endangered Great Crested Grebe *Podiceps cristatus australis*, as well as diverse plant communities ranging from tall reed-beds and tussockland to low turflands.

2d The wetlands are of special value for their endemic plant and animal species and communities.

3b The wetlands regularly support substantial numbers of waterfowl, especially Anatidae, highlighting their value as a large and diverse wetland system.

Source: Jenny Steven.

Lake Lyndon (58a)

Location: 43°18'S, 171°42'E. On the periphery of Rakaia River catchment, inland Canterbury, 12 km east of Lake Coleridge and approximately 80 km northwest of Christchurch, South

Island. The northern end of the lake is 3 km west of Porters Pass, adjacent to State Highway No.73. Lake Lyndon is within Torlesse Ecological District, but has strong ecological links with Coleridge Ecological District.

Area: 111 ha.

Altitude: 840 m.

Overview: Part of the Coleridge Lakes Complex. Glacial advances in the Rakaia catchment formed all of these high country lakes. Another common feature of these lakes is use by a population of Great Crested Grebe *Podiceps cristatus australis*. Lake Lyndon occupies a glacially carved trough and narrow valley. It is surrounded by gravel and stone beaches, with indigenous shrubland and tussock grasslands on slopes beyond. Shoreline vegetation is sparse and low growing. A seasonally-wet pond at the northern end of the lake supports a large turfland with some uncommon species. Aquatic plants occur throughout the lake bed. Lake waters are oligotrophic, with low chlorophyll levels, few algal blooms, low silica levels and no diatoms (Livingston *et al.*, 1986b).

Physical features: During the Pleistocene, a branch of the Rakaia Glacier moved up the Lyndon valley towards what is now part of the Waimakariri and Rakaia watershed. Since the ice retreat, alluvial fans have blocked drainage at both ends of the lake. The lake has a relatively small catchment area of 1,555 ha, and a maximum depth of 28 m (Shanks *et al.*, 1990; Livingston *et al.*, 1986b). There is no permanent inflow stream. Outflow, via Acheron River to the south, is episodic. A low wall has been built across the northern end of the lake. When water levels are high, a shallow extension of the lake develops beyond this wall. This pond is surrounded by a notable turfland. The shores of the lake comprise barren gravel and stone beaches and small areas of turfland. In and around the pond at the north end, gley soils have developed from loess and lake silt. Soils on adjacent hill slopes are high country yellow brown earths, dissected by eroded patches and chutes.

The area experiences warm summers, strong winds and cold frosty winters with regular snowfalls. During most winters, the lake surface freezes over for at least several days. In general, however, the waters are well mixed, with no significant temperature stratification (Livingston *et al.*, 1986b).

Ecological features: Lake Lyndon is an oligotrophic lake, typical of glacial lakes in New Zealand. The lake has a margin of *Isoetes alpinus* aquatic fernland, with *Elodea canadensis* (introduced), *Lilaeopsis novae-zealandiae* and *Myriophyllum triphyllum* in deeper water. On the periodically-dry turflands, there are diverse low herb species and two aquatic ferns. Species include *Myriophyllum propinquum* (predominant), *Rumex flexuosus*, *Leptinella maniototo*, *Limosella lineata*, *Galium perpusillum*, *Montia australasica*, *Agrostis muscosa*, *Epilobium komarovianum*, *Pratia perpusilla*, *Lachnagrostis* spp., *Cardamine* spp. and the aquatic ferns *Pilularia novae-zealandiae* and *Isolepis alpinus*. The tarn margin turfland in the shallow pond is the largest such community between the Rakaia and Hurunui Rivers.

Vegetation beyond the lake includes modified short tussock grassland and dense shrublands on slopes, which once supported forest of Mountain Beech *Nothofagus solandri* var. *cliffortioides*. Common species include *Dracophyllum longifolium*, Matagouri *Discaria toumatou*, a speargrass *Aciphylla aurea*, Red Tussock *Chionochloa rubra* in several valley wetlands, and distant remnants of Mountain Beech. Accidental and intentional burning has been a major agent of change in the catchment. Introduced trees grow around a picnic area beside State Highway No. 73.

Land tenure: The lake is Crown land. Surroundings areas are Crown land leased to private occupiers under Pastoral Lease and legal road.

Conservation measures taken: None.

Conservation measures proposed: The lake and its margin, including the northern pond, are proposed as a "recommended area for protection", following an ecological survey by the

Department of Conservation (Shanks *et al.*, 1990). Work has commenced on a landscape and facilities redevelopment plan for the roadside and lakeshore picnic area. Expected changes include replacement of introduced trees with native plants, and limits on vehicle access to the lake shore.

Land use: Non-commercial recreation activities are popular, but still occur at relatively low levels. The only buildings are an accommodation lodge at the more remote southern end of the lake, an old hut, and a toilet block and shelter near the highway. The lake has been stocked with trout (*Salmo* sp.) for recreational fishing. Surrounding land held under Pastoral Lease is used for extensive grazing of sheep and occasionally cattle. Some naturally-eroding high altitude lands have been retired from grazing. There is no permanent human habitation near the lake.

Possible changes in land use: Redevelopment of the picnic area is likely to enhance the natural character of the lake, through the removal of introduced trees and reduced disturbance of wildlife. There are no known development proposals within the lake catchment. In the future, the minor road that winds around the eastern edge of the lake may be upgraded to receive increased tourist traffic.

Disturbances and threats: Occasional use of motorboats may cause disturbance to wildlife, despite speed restrictions. The turflands are at risk from vehicle damage, especially by cars, motorbikes and off-road vehicles when water levels are low. The shallow pond is especially vulnerable to vehicle damage, as it is accessible, close to the highway and only partly fenced. Cattle may cause pugging of the silt substrate and turflands. Grazing by sheep may also damage the pond's vegetation and water quality. However, the area has already withstood over a century of grazing.

Hydrological and biophysical values: As the lake catchment is small, the area has little influence on downstream water flows. The lake is part of a network of high country lakes, all of which are used by a range of waterbird species.

Social and cultural values: The often-windswept lake surface, bare gravel beaches and open tussock grassland on the valley sides form a stark and remote landscape. Lake Lyndon is part of the Waimakariri Basin, an area identified as a regionally outstanding natural landscape (Boffa Miskell and Lucas Associates, 1993).

Noteworthy fauna: Lake Lyndon is used by moderate numbers of waterfowl. Low numbers of Great Crested Grebe *Podiceps cristatus australis* occur on the lake, but they do not breed here, possibly because of the lack of protective lakeshore vegetation.

Other notable species recorded at the lake include Black Shag *Phalacrocorax carbo*, Little Shag *P. melanoleucos*, Paradise Shelduck *Tadorna variegata*, Grey Duck *Anas superciliosa*, New Zealand Scaup *Aythya novaeseelandiae*, South Island Pied Oystercatcher *Haematopus finschi*, Pied Stilt *Himantopus leucocephalus* and Banded Dotterel *Charadrius bicinctus*.

Noteworthy flora: *Pilularia novae-zelandiae*, an endemic aquatic fern, is found in the turflands. The endemic *Leptinella maniototo* also occurs in the area (Shanks *et al.*, 1990). Many other species which are most commonly found in seasonally inundated wetlands are abundant here. The floristic representation of turfland species is notable, and includes a number of endemic species.

Scientific research and facilities: There are no research facilities at Lake Lyndon. Accessibility from the state highway, however, has encouraged research into lake chemistry and biology. Studies are listed in Livingston *et al.* (1986b).

Conservation education: None.

Recreation and tourism: Lake Lyndon is used mainly for short visits for picnics, travellers' rest stops, trout fishing, water-skiing, motor-boating and informal winter sports including ice-skating. Levels of use are low, except when snow or ice attract site-seers. Disturbance to

waterbirds is likely to be minimal at such times. As is the case elsewhere within the Coleridge Lakes Complex, there is, as yet, no commercial development.

Management authority: See under general account of Coleridge Lakes Complex.

Jurisdiction: See under general account of Coleridge Lakes Complex.

References: Boffa Miskell and Lucas Associates (1993); Livingston *et al.* (1986b); Shanks *et al.* (1990).

Reasons for inclusion:

1a Lake Lyndon is part of the Coleridge Lakes Complex, a good example of a group of small glacial lakes and tarns characteristic of the South Island eastern high country. Lake Lyndon is of special value because of the representative character of its turfland flora.

2b The lake supports a diverse turfland plant community with a number of plants which are scarce elsewhere in the region, as well as low numbers of Great Crested Grebe *Podiceps cristatus australis*, an endangered species in New Zealand; it is thus of special value in maintaining the genetic and ecological diversity of the region.

2d The lake is of special value for its endemic plant species, including *Rumex flexuosus*, *Leptinella maniototo*, *Galium perpusillum*, *Epilobium komarovianum*, *Pratia perpusilla*, *Pilularia novae-zealandiae* and *Isolepis alpinus*.

Source: John Andrew and Jenny Steven.

Ryton Lakes (58b)

Location: 43°15'S, 171°32'E (centred on Lake Selfe). Northeast of Lake Coleridge on the true left bank of the Rakaia River in inland Canterbury, South Island. The lakes are approximately 40 km north of Methven township and 140 km west of Christchurch. Within Coleridge Ecological District.

Area: c.214 ha of lake and swamp.

Altitude: 524-675 m.

Overview: The Ryton Lakes are a group of small shallow lakes within formerly glaciated valleys. They form part of the Coleridge Lakes Complex because of their common glacial origin, physical proximity and high value as a network of habitats for regularly dispersing and mobile waterfowl, especially Great Crested Grebe *Podiceps cristatus australis*. The group includes lakes Henrietta, Selfe, Evelyn, Ida, Catherine (also known as Lake Monck) and Georgina, and their associated wetlands, Moss Burn, Idaburn and Mt Hennah swamps. There are also over 90 other small, often ephemeral tarns on relic glacial surfaces nearby, *e.g.* on the Clay Range, Mt Georgina, Coleridge Downs, Scamander Stream and beneath Mt Barker. The tarns are noted for their floristically rich turflands. (These tarns and two outlying wetlands, Red Lakes and Lake Lilian, are not discussed further). The lakes renown as Great Crested Grebe habitat are described below.

Physical features: The Ryton Lakes are much smaller and shallower than Lake Coleridge, but they have very similar glacial origins. They occupy valley floors that were carved by various lobes of the Wilberforce Glacier. Drainage has been modified by alluvial processes. The main lakes, except for Lake Georgina, flow into Ryton River, which in turn feeds Lake Coleridge. The following descriptions are adapted from Shanks *et al.* (1990). (See also Glenny *et al.*, 1987).

- Moss Burn Swamp (35 ha) lies on an alluvial surface near Harper River. Movement along the Harper Fault probably influences drainage. The swamp is bounded by varied

terrain: ablation moraine, glacial outwash terraces and ice-smoothed slopes.

- Lake Henrietta (4 ha, 2 m deep) is a remnant of a once larger lake. It is within ablation moraine, and probably occupies the space once filled by a large block of glacial ice.
- Lake Selfe (33 ha, 30 m deep) occupies a trough below ice-scoured slopes of Mt Ida. Debris-flow fans have infilled parts of the lake and separated this lake and Lake Evelyn.
- Lake Evelyn (15 ha, 3 m deep) is bounded on the north and east by the slopes of Little Mt Ida, greywacke bedrock and moraine. An active debris-flow fan spreads into the lake on the west. Moraine and alluvium impede the drainage to the south.
- Mt Hennah Swamp (32 ha) is separated from Lake Evelyn by a road. Terminal moraine dams the eastern end of the swamp. Drainage reversal occurred after retreat of ice since the Pleistocene. The outlet today is near Lake Evelyn, down Hennah Stream to Ryton River.

The following sites occupy other branches of the Ryton catchment:

- Lake Ida (10 ha, 9 m deep) is higher than the adjacent lakes. It occupies a shaded, ice-gouged valley. A landslide at the eastern end forms a dam, and a fan from Mt Ida divides the lake in two. Part of the lake has been dammed artificially to form an ice-skating rink.
- Idaburn Swamp (c.50 ha) lies to the south east, in a fluvio-glacial meltwater channel on an undulating ablation moraine. There are two kettle hole tarns. Part of the swamp is underlain by alluvium from Ryton River.
- Lake Catherine (15 ha, 4 m deep), the furthest lake from Lake Coleridge, is a shallow fan-dammed lake between Mt Ida and the Clay Range. The permanent outflow stream runs southward into Ryton River.
- Lake Georgina (20 ha, 10 m deep) is an oval-shaped windswept lake that drains via Scamander Stream into Lake Coleridge. Harper Road passes close to this lake.

Most of the swamplands around the Ryton Lakes are underlain by mature gley soils with a peaty "A" horizon. Soils on adjacent hill slopes and glacially-moulded terrain are high country yellow brown earths. Extensive fans are covered in shallow recent soils or bare gravel and fine sediment.

The Ryton Lakes are subject to persistent winds and large seasonal and daily temperature variations, typical of the South Island inter-montane basins. The lakes freeze over during winter, for several days to weeks at a time. Lake waters are not stratified, probably as a result of their shallow depth and stirring by the wind.

Ecological features: The lakes are ecologically interesting because they are a cluster of little modified wetlands with a wide range of wetland communities. Sedgeland mosaics of *Carex virgata, C. secta, C. sinclairii, C. diandra, C. coriacea* and Bog Rush *Schoenus pauciflorus*, and Red Tussock *Chionochloa rubra* are the most widespread wetland communities in the area. New Zealand Flax *Phormium tenax* is common along swampland streams. Flax and sedgelands are extensive at Moss Burn, Idaburn and Mt Hennah swamps. The vegetation here is between 50 cm and 2 m high. Raupo *Typha orientalis* grows in standing water, forming thick reed-beds around much of Lake Evelyn and Henrietta. Small stands occur at Lake Catherine. *Baumea rubiginosa* rushland grows in shallow water at Lake Evelyn, Mt Hennah and Moss Burn swamps. This species is considered rare in Canterbury (Glenny *et al.*, 1987). Red Tussock areas occur near Moss Burn and in Idaburn Swamp. At Idaburn, the tussockland includes a *Sphagnum* moss bog with sparse tussocks and peat bottomed pools with emergent *Eleocharis acuta*.

Lake Evelyn and Lake Henrietta have the largest areas of marginal swamp, marsh and wet grasslands (Glenny *et al.*, 1987). Lake Evelyn has a particularly good sequence from raupo to sedges, then tussockland on drier soils. In contrast, Lake Selfe and Lake Ida (as well as much

of Lake Coleridge) have only minor swamplands because of their steep banks. The introduced willow *Salix fragilis* is present at most lakes, but not dominant. There are 93 small tarns in the Coleridge Lakes area. They support a very large number of plant species (approximately 100), many of which are found only in tarn habitats. Zonation of turf species is apparent in many periodically-flooded tarns. Submerged lake vegetation in the lakes and tarns has been studied by Glenny *et al.* (1987). The most extensive vegetation types are those dominated by charophytes, algae in the genera *Chara* and *Nitella*. The introduced pondweed *Elodea canadensis* is common throughout. In Lake Evelyn, the most swampy of the lakes, trophic status is mesotrophic (Livingston *et al.*, 1986b), despite particularly low chlorophyll levels. The other lakes are considered oligotrophic to mesotrophic.

Land tenure: Crown land, University of Canterbury Endowment Lease, freehold and legal road. Surrounding areas are predominantly University of Canterbury Endowment Lease and Crown Pastoral Lease, with smaller areas of freehold land, Crown land and legal road.

Conservation measures taken: Lake Evelyn, Lake Selfe and Lake Catherine have Wildlife Refuge status under the Wildlife Act 1958. This status protects the wildlife but does not ensure habitat protection.

Conservation measures proposed: The Ryton Lakes, surrounding wetlands and hill slopes have been proposed as a 550 ha "recommended area for protection" following a Protected Natural Areas (PNA) Programme survey (Shanks *et al.*, 1990). The survey concluded that the area is highly representative, diverse and viable, with high landform and "special feature" significance. Glenny *et al.* (1987) also recommended protection for these wetlands.

Land use: The wetlands are primarily wildlife habitat. Informal camping occurs at Lake Selfe and Lake Georgina. Lake Ida is used periodically for ice-skating. Facilities are run by a small winter sports club. There is no commercial use of the lakes. Some lakes margins are accessible to stock for drinking water and grazing.

Extensive pastoral farming is the dominant land use in the catchment. Minor roads provide access to visitors, workers on the few large farms (stations) and workers who maintain the Harper River Diversion. There is a small, almost empty settlement west of Moss Burn Swamp in the Harper River catchment. Formerly, this was one of two bases for the Coleridge hydro-electric power scheme.

Possible changes in land use: A resort complex, golf course and ski-field were proposed for the Ryton catchment. The proposal has been shelved at present.

Disturbances and threats: Cattle can cause considerable damage to the vegetation and substrate along the lake margins. Ephemeral tarns and swamps within farmland are particularly vulnerable. Fertiliser run-off from farm development operations is a potential risk of unknown seriousness. Because the lakes are small and most are adjacent to a public road, there is some risk that birds may be disturbed by visitors. Fire (accidental and intentional) is the main threat to shrubs and tussock grasslands around the wetlands.

Hydrological and biophysical values: The lakes and tarns are excellent examples of relic glacial landforms. Post-glacial landforms are also of interest. Lake Catherine is dammed by a large alluvial fan off Mt Ida. It is noted as "a good example of an hour glass fan" (Kenny & Hayward, 1993).

Social and cultural values: The Ryton Lakes are within a region traversed by Maori in historic times. It is likely that the wetlands were highly valued for their food and fibre resources. Inland sites such as this were used occasionally by travelling Maori and regularly for seasonal harvests. The resources and routes of travel are still highly valued by Maori. Today, the area is accessible by road. Despite this, the local landscape conveys impressions of remoteness, isolation and stark character. These attributes are sought after by many New Zealanders.

Noteworthy fauna: The Ryton Lakes are an important breeding and feeding area for the Great

Crested Grebe *Podiceps cristatus australis*, an endangered species in New Zealand. The birds are known to move between the various water bodies of the Coleridge Lakes Complex and, to an unknown extent, throughout Canterbury. Lake Selfe is the most important of the Ryton Lakes for the grebes. The lakes also support a variety of Anatidae, especially New Zealand Scaup *Aythya novaeseelandiae* (breeding) and Paradise Shelduck *Tadorna variegata*. Several heavily vegetated wetlands are ideal habitat for Australasian Bittern *Botaurus poiciloptilus*. Other notable species include Marsh Crake *Porzana pusilla affinis* and the occasional Great Egret or White Heron *Egretta alba*. Of the six main lakes, Selfe and Catherine support the highest numbers of waterbirds (Shanks *et al.*, 1990).

The most abundant animals among the rooted aquatic vegetation is the small black snail *Potamopyrgus antipodarum*. Lake Ida has the most diverse and abundant aquatic fauna (in open water, among rooted vegetation and in mud) of any of the six main lakes (Glenny *et al.*, 1987). Lake Georgina, at least, contains a freshwater crayfish *Paranephrops zealandicus*, a crustacean of potential commercial value as farmed or wild stock.

Noteworthy flora: The local wetland flora is known for its diversity rather than its rarity (Shanks *et al.*, 1990). The uncommon herb *Iphegina novae-zelandiae* occurs at the head of Mt Hennah Swamp. Locally uncommon wetland plants include *Elatine gratioloides* and *Baumea rubiginosa* (Shanks *et al.*, 1990). Lake Ida is noted as having an interesting and unusual phytoplankton.

Scientific research and facilities: Limited scientific research has been carried out, and there are no facilities at the lakes. Two major ecological surveys were conducted in the late 1980s, by Glenny *et al.* (1987) and Shanks *et al.* (1990), respectively. Tourist development proposals led to a variety of ecological assessments in the early 1990s. More recently, the Department of Conservation has assisted with research on tarn management near Mt Barker. Bird populations are monitored on a regular basis by the Department of Conservation, to gain, in particular, a better understanding of the population dynamics of the Great Crested Grebes.

Conservation education: None

Recreation and tourism: Following collapse of the resort proposal, it appears that recreation at Ryton Lakes will remain at a low level for some time to come. Fishing and picnicking are the main activities. Two small camping sites (beside Lake Selfe and Lake Georgina) receive moderate use during the fishing season and in mid-summer.

Management authority: See under general account of Coleridge Lakes Complex.

Jurisdiction: See under general account of Coleridge Lakes Complex.

References: Glenny *et al.* (1987); Kenny & Hayward (1993); Livingston *et al.* (1986b); Shanks *et al.* (1990).

Reasons for inclusion:

1a The Ryton Lakes are part of the Coleridge Lakes Complex, a good example of a group of small glacial lakes and tarns characteristic of the South Island eastern high country.

2a The lakes support a population of a globally threatened species of bird, the Australasian Bittern *Botaurus poiciloptilus*.

2b These small lakes support a wide variety of waterfowl, including the Great Crested Grebe *Podiceps cristatus australis*, an endangered species in New Zealand, and have diverse wetland habitats and plant communities (approximately 100 plant species), from tall reed-beds and tussockland to low turflands; they are thus of special value in maintaining the genetic and ecological diversity of the region.

2d The wetlands are of special value for their endemic plants (*e.g. Iphegina novae-zelandiae*) and animals, and are particularly important for their endemic plant communities.

Source: John Andrew and Jenny Steven.

Lake Coleridge (58c)

Location: 43°18'S, 171°31'E. North of the mid reaches of the Rakaia River in inland Canterbury, approximately 40 km northwest of Methven township, South Island. Within Coleridge Ecological District.
Area: 3,290 ha.
Altitude: 507 m.
Overview: Lake Coleridge is a large oligotrophic lake of glacial origin. The lake's hydrology has been modified as a result of hydro-electric power development. The lake is noted as habitat for Great Crested Grebe *Podiceps cristatus australis* and New Zealand Scaup *Aythya novaeseelandiae*, but also supports large numbers of other waterfowl of a diverse range of species. Habitats include open water, stony beaches and shores, river deltas and several lagoons formed behind shingle bars.
Physical features: With an area of 3,290 ha, Lake Coleridge is the largest lake within the Rakaia Catchment. It is similar in character to the other large, elongate high country lakes of inland South Island, *e.g.* lakes Sumner, Tekapo, Pukaki and Ohau. Lake Coleridge occupies an over-deepened glacial trough, up to 200 m deep and 17.8 km long, excavated by a lobe of the former Wilberforce Glacier, once a tributary of the Rakaia Glacier.
The natural outflow, Lake Stream at the northern end of the lake, represents a drainage reversal after moraine blocked outflow from the southern end. After the Wilberforce Glacier cut an alternative channel to the Rakaia River, beyond the northern end of the lake, the main surface inflow became the smaller Ryton River. Human activity has also changed the lake's hydrology. To facilitate hydro-electric power generation, Lake Stream was dammed, the lake level was raised, a tunnel became the main outflow, and the Harper and Wilberforce Rivers were partially diverted into the lake. Since completion of the Harper Diversion inflow in 1977, lake levels have not been allowed to fluctuate to extremes.
Strong winds funnel down this narrow lake and generate significant wave action. Most of the lake edge slopes steeply into the water as a result of past glacial action. Wave action continues to carve low cliffs, especially on the southern bank. Barrier beaches, spits and sheltered lagoons have formed in the southeast and near the mouth of Ryton River. Small deltas occur at this river mouth and in the west, where the Harper River diversion enters the lake. Large fans extend into the lake from Cottons Sheep Range and Mt Oakden. There is no soil development along the shoreline. Small areas of gley soil have developed in wetlands associated with the lagoons.
Like other lakes within this complex, Lake Coleridge is subject to strong winds, large temperature extremes in summer, and heavy frosts. It does not, however, freeze over in winter.
Ecological features: Lake Coleridge is described as an oligotrophic to highly oligotrophic lake. The lake water is virtually oxygen-saturated to 68 m depth. Nutrient levels are very low, with barely measurable microbial activity. Coarse gravel beaches are colonised by native mat plants (*Raoulia* spp.) and introduced grasses. Introduced willow trees *Salix fragilis* dominate Homestead Lagoon. The lake contains submerged charophytes, *Chara* spp. and *Nitella* spp., and introduced Canadian Pondweed *Elodea canadensis* (Shanks *et al.*, 1990). Lagoons frequently have a floating vegetation of *Potamogeton cheesemanii* and introduced *Ranunculus trichophyllus*.
The lake is surrounded mainly by steep hill sides covered in native, but fire-induced, plant communities. Two notable, though small, forest remnants occur at the base of Kaka Hill, close to the north eastern lake margin. An unusual dryland shrub community occurs on Peninsula Island, just offshore from the Ryton Peninsula (Shanks *et al.*, 1990).
Land tenure: The lake bed is Crown land. Land around the lake includes Crown land reserved from sale, Crown land reserved for the generation of electricity, and University of Canterbury

Endowment Lease land. Surrounding areas are a mixture of University of Canterbury Endowment Lease land, freehold land and Crown Pastoral Lease land.

Conservation measures taken: Lake Coleridge is given partial protection under the Rakaia River National Water Conservation Order, gazetted in 1988. The object of the order is to retain the water quantity and rate of flow in a natural state and to prevent loss of water quality (Shanks *et al.*, 1990). The order covers Lake Coleridge despite existing modifications due to hydro-electric power development. Wildlife and vegetation are not protected directly.

Conservation measures proposed: The lake and its associated shoreline features were recommended for protection after a Protected Natural Areas Programme Survey by Shanks *et al.* (1990), primarily because of the lake's value as waterbird habitat. Several shrub and forest communities near the lake were also recommended for protection. These are located on the slopes of Kaka Hill, on Peninsula Island and on a fan on Cottons Sheep Range.

Land use: The lake is used as a storage reservoir for the generation of electricity. It is also used for recreational fishing and boating. The principal land-use activity in surrounding areas is extensive pastoral farming, mainly of sheep.

Possible changes in land use: None known. The lake waters will continue to be used for generation of electricity. Water rights are due for renewal in the near future, and it is possible that conditions attached to those rights may be adjusted.

There are no known development proposals in the catchment area. A plan for tourist resort development has been shelved. Further intensification of farming is likely on gently sloping land near Harper River and on Coleridge Downs and Peak Hill in the southeast.

Disturbances and threats: The impacts of fluctuating water levels on breeding Great Crested Grebe and New Zealand Scaup at Lake Coleridge are not yet understood. It is probable that a large increase in water during the breeding season would flood and destroy nests. Sudden falls in water level may make it difficult for grebes to reach previously established nest sites. It should also be noted that artificially high water levels ensure there is ample water in Homestead Lagoon, a valuable site for Anatidae. Fertiliser run-off from adjacent farmland is a potential threat. The large volume of the lake minimises the risk of such pollution. As yet, most of the farmland remains as native pasture. Diversion of silt-laden floodwater from the Harper and Wilberforce Rivers may have negative effects on the lake ecosystem.

Hydrological and biophysical values: The lake is valued as a source of water for electricity generation. It is the most important lake in the Coleridge Ecological District for waterbirds (Shanks *et al.*, 1990). The variety of habitats, from shallow lagoons to deep, open water, provide diverse habitats for birds. The lake may also play a role as a resting place for birds moving and dispersing around the country.

Social and cultural values: The lake is close to historical routes taken by Maori between the east and west coasts. The lake is also incorporated into Maori mythology. It is likely that waterbirds were taken from the lake margin and former lagoons on seasonal hunting trips to the high country. The lake is valued today for its apparent naturalness, scenic beauty and remote landscape characteristics, and for its recreational opportunities.

Noteworthy fauna: Although Lake Coleridge does not have extensive swamps, it supports a good range and often large numbers of waterbirds. Birds tend to gather on the sheltered waters of Homestead Lagoon in the southeast, on the leeward (southeast) side of a peninsula near Ryton River, and around shallow water and dry land at the two delta areas (Ryton River and Harper Diversion). The lake is especially noted for its populations of Great Crested Grebe *Podiceps cristatus australis* and New Zealand Scaup *Aythya novaeseelandiae*. Both these species nest very close to the water and are likely to be affected by major fluctuations in water level. Other native waterbirds commonly encountered at Lake Coleridge include Black Shag *Phalacrocorax carbo*, Paradise Shelduck *Tadorna variegata*, Grey Teal *Anas gracilis*, Grey Duck *A. superciliosa*, New Zealand Shoveler *A. rhynchotis variegata* and Southern Black-

backed Gull *Larus dominicanus*. The introduced Black Swan *Cygnus atratus* and Mallard *Anas platyrhynchos* are common. Species recorded less frequently include Australasian Bittern *Botaurus poiciloptilus*, White-faced Heron *Egretta novaehollandiae*, Great Egret or White Heron *E. alba*, Pukeko *Porphyrio porphyrio melanotus* (uncommon in inland Canterbury), Common Coot *Fulica atra* (recently established and now breeding) and Banded Dotterel *Charadrius bicinctus*. Lake Coleridge supports two species of native bully *Gobiomorphus* spp., Koaro *Galaxias brevipinnis*, Long-finned Eel *Anguilla dieffenbachii* and the three common introduced sports fish, Brown Trout *Salmo trutta*, Rainbow Trout *S. gairdneri* and Quinnat Salmon *Oncorhynchus tshawytscha*.

Noteworthy flora: There are no notable aquatic plants in the lake or lagoons. Notable terrestrial plants found near the lake are Southern Rata *Metrosideros umbellata* on Peninsula Island and Kaka Hill West, and *Clematis paniculata* and *Brachyglottis rotundifolia* on Peninsula Island. These species are not recorded elsewhere in this ecological district. Shanks *et al.* (1990) give further details and a list of uncommon forest species in the area.

Scientific research and facilities: There are no research facilities in the area. The Department of Conservation is continuing a programme of bird surveys at this and other lakes in the complex, with the Great Crested Grebe being the main species under investigation. Research projects into water quality, productivity and fisheries are listed in Livingston *et al.* (1986b).

Conservation education: None.

Recreation and tourism: The lake and environs are used for non-commercial activities, including boating, fishing and camping. Lake Coleridge is particularly popular for sport fishing, and there are several clusters of fishing huts. The Electricity Corporation of New Zealand is seeking removal of the informal caravan settlement near Harper River Diversion. The lake is in a remote location, and access to the lake is limited by the terrain and lack of legal provisions. Overall recreational use of the lake is low, except at the opening of the fishing season.

Management authority: See under general account of Coleridge Lakes Complex.

Jurisdiction: See under general account of Coleridge Lakes Complex.

References: Livingston *et al.* (1986b); Shanks *et al.* (1990).

Reasons for inclusion:

1a Lake Coleridge is part of the Coleridge Lakes Complex, a good example of a group of small glacial lakes and tarns characteristic of the South Island eastern high country.

2a The lake supports a population of a globally threatened species of bird, the Australasian Bittern *Botaurus poiciloptilus*.

2b The lake supports a wide variety of waterfowl, including the Great Crested Grebe *Podiceps cristatus australis*, an endangered species in New Zealand, and is thus of special value in maintaining the genetic and ecological diversity of the region.

2d The lake is of special value as habitat for endemic bird species, particularly *Podiceps cristatus australis* and *Aythya novaeseelandiae*.

3b The lake regularly supports substantial numbers of waterfowl, especially Anatidae, highlighting its value as a large and diverse wetland habitat.

Source: Jenny Steven.

Ashburton Lakes Complex (59)

Location: 43°34'S, 171°10'E. In and near the Upper Ashburton catchment, approximately 150 km southwest of Christchurch, South Island. Road access is via Mount Somers township and

Ashburton Gorge. Within Hakatere Ecological District.
Area: c.1,850 ha.
Altitude: 624-854 m.
Overview: The Ashburton Lakes are a complex of lakes, tarns and swamps within a once-glaciated inter-montane basin. All but Lake Heron and Lake Denny drain into the south branch of the Ashburton River. Nine of twelve lakes are valuable habitat for waterfowl, *i.e.*, lakes Heron, Clearwater, Denny, Emily, Emma, Maori, Trinity, Roundabout and Spider. Less important wetlands are Lake Camp and the little-known Manuka and Seagull tarns. The whole complex is of outstanding value as habitat for waterbirds, especially Great Crested Grebe *Podiceps cristatus australis* and New Zealand Scaup *Aythya novaeseelandiae*. The lakes, particularly Lake Heron, are excellent examples of landforms and wetland habitats characteristic of the high country of the South Island. Harrington *et al.* (1986) surveyed the Hakatere Ecological District and recommended several areas for protection. Landforms and vegetation received particular attention in that survey. Birdlife and habitats have been described by Stokes and Grant (1992).
Physical features: The upper Ashburton basin lies southeast of the Southern Alps, and is surrounded by subalpine mountain ranges. The basin is elongate and flat to undulating, reflecting its formation by Pleistocene valley glaciers and subsequent alluvial deposition. The lakes are surrounded by a variety of relic and actively developing landforms: lateral, terminal and ablation moraines, outwash surfaces, terraces and alluvial fans. Soils around the wetlands are recent gleyed silt loams of high to medium fertility and shallow stony and sandy loams. Older high country yellow brown earths predominate on hill slopes and old glacial surfaces.
This inland basin experiences a cool windy climate. Moderately low precipitation (900-1,000 mm per year) falls as rain and snow. Many of the small lakes freeze over during severe winter frosts.
Each lake of importance to wildlife is described below (from Stokes & Grant, 1992):

- Lake Heron (684 ha, max. 37 m deep), the largest lake in this complex, is fed by small streams and shingle fan seepages. At the southern end, well preserved terminal moraine blocked and reversed the lake's original outflow. To the north, large alluvial fans impede drainage as Lake Stream flows towards Rakaia River. The result is an impressive stream-side swamp. It is linked to a 6 km long lake-margin wetland (350 ha) along the toe and lower slopes of Cameron Fan. Part of Cameron Fan wetland has been drained for farming purposes.
- Lake Clearwater (198 ha, 19 m deep) is bounded by lateral moraine and fed by stream flow. Lambies Stream flows from the lake, eventually joining Ashburton River. Exposed stony beaches, often pounded by waves, surround much of the lake. A narrow wetland has developed at the western end of the lake. Intense wind action, the small size and generally shallow depth prevent summer temperature stratification of the lake water. The lake has been classed as mesotrophic.
- Lake Emma (166 ha) and Lake Roundabout (13 ha) are linked by a 200 ha wetland which extends into the lakes on their western margins. The shallow lakes (less than 3 m deep) are bounded by terminal moraine and alluvial fan deposits from Balmacaan Stream. Narrow stony beaches occur beside dryland areas.
- Lake Denny (c.10 ha) is situated on a stony outwash surface at the base of a steep terrace. Wetlands have developed on gently sloping land to the north and west of the lake. Pudding Valley Creek drains the wetland and flows south eastward, around the terrace, towards the Rangitata River.
- The Maori Lakes are an important wetland system consisting of two areas of open shallow water (30 ha, 2 m deep) and a 100 ha swamp. The wetland sits on fluvio-

glacial outwash material and is dammed by alluvial fans. A small outlet stream flows towards Ashburton River.

- Lake Emily (20 ha, 2 m deep) occupies a circular depression on ablation moraine. Open water is linked to a 50 ha swamp which extends to the west and northwest. This area is the drainage focal point for numerous streams and seeps. The wetland drains via Jacobs Stream into Maori Lakes.
- The Spider Lakes are a group of small tarns, possibly kettle-holes, spread over 82 ha of lateral moraine. Most of the tarns have no defined inflow or surface outlet. Water levels fluctuate; some tarns drain or dry out completely, while others are inundated all year. Narrow turflands surround the tarns.
- Lake Trinity (c.8 ha, 0.5 m deep) is a shallow tarn with almost vertical sides, set apart from the other lakes to the south east of the basin.

Ecological features: Wetland plant communities are diverse and mostly in good condition (see Harrington *et al.* 1986 for details). Aquatic plants in shallow lakes and margins include *Myriophyllum propinquum, Potamogeton cheesemanii, Lilaeopsis novae-zelandiae, Crassula sinclairii* and the introduced weeds *Elodea canadensis* and *Ranunculus trichophyllus*. Small areas of native turfland occur around stony and muddy shores. The most extensive wetlands include mosaics of dense Red Tussock *Chionochloa rubra*, pedestal tussocks of *Carex secta*, large bands of Raupo *Typha orientalis* which extend into the lakes, and mixed sedge and rushlands with *Carex coriacea* and other *Carex* species, dense *Schoenus pauciflorus* and *Juncus* species. Willow (mainly *Salix fragilis*) is present at many of the lakes. Well-drained land beyond the wetlands supports a mixture of Matagouri *Discaria toumatou* shrubland and *Festuca novae-zelandiae* tussock grasslands, in various states of modification for pastoral use.

Land tenure: The lakes and swamps area a mixture of Crown land reserved from sale, Crown land held as Pastoral Lease, freehold land and University of Canterbury Endowment Lease. Freehold areas include Lake Denny and parts of Lake Emma wetland. The Maori Lakes, the Spider Lakes, Emily, Heron and Clearwater are Crown land with parts held as Pastoral Lease. A marginal strip reserved under Section 58 of the Land Act 1948 facilitates legal access to the edges of Clearwater, Camp, Manuka, Emma and Emily. Surrounding areas are predominantly Crown land held under Pastoral Lease. University of Canterbury Endowment Leases cover some land in the Upper Ashburton catchment, and there are small areas of privately owned freehold lands.

Conservation measures taken: Lake Clearwater, Lake Heron and the Maori Lakes have been given Wildlife Refuge status under the Wildlife Act 1953; this prohibits shooting and the use of motorboats. In addition, Lake Heron and the Maori Lakes have been given Nature Reserve status under the Reserves Act 1977; this protects the lake bed and a narrow marginal area, but does not control land use in the catchments. The Wildlife Act 1953 gives full protection to all indigenous species, except for game-birds and others listed in schedules to that Act.

The Rakaia River Water Conservation Order includes Lake Heron as part of the Rakaia catchment. This Order prohibits abstraction below a minimum flow level. This is primarily to protect the recreational sport fishery in the river. Wildlife values gain some protection under the managed flow regime.

A small area of the shoreline of Lake Clearwater has been cordoned-off to reduce disturbance to nesting Great Crested Grebes.

Conservation measures proposed: Natural areas recommended for protection by Harrington *et al.* (1986) encompass all lakes and wetlands except lakes Camp, Seagull and Manuka.

Land use: Recreational use of the lakes is mainly in summer and during the fishing and shooting seasons. Some wetlands are used as watering areas for domestic livestock. Tussock grasslands surrounding the wetlands are in various states of conversion to introduced pasture. The predominant land use in surrounding areas is extensive grazing by sheep and cattle.

Permanent habitation is limited to several isolated homesteads associated with large pastoral farms. A holiday house settlement between Lake Clearwater and Lake Camp has a fluctuating temporary population, as does an informal camping area at Lake Heron.

Possible changes in land use: None known; the catchment is not a focus for international tourism. Agricultural development is likely to continue, but the cool climate will limit crop diversification.

Disturbances and threats: Growth of recreational activities such as wind-surfing (at Lake Clearwater) and jet-skiing may increase disturbance to nesting birds. Restrictions on the use of motorboats and speed limits help reduce disturbance. Nesting birds are at risk from a range of feral and introduced predators such as stoats and rats. Domestic dogs and cats associated with the holiday settlement also pose a threat to nesting waterfowl. There are no immediate major threats to water quality or lake levels. Potential problems are drainage of wetlands for pasture, and eutrophication from fertiliser run-off. Domestic livestock can degrade swamps and turfland by trampling, grazing and defecation. The extent of fencing around the Ashburton Lakes is unknown. Willows trees tend to overwhelm other wetland plants. However, their overhanging branches may enhance the breeding habitat for Great Crested Grebes.

Hydrological and biophysical values: The wetlands play a general role in the maintenance of water quality, recharge and discharge of groundwater and the support of food chains. Several lakes within the complex are of high or outstanding importance for wildlife (Stokes & Grant, 1992). Lake Heron is the most important lake in the complex because of its species diversity and abundance. It is one of the largest and most valuable wildlife habitats of its type (high country lake and surrounding swamp) in Canterbury (O'Donnell, 1983, cited in Stokes & Grant, 1992). The wetlands have value as buffers to stream flow, helping prevent extremes of high or low flow in the Rakaia and Ashburton Rivers.

Social and cultural values: The lakes are valued as a regional recreational resource. It is likely that the area was used by Maori people as a traditional waterfowl hunting area.

Noteworthy fauna: The diverse wetland habitats of the Ashburton Lakes support a wide range of waterfowl (up to 20 species), many of which are often present in large numbers. Seasonal and annual fluctuations in use of the individual lakes suggest that birds may depend on a variety of habitats, moving within the catchment, as well to other regions. Some lakes are seasonally important sites for breeding or moulting, while the large ice-free water bodies such as Lake Heron are important for over-wintering.

The lakes are of outstanding value for their populations of Great Crested Grebe *Podiceps cristatus australis* and New Zealand Scaup *Aythya novaeseelandiae*. The Great Crested Grebe population in New Zealand was between 240 and 250 birds in 1980, but is now thought to be closer to 200 birds (Stokes & Grant, 1992). The Ashburton Lakes support between 20 and 50 birds. The resident breeding population appears to have declined by 57% between the 1980 and 1988. This may be part of a true national decline, or may indicate movement of grebes to other Canterbury Lakes. Lakes Heron, Emma, Clearwater and Emily are especially important as breeding sites for the grebes because of their extensive marginal vegetation which provides shelter, concealment and sites for the attachment of nests at water level.

The lakes support a breeding and over-wintering population of 500-2,000 New Zealand Scaup, *i.e.* 7-27% of the world population of this species. Although still locally common, the New Zealand Scaup has a restricted distribution because of predation and wetland drainage. Lakes Heron, Emma and Roundabout receive the most use by scaup. Shoreline swamps are key breeding sites, as scaup require good cover for their nests.

Other species occurring commonly at the lakes include Black Shag *Phalacrocorax carbo*, Little Shag *P. melanoleucos*, Black Swan *Cygnus atratus*, Canada Goose *Branta canadensis*, Paradise Shelduck *Tadorna variegata* (moulting in large numbers at Lake Denny), Grey Teal *Anas gracilis* (especially at Lake Heron and Lake Clearwater), Mallard *A. platyrhynchos*, Grey

Duck *A. superciliosa*, New Zealand Shoveler *Anas rhynchotis variegata* and Common Coot *Fulica atra* (especially at Lake Heron).

The Pukeko *Porphyrio porphyrio melanotus*, an uncommon species in upland habitats, is present. Australasian Bittern *Botaurus poiciloptilus* and Marsh Crake *Porzana pusilla affinis* have been recorded on rare occasions, and there is a single record of a Blue Duck *Hymenolaimus malacorhynchus*, an unexpected visitor usually found in mountain streams.

Little information is available on the invertebrate fauna of the lakes, and no unusual species or species distributions are known (Harrington *et al.*, 1986). Research by Stout and Burrows (in prep.) may provide more information.

Noteworthy flora: The wetland vegetation is diverse and generally healthy. The flora contains no unusual or notable species.

Scientific research and facilities: Other than regular bird counts and independent research by university students, there has been little scientific interest in this area. Members of the New Zealand Ornithological Society take an active interest in the wetland birds. There are no scientific facilities in the vicinity.

Conservation education: Little current use. In the past, school groups from Ashburton were actively involved with conservation of the New Zealand Scaup.

Recreation and tourism: Visitor numbers are high during the summer and trout fishing season (early November until the end of April). Overnight visitors tend to concentrate at the relatively informal holiday settlement at Lake Clearwater.

Wind-surfing, yachting, canoeing, fishing, bathing, picnicking and camping are the main activities. Game-bird shooting occurs on some lakes. Motorised vehicles are prohibited from Lake Heron and Lake Clearwater.

The smaller lakes receive little use except by anglers. Swampland vegetation, especially at the Maori Lakes, tends to restrict access even for anglers.

Management authority: The Department of Conservation has responsibility for the management of Wildlife Refuge lands, Nature Reserves and wildlife. The Canterbury Regional Council has management and policy responsibilities, under the Resource Management Act 1991, for land, soil and water resources, flood control and pollution control. The Council also issues resource consents under this Act. Ashburton District Council is also responsible for resource consents as well as district planning. The Central South Island Fish and Game Council manages sport fishing and game-bird hunting.

Jurisdiction: Functional: Department of Conservation and Central South Island Fish and Game Council. Territorial: Ashburton District Council and Canterbury Regional Council.

References: Harrington *et al.* (1986); Stokes & Grant (1992); Stout & Burrows (in prep.).

Reasons for inclusion:

1a The Ashburton Lakes Complex contains excellent examples of landforms and wetland habitats characteristic of high country lakes in New Zealand. Lake Heron, in particular, is an excellent representative example of a high country lake with associated swampland.

2b The complex supports a wide diversity of breeding waterfowl, including between 10% and 50% of the New Zealand population of Great Crested Grebe *Podiceps cristatus australis*, and is thus of special value in maintaining the genetic and ecological diversity of the region.

2c Several of the lakes provide valuable breeding habitat for waterfowl; Lake Heron, in particular, is an important breeding site for *Podiceps cristatus australis* and *Aythya novaeseelandiae*. Lake Denny is an important moulting site for *Tadorna variegata*.

2d The lakes are valuable habitat for several endemic species of plants and birds, including *Lilaeopsis novae-zelandiae, Crassula sinclairii*, *Tadorna variegata* and *Aythya novaeseelandiae*.

3a The lakes regular support between 7% and 27% of the world population of New Zealand Scaup *Aythya novaeseelandiae*.

Source: John Andrew and Jenny Steven.

Mackenzie Basin Wetlands Complex (60)

Location: 43°54'S, 170°25'E. At Glenmore Moraines in the Upper Waitaki catchment, central South Island. The wetlands are adjacent and downstream of Lake Tekapo and Lake Ohau. The nearest settlements are the small towns of Twizel, Tekapo and Omarama (162, 104 and 190 km from Timaru, respectively). Some wetlands are accessible from State Highway No.8 or side roads, whereas others are within pastoral farmland. Within Tekapo, Pukaki and Omarama Ecological Districts.

Area: Unknown.

Altitude: 780-1,001 m.

Overview: The Mackenzie Basin Wetlands Complex includes several groups of tarns, stream wetlands and lakes wetlands, considered together because of common ecological and geomorphic characteristics. The wetlands are very important feeding and/or breeding areas for the nationally endangered Great Crested Grebe *Podiceps cristatus australis*. Many other waterfowl also use the wetlands. The wetlands lie within moraine and outwash gravels of once extensive valley glaciers in the eastern Southern Alps. Wetland groups within the complex are described in greater detail below, as Sites 60a-d. (The large lakes of Tekapo, Pukaki and Ohau are described separately as Site 61 - Central Southern Lakes Complex; the braided rivers are described as Site 62 - Canterbury Braided Rivers Complex). The principal wetlands in the present site are as follows:

- Lake Alexandrina and Lake McGregor (60a): large glacial lakes west of Lake Tekapo.
- Tekapo Streams (60b): alluvial valley wetlands, cut into sloping moraine and outwash surfaces west of Lake Tekapo.
- Glenmore and Tekapo Tarns (60c): small moraine-bound tarns on undulating surfaces to the west and south of Lake Tekapo.
- Ohau Moraine Wetlands (60d): scattered tarns south of Lake Ohau.

All of these wetlands were identified by the Fauna Survey Unit of the New Zealand Wildlife Service as "Sites of Special Wildlife Interest" (SSWI) of "high" or "outstanding" value because of their importance for waterbirds (Jarman, 1987).

Physical features: Extensive deposits of greywacke moraine occur between Lake Tekapo and Lake Ohau. Moraine landscapes are characterised by open, undulating downland, pock-marked with scattered hollows. The melting of Pleistocene glaciers created an array of relic landforms. Unsorted rock, silt and till (glacial gravel) were carried within, under and on top of the ice. As the ice melted, the debris was dropped in uneven heaps and curved bands. Steep-sided kettle holes formed when a buried block of ice melted slowly, with gradual sinking of the moraine-hollow floor. Tarns and lakes now occupy many of the hollows, kettle holes and ice-gouged troughs. Large volumes of glacial meltwater carved deep channels. New patterns of stream flow have developed since glacial retreat. Upland yellow grey earth soils have formed on moraine surfaces. These soils have low natural fertility and are susceptible to drought. Fluctuating water levels, especially periodic drying and freezing, alter the ecological condition of shallow tarns throughout the year.

The climate of the Mackenzie Basin varies markedly with distance from the main divide. The wetlands receive between 700 and 1,000 mm of rainfall per year and lie just outside the semi-

arid zone in the basin floor. Prevailing northwesterly winds combine with high summer temperatures to produce high evaporation rates. Severe frosts are common, with hoar frosts and fog around Twizel and Lake Ohau during winter. Most tarns freeze for several weeks each year. Snow cover is intermittent.

Ecological features: Moraine tarns and lakes are set within depleted dry tussock grasslands. Common plants are introduced grasses, *Hieracium pilosella*, Hard Tussock *Festuca novae-zelandiae*, Blue Tussock *Poa colensoi*, the low growing plants *Coprosma petriei* and *Raoulia subsericea*, shrubs of Matagouri *Discaria toumatou* and the weed Sweet Briar *Rosa rubiginosa* (Espie *et al.*, 1984). Most tarns are surrounded by narrow beaches of mud or stones, with bare substrate or zoned turflands.

In places, open water merges with swampland. Species include clumped *Carex secta* and Bog Rush *Schoenus pauciflorus*, sward-forming *Carex*, *Isolepis* and *Juncus* spp., Raupo *Typha orientalis* and Red Tussock *Chionochloa rubra*. Willow trees *Salix fragilis* form a dense band around Lakes Alexandrina and McGregor.

The turfland vegetation and flora are of particular ecological interest. Tarns on Glenmore moraines and Lake Ohau terminal moraines are among four of the eleven principal kettle hole areas in the eastern South Island (Johnson, 1994). These four areas have especially high conservation value in terms of diversity of habitat, of vegetation types and representation of native wetland flora.

Zoned turflands have a relatively uniform structure: dense, low, firm turf. The often-concentric zones have distinctive colours and species composition. Plants typical of the turfland zones at Glenmore Tarns are described as an example.

- Aquatic zone: *Potamogeton cheesemanii* and the milfoil *Myriophyllum propinquum*.
- Mud zone (plants occasionally out of water): *Glossostigma* spp., *Lilaeopsis ruthiana*, *Crassula sinclairii* and *Limosella lineata*.
- Lower turf zone: *Isolepis aucklandica*, *Plantago triandra*, *Hydrocotyle hydrophilia*, *Hypsela rivalis* and *Carex gaudichaudiana*.
- Mid turf zone: *Galium perpusillum* and *Epilobium angustum*.
- Upper turf zone: *Poa lindsayi*, *Selliera microphylla* and the moss *Polystichum juniperinum*, plus naturalised plants, native herbs and sub-shrubs common also to the tussock grasslands on dry moraine slopes.

Moraine wetlands have a large flora, with 146 native species recorded at Glenmore Tarns, over 50 of which are confined to this habitat (Johnson, 1994). Turflands are particularly rich, with 58 native species in these zones, compared with only seven in the aquatic zone. The vegetation of Ohau Moraine Wetlands has been surveyed by Johnson (1978 & 1980). The kettle hole tarns and hollows are diverse in flora, vegetation and hydrology. The flora includes some plants not seen in Glenmore Tarns, *e.g. Ranunculus limosella* and *Typha orientalis*.

Tekapo Stream Wetlands have been modified heavily by grazing and weeds (Johnson, 1978), but they continue to be valuable wildlife habitats.

Land tenure: The wetlands are predominantly Crown land farmed under Pastoral Lease. Lake Alexandrina, a Recreation Reserve, is being reclassified. Wildlife Refuge status overlies the lake and surrounding land. There are also small areas of freehold land, Crown land held as Conservation area, Deferred Payment Licence grazing land, legal roads and "marginal strips" reserved from sale, *e.g.*, as around Lakes Alexandrina and McGregor. Lake McGregor is Crown land held for power development purposes.

Surrounding areas are mainly Crown Pastoral Lease. Large areas west of the Glenmore Moraines are occupied by the Ministry of Defence. The land is Crown land reserved for defence purposes. There are various reserves for forestry, soil conservation and recreation in the vicinity of Lake Tekapo.

Conservation measures taken: Only Lake Alexandrina and Lake McGregor have any form

of legal protection for conservation. Both lakes are classed as Wildlife Refuges under the Wildlife Act 1953. A predator-proof fence has been constructed at Micks Lagoon in the Tekapo wetlands, to provide a protected area for nesting Black Stilts *Himantopus novaezelandiae*. The land is being purchased by the Department of Conservation.

Conservation measures proposed: All the wetlands in this complex are "Sites of Special Wildlife Interest" (SSWI) (Jarman, 1987) and areas recommended for protection after a Protected Natural Areas Programme survey (Espie *et al.*, 1984). The Department of Conservation is negotiating with landholders to establish protected areas. Lake Alexandrina is being reclassified and is likely to become a Government Purpose (Wildlife Management) Reserve under the Reserves Act 1977.

Land use: The wetlands are within large tracts of pastoral land. Permanent settlements in the Mackenzie Basin are isolated farm homesteads and the small towns of Tekapo, Twizel and Omarama. There are several clusters of houses and huts around Lake Alexandrina and Lake Ohau, long-established fishing and camping areas. Target Tarn near the Glenmore Moraines has been used by the New Zealand Army as a firing target. Large areas of tussockland are used for training purposes.

Although the Upper Waitaki Power Scheme caused considerable environmental change in the Mackenzie Basin, only two of the wetlands in this complex were modified directly (*i.e.*, levels of Lake McGregor and temporary drainage of Wairepo Lake).

Possible changes in land use: There is a formal proposal for forestry development around the Glenmore Tarns, and there is an informal proposal to drain another area within Joseph Stream Swamp. Such developments will degrade the natural values of individual wetlands and of the wetland complex.

There are no major development proposals for the Mackenzie Basin. Tourism will continue to be a major force behind development, with further holiday housing likely in subdivisions at Lake Ohau and Lake Alexandrina. Recreational visitor numbers are expected to increase, but the small and remote wetlands are unlikely to be affected.

Disturbances and threats: Threats to tarn habitats include damage from vehicles, cattle, fertiliser, over-sowing, drainage, and removal of soil and rock for construction. The tarn margins appear to have withstood a century of grazing by sheep (Johnson, 1994). Major changes to the vegetation probably occurred long ago. Cattle and deer have the potential to cause serious damage to those tarns bound by mud and silt rather than stone cobbles. Protection by way of fencing may not be desirable in terms of protection of landscape values.

The wetlands in the lower Joseph Stream, near Lake Alexandrina, have been modified by drainage and pasture development. Large-scale plantation forestry has the potential to alter hydrology, landscape and scenic values, vegetation, wildlife habitat and patterns of habitat use among wetlands. Decreased fluctuations in the water level in the tarns may compress the vegetation zones, reduce intricacy of the plant communities, and encourage spread of weed and dryland species into the turflands (Johnson, 1994).

A large bloom of blue-green algae occurred in Lake Alexandrina in 1980. This raised concern about nutrient enrichment from fertiliser run-off and septic tank sewage discharges from holiday houses. Possible risks from future blooms include excessive waterweed growth and algal bloom toxicity to fish and birds (Edmonds *et al.*, 1980).

Hydrological and biophysical values: The wetlands have little influence on water flows in the extensive Waitaki catchment. Ohau Moraine Wetlands and Glenmore Tarns are excellent examples of a moraine and moraine kettle hole ecosystem. They are two of the four best areas in New Zealand, and are noted for their diversity, representativeness and size (Johnson, 1994). The turflands are significant as a remnant of a habitat type which was once much more common in eastern South Island. Such habitats were lost from the large lakes during hydro-electric power development (Johnson, 1978). The glacial kame terrace and tarn landforms

around Glenmore are classed as nationally important landforms; "a very large example of a kame, the best in New Zealand" (Priestley, 1990). Despite the small size of the individual water bodies, the complex as a whole is very important for waterfowl.

Social and cultural values: There are several Maori archaeological sites near Lake Alexandrina, which suggest the early Maori people valued the wetlands. At present, only the largest water bodies, Alexandrina and McGregor, are used extensively by visitors. Lake Alexandrina and the Glenmore Moraines are highly valued landscapes, part of the extensive "outstanding" landscape of the Mackenzie Basin (Boffa Miskell and Lucas Associates, 1993). The moraine landforms and landscape are an intact reminder of New Zealand's long glacial history.

Noteworthy fauna: The wetlands are very important sites for three waterfowl species, the globally endangered Black Stilt *Himantopus novaezelandiae*, the nationally endangered Great Crested Grebe *Podiceps cristatus australis* and the endemic New Zealand Scaup *Aythya novaeseelandiae*. Lake Alexandrina supports one of New Zealand's largest populations of New Zealand Scaup (c.1,200 birds), and the largest concentration of Great Crested Grebe (50 to 60 breeding birds). Although the smaller wetlands usually support only one or two pairs of Great Crested Grebe or Black Stilt, these sites, in combination, support significant proportions of the total populations.

The Black Stilt is now almost confined to the Upper Waimakariri catchment. About 10% of the population overwinter in lowland regions (Jarman, 1987). During the latter part of the 19th century, Black Stilts were present at many more localities, including wetlands in the North Island. The population has declined rapidly since the late 1960s, reaching a low of 50 to 60 adult birds between 1975 and 1979 (Reed *et al.*, 1993). Some sites within the Mackenzie Basin wetlands are noted as former breeding areas. These sites remain important as feeding habitats and potential breeding sites, should the population recover.

The wetlands of the Mackenzie Basin also support a wide variety of other waterfowl, with some species occurring in large numbers. Those on shallow water bodies include South Island Pied Oystercatcher *Haematopus finschi*, Pied Stilt *Himantopus leucocephalus*, Banded Dotterel *Charadrius bicinctus*, Wrybill *Anarhynchus frontalis*, Spur-winged Plover *Vanellus miles*, Black-billed Gull *Larus bulleri* and Black-fronted Tern *Chlidonias albostriatus*. Swampland birds include Australasian Bittern *Botaurus poiciloptilus*, White-faced Heron *Egretta novaehollandiae* and Marsh Crake *Porzana pusilla affinis*. Birds of open water include Black Shag *Phalacrocorax carbo*, Little Shag *P. melanoleucos*, Black Swan *Cygnus atratus*, Canada Goose *Branta canadensis*, Paradise Shelduck *Tadorna variegata*, Grey Teal *Anas gracilis*, Mallard *A. platyrhynchos*, Grey Duck *A. superciliosa*, New Zealand Shoveler *A. rhynchotis variegata* and New Zealand Scaup *Aythya novaeseelandiae*. The Australian (Chestnut-breasted) Shelduck *Tadorna tadornoides* and Common Coot *Fulica atra* have occurred in the area as migrants from Australia.

The non-avian fauna of the wetlands is less well known. Aquatic invertebrates in the Tekapo area belong to taxa typical of shallow waters elsewhere in New Zealand (Espie *et al.*, 1984). Four species of native fish and three introduced species occur in Lake Alexandrina and Lake McGregor. All are found elsewhere in New Zealand (Edmonds *et al.*, 1980).

Dryland fauna in the Mackenzie Basin includes four species of lizard (gecko and skinks). Notable invertebrates include several locally endemic moths and a rare grasshopper, *Brachaspis robustus* (Jarman, 1987).

Noteworthy flora: Three species found at the Glenmore Tarns are listed as threatened plants (Cameron *et al.*, 1993). These are: *Crassula peduncularis*, a tiny creeping herb listed as "vulnerable"; *Iphigenia novae-zelandiae*, a tiny bulbous, lily-like plant, listed as "rare"; and *Isolepis basilaris*, a small tufted sedge, listed as "indeterminate".

Scientific research and facilities: There are no research facilities associated with the

wetlands, although there have been several research projects on water management of Lake Alexandrina (see Ward & Stewart, 1989). A dryland area near Lake Alexandrina is used for soil conservation and crop research. The University of Canterbury runs an astronomical observatory and research station on Mt John, near Tekapo.

Conservation education: None known.

Recreation and tourism: Recreational use of the tarns and wetlands is minimal because of their relative isolation, scattered distribution, and location within private property. Lake Alexandrina and Lake McGregor are exceptions. They receive many New Zealand visitors for day outings, fishing, camping and other non-commercial activities. Fishing draws small numbers of visitors to other streams and tarns. Lake Alexandrina has potential to become a small-scale tourist area, although its location away from the state highway will probably limit visitor interest.

Management authority: The Department of Conservation (Canterbury Conservancy) is responsible for management of wildlife; day-to-day management is undertaken by the Department's Twizel Field Centre. Land Corporation Ltd. manages Pastoral Leases. Canterbury Regional Council has management and policy responsibilities under the Resource Management Act 1991 for water resources, soil, most lakes and river beds, and pollution control. Mackenzie District Council is responsible for resource consents granted under the Resource Management Act 1991. The Central South Island Fish and Game Council manages sport fishing and game-bird hunting.

Jurisdiction: Functional: Department of Conservation, Central South Island Fish and Game Council and Land Corporation Ltd. Territorial: Mackenzie District Council and Canterbury Regional Council.

References: Boffa Miskell and Lucas Associates (1993); Cameron *et al.* (1993); Edmonds *et al.* (1980); Espie *et al.* (1984); Jarman (1987); Johnson (1978, 1980, 1994); Priestley (1990); Reed *et al.* (1993); Ward & Stewart (1989).

Reasons for inclusion:

1a The Mackenzie Basin Wetlands Complex contains excellent representative examples of moraine wetlands in the relatively dry eastern South Island of New Zealand.

2a The wetlands support substantial populations of four globally threatened species of birds, *Botaurus poiciloptilus*, *Himantopus novaezelandiae*, *Anarhynchus frontalis* and *Chlidonias albostriatus*.

2b The wetlands are of special value in maintaining genetic and ecological diversity of the South Island high country because of the quality and diversity of the turf vegetation in moraine hollow tarns, and also because of the diversity of waterfowl which they support.

2c The wetlands provide important breeding habitat for a wide variety of waterfowl including a substantial proportion of the New Zealand population of *Podiceps cristatus* and several other indigenous species.

2d The wetlands are of special value for their endemic plant and animal species.

3b The wetlands regularly support substantial numbers of waterfowl, especially Anatidae.

3c The wetlands regularly support a large proportion of the world population of *Himantopus novaezelandiae* and over 15% of the population of *Aythya novaeseelandiae*. At certain times of the year, over half the population of *H. novaezelandiae* have been seen feeding on one wetland within the complex.

Source: John Andrew and Jenny Steven.

———

Lake Alexandrina and Lake McGregor (60a)

Location: 43°56'S, 170°27'E. Approximately 2 km west of Lake Tekapo and 12 km by secondary road from Tekapo township in the Mackenzie Basin, central South Island. The nearest cities are Timaru (118 km) and Christchurch (240 km). Within Tekapo Ecological District.
Area: Lake Alexandrina, 665 ha; Lake McGregor, 80 ha.
Altitude: 732 m.
Overview: Lake Alexandrina and Lake McGregor are part of the Mackenzie Basin Wetlands Complex. Lake Alexandrina fills a small glacially-carved trough (7.2 km long and 0.9 km wide) parallel to Lake Tekapo. The lake is bounded by sparsely-vegetated undulating moraine, and drains via a small stream for c.500 m into Lake McGregor. This smaller lake is bounded partly by moraine. To the east, only a narrow barrier of dry land and road separates the lake from Lake Tekapo. Water levels in Lake McGregor fluctuate with the controlled water storage levels in Lake Tekapo. Lake Alexandrina has a narrow margin of shallow water and a shingle beach, lined in many places by willow trees *Salix fragilis*. A swamp and sedge-covered island at the northern end of the lake are important wildlife habitats. Lake McGregor has areas of swampy margin with *Carex secta* and Raupo *Typha orientalis* wetlands. Tangled willow trees dominate much of the outlet wetland.
The lakes are of national importance for waterfowl. They support major populations of New Zealand Scaup *Aythya novaeseelandiae* and Great Crested Grebe *Podiceps cristatus australis* (Jarman, 1987; Espie *et al.*, 1984). A wide range of Anatidae and other waterbirds are present. Skinks and gecko are found on dry moraine slopes. A population of the Spotted Skink *Leiolopisma lineoocellatum* occurs near the southern end of Lake Alexandrina. This species is less abundant than the other three local species.
There are three low-cost holiday-house settlements at Lake Alexandrina, established particularly because of the area's attractiveness for trout fishing. Water quality in the lake has been threatened by domestic wastewater discharges and fertiliser run-off from farmland (Edmonds *et al.*, 1980). Lake Alexandrina is a Recreation Reserve and Wildlife Refuge. Re-designation to strengthen ecological protection is in progress. Ecology and management issues of Lake Alexandrina are described in a report by Ward and Stewart (1989).
Physical features: Lake Alexandrina has features characteristic of its glacial origin. It is elongate and bounded by smooth, rolling moraine surfaces, with narrow gravel and rocky shores that drop sharply into deeper water. The lake is relatively shallow, with an average depth of 13.6 m and maximum of 27 m (Hayes, 1980, and Moore *et al.*, 1962, cited in Ward & Stewart, 1989). A series of relic beach ridges lies at the southern end. Lake Alexandrina's topographic catchment is approximately 5,400 ha (Ward & Stewart, 1989), set within the larger Lake Tekapo catchment. Soils on slopes around the lakes are upland yellow brown earths. Friable sandy to very stony loams overlie loess and compact greywacke till (Edmonds *et al.*, 1980). Water enters the lake from several streams (less than one third of the total inflow), direct rainfall, overland and subterranean sources (Ward & Stewart, 1989). Scotts and Muddy Creeks are the main permanent tributaries. There are several ephemeral streams on the western shore. Much of the subterranean flow is thought to come from outside the topographic catchment, especially from the Cass River, entering the lake as springs or seepages (Ward & Stewart, 1989). The lake's water is usually clear, in contrast with the opaque, sediment-laden waters of glacier-fed lakes. The level in the lake remains stable (Edmonds *et al.*, 1980) and the turnover time of four years is relatively slow (Ward & Stewart, 1989). Outflow is via a stream that feeds Lake McGregor.
Lake McGregor (40 ha) is also set within smoothed moraine. Its water table is linked to that of Lake Tekapo; Lake McGregor almost becomes a lakeside lagoon. A shingle road and narrow

area of dry land separate Lake McGregor from the Lake Tekapo Western Bay wetlands. Beaches are similar to those of Alexandrina. Swamplands occur on the northern and eastern shores, especially around the outlet stream.

Both lakes are exposed to strong, often gale force winds. Wind mixes lake water, preventing de-oxygenation of the lake floor; it transports nutrients and eroded sediment into the lake, and helps prevent surface freezing during heavy frosts. Water temperature in the deeper parts of Lake Alexandrina is closely correlated with mean air temperature, but there is little daily fluctuation. Shallow water temperatures vary considerably (Ward & Stewart, 1989).

Until recently, Lake Alexandrina had very high water quality, typical of an undisturbed oligotrophic high country lake (Edmonds *et al.*, 1980). The lake is now considered to be mesotrophic. In 1980, a potentially toxic bloom of a blue-green alga, *Anabaena flos-aquae*, raised concern about management of the lake catchment. Changes in water quality are of particular concern because of Lake Alexandrina's high value as waterbird habitat and as a recreational fishing resource. Various research projects (cited in Ward & Stewart, 1989) have attempted to explain nutrient flows in Lake Alexandrina. Further research is required. Nitrogen levels in surface water range from 200 to 300 mg per cubic metre, which are considered medium to high for New Zealand lakes. Phosphorous levels range from 2 to 30 mg per cubic metre, with some very high records, despite naturally low levels in the greywacke parent material and no unusual accumulation in lake sediments. Nutrient sources include run-off (containing fertiliser, plant material and manure) and groundwater originating from outside the surface catchment. Input from the housing settlements is thought to be of minor importance.

Ecological features: The following discussion is adapted from a management study by Ward and Stewart (1989). Vegetation communities in the catchment have undergone major climate and human-induced changes, from forest in pre-Maori times to today's severely depleted grasslands and pockets of intensive farmland. Grazing and repeated large-scale burning transformed formerly extensive tussocklands of Red Tussock *Chionochloa rubra*. Dryland vegetation today is highly-modified short tussock grassland. *Festuca novae-zelandiae* tussock was dominant before the introduction of common grass species, White Clover *Trifolium repens* and the now extensive hawkweeds (mainly *Hieracium pilosella*). The northern swamp at Lake Alexandrina is dominated by *Carex secta* and Raupo *Typha orientalis*. Many other native species are present. Willows *Salix* spp., planted in the 1920s, provide shade for fish, domestic livestock and human visitors. Drooping branches and semi-submerged logs have also proven to be important nest-attachment sites for Great Crested Grebes.

Aquatic plants grow well in the relatively shallow and clear waters of Lake Alexandrina. Macrophytes with epiphytic algae, growing in depths up to 12 m, provide shelter for native fish, habitat for invertebrates, and food for many introduced waterfowl and Great Crested Grebe. Nine native aquatic plant species are present. In water over 6 m, *Chara globularis* and *C. corallina* are the dominant and often the only plants. Introduced plants are *Elodea canadensis* and a *Ranunculus* species. Contrary to earlier concerns, an underwater survey in 1986 indicated that *Elodea* had not caused further disappearance of native species in the 2-6 m depth range (Ward & Stewart, 1989).

Land tenure: Lake Alexandrina is Crown land. Lake margins are unformed legal road. Lake McGregor is Crown land held for power development purposes. Surrounding areas are predominantly Crown land held as Pastoral Lease. One property, "Mt John", has been taken over by the Ministry of Defence as a military training area.

Conservation measures taken: Lake Alexandrina is Crown land with overlying status of Recreation Reserve and Wildlife Refuge. The refuge status also extends over adjacent Pastoral Lease lands. Wildlife Refuge status under the Wildlife Act 1953 provides only a low level of protection; it prohibits disturbance to wildlife and use of motorboats, but does not provide

habitat protection (Ward & Stewart, 1989). The area is being re-classified, probably as a Government Purpose (Wildlife Management) Reserve. A 24 ha wetland area at the northern end of Lake Alexandrina has been cleared of domestic livestock, fenced and designated as Scenic Reserve. This is managed by the Department of Conservation. Other existing reserves are two Recreation Reserves managed by the Mackenzie District Council, and two Fishing Reserves managed by the Central South Island Fish and Game Council.

Both lakes have been identified as "outstanding" "Sites of Special Wildlife Interest" (Jarman, 1987) and "priority areas for protection" (Espie *et al.*, 1984). Although these classifications will lend weight to future conservation proposals, they convey no formal protection.

Conservation measures proposed: Lake Alexandrina Recreation Reserve and Wildlife Refuge is currently being re-classified, in an effort to improve protection of the lake's natural values and to rationalise management.

Land use: Nature conservation and recreation are the major uses of the wetland. Recreational use is high during the summer holiday period and during the trout fishing season (November to April inclusive). Three holiday-house settlements and two camping grounds provide visitor accommodation close to the edge of Lake Alexandrina. Most areas of lake shore are accessible to domestic livestock from the adjacent pastoral leasehold properties ("stations" or "runs"). Sheep make heavy use of the lake shore, especially for shade provided by willow trees. Glenmore Station homestead and an observatory on nearby Mt John are the only other places of residence near the lakes. Pastoral farming of sheep is the predominant use of the dry tussock grasslands. Part of Lake Alexandrina's swampland has been developed for intensive farming of deer. Land protection and crop trials are being conducted at a small agronomy research area near Mt John.

Possible changes in land use: Although there are no formal development proposals for the lakes, gradual upgrading of the holiday settlements is likely. Day use, especially for fishing and picnicking, is expected to remain high. A forestry development has been proposed for land to the west of Lake Alexandrina.

Disturbances and threats: The high values of the lakes for wildlife and fishing are threatened by loss of water quality and disturbance from visitors. Sewage and waste water from the settlements contribute to the nutrient loading in the catchment, but it is thought that this source, while obvious, is only a minor one (Ward & Stewart, 1989). Sewage-holding tanks, with disposal outside the catchment, are being used at one of the settlements. Threats to water quality from agriculture are increased nutrient levels and turbidity. Wind and water carry soil particles and fertiliser.

Sheep have access to the lake margins, making heavy use of shaded areas. Manure enters the water directly from waterbirds. Wetlands are at risk from trampling and grazing by stock. Additional nutrient inputs may enter the wetlands from groundwater originating outside the surface catchment. Large-scale plantation forestry in the catchment may alter local hydrology and damage landscape and ecological values at Lake Alexandrina.

Recreational activities have the potential to disturb birds, through direct interference and daily and seasonal displacement. Ward and Stewart (1989) concluded that, although visitors affect individual birds on Lake Alexandrina, populations are adapted to the present level of recreational pressure.

Hydrological and biophysical values: The lake waters are valued for their productivity and ability to support large populations of waterbirds. Streamflow into Lake Tekapo is consistent, but minor. Streams at the outlet and surrounding wetlands provide spawning grounds for introduced fish, helping to maintain the sport fishery. The lakes play a general role in recharge and discharge of groundwater, particularly Lake Alexandrina.

Social and cultural values: In the past, it is likely that Maori valued the wetlands for food and fibre resources. Several archaeological sites are recorded at and near Lake McGregor

(registered with the New Zealand Historic Places Trust). Today, the lakes are valued highly by visitors, many of whom appreciate the tranquil scenic environment and sport fishing.

Noteworthy fauna: Both lakes are important breeding and feeding areas for a variety of waterfowl. Lake Alexandrina supports one of New Zealand's largest populations of Great Crested Grebe *Podiceps cristatus australis*; 50-60 birds breed at the lake, and 70-100 birds are present during the winter. During bird counts over the last five years, the maximum number of grebes seen on the lake at any one time was 148, and at no time were fewer than 30 birds present (Department of Conservation, unpublished data). The lake is also notable for its large population of New Zealand Scaup *Aythya novaeseelandiae*. Up to 1,200 birds have been recorded at the lake (Jarman, 1987), one of the largest concentrations of this species in New Zealand.

Many other indigenous and introduced waterfowl have been recorded in the swamps and on the open waters of the two lakes (Jarman, 1987). They include the common waterbirds listed for the Mackenzie Basin Wetlands Complex, as well as Black Shag *Phalacrocorax carbo*, Little Shag *P. melanoleucos* (breeding on an island in Lake Alexandrina), Australasian Bittern *Botaurus poiciloptilus*, White-faced Heron *Egretta novaehollandiae*, Little Egret *Egretta garzetta* (a straggler to New Zealand), Great Egret or White Heron *E. alba*, Marsh Crake *Porzana pusilla affinis*, Pukeko *Porphyrio porphyrio melanotus*, Common Coot *Fulica atra* and Black Stilt *Himantopus novaezelandiae*. A single Hoary-headed Grebe *Poliocephalus poliocephalus* (a straggler from Australia) was recorded at Lake McGregor in 1987.

Lake Alexandrina has four native species of fish; the Common Bully *Gobiomorphus cotidianus*, Upland Bully *G. breviceps*, Koaro *Galaxias brevipinnis* and Long-finned Eel *Anguilla dieffenbachii* (an ageing, artificially-landlocked population). Three introduced species, liberated for sport fishing, are the abundant Brown Trout *Salmo trutta*, Rainbow Trout *S. gairdneri* and Quinnat Salmon *Oncorhynchus tshawytscha*. Of the aquatic invertebrates, the small native snail *Potamopyrgus antipodarum* is dominant in all lake plant communities.

Noteworthy flora: There are no notable species or dryland plant communities in this locality. The wetlands of *Carex secta* and Raupo *Typha orientalis* provide valuable habitat for wildlife, but are not unusual in Canterbury.

Scientific research and facilities: There are no research facilities at the lakes. The area has, however, been the subject of numerous ecological and management studies (listed in Ward & Stewart, 1989). There are two research sites in the vicinity, both unrelated to the wetlands. Landcare Crown Research Institute is conducting plant trials at the base of Mt John, near Lake Tekapo. The University of Canterbury operates an astronomical observatory on the top of Mt John, several kilometres from Lake Alexandrina.

Conservation education: There are no known education programmes based on the lakes, and despite their high visitor usage, the lakes are not a focus for nature interpretation.

Recreation and tourism: The lakes are popular recreational areas. Most visitors are residents of the Canterbury Region who value the opportunity for families to relax in quiet, scenic surroundings. Fishing is also very popular, but a survey showed it was undertaken by less than half of the visitors (Stewart & Cameron, 1983).

The fishing season attracts large numbers of visitors, with up to 300 visitors at the lake at one time during the start of the season. Three hut and holiday-house settlements and two informal camping grounds cater for overnight visitors. There is no resort-style accommodation. Day visitors tend to stay within one kilometre of the settlements. It has been estimated that the equivalent of 25,000 people spend one day per year at Lake Alexandrina, equal to a township of 70 permanent residents (Stewart & Cameron, 1983). This level of use has raised concern about visitor impacts on wildlife and water quality.

Management authority: See under general account of Mackenzie Basin Wetlands Complex.

Jurisdiction: See under general account of Mackenzie Basin Wetlands Complex.

References: Edmonds *et al.* (1980); Espie *et al.* (1984); Jarman (1987); Stewart & Cameron (1983); Ward & Stewart (1989).

Reasons for inclusion:

1a Lake Alexandrina and Lake McGregor are excellent representative examples of moraine wetlands in the relatively dry eastern South Island of New Zealand.

2a The lakes support populations of two globally threatened species of birds, *Botaurus poiciloptilus* and *Himantopus novaezelandiae.*

2c The lakes provide important breeding habitat for a wide variety of waterfowl including a substantial proportion of the New Zealand population of *Podiceps cristatus* and several other indigenous species.

3b The lakes regularly support substantial numbers of waterfowl, especially ducks and introduced Black Swan *Cygnus atratus*.

3c The wetlands regularly support over 15% of the world population of *Aythya novaeseelandiae.*

Source: John Andrew and Jenny Steven.

Tekapo Streams (60b)

Location: 43°57'S, 170°23'E. Within farmland north of State Highway No.8 and west of Lake Tekapo in the Mackenzie Basin, central South Island. Within Tekapo Ecological District.

Area: c.210 ha.

Altitude: 770-880 m.

Overview: The Tekapo Streams are three stream wetlands within the Mackenzie Basin Wetlands Complex. Fork Stream Swamp, Joseph Valley Wetland and Old Man Range Wetland are riverine wetlands, set within relic-glacial outwash surfaces. Wetland habitats of meandering streams, pools, vegetated swamps and, in Fork Stream, braided shingle channels are of high value for waterbirds, especially shorebirds. In the past, Joseph Valley Wetland was a regular breeding site for Black Stilt *Himantopus novaezelandiae*. Black Stilt still feed here and at Old Man Range Wetland. The streams are part of a regional network of wetlands used periodically by Black Stilt, other shorebirds, terns and Anatidae.

Physical features: Joseph Valley Wetland lies between a glacially-carved mountain slope and the elevated surface of Glenmore Moraines. A small meandering stream flows northeastward along a straight "V"-shaped valley into the Cass River. Extensive swamplands occur in the upper two-thirds of the valley floor.

The lower valley has been drained for farmland. Fork Stream Swamp is located beside a braided section of Fork Stream, a tributary of Tekapo River. The area includes meandering streams and sedge swampland. Old Man Range Wetland is a swampy valley 3 km long, with small pools and a stream. The wetland is situated at the northwestern end of Old Man Range. The regional pattern of drainage from the north and northwest has been disturbed by the relatively recent tectonic activity along a fault zone (Speight, 1963). Old Man Range was formed when glacial gravels were uplifted and tilted.

Ecological features: The Tekapo Stream Wetlands have been heavily modified in the past by grazing and the spread of exotic weeds (Johnson, 1978), but they continue to be valuable habitat for wildlife. Joseph Valley Wetland is dominated by Bog Rush *Schoenus pauciflorus* and *Juncus* spp., but there are also some areas of Red Tussock *Chionochloa rubra*. The vegetation of Fork Stream Swamp includes *Carex* spp., *Juncus* spp. and *Schoenus pauciflorus*. Old Man Range Wetland is a Red Tussock *C. rubra* wetland. Red Tussock was once

widespread over the morainic country between Lake Tekapo and Lake Pukaki, but is now restricted to localised depressions and watercourses (Espie *et al.*, 1984).
The current condition of the vegetation at these three wetlands is not known.
Land tenure: Crown land held as Pastoral Lease and Crown land reserved for defence purposes.
Conservation measures taken: None.
Conservation measures proposed: The three stream wetlands have been identified as "priority natural areas" (Espie *et al.*, 1984) and "Sites of Special Wildlife Interest" (SSWI) (Jarman, 1987), primarily because of their values as waterbird habitat. Fork Stream was rated as a SSWI of "high" value, while Old Man Range Wetland and Joseph Valley Wetland were rated as "outstanding".
These classifications do not, however, convey any formal protection. The SSWI system is a nationwide wildlife habitat ranking system which was used by the former Fauna Survey Unit of the New Zealand Wildlife Service and is officially recognised by the Department of Conservation.
Land use: The wetlands have been grazed by domestic livestock in the past. Current stocking rates are not known. The alluvial soils of lower Joseph Valley have been drained and developed for intensive agriculture, and the stream has been channelised. Gravel has been extracted from Fork Stream Swamp.
The main land uses in surrounding areas are extensive pastoral farming and military training. Land adjacent to Braemar Road, near Old Man Range Wetland and Fork Stream Swamp, has been developed for more intensive farming.
Possible changes in land use: Joseph Valley Wetland is at risk from more drainage for farm development purposes. A large forestry development proposed for the Glenmore Moraines may further modify hydrology of the adjacent Joseph Valley.
Disturbances and threats: On-going intensification of farming near and within the stream wetlands threaten ecological values. Domestic livestock, exotic weeds and changes in fertility threaten the vegetation communities. Drainage is a very real threat to the wetlands, especially around swamp margins where the wetlands have already been damaged. Forestry may alter regional and local hydrological regimes.
Hydrological and biophysical values: The stream wetlands have only a minor hydrological role in the upper Waitaki River catchment. Fork Stream was not tapped to feed the Upper Waitaki Power Scheme; its waters were piped a short distance to flow under a canal and freely into the Tekapo River. The wetlands play a general role in supporting food chains. The meandering pattern of Joseph Stream is classed as an extremely well-defined landform of scientific and educational value. The "random walk meanders" are ranked as nationally important features (Kenny & Hayward, 1993).
Social and cultural values: None known.
Noteworthy fauna: The wetlands support four endemic species of waterfowl whose survival is at risk: Black Stilt *Himantopus novaezelandiae*, Wrybill *Anarhynchus frontalis*, Banded Dotterel *Charadrius bicinctus* and Black-fronted Tern *Chlidonias albostriatus*. Black Stilts regularly bred at Joseph Valley Wetland until 1978, and still visit the wetland to feed. This wetland is currently a breeding site for Paradise Shelduck *Tadorna variegata*, South Island Pied Oystercatcher *Haematopus finschi* and Pied Stilt *Himantopus leucocephalus*. Black-fronted Tern and White-winged Black Tern *Chlidonias leucopterus* have been recorded as present but not breeding at the wetland (Jarman, 1987). Fork Stream Swamp is a breeding site for Paradise Shelduck, Banded Dotterel and Pied Stilt. South Island Pied Oystercatcher, Wrybill and Black-fronted Tern are also present at this site. Old Man Range Wetland is a feeding area for Black Stilt, as well as other shorebirds and Anatidae.
Noteworthy flora: None known.

Scientific research and facilities: The streams are not the focus of any research projects within Project River Recovery, a programme managed by the Department of Conservation, and there are no facilities for research in the area.
Conservation education: None known.
Recreation and tourism: The streams are all relatively remote and receive very little public attention.
Management authority: See under general account of Mackenzie Basin Wetlands Complex.
Jurisdiction: See under general account of Mackenzie Basin Wetlands Complex.
References: Espie *et al.* (1984); Jarman (1987); Johnson (1978); Kenny & Hayward (1993); Speight (1963).
Reasons for inclusion:

1a The Tekapo Streams are excellent representative examples of moraine wetlands in the relatively dry eastern South Island of New Zealand.
2a The streams support significant numbers of three globally threatened species of birds, *Himantopus novaezelandiae, Anarhynchus frontalis* and *Chlidonias albostriatus*.
3c The streams regularly support over 1% of the world population of *Himantopus novaezelandiae*.

Source: John Andrew and Jenny Steven.

Glenmore and Tekapo Tarns (60c)

Location: 43°54'S, 170°25'E. Near Lake Tekapo in the Mackenzie Basin, in the eastern high country of South Island. Access is by foot or off-road vehicle via farm tracks and grassland, and there is no formal public access. Within Tekapo Ecological District.
Area: Unknown.
Altitude: 720-1,001 m.
Overview: The Glenmore and Tekapo Tarns are part of the Mackenzie Basin Wetlands Complex. The tarns are a scattered collection of permanently wet tarns, periodically-inundated kettle holes and damp wetland hollows, all located within old glacial moraines (including the extensive Glenmore Moraines). The tarns are notable because they represent diverse kettle hole wetland ecosystems and support large numbers of waterfowl, including the globally endangered Black Stilt *Himantopus novaezelandiae* and nationally endangered Great Crested Grebe *Podiceps cristatus australis*. Many individual tarns or tarn clusters have been ranked as "high" or "outstanding" "Sites of Special Wildlife Interest", primarily because of their value as habitat for Black Stilt or Great Crested Grebe (Jarman, 1987). Over 1,800 ha of the moraine lands and tarns have been recommended for protection (Espie *et al.*, 1984; Johnson, 1994).
The Glenmore Moraines are considered to be the largest area of kettle hole terrain with the greatest concentration of kettle holes in the eastern South Island (Johnson, 1994). The overall kame landform, an ice-margin deposit, is listed in the New Zealand Landform Inventory as a landform of national importance; "the best example of a kame in New Zealand" (Priestley, 1990). The Glenmore Moraines are one of four kettle hole areas which stand out because of the diversity of their habitats and vegetation types, and representation of native wetland flora (Johnson, 1994). The native flora of the turf shore habitats is especially diverse.
Physical features: The site comprises numerous tarns within undulating moraine on Glenmore Station (a pastoral farm) west of Lake Tekapo. Named tarns are as follows:

- Boundary, Cluster and Glenmore Tarns (three groups of tarns);
- Lake Murray and Sunday, Grebe, Stony, Tui and Hartley Tarns (large, single

permanently-wet tarns);
- Mt Hay Tarns and Mt Richmond Tarns (two groups of tarns on lateral moraine, southeast of Lake Tekapo);
- Target Tarn (a large solitary tarn on moraine, within Ministry of Defence land southwest of Glenmore Tarns);
- Micks Lagoon and Raupo Lagoon (separate tarns north of the Cass River).

The tarns are part of a large relic-glacial landform system which formed at the end of the last glacial maximum, probably 13,500 years ago (Johnson, 1994). Tarns southeast of Lake Tekapo are bound by curved lateral moraines from the main Tekapo glacier (now non-existent). West of the lake, vast quantities of unsorted greywacke till accumulated as the margin of the Tekapo Glacier thinned and retreated. Ice, gravel and meltwater also flowed from the tributary Cass Valley and helped create an array of landforms. The tarns have a common shape, but variations in size and degree of inundation produce considerable habitat diversity. Most tarns are rounded, oval or slightly oblong, with a smooth, concave profile, steep sides, a flat base and no surface stream flows.

The smallest tarns (as small as 10 m across) occur in clusters within pock-marked "knob and kettle" topography, typical of undisturbed ablation moraine. Large shallow hollows (50-100 m across) often only hold water for short periods of time. Boggy tarns within outwash channels are unusual because they are drained by surface streams and their water levels remain very stable. Large tarns (up to 12 ha) were formed where outwash gravels engulfed isolated blocks of stagnant ice. Examples of large tarns within smoothly undulating outwash gravels are the Tui, Stony and Hartley Tarns.

Other large tarns are Sunday Tarn, Grebe Tarn, the Target Tarns and Lake Murray. Water levels usually fluctuate by at least 2-3 m, but in Hartley Tarn and several others, water levels are highly stable. Tarn margins vary from fine muddy sediments to stone stripes and bands. Wave action on the windswept large tarns has produced stony beaches and reduced areas of turfland. Silty mineral soils predominate. Organic peat soils occur around boggy tarns with stable water levels.

The Glenmore and Tekapo Tarns are on the edge of the Mackenzie inter-montane basin. The climate here is influenced strongly by the Southern Alps to the northwest. Conditions are humid to sub-humid, with cold winters and warm summers (Espie *et al.*, 1984). The prevailing west and northwest winds are often strong. Snow cover is intermittent. Heavy frosts cause the tarns to freeze over for up to several weeks each winter.

Ecological features: Zoned turflands are a feature of many of the Glenmore and Tekapo Tarns. These vegetation communities have a relatively uniform structure, a dense, low, firm turf, in concentric zones of distinctive colours and species composition (Johnson, 1994). The zones may extend for 30 m around the tarn, or be compressed into narrow zones over only several metres. Plants typical of the turfland zones at Glenmore are described below. (All vegetation data are from Johnson, 1994).

- Aquatic zone: *Potamogeton cheesemanii* and milfoil *Myriophyllum propinquum*.
- Mud zone (plants occasionally out of water): *Glossostigma* spp., *Lilaeopsis ruthiana*, *Crassula sinclairii* and *Limosella lineata*.
- Lower turf zone: *Isolepis aucklandica*, *Plantago triandra*, *Hydrocotyle hydrophilus*, *Hypsela rivalis* and *Carex gaudichaudiana*.
- Mid turf zone: *Galium perpusillum* and *Epilobium angustum.*
- Upper turf zone: *Poa lindsayi*, *Selliera microphylla* and the moss *Polystichum juniperinum*, plus naturalised plants, native herbs and sub-shrubs common also to the tussock grasslands on dry moraine slopes.

Mosses replace turf in some shallow kettle holes. Mud and *Crassula sinclairii* cover the tarn base. Tarn sides have a band of *Galium perpusillum*, *Carex gaudichaudiana* and *Hydrocotyle*

hydrophila; then one of mosses, *Aulacomnion palustre* and *Polytrichum juniperinum*. The final wetland zone is dominated by comb sedge *Oreobolus pectinatus*.

Boggy tarns with stable water levels typically have a raised berm of sphagnum moss *Sphagnum cristatum* surrounded by sedges and mosses. Raupo *Typha orientalis* grows in several of the six Mt Hay Tarns, in a shallow tarn on an old delta surface at Glenmore, and in an impressive stand at Raupo Lagoon on Godley Peaks Station (Johnson, 1994; Espie *et al.*, 1984). This species is not widespread in the Mackenzie Basin. It provides valuable shelter, breeding and feeding sites for waterfowl. Red Tussock *Chionochloa rubra* occurs at Micks Lagoon and Target Tarn.

Moraine wetlands have a large flora, with 146 native species recorded at the Glenmore Tarns, over 50 of which are confined to this habitat (Johnson, 1994). Turflands are particularly rich, with 58 native species in these zones, compared with only seven in the aquatic zone. Dry land surrounding the wetlands is covered mainly in depleted short tussock grassland. The flatweed *Hieracium pilosella* covers 30-60% of the ground. Native species include Hard Tussock *Festuca novae-zelandiae*, Matagouri *Discaria toumatou*, *Leucopogon fraseri* and *Coprosma perpusilla*.

Land tenure: All of the tarns except Micks Lagoon and Target Tarn are within large tracts of Crown land farmed under Pastoral Lease. Micks Lagoon is Crown land, acquired from Pastoral Lease by the former Wildlife Service to be reserved for wildlife management purposes. Target Tarn is within Crown land held for defense purposes. Surrounding areas are predominantly Crown Pastoral Lease. Land west of Glenmore Station includes a tract of Crown land held by the Ministry of Defence for army purposes.

Conservation measures taken: There is very little existing protection. Micks Lagoon is the only protected tarn; this area has a predator-proof fence, to protect nesting Black Stilts.

Conservation measures proposed: All tarns are included in areas identified as "priority natural areas" following a Protected Natural Areas Programme survey of the Mackenzie Ecological Region (by Espie *et al.*, 1984). Precise boundaries and eventual protection mechanisms have yet to be defined, through negotiation with lessees and the Crown. The largest proposed protected area is Glenmore Tarns, covering 930 ha. Recently, the botanical values of this area were reassessed (Johnson, 1994). The area remains one of outstanding ecological value.

The Department of Conservation is researching methods for enhancing wetland habitats for invertebrates and birds. The results may be applied at Micks Lagoon (Department of Conservation, 1994).

Land use: Most tarns are within extensive pastoral grazing land. Domestic livestock have unrestricted access to the tarns for drinking water, except at Micks Lagoon. The isolated tarns are rarely disturbed by visitors or farming activities. Target Tarn, however, has been used as an artillery firing target by the army. The principal land use in surrounding areas is extensive pastoral farming, with some pastoral improvement such as the spreading of fertiliser, over-sowing of new pasture species, and cultivation of alluvial soils. Human habitation is limited to isolated farm homesteads and informal holiday settlements at Lake Alexandrina.

Possible changes in land use: The Glenmore Tarns are within an area proposed for forestry development. Glenmore Station has recently applied to Land Corporation Ltd. (the Crown's agent for administration of Pastoral Leases) for approval for forestry on portions of the Glenmore Moraines.

Disturbances and threats: The margins of the tarns have been grazed by sheep and rabbits for many years. The short tussock grasslands around the tarns are in a degraded state, particularly after heavy infestations of rabbits and *Hieracium pilosella*, a colonising flatweed. Cattle and deer have the potential to cause severe damage to swampy tarns. Willow trees *Salix fragilis* threaten the botanical values at three of the four Mt Richmond Tarns. Willows also occur on

the shores of Hartley Tarn. Their impact on wildlife is not known.
Forestry has the potential to damage the tarn habitats, by reducing the local water yield. A permanent reduction of the water tables and reduced fluctuations may threaten the zoned turflands by reducing their area and complexity (Johnson, 1994). Pasture weeds such as Scotch Thistle *Cirsium vulgare*, Woolly Mullein *Verbascum thapsus* and *Hieracium* spp. readily colonise bouldery tarn margins when water levels drop. Hydrological changes may also degrade waterfowl habitats. Forestry threatens to alter the existing landscape character of the moraine and cover the complexities of a notable landform. The uncontrolled spread of pine seedlings is a problem already encountered, but not yet resolved, in the Mackenzie Basin.
Hydrological and biophysical values: The tarns play a general role in supporting food chains, but have little significance in terms of water flows and volumes in the Upper Waitaki catchment. The moraine landform is rated as nationally significant (Priestley, 1990). It is very large, has little post-glacial modification, and clearly illustrates past geomorphic processes and part of New Zealand's glacial history.
Social and cultural values: The individual tarns have no special social or cultural values. However, Glenmore Moraines are a key element in the highly-valued natural landscape of the Mackenzie Basin (Boffa Miskell and Lucas Associates, 1993).
Noteworthy fauna: The tarns regularly support small numbers of the nationally threatened Great Crested Grebe *Podiceps cristatus australis* and globally endangered Black Stilt *Himantopus novaezelandiae*. The tarns at Glenmore include six of the eleven sites where Great Crested Grebes have been recorded in the Mackenzie Basin. Glenmore Tarns (a cluster of tarns within the overall Glenmore Tarns wetland unit), Grebe Tarn, Hartley Tarn and Lake Murray are known to have been breeding areas for this species in the past (Jarman, 1987). The shallow tarns provide important feeding grounds for wading birds, notably the Black Stilt. Only Micks Lagoon is currently a breeding site for Black Stilts; Lake Murray, the Glenmore Tarns and the Cluster Tarns are feeding sites and/or former breeding sites for this species.
The Australasian Bittern *Botaurus poiciloptilus* has been recorded from several tarns. Banded Dotterel *Charadrius bicinctus* feed at terrestrial and aquatic sites in and around sparsely-vegetated tarns.
Many of the tarns support moderate numbers of waterfowl (in relation to their size). Micks Lagoon is an important breeding area for Grey Teal *Anas gracilis*, New Zealand Scaup *Aythya novaeseelandiae* and Marsh Crake *Porzana pusilla affinis*. Other waterfowl recorded from the tarns include Little Shag *Phalacrocorax melanoleucos*, Little Black Shag *P. sulcirostris*, White-faced Heron *Egretta novaehollandiae*, Great Egret or White Heron *E. alba*, Black Swan *Cygnus atratus*, Canada Goose *Branta canadensis*, Paradise Shelduck *Tadorna variegata*, Australian (Chestnut-breasted) Shelduck *T. tadornoides* (a vagrant from Australia), Mallard *Anas platyrhynchos*, Grey Duck *A. superciliosa*, New Zealand Shoveler *A. rhynchotis variegata*, South Island Pied Oystercatcher *Haematopus finschi*, Pied Stilt *Himantopus leucocephalus*, Black-fronted Tern *Chlidonias albostriatus* and White-winged Black Tern *C. leucopterus*.
Noteworthy flora: Three species found at the Glenmore Tarns are listed as threatened plants (Cameron *et al.*, 1993). They are *Crassula peduncularis* (a tiny creeping herb), *Iphigenia novae-zelandiae* (a tiny bulbous, lily-like plant) and *Isolepis basilaris* (a small tufted sedge).
Scientific research and facilities: There are no research facilities at the tarns. The Department of Conservation is conducting and sponsoring research projects on waterbirds and wetland habitats as part of "Project River Recovery", a programme designed to rehabilitate a number of rivers degraded by weeds and hydro-electric power development. Knowledge gained elsewhere in the Mackenzie Basin may contribute to future management of the Glenmore and Tekapo Tarns.
Conservation education: None known.

Recreation and tourism: Some of the larger tarns are used for fishing, but otherwise the area is subject to very little public use.
Management authority: See under general account of Mackenzie Basin Wetlands Complex.
Jurisdiction: See under general account of Mackenzie Basin Wetlands Complex.
References: Boffa Miskell and Lucas Associates (1993); Cameron *et al.* (1993); Department of Conservation (1994); Espie *et al.* (1984); Jarman (1987); Johnson (1994); Priestley (1990).
Reasons for inclusion:

1a The Glenmore and Tekapo Tarns are excellent representative examples of moraine wetlands in the relatively dry eastern South Island of New Zealand.

2a The tarns support significant numbers of three globally threatened species of birds, *Botaurus poiciloptilus*, *Himantopus novaezelandiae* and *Chlidonias albostriatus*.

2b The tarns are of special value in maintaining genetic and ecological diversity of the South Island high country because of the quality and diversity of the turf vegetation in moraine hollow tarns, and also because of the diversity of waterfowl which they support.

2c The tarns provide important breeding habitat for a wide variety of waterfowl including a substantial proportion of the New Zealand population of *Podiceps cristatus* and several other indigenous species.

2d The tarns are of special value for their endemic plant and animal species, notably the plants *Iphigenia novae-zelandiae*, *Isolepis basilaris*, *Lilaeopsis ruthiana*, *Crassula sinclairii*, *Plantago triandra*, *Hydrocotyle hydrophilus*, *Hypsela rivalis*, *Galium perpusillum* and *Epilobium angustum*, and the Black Stilt *Himantopus novaezelandiae*.

3c The tarns regularly support over 1% of the total population of *Himantopus novaezelandiae*.

Source: John Andrew and Jenny Steven.

Ohau Moraine Wetlands (60d)

Location: 44°19'S, 169°54'E. In the upper Waitaki River catchment south of Lake Ohau, about 15 km southwest of Twizel township and adjacent to Lake Ohau road, central South Island. Within Omarama Ecological District.
Area: c.440 ha (minimum).
Altitude: 520-620 m.
Overview: The Ohau Moraine Wetlands are part of the Mackenzie Basin Wetlands Complex. They comprise a cluster of numerous seasonally wet tarns, depressions and permanent ponds on terminal moraine and outwash gravels south of Lake Ohau. The wetlands include those known as Swan, Raupo and Red Lagoons, Six Mile Creek Tarns, Shelton Downs Wetlands, Ohau Downs Ponds, Wairepo Lake and Benmore Homestead Tarn (a notable outlier to the east). The "lagoons" and tarns are valuable waterfowl habitat, especially as seasonal and occasional feeding areas for Black Stilt *Himantopus novaezelandiae*. The wetlands also contain excellent representative examples of uncommon turf vegetation and typical relic-glacial landforms.
Physical features: The Ohau Moraine Wetlands include the following named wetlands:

- Swan Lagoon, 25 ha
- Shelton Downs Wetlands, 157 ha
- Raupo Lagoon, 15 ha

- Six Mile Creek Swamp and Tarn, 16 ha
- Ohau Downs Ponds, 195 ha
- Wairepo Lake, 20 ha
- Benmore Homestead Tarn, 12 ha.

Many other unnamed tarns and several stream-side swamps are also included as part of this site.

Physical features vary considerably. Most kettle hole tarns and hollows lack obvious surface inflows or outlets. Peak water levels are thought to occur during spring, when snow-melt raises the region's water tables (Johnson, 1978).

Many small tarns dry out completely during summer, while others rarely hold water. Soils around the wetlands are thin, rocky upland yellow grey earths. Soils in the wetlands vary, depending on local substrate and drainage.

The wetlands include a cluster of 12 or more kettle hole tarns within hummocky moraine, near an old loop in Lake Ohau Road. These range in size from 5 m to 40 m diameter. All except one appear to dry out during summer (see Johnson, 1978 & 1980). Three shallow hollows (200-400 m in diameter) beside Lake Ohau Road are completely turf-covered, dry in summer and inundated during winter. Several periodically-dry kettles and a series of tarns linked by wetland flushes and streams occur near the margin of Lake Ohau. Swan, Raupo and Red Lagoons, Wairepo Lake and Benmore Homestead Tarn are large, almost permanently-wet tarns.

- Swan Lagoon is 1,100 by 400 m, with a vertical rise of 2.5 m from tarn floor to the dryland plant zone. Much of the shore is gently-sloping and muddy. Stone cobbles occur in the higher zones. A band of zoned wetland vegetation, 50 m wide, surrounds the tarn.
- Raupo Lagoon has a bed of deep silt, permanent water (average depth less than 1 m deep), and a turf zone 20-25 m wide. The lagoon is approximately 1,000 m by 250 m, two thirds of which is Raupo reed-beds rather than open water.
- Wairepo Lake occupies a large shallow depression within a moraine-dammed swamp. Lake levels have fluctuated since the lake was drained and refilled in 1968, during construction of the Upper Waitaki River Power Scheme. In times of drought, the lake may become completely dry.
- Benmore Homestead Tarn is a large shallow tarn with *Carex* spp. sedgelands around parts of the margin. It is located downstream from Wairepo Lake, near the junction of Lake Ohau Road and State Highway No.8.

At times, the area experiences harsh environmental conditions, such as heavy frost, temperature extremes, strong wind and high light intensity.

Ecological features: The Ohau Moraine Wetlands are noted for their turfland communities (Johnson, 1978 & 1980). Tarn vegetation, habitat and flora are diverse and of high botanical interest. The native wetland flora is well represented in this area (see Johnson, 1978, for details about several tarns). Each tarn has a different vegetation pattern. Only two tarns are discussed below.

The zoned vegetation of Swan Lagoon contains 43 native plant species. Plants of the muddy shore include *Ranunculus limosella*, *Neopaxia australasica*, *Lilaeopsis* sp., *Isoetes* sp. and *Scirpus aucklandicus*. Common turfland plants are *Pratia perpusilla*, *Selliera* sp., *Hydrocotyle novae-zelandiae*, *Epilobium angustum*, *Galium perpusillum*, *Stackhousia minima*, *Carex berggrenii* and *Carex gaudichaudiana*.

The aquatic vegetation of Raupo Lagoon is not typical of the Mackenzie Basin. Dense beds of Raupo *Typha orientalis* cover much of the wetland. Other common aquatic plants include *Chara* sp., *Lilaeopsis* sp., *Myriophyllum pedunculatum*, *M. elatinoides* and *Potamogeton ochreatus*.

The shallow water and soft tarn-floor substrates provide essential feeding grounds for Black Stilts and other wading birds.

Land tenure: Most of the tarns and the surrounding area are within Crown land, farmed under Pastoral Lease or Deferred Payment Licence. Some areas are freehold land. The beds of Lake Ohau and Lake Ruataniwha are Crown land, and there are areas of legal road and Crown-owned Conservation area and Recreation Reserves nearby.

Conservation measures taken: There is no formal site protection. The Department of Conservation has an active programme to protect the endangered Black Stilt, as set out in the Black Stilt Recovery Plan (Reed *et al.*, 1993). Habitat protection is one component of the recovery plan.

Conservation measures proposed: A Protected Natural Areas (PNA) Programme survey (Espie *et al.*, 1984) identified three wetland areas worthy of protection in the area south of Lake Ohau. The Lake Ohau Road/Shelton Downs area (925 ha) covers many of the tarns and swamps, including Ohau Road Ponds, Red Lagoon, Swan Lagoon and Raupo Lagoon. The other two sites are Wairepo Lake/Glen Eyrie Downs (96 ha) and Benmore Homestead Lagoon (20 ha). These areas encompass most of the "outstanding" "Sites of Special Wildlife Interest" listed in Jarman (1987). Future conservation management options are yet to be pnegotiated with the landowners. The proposed areas would protect Black Stilt habitat, botanically-diverse turflands, and at least part of a regionally significant moraine landform (Johnson, 1980 & 1994). Johnson (1980) also identified moraine wetlands worthy of protection. Some of these areas are covered by the PNA survey proposals.

Land use: The wetlands are used as a source of water for domestic livestock, and are occasionally grazed by livestock, mainly sheep. The principal land use in surrounding areas is pastoral farming of sheep and cattle. Summer recreational activities take place at nearby Lakes Middleton, Ohau and Ruataniwha. The nearest human settlements are sparsely scattered farm homesteads, Lake Ohau Lodge (hotel accommodation near a ski-field), and a small, recently developed holiday house subdivision beside Lake Ohau.

Possible changes in land use: None known; the uneven ground and poor soils are likely to discourage major farm development.

Disturbances and threats: Sheep have had access to the tarns for many years, and have probably already modified the habitats. Turf and swamplands are at risk from cattle grazing, over-sowing of pasture plants, the spread of weeds and fertiliser "drift" from aerial top-dressing of adjacent land. Forestry and drainage schemes may alter the hydrology of the tarns, as well as scenic and habitat values. In the past, turflands have been damaged by off-road vehicles, soil disturbance during rabbit poisoning operations, and soil and rock removal.

Hydrological and biophysical values: The kettle hole tarns of Ohau Moraine are among the four best examples of this landform and habitat type in the eastern South Island (Johnson, 1994). The wetlands play a general role in supporting food chains.

Social and cultural values: None known.

Noteworthy fauna: The Ohau Moraine Wetlands are very important feeding areas for the endangered Black Stilt *Himantopus novaezelandiae*, although the species does not at present breed here. Use is irregular, and Black Stilt numbers are very low (only one or two birds) at most of the wetlands. Swan Lagoon, Six Mile Creek Tarn, Shelton Downs Wetland and Benmore Homestead Tarn have been rated as "outstanding" "Sites of Special Wildlife Interest" (SSWI) because they are key sites for Black Stilt (Jarman, 1987). This is a nationwide wildlife habitat ranking system used by the former Fauna Survey Unit of the New Zealand Wildlife Service and officially recognised by the Department of Conservation.

Swan Lagoon and Shelton Downs Wetlands are very important Black Stilt feeding areas (11 birds were observed at Swan Lagoon during a single visit). The Hoary-headed Grebe *Poliocephalus poliocephalus*, an irregular vagrant from Australia, was recorded at both sites in

the late 1970s. The Wrybill *Anarhynchus frontalis* is often present, as are a wide range of other shorebirds, Anatidae, gulls and terns.

Ohau Downs Ponds, three artificially dammed ponds, are also very important feeding areas for Black Stilt. Other native birds at these ponds include Australasian Bittern *Botaurus poiciloptilus* and Paradise Shelduck *Tadorna variegata*.

Six Mile Creek Tarn is a feeding area for Black Stilt and possibly also a moulting site for Paradise Shelduck. A nearby swamp in Six Mile Creek, with dense *Carex* sp. and stands of *Typha orientalis*, provides ideal habitat for Australasian Bittern *Botaurus poiciloptilus*. This swamp, which is also used by herons, ducks, shorebirds and terns, has been ranked as a SSWI of "moderate to high" value.

Benmore Homestead Tarn is especially important for Black Stilt; up to 50% of the total Black Stilt population have been observed here at one time. The tarn is also an important moulting site for Paradise Shelduck, with up to 1,000 birds present at one time. A wide range of other waterfowl use the wetland for feeding and loafing. The Australasian Bittern *Botaurus poiciloptilus* is present, as are breeding populations of Black Shag *Phalacrocorax carbo* and Little Shag *P. melanoleucos*. Wairepo Lake supports numerous ducks and shorebirds, and Black Stilts have been observed here.

Other notable waterfowl which occur at the Ohau Moraine Wetlands include New Zealand Shoveler *Anas rhynchotis variegata*, New Zealand Scaup *Aythya novaeseelandiae*, Banded Dotterel *Charadrius bicinctus* and Black-fronted Tern *Chlidonias albostriatus*.

Noteworthy flora: No rare plants are known from the area, but the flora is diverse and of a type which is generally uncommon.

Scientific research and facilities: There are no research facilities in the area and no known special research projects that focus on the wetlands.

Conservation education: There are no special programmes based at the wetlands, but there is an interpretation centre and bird hide near Twizel to inform visitors about the Black Stilts.

Recreation and tourism: The area is subject to very little public use. Recreation mainly takes place at nearby Lake Middleton and around the shores of Lake Ohau.

Management authority: See under general account of Mackenzie Basin Wetlands Complex.

Jurisdiction: See under general account of Mackenzie Basin Wetlands Complex.

References: Espie *et al.* (1984); Jarman (1987); Johnson (1978, 1980, 1994); Reed *et al.* (1993).

Reasons for inclusion:

1a The Ohau Moraine Wetlands are excellent representative examples of moraine wetlands in the relatively dry eastern South Island of New Zealand.

2a The wetlands support substantial populations of four globally threatened species of birds, *Botaurus poiciloptilus*, *Himantopus novaezelandiae*, *Anarhynchus frontalis* and *Chlidonias albostriatus*.

2b The wetlands are of special value in maintaining genetic and ecological diversity of the South Island high country because of the quality and diversity of the turf vegetation in the moraine hollow tarns.

2c Benmore Homestead Tarn is of special value as a moulting site for large numbers of *Tadorna variegata*.

3c The wetlands regularly support a large proportion of the world population of *Himantopus novaezelandiae*. Benmore Homestead Tarn occasionally holds over half of the total population of this species.

Source: John Andrew and Jenny Steven.

Central Southern Lakes Complex (61)

Location: Tekapo, 43°54'S, 170°32'E; Pukaki, 44°07'S, 170°11'E; Ohau, 44°14'S, 169°51'E. Southeast of the Southern Alps in the Mackenzie Basin, central South Island. The townships of Tekapo, Mount Cook and Twizel are the nearest settlements to the lakes. State Highway No.8, a major tourist route, passes beside Lakes Tekapo and Pukaki. Within Tekapo and Ben Ohau Ecological Districts.
Area: Tekapo, 8,680 ha; Pukaki, 9,890 ha; Ohau, 5,385 ha.
Altitude: 710 m, 524 m and 520 m.
Overview: The site comprises three large lakes, Lake Tekapo, Lake Pukaki and Lake Ohau, within a large inter-montane basin. Landscapes are expansive, smoothed and barren, with a contrasting backdrop of rugged mountain chains. The lakes occupy elongate glacial troughs, impounded by large terminal moraine deposits. The deep waters of Tekapo and Pukaki are oligotrophic, windswept and laden with suspended glacial rock flour. Hydro-electric power development has modified the hydrology of the Mackenzie Basin. Lakes Tekapo and Pukaki have elevated and fluctuating lake levels, controlled outlets and severely modified outflow rivers. The level of Lake Ohau is limited by a concrete weir, and the Ohau River is dammed further downstream.
This lake complex includes several areas identified as "Sites of Special Wildlife Interest" (SSWI) by the Fauna Survey Unit of the New Zealand Wildlife Service, particularly because of their value as habitat for shorebirds, including Black Stilt *Himantopus novaezelandiae*, and as habitat for Great Crested Grebe *Podiceps cristatus australis* (Jarman, 1987). The most important wildlife habitats are several shallow bays (discussed as part of this site) and the headwater deltas (discussed as part of Site 62c - Waitaki Headwaters Braided Rivers). Parts of all three lakes are popular recreation areas during summer.
Physical features: Lake Tekapo, Lake Pukaki and Lake Ohau are large glacially-carved lakes that are fed by rainfall, snow-melt and glacial meltwater from extensive subalpine and alpine catchments. Lake Tekapo has two small islands and a maximum depth of 120 m. Generally, the shoreline is steep, with narrow shingle beaches and areas of eroding banks as a result of lake level changes. Shallow bays occur in the north, southeast and west, near Lake McGregor. Gently-sloping shingle deltas merge into the lakes from the headwater rivers, the Godley, its tributary the Macaulay, and the Cass. The lake has a distinctive milky-blue colour as a result of summer glacial meltwater inflow and permanently suspended rock flour. Originally, the outflow was via Tekapo River in a terraced channel cut through moraine. The river is now controlled and flows are minimal. A tunnel taking water to a power station and canal now serves as the lake's main outlet. Lake levels fluctuate depending on water storage needs and power demand. Low levels, especially during winter, expose the shoreline bays and inlets in the southeast corner of the lake and along the western shore (Western Bays and Mailbox Inlet). The "outstanding" wildlife habitat rating for Lake Tekapo (Jarman, 1987) stems from the importance of these shallow waters.
South East Bay of Lake Tekapo has shallow areas of open water, with varied substrate of mudflats, sand, rock and shingle. The mudflats are usually fully exposed by the end of winter. Willow trees *Salix fragilis* and small patches of swamp vegetation extend into the lake. A vehicle track follows the lake edge. Mailbox Inlet is 18.9 ha of shallow open water on the western shore of Lake Tekapo, near the Cass River delta (Jarman, 1987; Espie *et al.*, 1984). The inlet has a gently-sloping shoreline, exposed mudflats, gravel banks, grass, willows and short swamp vegetation. Western Bays at the outlet of Lake McGregor include shallow open water, mudflats, swampland and silty turfland. The area of each community varies with fluctuations in lake level. The bays are accessible from a public road (see Anon, 1980, for maps).

Lake Pukaki (70 m deep) is very similar in character to Lake Tekapo. It is fed mainly by the Tasman River and its large, heavily-glaciated catchment. Water from Lake Tekapo feeds Pukaki via a canal and power station. A high dam at the southern end of the lake raised the lake level, destroying 4,500 ha of valuable braided river habitat at the Tasman River Delta (Jarman, 1987). Large freshwater swamps were also lost. Lake levels have been allowed to fluctuate markedly. Landforms are gradually readjusting to the change in base level, and eroding cliffs are now a marked feature of the western lake shore. The original outlet, Pukaki River, is now a redundant dry channel, as all but emergency flow passes along a canal to feed a power station at Lake Ruataniwha.

Lake Ohau is the smallest but deepest (129 m deep) of the three lakes. The Hopkins and Dobson Rivers enter the northern end of the lake via a broad shingle delta. The eastern lake shore rises steeply along the edge of Ben Ohau Range. Lake Ohau receives little glacial meltwater and contains less suspended rock flour.

The lakes are within a large inter-montane basin which has a semi-continental climate. Winters are cold, often clear, with severe frosts; summers are usually warm and dry, with strong northwesterly winds. The lakes do not freeze over. (See Espie *et al.*, 1984 for further information).

Ecological features: All three lakes are deep, cold and oligotrophic, with "weak and deep stratification" (Livingston *et al.*, 1986b). The lakes are very important seasonal feeding areas for waterfowl, especially when shallow wetlands in the Mackenzie Basin have frozen during winter, and when low lake levels in early spring coincide with pre-nesting feeding needs. Shallow bays and headwater river deltas are the areas used most heavily by waterfowl.

Land surrounding the lakes is dominated by dry short tussock grassland, most of which is in a degraded state. Several interesting shrub communities have survived on the smallest of two islands in Lake Tekapo, *e.g.* shrubland with hybrid kowhai *Sophora* spp. and two species of mistletoe (Espie *et al.*, 1984). A notable scrub community on the shoreline of Lake Ohau includes Matagouri *Discaria toumatou*, *Coprosma* sp., thick Manuka *Leptospermum scoparium* and Red Tussock *Chionochloa rubra* (Espie *et al.*, 1984).

Land tenure: Lake beds are Crown land. Margins of Lake Tekapo are Crown land controlled by Electricity Corporation, a state-owned enterprise, for power development purposes. Land surrounding Lake Pukaki is Crown land held as Pastoral Lease, legal road and reserves for the generation of electricity. Margins of Lake Ohau are Crown land held mainly as legal road, but with small areas of Recreation and Camping Reserve. Land within a fenced enclosure at Mailbox Inlet is to be acquired by the Department of Conservation. It is expected that the land will become a Government Purpose (Wildlife Management) Reserve.

Surrounding areas are predominantly Crown land held under Pastoral Lease. There are also small areas of freehold land, land reserved for recreation, soil conservation and forestry purposes, and legal roads (formed and unformed) (Anon, 1980).

Conservation measures taken: An 18.9 ha fenced enclosure has been built at Mailbox Inlet to provide a predator-free breeding area for Black Stilt. The Department of Conservation is in the process of acquiring this land. All three lakes have been identified as "outstanding" "Sites of Special Wildlife Interest" (SSWI) (Jarman, 1987). The SSWI system is a nationwide wildlife habitat ranking system which was used by the former Fauna Survey Unit of the New Zealand Wildlife Service and is officially recognised by the Department of Conservation. The valuable headwater delta habitats (discussed under Site 62c - Waitaki Headwaters Braided Rivers) boost the SSWI ratings for the lakes as a whole. The SSWI classification does not, however, convey any formal protection.

Conservation measures proposed: A Protected Natural Areas Programme survey identified priorities for protection (Espie *et al.*, 1984). These coincide with the SSWI areas. Proposals include the three lakes, plus Mailbox Inlet. The headwater rivers were not surveyed.

Land use: The lakes are used for water storage for hydro-electric power generation in the Upper Waitaki Power Scheme. During summer, recreational use is high, especially in sheltered bays of Lakes Tekapo and Ohau. The permanent population near the lakes is no more than several hundred, clustered mainly around Tekapo township and in isolated farm homesteads.
Most of the land surrounding the lakes is used for extensive grazing of sheep on Pastoral Lease land. Cropping and plantation forestry occupy a small proportion of the Mackenzie Basin. Other land uses include a 1,000 ha Scenic Reserve for nature conservation south of Tekapo, a Soil Conservation Reserve beside South East Bay of Lake Tekapo, a military training ground and an astronomical observatory.
Possible changes in land use: The issue of afforestation of degraded tussock grassland in the Mackenzie Basin has been under public scrutiny, particularly during 1993. More large-scale forestry projects on Pastoral Lease land are likely to be proposed in the future. The spread of pines from existing plantations has already altered the tussock grassland ecosystem and the landscapes of the Mackenzie Basin.
Disturbances and threats: The habitat values of Lakes Tekapo and Pukaki are threatened by unseasonal changes in water levels as a result of demands for hydro-electric power. When shallow bays, such as Western Bays, are exposed, birds and turflands are disturbed by use of off-road vehicles. Recreational boating also has the potential to disturb waterfowl as Lake Tekapo receives moderately high use during summer.
Hydrological and biophysical values: The lakes are key storage reservoirs for the Waitaki hydro-electric power scheme. They also buffer water and sediment levels when headwater rivers flood during the spring thaw and rain storms.
Social and cultural values: The Central Southern Lakes have important spiritual value to Maori people. Traditional stories tell of the origins of the lakes and their "kaitiaki" (spiritual guardians). Maori people are thought to have hunted birds and camped near the lakes, probably on a seasonal basis. Artifacts have been found between Lakes Alexandrina and Tekapo (Tau *et al.*, 1990).
The Central Southern Lakes are part of the extensive inter-montane range and basin landscape of the Mackenzie Basin. This landscape is considered to be outstanding on a regional and national scale (Boffa Miskell and Lucas Associates, 1993).
Noteworthy fauna: All three lakes have been ranked as "outstanding" "Sites of Special Wildlife Interest" (Jarman, 1987) because they support the globally endangered Black Stilt *Himantopus novaezelandiae* and/or the nationally threatened Great Crested Grebe *Podiceps cristatus australis*, as well as other vulnerable endemic waterfowl.
Lake Tekapo is one of only eleven sites in the Mackenzie Basin where Great Crested Grebe *Podiceps cristatus australis* have been recorded (Jarman, 1987). The lake also supports breeding populations of a wide range of native and introduced Anatidae. The lakeshore and bay wetlands are valuable for pre-breeding shorebirds, especially during late winter and spring. Wrybill *Anarhynchus frontalis* and Banded Dotterel *Charadrius bicinctus* feed at South East Bay if water levels are low. Western Bays are an occasional feeding area for Black Stilt and Wrybill, and a breeding and feeding site for Banded Dotterel. Mailbox Inlet supports one or two breeding pairs of Black Stilt. It is also a feeding area for Black Stilt and Banded Dotterel, and an excellent site for breeding Anatidae, notably Grey Teal *Anas gracilis* and New Zealand Shoveler *Anas rhynchotis variegata*. The White-winged Black Tern *Chlidonias leucopterus* has been recorded at the lake. The open water and margins of Lake Ohau are used by shags *Phalacrocorax* spp., Anatidae and shorebirds. Paradise Shelduck *Tadorna variegata* and Grey Duck *Anas superciliosa* breed, and Great Crested Grebes are occasionally seen here. Notable endemic species recorded at Lake Ohau include Black Stilt, Banded Dotterel, Wrybill and Black-fronted Tern *Chlidonias albostriatus*.

Lake Pukaki provides important over-wintering sites for Black Stilt. Drawdown for hydro-electric power generation exposes new feeding grounds in the Tasman River delta and in shallow bays on the lake margin. Falling water levels in autumn also provide feeding grounds for other shorebirds and Anatidae. The lake supports populations breeding of Black Shag *Phalacrocorax carbo*, White-faced Heron *Egretta novaehollandiae*, Paradise Shelduck, South Island Pied Oystercatcher *Haematopus finschi* and Banded Dotterel. Non-breeding visitors include Australasian Bittern *Botaurus poiciloptilus*, Black Stilt, Wrybill, Caspian Tern *Sterna caspia* and Black-fronted Tern.

Commoner species occurring at the lakes include Grey Duck *Anas superciliosa*, New Zealand Scaup *Aythya novaeseelandiae* and Pied Stilt *Himantopus leucocephalus*. The dry lands around the lakes support a range of bird, lizard and invertebrate species (Espie *et al.*, 1984; Jarman, 1987).

Noteworthy flora: None known in aquatic or shoreline habitats. Any original turflands at Lakes Tekapo and Pukaki were lost when lake levels were raised.

Scientific research and facilities: There are no research facilities at the lakes. The Waitaki Working Party (1992) recently conducted and commissioned research into the effects of reducing the lake level at Lake Pukaki, as a result of excessive draw-off for power generation. Projects covered assessment of visual effects; potential physical effects, such as shoreline erosion, slumping, increased turbidity and dust storms; and impacts on the endangered Black Stilt.

Conservation education: None known.

Recreation and tourism: The highly scenic lakes and mountains of the Mackenzie Basin are a focus for international and domestic tourism. Tourist facilities include accommodation, lakeside camping areas, two airports for scenic and internal flights, and a major resort complex at Mt Cook. Holiday homes have been built at Lake Tekapo township and at Lake Ohau. Popular water-based activities include trout fishing, boating, water-skiing, lakeside picnics and camping. Walking, mountaineering, skiing and hunting are popular in the adjacent mountains.

Management authority: The Department of Conservation (Canterbury Conservancy) is responsible for management of wildlife; day-to-day management is undertaken by the Department's Twizel Field Centre. The Electricity Corporation of New Zealand Ltd. is responsible for the water levels in Lake Tekapo and Lake Pukaki. Land Corporation Ltd. manages Pastoral Leases on behalf of the Crown. Canterbury Regional Council has management and policy responsibilities under the Resource Management Act 1991 for water, soil, gravel and other natural resources, as well as flood and pollution control. Mackenzie District Council is responsible for resource consents and district planning under the Resource Management Act 1991. The Central South Island Fish and Game Council manages sport fishing and game-bird hunting.

Jurisdiction: Functional: Department of Conservation, Central South Island Fish and Game Council, Land Corporation Ltd. and Electricity Corporation of New Zealand Ltd. Territorial: Mackenzie District Council and Canterbury Regional Council.

References: Anon. (1980); Boffa Miskell and Lucas Associates (1993); Espie *et al.* (1984); Jarman (1987); Livingston *et al.* (1986b); Tau *et al.* (1990); Waitaki Working Party (1992).

Reasons for inclusion:

1a Lake Tekapo, Lake Pukaki and Lake Ohau (the Central Southern Lakes Complex) form a complex of high quality glacial-carved lakes, a wetland type characteristic of New Zealand.

2a The lakes support significant numbers of at least three globally threatened species of birds, *Himantopus novaezelandiae, Anarhynchus frontalis* and *Chlidonias albostriatus*.

2c The lakes provide important breeding habitat for a wide variety of waterfowl including a substantial proportion of the New Zealand population of *Podiceps cristatus* and several other indigenous species.

3c The lakes regularly support over 1% of the world population of *Himantopus novaezelandiae*. The lakes are part of a network of wetlands in the Mackenzie Basin which support almost the total population of *H. novaezelandiae*.

Source: John Andrew and Jenny Steven.

Canterbury Braided Rivers Complex (62)

Location: The reference 43°31'S, 171°39'E locates Rakaia Gorge, one site within the extensive braided river systems of Canterbury. Canterbury's braided rivers flow either from the foothills or from alpine sources to the Pacific Ocean on the east coast of the South Island. From north to south, the major rivers are the Waiau, Hurunui, Ashley, Waimakariri, Rakaia, Ashburton, Rangitata, Opihi and Waitaki. Tributaries of the Waitaki include lake headwater rivers (the Macaulay, Godley and Cass, which flow into Lake Tekapo, the Tasman at the head of Lake Pukaki, and the Dobson and Hopkins above Lake Ohau) and the Ahuriri, Ohau and Tekapo Rivers.

Area: Not estimated.

Altitude: Sea level to 3,745 m (highest point in the Main Divide).

Overview: Braided rivers are a conspicuous and common habitat type in Canterbury, but are uncommon on a global scale (O'Donnell & Moore, 1983). The rivers in this wetland complex have similar physical form, origin and ecological character. There are two distinct hydrological regimes: the largest rivers are snow-fed from mountainous headwaters in the Southern Alps, while most of the smaller rivers are rain-fed, with foothill catchments. Braided rivers have numerous interlinked channels, spread across a wide gravel-filled floodplain. The position and depth of the channels change with every flood, as large mobile sediment loads are shifted downstream. Backswamp wetlands form within the floodplain on low terraces and relic side channels. River beds have a distinctive flora, dominated by low growing shrubs, herbs, mat plants and dry mosses. Typical genera include *Raoulia*, *Epilobium*, *Racomitrium* (a moss), *Coprosma*, *Helichrysum*, *Leucopogon*, *Gnaphalium* and *Muehlenbeckia*.

The Canterbury rivers provide essential habitat for several specialised birds, especially during the breeding season between August and January. Some endemic birds are particularly well adapted to the unstable river-bed habitat, *e.g.* the Wrybill *Anarhynchus frontalis*. Tidal lagoons and river mouths are also very important as wildlife habitat, especially for aerial feeders, Anatidae and migratory and indigenous shorebirds.

The following braided rivers were identified as "outstanding" "Sites of Special Wildlife Interest" (SSWI) by the Fauna Survey Unit of the New Zealand Wildlife Service: Ashley, Waimakariri, Rakaia, Rangitata, Ashburton, Ahuriri, Waitaki headwater braided rivers, Tekapo and Ohau. This is a nationwide wildlife habitat ranking system officially recognised by the Department of Conservation.

The Ashley River, Ahuriri River and Waitaki headwater braided rivers are described in greater detail as Sites 62a-c, below.

Resource reports have been published for several major braided rivers. Other key references are O'Donnell and Moore (1993), Jarman (1987) and Canterbury Regional Council (in prep.).

Physical features: Inland Canterbury is drained by a vast network of tributaries that occupy previously glaciated valleys and basins. The rivers have a common geomorphic form. There

are short torrent reaches and limited meandering sections in the upper headwaters. Extensive braided flow patterns occur where the rivers cross wide gravel filled basins. Flow is constricted through foothill gorges. Most rivers then cut a swathe across the plains, a surface constructed since the Pleistocene by those same rivers.

River-bed topography is complex and changeable. Braided rivers are usually formed by aggradation of fine sediment into transverse bars (Miall, 1977, cited in O'Donnell & Moore, 1983). In Canterbury, however, braided river channels have formed by aggradation of coarse, poorly sorted sediment into longitudinal bars. Where the flow is unable to move coarse material, fine sediment also begins to be trapped. Eventually river flow is diverted around the gravel build-up. Most sediment derives from greywacke sandstone. Soil development is minimal, except for gley soils in some river-bed backswamps.

The Canterbury rivers are characterised by highly variable seasonal flows. Rivers that extend into the Southern Alps are snow-fed, with periodic large floods during snow-melt and northwesterly rain storms from October to January.

The large Waitaki catchment (which includes the Ahuriri, Tekapo, Pukaki and Ohau catchments) has been modified by major hydro-electric power development over the past 60 years. Lake levels are controlled, and four new lakes have been created. Tekapo, Pukaki, Ohau and the lower Waitaki Rivers are also controlled. Pukaki River has become a redundant channel, used only as an overflow spillway. Dams at Lake Pukaki, Tekapo and Ruataniwha (on the Ohau River) divert water into canals.

Braided rivers supply extensive aquifers. Large volumes of groundwater and surface water are drawn off for irrigation during summer, especially on the Canterbury and Culverden plains.

Ecological features: Native vegetation on the active floodplain is usually limited to low growing mats of *Raoulia* spp., Woolly Moss *Racomitrium lanuginosum*, *Leucopogon fraseri* and *Muehlenbeckia axillaris*, low twiggy shrubs of *Coprosma* sp., *Pimelia* sp. and *Helichrysum depressum*, the native grasses *Rytidosperma* spp. and *Poa cita*, and herbs *Epilobium* sp. and *Gnaphalium* sp. Matagouri shrubs *Discaria toumatou* plus trees of Kowhai *Sophora microphylla*, Ti *Cordyline australis* and Kanuka *Kunzea ericoides* have survived on undisturbed islands, banks and terraces. The last remnants of river-bed forest survive on an island near the Rakaia River mouth, and on the Opihi River floodplain at Temuka. Some gorge-wall and terrace sites have also been protected from domestic livestock, floods and fire. Remnant shrublands and forest contain a diverse mixture of lowland and upland plants.

Most of Canterbury's braided rivers are highly modified by weeds, especially Tree Lupin *Lupinus arborea*, Spanish Broom *Cytisus scoparium*, Gorse *Ulex europaeus*, willows (especially *Salix fragilis*) and introduced grasses (Molloy, 1983). Russell Lupin *Lupinus polyphyllus* x *arboreus* has become extensive in the Upper Waimakariri, Ahuriri and Waitaki catchments.

Lagoons and river mouths are dominated by introduced grasses, willows *Salix* spp. and poplar trees *Populus* spp. Native species include Saltmarsh Ribbonwood *Plagianthus divaricatus*, Toetoe *Cortaderia richardii*, Raupo *Typha orientalis*, *Juncus* spp. and Jointed Wire Rush *Leptocarpus similis*.

Instability is a key ecological feature of the braided rivers. "The natural characteristics of braided river instability are essential to the maintenance of shingle habitats and food supply in a state suitable for some specialised wetland birds. Specific adaptations by bird species include a short breeding cycle, an ability to nest at least twice, ability to re-nest quickly if disturbed by floods, rapid independence of the young, and specialised feeding techniques, such as the unique sideways-bent bill of the wrybill" (Robertson *et al.*, 1984).

Relatively low numbers of aquatic invertebrates are present in braided rivers because of substrate movement and flooding. Density is inversely related to stream flow (Hughey *et al.*, 1989). Large unstable rivers, such as the Rakaia and Waimakariri, have lower invertebrate

densities and biomass than much smaller stable foothill rivers. Benthos species abundance is greatest in winter when flows are stable and low. Although these findings suggest that stability boosts invertebrate numbers, it is instability during spring and summer that releases invertebrates into "the drift" (flowing water) in the greatest numbers, to become available as food for birds (O'Donnell & Moore, 1983). Mayfly larvae (*Deleatitium*) are the most common invertebrates and food source for birds. Other common invertebrates are midge larvae (Chironomidae), black flies (Simulidae), caddis flies (Trichoptera), crane flies (Tipulidae) and various worms (O'Donnell & Moore, 1983).

Use of major channels by wading birds is limited by water depth and velocity. Aerial-feeding gulls and terns are not affected. Seepage channels, shallow riffles where water is filtered through shingle substrate, support a prolific and available supply of benthic invertebrates (Hughey *et al.*, 1989).

Features of selected rivers: The following rivers, although not described in individual site accounts, have outstanding ecological values.

- Waimakariri River has extensive upper headwaters that are little modified by weeds, river engineering works or water abstraction. It has an extensive estuary, of high value to wildlife.
- Rakaia River is the best example of a braided river in New Zealand. It is the largest braided river (c.140 km long and 2-5 km wide) and is exceptional in terms of habitat for river birds. It is also the most valuable sport fishery for Quinnat Salmon *Oncorhynchus tshawytscha* in New Zealand. A major spring-fed wetland, the Hydra Waters, is an area of special value for its fish spawning habitat, unusual hydrology, and Red Tussock *Chionochloa rubra* and cushion sedgeland communities (Arund & Glenny, 1990).
- Rangitata River is a less well known braided river system. Like the Rakaia, the upper tributaries are remote and little modified. The river has been rated, tentatively, as outstanding (O'Donnell & Moore, 1983). The very wide braided floodplain above the gorge is up to 7 km wide in places.
- Ashburton River is a relatively small and narrow braided river located in mid Canterbury (O'Donnell, 1992). It comprises two main tributaries, the glacially-fed South Branch and rain-fed North Branch, a total of 130 km of river bed. Flows are more stable than those of the much larger rivers such as the Rangitata and Rakaia. Both branches of the river have been modified by river control work and the spread of willows, poplars, broom and gorse. Despite the small area and modified river-bed conditions, the Ashburton River is of outstanding value to wildlife.
- Tekapo and Ohau Rivers are modified braided rivers that cross the inland Mackenzie Basin. Hydro-electric power development has altered natural flow regimes, to the detriment of wildlife habitat. Tekapo River is a focus of habitat restoration work under Project River Recovery, and the delta at the head of Lake Benmore has recently been cleared of willow trees. Ohau River has been disrupted by the creation of Lake Benmore which drowned the lower river, and Lake Ruataniwha which flooded the middle reaches. Ruataniwha and adjacent constructed ponds have become valued habitats for Anatidae. Two wetlands in the lower river, Ruataniwha Springs and Airport Swamp, are also outstanding "Sites of Special Wildlife Interest", mainly because of use by Black Stilt *Himantopus novaezelandiae* (Jarman, 1987).

Land tenure: Most riverbed land in Canterbury is unalienated Crown land managed by the Department of Conservation in conjunction with Canterbury Regional Council. Inland reaches are usually bordered by large tracts of Crown Pastoral Lease. Floodplain wetlands and channels may be included in the leased area or in freehold land. There are also small areas of unformed legal road, un-named reserve land, gravel and Recreation Reserves. In some places

the local authority, a district council, has responsibilities for reserve management. In places, the instability of the river channels has meant that legal boundaries do not coincide with physical features on a floodplain.

Most land above the foothill gorges is Crown land farmed under Pastoral Lease. There are small areas of privately-owned freehold land, particularly around homesteads. Below the gorges, most land is in freehold title.

Conservation measures taken: Braided river habitats are not protected within existing reserves. Several small remnants of riparian forest are protected as Scenic or Regional Council Reserves, *e.g.* the river-bed forest in the lower Rakaia River. The Hydra Waters, a backswamp and fan wetland in the upper Rakaia River, has been protected under a conservation agreement between the owners of Mt Algidus Station and Department of Conservation (Arund & Glenny, 1990). Some parts of catchment headwaters are Crown land, within stewardship, national park or conservation areas managed by the Department of Conservation, *e.g.* in the upper Rangitata, Hopkins, Tasman, Waimakariri, Rakaia and Ashley Rivers.

The Rakaia River Water Conservation Order, under the Wild and Scenic Rivers provisions of the Soil and Water Conservation Act 1967, established a minimum flow regime, primarily to stop excessive abstraction of water for irrigation and thereby maintain the river's sport fishery. Wildlife receive *de facto* protection through maintenance of adequate flows.

The Ahuriri River is also subject to a Water Conservation Order. This order prohibits allocation of additional rights to extract, divert, dam or discharge the waters of the Ahuriri. Sport fishing and wildlife values benefit from this regime.

Programmes of willow and lupin removal are under way in the Ahuriri and Tekapo Rivers, to rehabilitate the open braided river environment. Named "Project River Recovery", this ongoing work is focused on restoration of habitat for river-bed birds. Project River Recovery is part of an agreement (the ECNZ Waitaki Water Rights Working Party Agreement) negotiated between the Electricity Corporation of New Zealand (ECNZ) and interested parties, including the Department of Conservation. The Agreement relates to conditions upon ECNZ's renewed water rights in the Waitaki Basin.

Conservation measures proposed: Some 3,000 ha of the upper Rakaia river bed have been proposed as a "Recommended Area for Protection" (RAP) (Shanks *et al.*, 1990). This area is of outstanding value as wildlife habitat and a prime example of a little modified braided river. Another RAP covers 8,229 ha of the upper Rangitata River (Harrington *et al.*, 1986). The narrow gorge and extensive braided floodplain are included in this proposal. Several upland tributaries of the Waitaki River have been identified as priority areas because of their importance for wildlife (Espie *et al.*, 1984).

Land use: The braided rivers provide a supply of water for irrigation, domestic consumption, livestock and power generation. They support commercial (salmon) and sport fisheries, and are used for outdoor recreation and grazing. They also provide a source of gravel for road building and other construction purposes. Public use is significant, but is either thinly spread over the large river beds, or concentrated at road access points or fishing sites at river mouths. A variety of rights and leases are held over parts of many rivers. Members of the public often assume, however, that there are unrestricted rights of access along the rivers. Debate about management responsibilities and public access is continuing.

In the upper catchments, land adjacent to the rivers is used for extensive pastoral farming. The human population of these areas is low. Small settlements such as Tekapo, Twizel, Coleridge and Otematata lost residents as a result of "wind-down" of power scheme construction and reduced staffing levels. Tourism has become the main reason for population growth in some of these towns. Arable agriculture is the predominant land use beside the lower reaches of the braided rivers.

Possible changes in land use: There is a proposal to dam the Opuha River, a tributary of the Opihi, to increase summer flow levels for irrigation. The dam may also be used for power generation. This replaces a proposal to augment the Opihi River flow using water diverted from Lake Tekapo, an inland glacial lake. Future proposals are likely to relate to projects and irrigation schemes, especially regionally or locally-funded works. Further agricultural development may see an increase in animal feed-lots and intensified farming. These may affect groundwater quality. Tourist resort development is another area of likely change.

Disturbances and threats: Excessive stability may devalue wildlife habitat. The Lower Waitaki River has stable "armoured" riffles, with no renewed gravel supply below the dams. Armouring and siltation are thought to have altered the invertebrate fauna. Riffles become unusable habitats as fewer invertebrates are available to probing birds. Mayflies are replaced by elmid beetle species (Rutledge, 1987). Stable sediment has promoted weed growth, which restricts nesting habitat (Hughey *et al.*, 1989), and weed encroachment is now the most widespread problem on the braided rivers.

The lower reaches of most of Canterbury's rivers have been modified to prevent flooding. Stop banks, groynes, in-stream tracks, artificial channels and willow-covered margins are commonplace. These structures alter the braid patterns and their permanence, assist the spread of weeds and restrict bird habitat. Irrigation of crop and dairy farms has increased the demand for surface and groundwater supplies, and excessive water extraction for irrigation in the past has caused total drying of some reaches. Agricultural industries, such as abattoir and wool-processing factories, have polluted the lower stretches of the Waimakariri and Opihi Rivers.

Other threats to habitat and water resources include further hydro-electric power development and possible environmental changes as a result of tourist resort development and plantation forestry. The breeding success of river-bed birds can be affected by use of off-road vehicles. Black-fronted Terns *Chlidonias albostriatus* are particularly susceptible to disturbance.

Hydrological and biophysical values: Braided rivers are uncommon on a global scale. Canterbury's braided rivers support endemic birds that have evolved to become specially adapted for breeding and feeding on these river beds. The Waimakariri, Rakaia, Rangitata and Ahuriri Rivers are among the largest and least-modified braided rivers in New Zealand. (The Landsborough River in Westland and Wairau River in Marlborough are also extensive braided rivers.) Waimakariri River feeds extensive aquifers that are tapped for high quality water by Christchurch City, numerous small towns and individual properties. Extensive irrigation schemes use water diverted from the braided rivers or drawn from groundwater. Braided rivers in the Waitaki catchment are the primary water sources for a large hydro-electric power scheme.

Social and cultural values: The braided rivers provided access routes for Maori people travelling across the South Island. Traditionally, the rivers and associated wetlands were used for eel fishing, bird hunting and collection of fibre (Tau *et al.*, 1990). Water has always been held in very high spiritual regard by the Maori. Its pollution and depletion have been cause for grievance hearings under the Waitangi Tribunal and Treaty of Waitangi.

The upper reaches of many braided rivers are of outstanding landscape value. They are places dominated by natural landscape elements, patterns and processes. (See Boffa Miskell and Lucas Associates, 1993, for a discussion of the various catchments).

Noteworthy fauna: The braided rivers of Canterbury have been identified as "Sites of Special Wildlife Interest" (SSWI) by the Fauna Survey Unit of the New Zealand Wildlife Service, and ranked in terms of habitat value (Jarman, 1987; O'Donnell & Moore, 1983). They are particularly notable for their distinctive bird fauna. A total of 86 species of birds has been recorded from the braided river beds and river mouths. The river beds themselves support up to 34 wetland species, 17 of which are common. Fifty-nine wetland species (including all those from the river beds) have been recorded in river-mouth habitats (O'Donnell & Moore, 1983).

Various habitats are used as breeding, feeding, moulting, loafing and wintering sites. Some species migrate in autumn and winter to coastal areas and/or the North Island, *e.g.* Banded Dotterel *Charadrius bicinctus* and Wrybill *Anarhynchus frontalis* spend the winter at the Firth of Thames and Manukau Harbour in the North Island and at other coastal locations. Notable endemic and indigenous birds include Australasian Bittern *Botaurus poiciloptilus*, Paradise Shelduck *Tadorna variegata*, Blue Duck *Hymenolaimus malacorhynchus* (mainly in the headwater torrents), Marsh Crake *Porzana pusilla affinis*, South Island Pied Oystercatcher *Haematopus finschi*, Pied Stilt *Himantopus leucocephalus*, Black Stilt *H. novaezelandiae*, Banded Dotterel *Charadrius bicinctus*, Wrybill *Anarhynchus frontalis*, Black-billed Gull *Larus bulleri* and Black-fronted Tern *Chlidonias albostriatus*. Unusual visitors have included Black-fronted Dotterel *Charadrius melanops*, Red-capped Dotterel *C. ruficapillus* and White-winged Black Tern *Chlidonias leucopterus*. The Southern Black-backed Gull *Larus dominicanus* dominates some stretches of river, to the detriment of smaller birds (Robertson *et al.*, 1984). In 1987, almost 10,000 of these gulls were recorded on the Ashburton River (O'Donnell, 1992).

The river-mouth and lagoon habitats support a wide diversity of waterfowl, notably Anatidae and migratory shorebirds.

Further details of the bird fauna of Ashley River, Ahuriri River and the Waitakai headwater braided rivers are given in the individual site accounts (60a-c). Other important areas for wildlife include the Waimakiriri River, Rakaia River, Rangitata River, Ashburton River, Tekapo River and wetlands along the lower Ohau River.

Waimakariri River supports relatively high numbers of all of the main river-bed species. Surveys in 1980 and 1981 showed that the braided reaches of this river supported the second largest population of Wrybill (Rakaia River has the largest), while the Blue Duck is present in torrent reaches of the upper headwaters. The wide braided reaches that cross Canterbury Plains support very large colonies of Southern Black-backed Gulls, and there are high numbers of Paradise Shelduck in the upper catchment. Other species of note include South Island Pied Oystercatcher, Black-billed Gull, Black-fronted Tern, Caspian Tern *Sterna caspia* and the only known inland breeding colony of White-fronted Tern *S. striata*. The Black-fronted Dotterel, a vagrant to New Zealand, is reported to have bred here in 1980/81. Other unusual records of migratory species from this river include Lesser Sand Plover *Charadrius mongolus*, Ruddy Turnstone *Arenaria interpres* and White-winged Black Tern. The river has an extensive estuary, of high value to wildlife.

Rakaia River is particularly important for Wrybill. In 1978/79, the river supported 301 birds, 75% of the known Wrybill population. The river bed between the gorge and Wilberforce confluence is especially important for Wrybill, as well as Banded Dotterel. Twenty-one species of wetland birds were recorded along this river during surveys in the 1970s.

The very wide braided floodplain above the gorge on the Rangitata River is used by all of the typical river-bed species, including Wrybill, Black-billed Gull and Black-fronted Tern. The Blue Duck is probably present in low numbers in several headwater torrents. It has been recorded in a non-braided tributary below the gorge.

Ashburton River is of outstanding value to wildlife. It supports 39 species of wetland birds, many of which occur in high numbers. Between 14,000 and 26,000 birds were recorded during annual surveys between 1981 and 1990. Bird densities on the South Branch have been as high as 699/km. However, overall numbers, and numbers of Black-fronted Tern in particular, are in decline, a serious trend recognised throughout Canterbury. The river supports nationally significant populations of Banded Dotterel, Black-fronted Dotterel, Black-billed Gull and Black-fronted Tern (the largest lowland population in Canterbury). There are also regionally significant populations of South Island Pied Oystercatcher, Pied Stilt, Wrybill and Southern Black-backed Gull.

Tekapo River continues to be a very important area for three endemic species, Black Stilt, Wrybill and Black-fronted Tern. A wide range of other wetland birds also breed here (Jarman, 1987). The delta at the head of Lake Benmore has recently been cleared of willow trees, and there has been an encouraging response from birds; over 150 Black-fronted Terns attempted to nest here in 1993 (Department of Conservation, unpublished data).

Two wetlands along the lower Ohau River, Ruataniwha Springs and Airport Swamp, are used by Black Stilts.

Further information on the wildlife of the Canterbury braided rivers is given by O'Donnell and Moore (1983).

Noteworthy flora: There are no rare species on braided river beds, but the flora in general is highly distinctive. Natural succession sequences are uncommon because of the vigour of introduced weeds and grasses. Some gorge-wall sites support rich and relatively undisturbed plant communities, in contrast with the river beds below. These sites support a number of threatened and uncommon species, such as *Hebe cupressoides* and *Helichrysum dimorphum*.

Scientific research and facilities: The Waitaki and Rakaia Rivers were subject to scientific scrutiny during the 1960s to 1980s, when power and irrigation schemes were being investigated. A wide range of ecological research projects is being conducted as part of Project River Recovery in the Waitaki Catchment. Research recently completed or in progress in 1994 has explored the breeding success of Banded Dotterels, movements of Southern Black-backed Gulls and Australasian Harriers *Circus approximans*, distribution of aquatic invertebrates, predator assessments and behavioural training of juvenile Black Stilts to help them cope with predators. There are no research facilities based at braided river sites, although Cass Field Station (University of Canterbury) is within 5 km of the Waimakariri River.

Conservation education: The Department of Conservation in Twizel provides conservation education relating to braided rivers through information panels and community-based work. Rivers outside the Waitaki catchment do not yet receive similar attention.

Recreation and tourism: The braided rivers are used extensively for recreation, especially salmon fishing, trout fishing, jet-boating, canoeing, rafting, picnicking, off-road motor-biking, camping, tramping, shooting and bird-watching. The Quinnat Salmon fishing opportunities on the Rakaia River, in particular, are considered to be of exceptional recreational value. A survey by the North Canterbury Catchment Board and Regional Water Board in 1983 found that 65% of the visitors to this river were fishing for salmon. A least 75,000 visitors use the Rakaia River catchment each year, with higher numbers expected in the Waimakariri catchment which is closer to a major city. Some recreational activities, notably salmon fishing, jet-boating and rafting, are being promoted to overseas visitors.

Management authority: The Department of Conservation has responsibility for the management of protected wildlife and some areas of Crown land within river beds. Canterbury Regional Council has responsibility for the management of water, gravel, soil and other natural resources, as well as pollution and flood control. Land Corporation Ltd. is responsible for the management of Pastoral Leases on behalf of the Crown. The various District Councils have responsibilities set out in the Resource Management Act 1991 for resource consents and district planning. The Central South Island Fish and Game Council and North Canterbury Fish and Game Council manage sport fishing and game-bird hunting.

Jurisdiction: Functional: Department of Conservation, Canterbury Regional Council and Central South Island and North Canterbury Fish and Game Councils. Territorial: Canterbury Regional Council, and Hurunui, Waimakariri, Selwyn, Ashburton, Timaru, Mackenzie, Waimate and Waitaki District Councils.

References: Arund & Glenny (1990); Boffa Miskell and Lucas Associates (1993); Bowden (1982); Canterbury Regional Council (in prep.); Department of Conservation (1994); Dons & Stringer (1992); Espie *et al.* (1984); Harrington *et al.* (1986); Hughey *et al.* (1989); Jarman

(1987); Molloy (1988); North Canterbury Catchment Board and Regional Water Board (1974, 1977, 1983, 1986, 1989); O'Donnell (1992); O'Donnell & Moore (1983); Robertson *et al.* (1983); Rutledge (1987); Shanks *et al.* (1990); Tau *et al.* (1990); Waitaki Catchment Commission and Regional Water Board (1982).

Reasons for inclusion:

1a The Canterbury Braided Rivers are excellent representative examples of braided rivers, a wetland type characteristic of the eastern South Island of New Zealand, but uncommon on an international scale. The habitat is distinctive because of its unusual physical and hydrological characteristics, its flora and the presence of endemic and highly specialised birds.

2a The complex supports appreciable numbers of four globally threatened species of birds, *Hymenolaimus malacorhynchus*, *Himantopus novaezelandiae*, *Anarhynchus frontalis* and *Chlidonias albostriatus*.

2b The rivers are of special value for maintaining the genetic and ecological diversity of the region, particularly because of their diverse avifauna.

2c The complex is of special value as breeding habitat for many species of birds. Several species are so specifically adapted to this habitat that they rarely breed elsewhere.

2d The rivers are of special value for their endemic bird species, notably *Hymenolaimus malacorhynchus*, *Himantopus novaezelandiae*, *Anarhynchus frontalis*, *Larus bulleri* and *Chlidonias albostriatus*.

3a As a complex, the rivers regularly support over 20 000 waterfowl.

3c The wetlands regularly support a substantial proportion of the world populations of *Himantopus novaezelandiae*, *Anarhynchus frontalis* and *Chlidonias albostriatus*. Those braided rivers within the Mackenzie Basin support almost 100% of the *H. novaezelandiae* population for at least part of each year.

Source: John Andrew and Jenny Steven.

Ashley River and Estuary (62a)

Location: 43°31'S, 172°39'E. Ashley River headwaters extend into the Puketeraki Range and Canterbury foothills northwest of Christchurch. The river flows into the Pacific Ocean via an estuary 30 km north of Christchurch, on the east coast of South Island.

Area: Catchment area 134,000 ha.

Altitude: Sea level to 1,934 m at the highest point in the catchment.

Overview: Ashley River is part of the Canterbury Braided Rivers Complex. It is a small rain-fed river that flows for 90 km from the Canterbury foothills, through a narrow gorge and across the gently sloping fluvio-glacial gravels of the Canterbury Plains. The channel across the plain consists of numerous braids (inter-twined dry and wet channels that cut through a gravel bed) on a floodplain about 500 m wide. Although the braided river habitat is similar to that of the larger rivers in this wetland complex, Ashley River merits separate treatment because it is a small river of "outstanding" value for braided river-bed birds, especially the Wrybill *Anarhynchus frontalis*.

The river-mouth habitats are an unusually diverse combination of delta, estuarine mudflats and saline swamplands behind a sand dune barrier (O'Donnell & Moore, 1983). The estuarine habitats regularly support a wide variety of rare, uncommon and migratory waterfowl, as well as high numbers of more common species. The estuary is considered to be of "outstanding" value for wildlife (O'Donnell & Moore, 1983), and "one of the most important bird habitats on

the east coast of the South Island because of the diversity of species" and "because of its role as a sanctuary for migratory wading birds" (North Canterbury Catchment Board & Regional Water Board, 1982). Lake Ellesmere and the Avon Heathcote Estuary are also important shorebird habitats.

Physical features: The upper tributaries of Ashley River are single threads, with minor braiding in the gravel deposits of Lees Valley. River down-cutting has kept pace with uplift of greywacke sandstone to produce Ashley Gorge, a narrow winding channel. In the braided reaches below the gorge, two or three of the shallow braids carry water during normal flow conditions. Large areas of open gravel within the active floodplain provide prime breeding sites for river-bed birds (North Canterbury Catchment Board & Regional Water Board, 1982; O'Donnell & Moore, 1983).

Ashley River is characterised by low natural water storage and low water flows, particularly in summer. Annual rainfall in the catchment varies from 2,000 mm in the Puketeraki Ranges to 750 mm at the coast. However, a sharp decrease in rainfall away from the ranges, a rain-shadow effect in the upper catchment and losses to groundwater combine to produce low river water levels. The mean annual flow at Ashley Gorge is 15.3 cubic metres per second and the lowest recorded flow at that site is 1.22 cubic metres per second. For several weeks each summer, the middle reaches of the river may be dry. This contrasts with the high summer flows of snow-fed braided rivers, such as the Rakaia and Waimakariri. Peak flood discharges in Ashley River can exceed 200 cubic metres per second. Major river engineering works, such as stop-banks and rock barriers, have been constructed to contain floodwaters in the middle and lower reaches.

The estuary includes sand dunes and spits, open brackish water, a river delta, low mud banks and extensive mudflats. Saltwater Creek joins the estuary as a meandering tidal swampland.

Ecological features: Little indigenous vegetation remains in the Ashley River. Introduced trees and weedy shrubs dominate the river margins and stable areas of the floodplain. The estuary includes some vigorous stands of salt-tolerant species that are typical of the Canterbury coast. Species include New Zealand Flax *Phormium tenax, Juncus* spp., Jointed Wire Rush *Leptocarpus similis*, Saltmarsh Ribbonwood *Plagianthus divaricatus* and *Schoenoplectus* sp. Saltmarsh and turfland communities include *Leptinella* sp. and *Salicornia australis*.

Invertebrate fauna of the river is dominated by mayflies of the genus *Deleatidium*. Elmid beetle larvae (Elmidae) are also very common (Hughey *et al.*, 1989). Total invertebrate densities and dry weights are much greater in the Ashley than in the Waimakariri, a large snow-fed, flood-prone braided river. *Deleatidium* species have adapted to cope with substrate instability. The relatively long interval between major floods on the Ashley River creates conditions suitable for elmids (Hughey *et al.*, 1989). Mayflies are an important component of the diet of the Wrybill and other river-bed birds (Hughey, 1985, and Pierce, 1979, cited in Hughey *et al.*, 1989). The fishery is considered to be highly productive, "having, on a per unit area basis, approximately 2 times the fish population of the Rakaia" (Glova, 1982, cited in North Canterbury Catchment Board & Regional Water Board, 1982). Low flows are a major limiting factor. The estuary is also a highly productive unpolluted area.

Land tenure: The wetland is Crown land. Adjacent land in the headwaters is predominantly Crown land. Below the gorge, adjacent areas are mainly freehold land, with small areas of Crown land, Maori Reserve and University of Canterbury Endowment land.

Conservation measures taken: Part of the upper Ashley River including the gorge and parts of the Okuku River, a main tributary, are protected within Mount Thomas and Oxford forests, indigenous forest land managed by the Department of Conservation. There is an unusual joint protection agreement over river-bed land near Rangiora, established by the former North Canterbury Catchment Board (whose functions are now carried out by the Canterbury

Regional Council), Rangiora District Council (now Waimakariri District Council) and the Department of Conservation. The wildlife management area is for protection of Wrybill and other river-bed birds (Canterbury Regional Council, in prep.).

Conservation measures proposed: An area of privately-owned red tussock swampland is proposed for protection. Details are not known.

Land use: Gravel and water are extracted from the river. Both the river and its estuary are popular for outdoor recreation. Large areas of the upper catchment are used for extensive pastoral farming. High natural erosion rates have been accelerated by removal of forest. As a result, parts of the catchment are now unsuitable for livestock. Few people live in the upper catchment. Lees Valley is recently developed farmland, on what was a red tussock swampland. Parts of the valley remain undrained.

Mount Thomas and Oxford forests are indigenous forests managed for conservation and recreation. Much of the Okuku tributary catchment and foothill toe-slopes are planted in *Pinus* species for commercial forestry. Ashley and Mount Thomas plantation forests are now privately owned.

Land in the middle and lower catchment is mainly private. Arable agriculture, horticulture, dairying and "rural lifestyle" small-holdings (usually less than 10 ha) are the main land uses. The fast-growing town of Rangiora is situated near the river. Waikuku Beach settlement near the estuary includes permanent residents, holiday housing and a camping ground. Recreational use of the area increases during the summer months. There is also a heavily-used camping ground at the mouth of Ashley Gorge.

Possible changes in land use: No major changes are expected. Demand for groundwater and surface water is expected to increase, particularly with land subdivision and horticultural development, but there are no known plans to establish industries which would require significant quantities of water, either consumptively or for waste assimilation.

Disturbances and threats: The withdrawal of water (from both groundwater and surface water) for irrigation purposes may exacerbate low flows in the river. Large floods are needed periodically to re-open gravel surfaces. The extraction of gravel and maintenance of flood protection works cause unnatural disturbance. Use of off-road vehicles, especially near the town of Rangiora, may disturb breeding birds. Introduced weeds dominate the river bed below the gorge, a situation typical of Canterbury's braided rivers. Willow *Salix* spp. and poplar *Populus* spp. were originally planted along the berms and stop-banks for flood control. The impact of weed growth on wildlife values is not fully understood.

In the estuary, a fringe of grass and saltmarsh vegetation is important for spawning of Galaxiid fish species. Galaxiid fish form the basis of the commercial and recreational whitebait fishery. Domestic livestock have damaged part of the upper estuary margins, and reclamation is a potential threat to this important habitat. Waterfowl in the estuary may be disturbed during the duck-hunting season in early winter. The extent of disturbance is unknown.

Hydrological and biophysical values: The estuary is a highly productive wetland that is relatively free from toxic chemicals and heavy metals (North Canterbury Catchment Board & Regional Water Board, 1982). It plays an important role in the support of food chains, and is particularly important as habitat for spawning fish.

Social and cultural values: Coastal wetlands of Canterbury have long been valued as traditional food sources for the Maori people. Maori regard water as a "taonga" (treasure), and attribute it with spiritual values. Ashley estuary (Te Akaaka) was traditionally a very important place, an outpost of the large Kaiapoi "pa" (settlement), valued for "mahinga kai" (seafood) and as a "tauranga waka" (canoe landing site). Further details are given in Tau *et al.* (1990). The local "iwi" (tribe), Ngai Tahu, still own land adjacent to the estuary. Taranaki Stream, a tributary of the estuary, remains an important whitebait fishing area. The gorge and braided

river sections of Ashley River are classed as significant regional landscape features (Boffa Miskell and Lucas Associates, 1993).

Noteworthy fauna: The braided river is of outstanding value to wildlife, supporting a high diversity of species. This is the only known breeding site in New Zealand for the Red-capped Dotterel *Charadrius ruficapillus*, an Australian species. Waterfowl occurring in large numbers include Pied Stilt *Himantopus leucocephalus*, Banded Dotterel *Charadrius bicinctus*, Black-billed Gull *Larus bulleri* (a large colony of c.1,000 birds) and Black-fronted Tern *Chlidonias albostriatus*. The Wrybill *Anarhynchus frontalis* occurs in low numbers.

Sixty-nine species of birds have been recorded in the estuary. Of these, 45 are wetland species (see O'Donnell & Moore, 1983, for lists of species). The Red-capped Dotterel is known to have bred in the area, but has not been reported in recent years. Migratory shorebirds from the northern hemisphere have included Pacific Golden Plover *Pluvialis fulva*, Grey Plover *P. squatarola*, Asiatic Whimbrel *Numenius phaeopus variegatus*, American Whimbrel *N. p. hudsonicus*, Little Whimbrel *N. minutus*, Bar-tailed Godwit *Limosa lapponica*, Black-tailed Godwit *L. limosa*, Red Knot *Calidris canutus*, Pectoral Sandpiper *C. melanotos*, Sharp-tailed Sandpiper *C. acuminata* and Red-necked Stint *C. ruficollis*. Several of these are uncommon in New Zealand.

Eighteen fish species have been recorded from the river and estuary (Glova, 1982, cited in North Canterbury Catchment Board & Regional Water Board, 1982).

Noteworthy flora: No significant plant species have been recorded.

Scientific research and facilities: There are no research facilities in the catchment. Minor research and monitoring is carried out for management purposes.

Conservation education: The secondary school in Rangiora in association with the Department of Conservation has been active in the past, teaching students through projects that actively protect the Wrybill and its habitat.

Recreation and tourism: Ashley River is an important recreation resource, particularly because of its proximity to Christchurch, a major urban centre. Water-based recreation is partly dependent on flow; kayaking in the gorge is only possible at high flows, whereas trout fishing is limited by low water levels and associated algal growth, as well as floods. Camping and day visits are popular in summer. Visitor use is particularly high at the ends of roads. Fishing occurs for trout, salmon, saltwater fish and shellfish. Whitebaiting (netting of immature fish, mainly Galaxiids) occurs in the tidal reaches of the main river and Saltwater Creek. The estuary is open for game-bird hunting on a seasonal basis.

Management authority: The Canterbury Regional Council has responsibility for the management of water, soil, gravel and other natural resources, as well as pollution and flood control. Waimakariri District Council has statutory responsibilities under the Resource Management Act 1991 for resource consents and district planning. The North Canterbury Fish and Game Council manages sport fishing and game-bird hunting.

Jurisdiction: Functional: North Canterbury Fish and Game Council. Territorial:
Waimakariri District Council and Canterbury Regional Council.

References: Boffa Miskell and Lucas Associates (1993); Canterbury Regional Council (in prep.); Hughey *et al.* (1989); North Canterbury Catchment Board and Regional Water Board (1982); O'Donnell & Moore (1983); Tau *et al.* (1990).

Reasons for inclusion:

1a The Ashley River is an excellent representative example of a braided river, a wetland type characteristic of the eastern South Island of New Zealand. The habitat is distinctive because of its unusual physical and hydrological characteristics, its flora and the presence of endemic and highly specialised birds. The river forms part of the Canterbury Braided Rivers which, individually and as a complex, are outstanding examples of a wetland habitat type typical of eastern New Zealand.

2a The river supports an appreciable number of two globally threatened species of birds, *Anarhynchus frontalis* and *Chlidonias albostriatus*.
2b The river and its estuary are of special value for maintaining the genetic and ecological diversity of the region, particularly because of their diverse avifauna.
2c The river provides important breeding habitat for several species of birds, while the estuary is an important spawning ground and nursery for a number of fish species.

Source: John Andrew and Jenny Steven.

———

Ahuriri River (62b)

Location: 44°27'S, 169°59'E, at State Highway No.8 bridge. Ahuriri River extends approximately 85 km from the Southern Alps in central South Island to Lake Benmore in the southeast of the Mackenzie Basin. This river and its associated floodplain wetlands are part of the Waitaki River catchment, which flows into the Pacific Ocean north of Oamaru. State Highway No.8 and several minor roads run close to the lower half of the river. The upper reaches are remote, accessible by one gravel road and rough tracks over private and Crown land. The closest settlements are Omarama (4 km) and Twizel (27 km), both small towns. Within Ahuriri and Omarama Ecological Districts.

Area: 150,640 ha (approximate catchment area).

Altitude: 362 m at Lake Benmore to 2,505 m at the highest point in the watershed.

Overview: Ahuriri River is part of the Canterbury Braided Rivers Complex. It is a large, relatively-unmodified inland river of outstanding value for waterbirds (Jarman, 1987). The braided river and associated wetlands support a breeding population of Black Stilt *Himantopus novaezelandiae*, one of the largest breeding populations of Black-fronted Tern *Chlidonias albostriatus* (c.1,200 birds) and a large breeding population of Wrybill *Anarhynchus frontalis* (c.100 birds).

The river and adjacent wetlands are also very important habitat for Banded Dotterel *Charadrius bicinctus*, other birds typical of braided river beds, and Anatidae. Bird numbers per kilometre of river are the highest of any river in the Waitaki catchment (Robertson *et al.*, 1983). Although the lower reaches of the Ahuriri River were flooded by the construction of Lake Benmore in the 1960s, the remainder of this river has a relatively unmodified flow regime. It is, therefore, an important example of a typical braided river ecosystem. The extent of floodplain wetlands is also notable. All other large braided rivers that cross the Mackenzie Basin have been modified for hydro-electric power production.

Robertson *et al.* (1983) studied the habitat requirements of wetland species on this river and its associated wetlands. Much of the information provided here is taken from that report. A management statement and resource report was prepared for the Waitaki Catchment Commission by Robinson (1983).

Physical features: The catchment is bounded by steep, formerly-glaciated mountain ranges. The wide valley contains relic landforms from glacial retreat, such as moraines and kettle hole ponds, plus extensive outwash and alluvial features, such as terraces, alluvial fans and deep shingle deposits. Greywacke sandstone is the predominant rock type. Soils vary considerably because of differences in available moisture.

High country yellow brown earths are widespread on hill slopes. Yellow grey earths occur on very dry areas, especially on the low hills and main basin around Omarama. These soils are drought-prone, with low natural fertility. Fertile recent soils in the upper valley floor have been developed for agriculture. Recent gley soils occur in the mid Ahuriri swamps.

River flow originates from rainfall and snow-melt, rather than glacial sources. Northwesterly rain storms bring high and sudden increases in flow, especially during the spring thaw. Winter flows tend to be low and stable. This highly variable flow regime is typical of Canterbury's large braided rivers. Mean flow at the Ahuriri Gorge is 22.5 cubic metres per second, with a mean annual flood flow of 221 cubic metres per second. The maximum recorded flow is 518 cubic metres per second (Robertson *et al.*, 1983).

Water quality surveys were conducted on the Ahuriri River during the 1980s, to assess proposals for increased water abstraction (Robinson, 1983). Water temperatures vary widely throughout the year and have their highest daily variation during summer. Dissolved oxygen content is at, or near, saturation. Turbulent flows help maintain oxygen levels when waters are warmer, and serve to minimise algal growth. There is little organic pollution and the water is clear, except for an area near the clay cliffs and when flows reach 50 cubic metres per second. Alkalinity, pH, conductivity and negative faecal coliform counts all indicate the water is of high quality, though not highly productive in terms of aquatic biota.

The river channel begins as a narrow, unstable channel with marginal seepage areas. It becomes increasingly braided, then slows and meanders through Birchwood Wetland, Ben Avon Swamp and Birch Creek Wetland. These are areas of swampland, drained wetland, ponds and meandering water courses (see below). Ahuriri Gorge then cuts through high glacial terraces before the river opens out onto a broad alluvial plain. A reach of braided river bed extends 13 km down to the highway bridge near Omarama. The river's gradient is steep and the channels change considerably as a result of floods. There is a cluster of wetlands on alluvial flats and backswamps adjacent to, and north of the river, *i.e.*, Ben Omar, Willowburn, Buscot and Henburn Swamps. In recent prehistoric times, the river has run "at will" across a broad, low-angled fan. River engineering works now attempt to channelise the mid to lower river. Adjacent to this section of river are the Omarama clay cliffs, spectacular badlands of eroded tertiary sediment, uplifted by an active fault. Braided channels continue downstream for another 8 km. A delta (1.5 km wide) has formed where the river enters Lake Benmore. Habitats include several major channels, numerous streams, mud flats, backwaters and the permanent swampland of Glenburn Swamp, south of the delta. Delta characteristics vary considerably, as water levels fluctuate with changes in hydro-electric power demand. In 1982, for example, the exposed delta flats expanded from 10-50 ha to 250-300 ha as a result of very low winter lake levels (Robertson *et al*., 1983).

The main Ahuriri swamplands are described below.

- Birchwood Wetlands are several small and large oxbow lagoons surrounded by partially-drained land, tussock grassland and pasture (Jarman, 1987). The wetland is bisected by the river. One large pond is being infilled with sediment from an alluvial fan.
- Birch Creek Wetland is a 100 ha remnant of a once much larger floodplain swamp downstream from Birchwood Wetlands. Ben Avon Swamp is part of the same wetland area. Previously the swamp was partially drained, but a dam has reverted some of the loss. Two large ponds, Ahuriri Pond and Ben Avon Pond, are dominant features. There are large numbers of small ponds, many of which are directly attached to river channels. Also present are several infertile morainic kettle hole tarns on old surfaces above the river.
- Ben Omar Swamp (c.250 ha) is the largest wetland beside the lower Ahuriri. It is situated on gently-sloping alluvial deposits, is fed by small streams off surrounding hills, and drains into a slow moving creek. There is little open water.
- Buscot, adjacent Willowburn, and Henburn Swamps are swampy stream channels with small areas of open water. The streams are tributaries of the Ahuriri. Drainage at the base of low-angled alluvial fans is impeded by hill slopes.

- Riverside Wetland is a stable stream within the floodplain of the Ahuriri River. Wetland margins have been modified by weeds and grazing.
- Tara Hills Wetland is an isolated swamp with 60% open water in the south of the catchment.
- Glenburn Swamp (c.150 ha), beside the Ahuriri Delta, is a low-lying area at the head of Lake Benmore. Its character prior to construction of the lake in the 1960s is not known. More recently, parts of the wetland have been modified for agriculture.

The climate in the Ahuriri catchment is semi-continental. Annual rainfall is above 5,000 mm in the headwaters, decreasing eastward to about 520 mm in the semi-arid land around Omarama (Douglas, c.1983). Winters are cold and clear, with severe frosts. Most ponds and tarns freeze over for several weeks each year. Summers are hot, dry and windy, with high evapo-transpiration rates. Because of the predominant northwesterly airflow, weather conditions in the headwaters are often very different from conditions near Omarama and Lake Benmore.

Ecological features: The vegetation of the mid and lower braided river has changed considerably since the introduction and spread of willows *Salix* spp., Sweet Briar *Rosa rubiginosa*, Broom *Cytisus scoparius* and, most recently, Russell Lupin *Lupinus polyphyllus* x *arborea*. Weed spread is less extensive above the gorge. Common native plants are the low-growing *Raoulia* and *Epilobium* species, and Matagouri *Discaria toumatou* shrubs. Common wetland plants throughout the catchment are *Carex secta*, in its typical pedestal tussock form, Bog Rush *Schoenus pauciflorus*, *Juncus* spp., swathe-forming species of *Carex*, and introduced willows. Turfland communities occur around some ponds in the Birchwood and Ben Avon Wetlands, and around the Ahuriri delta mudflats.

Most dry land away from the floodplain is semi-developed *Festuca novae-zelandiae* tussock grassland, with introduced pasture species and the widespread mat plant *Hieracium pilosella*. Notable shrublands in the catchment include *Hebe cupressoides* on rocks at the gorge, *Olearia odorata*, *Carmichaelia petriei* and *Discaria toumatou* on the clay cliffs, and occurrences of bog pine *Dacrydium bidwillii*, Snow Totara *Podocarpus nivalis*, Hall's Totara *P. hallii* and Celery Pine *Phyllocladus alpinus* (Espie *et al.*, 1984). Mountain beech forest of *Nothofagus solandri* var. *cliffortioides* occurs in the upper Ahuriri Valley.

Land tenure: The river, except for a small section of the current river bed, and all of the adjacent wetlands are held by the Crown as unalienated Crown land. Long term, renewable Pastoral Leases over Crown land and University of Otago Endowment Leases account for over three quarters of the land in the Ahuriri catchment. Several of the large farms are freehold properties. Former State forest land in the upper catchment is now managed by the Department of Conservation. "Tara Hills" is an agricultural research station in Crown ownership.

Conservation measures taken: Proposals to expand irrigation and divert more water from the Ahuriri River prompted concern about the effects of low flows on riverine birds and fish. The river is now subject to a Water Conservation Order under the Water and Soil Conservation Act 1967. The application was made by the Department of Conservation and the Fish and Game Council. The Order, gazetted on 2 July 1990, limits the extent of extraction to the current levels. No additional water allocations may be made.

Glenburn Swamp (20 ha) and part of Ben Omar Swamp (67 ha) have been fenced to protect wildlife values. Processes of acquisition by the Crown and formal reservation have not yet been completed.

Project River Recovery is a braided rivers restoration programme coordinated by the Department of Conservation. Current work to restore and maintain wildlife habitat on the Ahuriri involves removal and control of Russell Lupin *Lupinus polyphyllus* x *arborea*. The project is part of an agreement negotiated between the Electricity Corporation of New Zealand

(ECNZ) and interested parties, including the Department of Conservation. The ECNZ Waitaki Water Rights Working Party Agreement relates to conditions upon ECNZ's renewed water rights in the Waitaki Basin.
A recovery plan is in place for the endangered Black Stilt (Reed *et al.*, 1993).
Conservation measures proposed: Ben Avon Wetlands were recommended for protection in 1984 (Espie *et al.*, 1984). Negotiations involving the pastoral lessee, Land Corporation, as lease manager and the Department of Conservation are being finalised. It is expected that land will be reserved under a private land protection covenant and as a Wildlife Management Reserve managed by the Department of Conservation.
Several other wetlands and the main channel of the Ahuriri River have also been recommended for protection (Espie *et al.*, 1984), principally because of their value as wildlife habitat. The wetlands are Ben Omar Swamp, Birchwood Lagoon, kettle holes within the Mid Ahuriri recommended area, and Glenburn Swamp. Implementation of these proposals, through negotiation, is planned or under way.
Land use: The river is used for outdoor recreation and as a source of gravel and water. It is a major contributor to Lake Benmore, a lake used for hydro-electric power generation. The river is also used as a water supply for domestic consumption and livestock. Several diversion channels take water from the Ahuriri and lower tributaries for irrigation, particularly of the yellow grey soils in the mid and lower river (Robinson, 1983).
Extensive pastoralism is the predominant land use in the catchment. Sheep and cattle have access to the river bed in places. Only about 15,000 ha of the 152,640 ha catchment are farmed intensively. The threat of flooding of farmland in the lower catchment and concern of landholders led to the construction of river control works. However, the lack of integrated planning limited the effectiveness of the stop-banks, groynes and tree planting projects (Robinson, 1983).
Possible changes in land use: Not known.
Disturbances and threats: Many of the wetlands have been damaged or reduced in area by drainage for agriculture and grazing-related changes. These threats continue, although recent protection agreements at Ben Avon Wetland highlight a degree of landholder support for wetland conservation. The spread of weeds and willows in the river bed is a major concern because of the consequent loss of suitable open breeding areas and shallow, highly-variable channels, essential habitat for specialised river-bed birds. Russell Lupins have spread thickly, from Longslip Creek tributary below the gorge. Removal work is in progress under Project River Recovery. Water abstraction for irrigation was perceived to be a threat to birds and fish. The Ahuriri River Water Conservation Order reduces the threat from low flows. Pollution from fertiliser run-off is a small, but realistic threat to the quality of surface water and groundwater. Threats to ground-nesting birds include predation by mustelids and cats, trampling by livestock, disturbance caused by recreational vehicles, and further loss of wetland habitats.
Hydrological and biophysical values: The river is notable as the only major tributary of the Waitaki River to flow unimpeded across the Mackenzie Basin. In contrast, the Ohau, Pukaki and Tekapo Rivers have been controlled for power generation purposes. The river is a major contributor to the Waitaki lakes used in power generation. It plays a general role in the support of food chains.
Social and cultural values: None known.
Noteworthy fauna: The Ahuriri River and its associated wetlands are classed as "Sites of Special Wildlife Interest" (SSWI) (Jarman, 1987). Like other braided rivers in Canterbury, the Ahuriri is notable for its specialist birds (see Robertson *et al.*, 1983, for details). Fifty-eight species of birds have been recorded in the catchment; at least 45 species breed, and 15 are endemic species. The braided river and associated wetlands support a breeding population of the endangered Black Stilt *Himantopus novaezelandiae*, one of the largest breeding

populations of Black-fronted Tern *Chlidonias albostriatus* (c.1,200 birds), and a large breeding population of Wrybill *Anarhynchus frontalis* (c.100 birds). The river and wetlands are also very important habitat for Banded Dotterel *Charadrius bicinctus*, other birds typical of braided river beds and ducks and geese (Anatidae). Other notable species, never found in large numbers in the high country, include Australasian Bittern *Botaurus poiciloptilus*, Marsh Crake *Porzana pusilla affinis* and Black-fronted Dotterel *Charadrius melanops*.

Bird numbers per kilometre of river are the highest of any river in the Waitaki catchment (Robertson *et al.*, 1983). As the river habitats change throughout the year, numbers and species composition also change markedly. Most shorebirds, gulls and terns, except for Black Stilt, migrate to the coast for winter, then return to breed on open shingle during high spring flows. The Black Stilt remains at upland braided rivers and adjacent wetlands throughout the year, although it is mobile within this catchment and the wider Waitaki catchment. Ducks and geese are most abundant during winter.

Native fish occur in moderate numbers. Introduced trout *Salmo* spp. are present in high numbers. Large numbers of aquatic and terrestrial insects have been recorded, including a new species of *Zealandotipula* (Diptera: Tipulidae). *Leiolopisma lineoocellatum* and large numbers of the common skink and gecko have been recorded here. The rare grasshopper, *Brachaspis robustus*, was first collected beside the Ahuriri River (Bigelow, 1967, cited in Espie *et al.*, 1984).

Noteworthy flora: The vegetation of the river bed and floodplains is typical of Canterbury's inland braided rivers. A full investigation of the upper Ahuriri wetlands may reveal uncommon species. A rare shrub, *Hebe cupressoides*, grows on rock bluffs at the Ahuriri Gorge (Robertson *et al.*, 1983). This is the southernmost record of this species.

Scientific research and facilities: Tara Hills Research Station, run by the Ministry of Agriculture and Fisheries, is the only research base in the Ahuriri catchment. The research focus is on high country land use. Water use is an area of research interest, but there is no focus on river ecology. The Department of Conservation conducts research as part of the Project River Recovery and Black Stilt recovery programme, and also for individual wetland protection proposals, *e.g.* as at Ben Avon Wetland.

Conservation education: Project River Recovery includes programmes for conservation education. Information panels have been placed at several road and riverside picnic areas in the Mackenzie Basin.

Recreation and tourism: Recreational activities in the river bed include trout fishing, picnicking, informal camping, walking, swimming, canoeing, rafting and waterfowl hunting. Regulations prevent the use of jet-boats on the river. The river is highly valued as a trout fishing river. The scenic landscape, uncrowded spaces and easy access make the middle and lower reaches very popular (Robinson, 1983).

Good fishing and boating opportunities are also found at nearby Lake Benmore. The small tourist and residential centre of Omarama provides a range of accommodation and services. Hot, stable weather conditions in summer attract large numbers of campers to the Omarama area for active and passive recreation.

Management authority: The Department of Conservation has responsibility for the management of Crown land including the Ahuriri river bed, reserves, conservation area and wildlife. Day-to-day management is undertaken by Twizel Field Centre. Canterbury Regional Council has responsibility for the management of water, gravel, soil and other natural resources, as well as pollution and flood control. Land Corporation Ltd. is responsible for the management of Pastoral Leases on behalf of the Crown. Mackenzie District Council is responsible for resource consents and district planning. The Central South Island Fish and Game Council manages sport fishing and game-bird hunting.

Jurisdiction: Functional: Department of Conservation, Central South Island Fish and Game Council and Land Corporation Ltd. Territorial: Mackenzie District Council and Canterbury Regional Council.
References: Douglas (c.1983); Espie *et al.* (1984); Jarman (1987); Reed *et al.* (1993); Robertson *et al.* (1983); Robinson (1983).
Reasons for inclusion:

1a The Ahuriri River is an excellent representative example of a braided river, a wetland type characteristic of the eastern South Island of New Zealand. The habitat is distinctive because of its unusual physical and hydrological characteristics, its flora and the presence of endemic and highly specialised birds. The river forms part of the Canterbury Braided Rivers which, individually and as a complex, are outstanding examples of a wetland habitat type typical of eastern New Zealand.

2a The river and associated wetlands support an appreciable number of three globally threatened species of birds, *Himantopus novaezelandiae*, *Anarhynchus frontalis* and *Chlidonias albostriatus*.

2b The river and associated wetlands are of special value for maintaining the genetic and ecological diversity of the region, particularly because of their diverse avifauna.

2c The river and associated wetlands provide important breeding habitat for many species of birds, notably shorebirds, gulls and terns.

2d The river and associated wetlands are of special value for their endemic birds (15 species and subspecies).

3b The river and associated wetlands regularly support substantial numbers of shorebirds, gulls and terns (during spring and summer) and ducks and geese (during autumn and winter), a feature indicative of wetland values and productivity. Bird numbers per kilometre of river bed are the highest of any tributary in the Waitaki catchment.

3c The river and associated wetlands regularly support well over 1% of the total populations of *Himantopus novaezelandiae*, *Anarhynchus frontalis* and *Chlidonias albostriatus*.

Source: John Andrew and Jenny Steven.

Waitaki Headwater Braided Rivers (62c)

Location: 44°06'S, 169°52'E at Hopkins River. Extensive braided rivers and associated wetlands which flow into the remote northern ends of Lakes Tekapo, Pukaki and Ohau in central South Island. The rivers are within the Waitaki catchment. Major rivers feeding Lake Tekapo are the Macaulay, Godley and Cass; those feeding Lake Pukaki, the Tasman and upstream branches Hooker and Murchison; and those feeding Lake Ohau, the Dobson and Hopkins. The lower reaches are accessible by boat up the lakes or by road or rough vehicle track. Tekapo (30 km by road), Mount Cook (20 km) and Twizel (30 km) are the closest townships to the respective lake heads. Within Tekapo, Godley, Murchison, Dobson, Ben Ohau and Huxley Ecological Districts.
Area: c.21,500 ha.
Altitude: From a minimum of 520 m to a maximum of 3,760 m.
Overview: The braided rivers and stream wetlands that flow into the glacial lakes in the Waitaki catchment are part of the Canterbury Braided Rivers Complex. Like other braided rivers in Canterbury, these rivers are very important for waterfowl, especially shorebirds, gulls

and terns. They are of international significance because of the presence of an endangered endemic shorebird, the Black Stilt *Himantopus novaezelandiae*. Several sites identified as key breeding or feeding areas for Black Stilt and other indigenous birds were listed as "Sites of Special Wildlife Interest" (SSWI) by the Fauna Survey Unit of the New Zealand Wildlife Service (Jarman, 1987).

Each river flows from alpine, partly-glaciated sources along a wide shingle bed, then into Lake Tekapo, Pukaki or Ohau via a delta. As yet, introduced shrubby weeds and willows *Salix* spp. have not spread to any extent in these rivers. Most other Canterbury rivers have severe weed infestations. The river beds are grazed periodically by sheep and cattle.

Physical features: All three headwater areas have physical features in common. The braided river beds occupy vacated glacial channels up to 6 km wide. Valley sides are steep and mountainous. River margin landforms include terminal moraine remnants, vegetated flats of compacted shingle, truncated alluvial fans, undulating fan and debris flow deposits that extend onto the river bed, stable single-thread streams, ponds and river-bed backswamps. In the more active river beds, unconsolidated sand and shingle forms bars and channels. These are altered during high flows, especially during the spring thaw. Delta channels may be highly mobile shingle, as in the Godley and Tasman Rivers, or semi-stable, vegetated and grazed, as at the Cass mouth and the head of Lake Ohau. At Lakes Tekapo and Pukaki, the delta areas have been altered and inundated by power scheme lake level changes.

Distinctive features of each lake headwater are noted below:

Lake Tekapo tributaries

The Macaulay River joins the larger Godley before entering Lake Tekapo. The Godley River is fed by side streams and two valley glaciers with terminal moraine lakes. Godley Wetland SSWI on the true right is a slow-moving stable stream on the edge of the floodplain. Lilybank Swamp SSWI, a river-bed backswamp with a stable stream, is located on the Godley floodplain upstream of the confluence. This area is partly drained and grazed. Mount Gerald Wetlands are a series of tarns, oxbows, streams and swamps bordering the lower Macaulay River. Cass River has an open, braided bed, with one swampland of Red Tussock *Chionochloa rubra*, a short gorge, then a broad swampy delta.

Lake Pukaki tributaries

Tasman River originates from extensive glaciers in Tasman, Murchison, Hooker and Mueller valleys of the Southern Alps. River levels are highly variable depending on daily and seasonal meltwater flows. The Tasman carries very large quantities of shingle and suspended rock flour from the active glacier faces. Three distinct wetlands are important for waterbirds. All have "outstanding" SSWI ratings. Jollie River Delta is at the mouth of a narrow braided tributary on the true left bank of the Tasman River. River bed, shallow streams, lateral moraine and backswamps provide diverse wetland habitats. Birch Hill Stream and Glentanner Station Swamp, on the true right bank, are a braided stream and lagoon, and a floodplain backswamp with meandering streams, respectively.

Lake Ohau tributaries

The Hopkins and Dobson Rivers join before flowing through well-vegetated swampland and braided channels of the Lake Ohau delta. Both rivers have long narrow catchments fed by short torrent streams off mountain slopes. Stream wetlands (both classed as outstanding SSWI) are the Glen Lyon Lagoons, which consist of six large shallow ponds and partly drained swampland covering 60 ha between the Hopkins/Dobson confluence and the lake; and Stony Stream Lagoon, a 4 ha oxbow pond with open water and a small area of swamp on the Dobson floodplain. Temple

Stream is a small braided tributary with open pools on the true right bank. It flows through fertile river flats to join the lower Hopkins River.

Ecological features: Plant species typical of the sparsely-vegetated river beds are the mat-forming *Raoulia* spp., *Helichrysum depressum*, *Muehlenbeckia axillaris*, *Epilobium melanocaulon* and introduced *Hieracium* spp. Backswamp wetlands, pond and side streams are usually flanked by Bog Rush *Schoenus pauciflorus* and *Carex* spp. Several wetlands are dominated by tall Red Tussock *Chionochloa rubra*. The wetlands are surrounded by short tussock grasslands and low shrublands on steep eroding valley sides and alluvial fan surfaces. Common native plants in grassland are Fescue Tussock *Festuca-novae zelandiae*, *Celmisia* spp., Snow Tussock *Chionochloa* spp., Speargrass *Aciphylla* spp. and *Poa colensoi*. Native shrubs near river level include Matagouri *Discaria toumatou*, *Olearia odorata*, *Hebe* spp., *Coprosma* spp. and Mountain Ribbonwood *Plagianthus angustifolia*. Forests of Mountain Beech *Nothofagus solandri* var. *cliffortioides* occur on slopes in the upper Dobson and Hopkins valleys. Widespread introduced plants include Sweet Vernal *Anthoxanthum odoratum*, Clover *Trifolium repens*, *Hieracium pilosella* and Sweet Briar *Rosa rubiginosa*. Native plant communities in the lower parts of the catchments have been modified by domestic livestock, over-sowing of pasture species and applications of fertiliser.

Land tenure: Tenure of the Waitaki river beds somewhat confused at present because of varied responsibilities over any one tract of land, and changed resource requirements since completion of the Upper Waitaki Power Scheme. Large tracts of river bed are designated for power production purposes (Anon, 1980), and are administered by the Electricity Corporation of New Zealand. Discussions are in progress to rationalise river-bed management.

Most river beds are Crown land reserved from sale, and are managed by the Department of Conservation in conjunction with Canterbury Regional Council. Most rivers are bordered by large tracts of Crown land held as Pastoral Lease. There are small areas of unformed legal road, freehold land and plantation reserves managed by the local authority, Mackenzie District Council. In places, instability in river channels has meant that legal boundaries do not coincide with physical features on a floodplain.

The surrounding areas are predominantly Crown land held as Pastoral Lease. The uppermost headwaters of the Godley, Tasman, Dobson and Hopkins Rivers adjoin or are included in Mt Cook National Park. Tracts of native forest in the upper Dobson and Hopkins Rivers are former State Forests, now Crown land managed by the Department of Conservation.

Conservation measures taken: The upper reaches of the Godley and Tasman Rivers are protected within Mt Cook National Park. The rivers and several associated wetlands were identified by the former New Zealand Wildlife Service as "Sites of Special Wildlife Interest" (SSWI). The Department of Conservation recognises the importance of these sites, but sites are not formally protected. The Department of Conservation has a Species Recovery Programme for the endangered Black Stilt (see Reed *et al.*, 1993). Bird numbers in the headwater rivers may increase eventually as a result of management of breeding populations in the lower Mackenzie Basin and near the Cass River delta.

Conservation measures proposed: A Protected Natural Areas Programme survey identified the lower Cass River as a "Priority Natural Area" (Espie *et al.*, 1984). The river has high value for wildlife, and is a typical and little-modified example of a river-bed ecosystem in the Mackenzie Ecological Region. Conservation measures are not yet in place. The 1984 survey boundaries did not include any other lake headwater rivers.

Conservation of headwater river habitats may be assisted through Project River Recovery. This ongoing rehabilitation project is managed by the Department of Conservation and funded by the Electricity Corporation of New Zealand (the state-owned power production corporation) as part of its water right conditions. The current management focus is on rehabilitation of weed-infested rivers in the lower Mackenzie Basin.

Land use: The river beds are used as access-ways for recreational hunting, climbing and walking, and for fishing, to a limited extent. Cattle and sheep from the adjacent Pastoral Lease properties graze the river beds. The predominant land use throughout the region continues to be extensive pastoral farming of sheep and cattle. There are eight properties, based at isolated homesteads. Each "station" covers several thousand hectares. Crops and hay are grown on limited areas of arable land, often on alluvial soils of fans and river flats. Mount Cook village, a tourist resort and national park headquarters, has a small permanent population, but high short-term visitor numbers. Airfields and tourist facilities are located near the Tasman River, at Mt Cook, and at Glentanner Station. A tourist lodge associated with safari hunting is being built near the Godley River.

Possible changes in land use: There are no major development plans for the rivers or associated wetlands. Drainage, cultivation and improvement of pasture may cause gradual and permanent changes to river-side swamplands. Predicted increases in the numbers of international visitors may stimulate further tourist development in the Tasman Valley. The permanent population is unlikely to grow significantly. Rehabilitation of land damaged by grazing, the spread of the weed *Hieracium pilosella* and rabbits may involve extensive tree planting, introduction of new species and different farm management techniques. Such changes may affect the lower reaches of the headwater braided rivers.

Disturbances and threats: The rivers are partially protected from human disturbance by their rugged catchments and physical isolation. Domestic livestock and vehicles may disrupt the breeding of river-bed birds. Shrubby weeds such as Broom *Cytisus scoparius*, Briar Rose *Rosa rubiginosa* and Russell Lupin *Lupinus polyphyllus* x *arborea* have the potential to spread. The spread of introduced weeds devalues wildlife habitats, particularly because many river-bed birds breed only on open shingle. Farming operations, afforestation and delta drainage may alter the hydrology and natural character of the lower reaches of these rivers.

Hydrological and biophysical values: The rivers are examples of little disturbed upland braided rivers. The lack of weeds, *e.g.* in the Cass River, is a notable and increasingly unusual feature. Tasman River is the largest glacially-fed river on the eastern side of the Southern Alps. The rivers play a general role in supporting food chains, and are the main sources of water for the extensive Waitaki hydro-electric power scheme.

Social and cultural values: Not known.

Noteworthy fauna: The Waitaki headwater rivers and several of the associated wetlands were identified as "Sites of Special Wildlife Interest" (SSWI) by the Fauna Survey Unit of the New Zealand Wildlife Service (Jarman, 1987). This is a nationwide wildlife habitat ranking system officially recognised by the Department of Conservation.

The rivers are especially important as habitat for the endangered Black Stilt *Himantopus novaezelandiae*. This is the rarest species of shorebird in the world, and New Zealand's rarest mainland bird (Pierce, 1982; Reed *et al.*, 1993).

The Black Stilt now breeds only in the Upper Waitaki catchment, although last century they were found in numerous locations throughout New Zealand. Black Stilts are specialised feeders who peck and probe for aquatic benthic invertebrates. Sites with flowing water are used most intensively during high flows in early summer. Nests are built on river beds, dry banks or islands, and only in places where vegetation is sparse. By late summer, after breeding, the stilts migrate to sites with slow or standing water (Jarman, 1987). Delta areas provide important wintering habitat for the stilts.

The rivers also support large breeding populations of Banded Dotterel *Charadrius bicinctus*, Wrybill *Anarhynchus frontalis*, Black-billed Gull *Larus bulleri* and Black-fronted Tern *Chlidonias albostriatus*. Other common birds include Black Shag *Phalacrocorax carbo*, South Island Pied Oystercatcher *Haematopus finschi*, Pied Stilt *Himantopus leucocephalus* and Southern Black-backed Gull *Larus dominicanus*. Backswamp wetlands provide sheltered

habitat for Australasian Bittern *Botaurus poiciloptilus* (recorded at Stony Lagoon in the Dobson Valley) and the rarely observed Marsh Crake *Porzana pusilla affinis*. Ponds support large numbers of Anatidae and shorebirds throughout the year. Occasional visitors to the area have included White-winged Black Tern *Chlidonias leucopterus* and Caspian Tern *Sterna caspia*.

Noteworthy flora: The flora of the river beds and wetlands is typical of upland braided rivers, and contains no unusual elements. However, the limited extent of weedy vegetation contrasts markedly with the situation in most other braided rivers in Canterbury.

Scientific research and facilities: No research facilities are available. River-bed birds have been studied by the Department of Conservation, the former New Zealand Wildlife Service and university researchers, *e.g.* Pierce (1982). Research on species and habitats is continuing as part of Project River Recovery. The project also funds an on-going and coordinated programme of bird counts on the region's braided rivers.

Conservation education: There are no conservation education programmes that focus specifically upon these remote headwater rivers, but a secondary school in Timaru has an outdoor education lodge on the true right bank of the Godley River.

Recreation and tourism: The upper Tasman and its glacial headwaters are visited by numerous sightseers and people seeking active mountain recreation. Mt Cook village is a major New Zealand tourist destination. Other headwater rivers receive light, though consistent, use by walkers, mountaineers, hunters and anglers.

Management authority: The Department of Conservation has responsibility for the management of Crown land, conservation area and wildlife, while the Department's Twizel Field Centre is responsible for day-to-day management. Canterbury Regional Council has various management and policy responsibilities for natural resources under the Resource Management Act 1991, while Mackenzie District Council is responsible for resource consents under the same Act. Land Corporation Ltd. is responsible for the administration of Pastoral Lease lands. The Central and Southern Fish and Game Council manages sport fishing and game-bird hunting.

Jurisdiction: Functional: Canterbury Regional Council, Department of Conservation and Central South Island Fish and Game Council. Territorial:
Mackenzie District Council and Canterbury Regional Council.

References: Anon. (1980); Espie *et al.* (1984); Jarman (1987); Pierce (1982); Reed *et al.* (1993).

Reasons for inclusion:

1a The Waitaki Headwater Braided Rivers are an excellent representative example of braided rivers, a wetland type characteristic of the eastern South Island of New Zealand. The habitat is distinctive because of its unusual physical and hydrological characteristics, its flora and the presence of endemic and highly specialised birds. The rivers forms part of the Canterbury Braided Rivers which, individually and as a complex, are outstanding examples of a wetland habitat type typical of eastern New Zealand.

2a The rivers support an appreciable number of at least three globally threatened species of birds, *Himantopus novaezelandiae*, *Anarhynchus frontalis* and *Chlidonias albostriatus* (a fourth species, *Botaurus poiciloptilus*, has also been recorded in the area).

2b The rivers are of special value for maintaining the genetic and ecological diversity of the region, particularly because of their diverse avifauna.

2c The rivers provide important breeding habitat for many species of birds, including several endemic species which are specially adapted to life on braided rivers.

3c The rivers regularly support almost 100% of the world population of *Himantopus*

novaezelandiae, as well as a significant proportion of the populations of *Anarhynchus frontalis* and *Chlidonias albostriatus*.

Source: John Andrew and Jenny Steven.

Avon-Heathcote Estuary (63)

Location: 43°32'30"S, 172°43'30"E. Abutting the northern boundary of Banks Peninsula, 12 km east of the centre of Christchurch City, South Island.

Area: c.880 ha.

Altitude: Sea level to 2 m.

Overview: The Avon-Heathcote Estuary is the largest, semi-enclosed shallow estuary in Canterbury, and remains one of New Zealand's most important coastal wetlands, despite being almost totally surrounded by the residential housing suburbs to the east of Christchurch City. The estuary skirts the northern edge of Banks Peninsula, is protected from the Pacific Ocean by the South Brighton Spit and has an average depth of 1.4 metres at high tide. The Avon and Heathcote Rivers, after which the estuary is named, flow in a generally eastward direction from their respective sources, the Avon discharging into the northwestern head and the Heathcote, almost directly opposite, into the southwestern head of the estuary. The estuary hosts the largest concentrations of arctic and native shorebirds on the east coast of the South Island, and usually supports a significant collection of rarer species as well. Some 102 species of birds were recorded in the area between 1980 and 1992. Between 15,000 and 20,000 waterfowl use the estuary and associated Bromley oxidation ponds or their margins, with a maximum of approximately 32,000 present in late summer-autumn. The area is also an important venue for a variety of recreational activities, including fishing, game-bird shooting, swimming and a wide variety of boating activities.

Physical features: The estuary of the Avon and Heathcote Rivers lies immediately to the north of the volcanic mass of Banks Peninsula, and as it presently exists, is believed to be a relatively recent formation, probably in the vicinity of 450 years old. It is roughly the shape of an equilateral triangle, approximately 880 ha in area and with an average depth of 1.4 m at mean high water. It is bounded on its three sides by areas of completely different landform. To the west is the flat, originally swampy land overlying the alluvial shingle of the Canterbury Plains, now occupied by Christchurch City. To the south are the Port Hills forming part of the volcanic mass of Banks Peninsula, and to the east lies the 5-km long sand spit, the South Brighton Spit, which separates and protects the Estuary from the Pacific Ocean.

Land underlying the estuary consists of alternate gravel layers sandwiched between finer silts and sands left by the rivers and the sea. Rainfall over the Canterbury Plains to the west of Christchurch and water from the Waimakariri River drain through the soil to these gravel layers, forming aquifers, and springs from these feed the Avon and Heathcote Rivers which drain to the estuary. Small streams flowing off the Port Hills also comprise approximately 30% of the Heathcote catchment. Major storms often cause localised flooding of the Heathcote River, but flooding of the Avon River is rare.

Tides are semi-diurnal, having a range of about 2.1 m for spring tides and 1.1 m for neap tides. Over 11 million cubic metres of water pass through the estuary twice each day. Tidal influences extend considerable distances up both rivers from the estuary proper. The mixing of saline and fresh water extends up the Avon River to the Wainoni Road Bridge, a distance of 8 km, and up the Heathcote River almost to the Radley Street Bridge, a distance of 11 km.

The Bromley Sewage Purification Works, operated by the City of Christchurch, adjoins the western edge of the estuary, and discharges in excess of 180 million litres of treated sewage into it each day. All effluent entering the Works is subjected to both primary and secondary treatment before discharge into the estuary from oxidation ponds. Timing of the discharges coincides with the outgoing tide.

The climate is influenced by the coastal situation and is therefore less variable than landward areas to the west. Situated in the lee of the Port Hills and the volcanic mass of Banks Peninsula, the estuary and surrounding areas are largely sheltered from the direct impact of adverse weather from the south and are almost frost-free as a result. The average annual rainfall, as measured at the adjacent Bromley Sewage Purification Works, is 553 mm, and while it is distributed throughout the year, the autumn and spring months tend to be wettest.

Ecological features: The original swamplands and native vegetation which once extended over much of the land to the west of the estuary and between the two rivers have been almost completely drained and cleared, to be covered by roads, housing and other forms of development generated by the City of Christchurch. Plant communities on lands bordering the estuary in the early 1850s were dominated by Raupo *Typha orientalis* and New Zealand Flax *Phormium tenax*, interspersed with tussock, fern and tutu on drier areas to the south and west, and Sea Rush *Juncus maritimus* backed by Saltmarsh Ribbonwood *Plagianthus divaricus* along the New Brighton Sandspit.

Today, the plant communities bordering undeveloped sections of the estuary shoreline are dominated by saltmarsh communities, with the greatest variety of vegetation types existing in the area around the mouth of the Avon River. Species such as Glasswort *Sarcocornia quinqueflora*, Sea Blite *Suaeda novaezelandiae* and Sea Rush *Guncus maritimus* grow immediately above mid-tide where salinities are highest. Further inshore, Selliera *Selliera radicans*, Buck's Horn Plantain *Plantago coronopus* and other less salt-tolerant species occur, to be replaced by Jointed Wire Rush *Leptocarpus similis*, Coastal Ribbonwood and Tall Fescue *Festuca arundinacea* in the upper marsh. The more diverse plant communities which exist in the vicinity of the Avon River mouth include Native Musk *Mimulus repens*, Raupo *Typha orientalis*, Three-square *Schoenoplectus pungens*, Lake Club Rush *S. validus* and Orache *Atriplex prostata*. There is an extensive area of pure Sea Rush immediately above mid-tide in the first bend of the Heathcote River upstream of the Ferrymead Bridge (an important feeding area for wildlife).

Land tenure: The bed of the Avon-Heathcote Estuary and the foreshore lands immediately above mean high water are Crown land which is jointly managed by the Christchurch City Council and Canterbury Regional Council. The Regional Council Plan administered by the latter authority oversees water quality and human activities on the estuary, while the City Council administers activities on land above mean high water spring tides. The southern end of the New Brighton Sandspit, an extensive area of land occupied by the Bromley Sewage Works and settling ponds immediately to the north and west of the estuary, strips of land bordering the Avon and Heathcote river mouths, and various small areas adjoining the estuary to the south are public lands administered by the Christchurch City Council as various types of reserves. Land beyond these areas is largely held in private ownership and occupied for residential housing.

Conservation measures taken: Most land immediately adjoining the estuary is publicly owned and designated under a variety of reserve categories including Local Purpose, Recreation, Plantation, Esplanade, Drainage and Waterworks Reserves. The six oxidation ponds and adjacent paddocks bordering the western side of the estuary have been designated as a Wildlife Management Reserve.

Ongoing effort over many years has been directed toward reducing sedimentation of the estuary, terminating or redirecting industrial and stormwater effluents from direct discharge

into the estuary, and progressive improvement in the treatment of sewage at the Bromley Sewage Works before its discharge into the estuary from the settling ponds. Timing of discharges from the ponds has been synchronised with that of ebbing tides in an effort to minimise the residency period of the nutrient enriched water from the settling ponds within the confines of the estuary.

Conservation measures proposed: A comprehensive range of proposals for the conservation management of fifteen separate areas of the estuary is included within a Department of Conservation Technical Report entitled "Birdlife of the Avon-Heathcote Estuary and Rivers, and their margins" (Crossland, 1993). Recommendations in this report cover a very wide range of wildlife habitat, active and passive recreation and land use issues including restoration of degraded wetlands, channel excavation, walkway development, litter removal, effluent diversion, provision of roosts and nesting facilities for Anatidae and other waterfowl, zoned restrictions of water-based recreational activities, interpretational sign-posting and many others intended to safeguard and/or enhance existing wetland values.

A recent "Issues and Options" document for the Avon and Heathcote Rivers' catchment and estuary, which was jointly prepared by the Christchurch City Council, Canterbury Regional Council and the Department of Conservation to ensure good management of the estuary and inflowing rivers now and in the future, also includes a number of proposed conservation measures.

The estuary is situated within a highly developed catchment area and is the focus of regular, comparatively intense human use, both active and passive. Current and future uses will no doubt lead to adverse impacts in various areas of the estuary which will prompt the development of new proposals to prevent or mitigate such impacts.

Land use: The estuary constitutes a locally important fishery for Yellow-eyed Mullet, Red Cod, Huhawai, flounders, eels, whitebait and trout, with small numbers of Quinnat Salmon also appearing in catches during recent years. A strictly controlled cull of Canada Geese *Branta canadensis* is carried out by recreational hunters in the vicinity of the Bromley Oxidation Ponds during the annual game-bird shooting season, under management of the North Canterbury Fish and Game Council in cooperation with Christchurch City Council farm staff. The estuary is also very popular for a range of boating activities including water-skiing, yachting, wind-surfing and rowing, while the adjacent beaches are all popular swimming and surfing areas. Well established walkways extending north from the Avon River mouth along both banks of the river and south along the estuary shoreline bordering the South Brighton Spit provide many opportunities for observing wildlife. Other walkways are proposed around southern portions of the estuary, at Moncks Bay, McCormacks Bay and the Heathcote Loop beside the lower Heathcote River.

With the exception of the South Brighton Sandspit to the east of the estuary, the Linwood paddocks and the adjacent Bromley Oxidation Ponds bordering the shoreline to the west, the estuary is almost surrounded by private land which has been developed for housing or a variety of minor industrial uses.

Possible changes in land use: Beneficial changes are likely to include the following:

- exclusion of watercraft from selected areas of the estuary and adoption of farm management practices on the Linwood farm paddocks to maximise wildlife habitat values and use;
- dredging and channel deepening to reverse the effects of past silt deposition;
- re-establishment of previously destroyed or modified areas of saltmarsh;
- progressive improvement in the diversion and treatment of industrial effluent, stormwater run-off and sewage discharges;
- extension of public walkways and installation of wildlife observation platforms and interpretation signs at selected locations.

Further expansion of housing, light industrial and business sectors and extension or modification of the road transport network will occur throughout the metropolitan Christchurch area over time. However, widespread public interest in and support for protection of the estuarine wetlands should ensure that such development does not result in substantive damage being inflicted on the estuary.

Disturbances and threats: The intensity and variety of recreational activities will increasingly disrupt and conflict with wildlife habitat values and use of the estuary unless identified management solutions are applied and accepted by all user groups. Nutrient enrichment is likely to increase as the city expands and discharge volumes from the Bromley oxidation ponds increase, unless nutrient stripping or piping of the effluent to an open ocean discharge is implemented. Heavy metal accumulation in the estuarine sediments is likely to increase, particularly as long as lead remains an additive of high octane road transport fuel.

Hydrological and biophysical values: The estuary is a semi-enclosed basin with a surface area of over 800 ha, within which the combined flows of the Avon and Heathcote Rivers meet and mix with seawater during each tidal cycle. It functions as a trap for sediments transported down the beds of the two inflowing rivers. The extensive mudflats support an abundant and diverse invertebrate community which forms much of the food source for a wide variety of fish species, as well as resident and migratory waterfowl.

Social and cultural values: Situated immediately adjacent to the City of Christchurch, the estuary is of very high social significance, with public participation in a wide variety of aquatically-oriented outdoor activities which include yachting, water-skiing, power-boating, rowing, wind-surfing, fishing, swimming and walking. Peak utilisation of the wetland for all of these activities extends throughout the spring, summer and autumn months, with continuation of some throughout the winter months whenever clear, settled weather conditions permit.

During pre-European times the Avon-Heathcote Estuary was among the most important and highly valued food-gathering sites for South Island Maori on the east coast. The estuary was rich with "tuna" (eels), "karakara" (lamprey), "inanga" (adult whitebait), "patiki" (flounder) and "pipi" (shellfish), and at one time was widely known for a soft-shelled periwinkle snail called "whetiko". A number of features of the catchment have Maori names, including the Avon River (Otakoro), Heathcote River (Opawaho) and the New Brighton Spit (Te Karoro Karoro). Sewage discharge into the estuary from the Bromley settling ponds has severely compromised the value of the estuary as a food-gathering area for Maori, and the local Ngai Tahu people have put a "rahui" (prohibition) on the collection of shellfish from the area.

Past archaeological discoveries in the immediate vicinity have confirmed that Maori people lived beside the Avon-Heathcote Estuary for several hundred years before the arrival of the first Europeans. Maori tools, "urupa" (burial sites), "parahanga" (middens), stone artifacts, a kauri steering paddle, sinkers and spears unearthed in the Redcliffs area all attest to a focus on the estuary as a reliable food source by early Maori residents. A number of "kaika" (settlements) existed on the banks of the Avon and Heathcote Rivers, at Horseshoe Lake and at three other sites around the shores of the estuary. It was an important route for trade between Maori and early whalers and sealers operating around the coast of the South Island, and continued to serve as a route for the transport of early settlers' household and other trade goods from the arriving sailing ships to the Christchurch City settlement until the late 1860s, when road and rail links were established between Christchurch and the port of Lyttelton.

Noteworthy fauna: Thirty-four species of fish have been identified from the Avon-Heathcote Estuary and catchment, but many occur only rarely. Species most commonly occurring are Sand Flounder *Rhombosolea plebia*, Yellow-bellied Flounder *R. leporina*, Common Sole *Peltorhampus novaezeelandiae*, Yellow-eyed Mullet *Aldrichetta forsteri*, Kahawai *Arripis trutta*, Globefish *Contusus richei*, Spotty *Pseudolabrus celidotus*, Common Bully

Gobiomorphus basalis and Cockabully *Tripterygion rigripenne*. Other species less commonly encountered include Long-finned Eel *Anguilla dieffenbachii*, Short-finned Eel *A. australis*, whitebait *Galaxias* spp., Brown Trout *Salmo trutta* and Quinnat Salmon *Oncorhynchus tshawytscha*.

One hundred and two species of birds have been recorded on or in the immediate vicinity of the estuary since 1980, and between 15,000 and 20,000 waterfowl make use of the estuary and oxidation ponds or their margins, peaking at around 32,000 in late summer and autumn (Crossland, 1993). Noteworthy species include Little Shag *Phalacrocorax melanoleucos*, Spotted Shag *Stictocarbo punctatus*, Australasian Bittern *Botaurus poiciloptilus*, Great Egret or White Heron *Egretta alba*, Royal Spoonbill *Platalea regia*, Grey Teal *Anas gracilis*, New Zealand Shoveler *A. rhynchotis variegata*, New Zealand Scaup *Aythya novaeseelandiae*, Marsh Crake *Porzana pusilla affinis*, South Island Pied Oystercatcher *Haematopus finschi*, Banded Dotterel *Charadrius bicinctus*, Caspian Tern *Sterna caspia*, Black-fronted Tern *Chlidonias albostriatus* and New Zealand Kingfisher *Halcyon sancta vagans*. At various times of the year, the bird population of the wetlands may include up to 600 shags, 200 herons and spoonbills, 15,000 ducks, geese and swans, 400 Pukeko *Porphyrio porphyrio melanotus*, 8,000 shorebirds, 10,000 gulls, 1,800 terns and over 100 kingfishers.

Noteworthy flora: Progressive development of housing, road building, sewage treatment facilities and other amenities by the City of Christchurch has resulted in the destruction or extensive modification of the original native vegetation bordering the estuary, particularly along the western and southern shorelines where the original plant communities have been replaced by open grassland bordering the Bromley settling ponds and Linwood paddocks, or completely destroyed by road construction which skirts the southern shoreline from the Heathcote River to Monks Bay.

The most extensive remaining areas of native vegetation are the saltmarsh communities prominent along the South Brighton Spit and extending to the Avon River mouth, and the freshwater wetland plant associations which extend some distance up the Avon, throughout the Bexley wetland, Humphreys Drive Wetland, the Heathcote Loop and bordering McCormacks Bay. Sea Rush *Juncus maritimus* and Glasswort *Sarcocornia quinqueflora* are the most common species immediately above mid-tide, with Selliera *Selliera radicans*, Buck's Horn Plantain *Plantago coronopus*, Sea Primrose *Samolus repens* and Tussock Sedge *Carex secta* appearing further up the shore. Plant communities in the vicinity of the Avon River mouth include Lake Club Rush *Schoenoplectus validus*, Jointed Wire Rush *Leptocarpus similis*, New Zealand Flax *Phormium tenax*, Raupo *Typha orientalis* and Saltmarsh Ribbonwood *Plagianthus divaricatus*, with communities of smaller plants closer to the shore which include Native Musk *Mimulus repens*, Batchelor's Button *Cotula coronopifolia*, Orache *Atriplex prostrata* and Three-square *Schoenoplectus pungens*. Below the mid-tide level, patches of eelgrass *Zostera novazelandica* grow between low and mid-tide close to the Avon channel.

Scientific research and facilities: Over 100 reports, studies, theses and B.Sc. Honours projects which focus on a very wide range of ecological, biological, toxic waste, drainage and catchment management issues specifically associated with the estuary, are on record. Research and studies have been completed on riparian, landscape, historic and recreational values, erosion and sedimentation, contaminant and nutrient loadings, benthic invertebrates, fish stocks and movements, birdlife, riparian vegetation, educational use and floodplain management. Faculty staff and students of the University of Canterbury (Ilam campus) within the city have made significant contributions to past studies and research work on the estuary, as have also the staff of the Canterbury Regional Council and Christchurch City Council. The Lincoln University campus is situated approximately 15 km southwest of the city, and several Crown Research Institutions, including Landcare and the National Institute of Water and

Atmospheric Research (NIWAR), maintain regional offices within the greater Christchurch area.

Conservation education: Considerable use is made of the estuary for instructional purposes by many of the schools in the greater Christchurch area, the Christchurch Teacher's College and the University of Canterbury. The estuary, with its readily accessible tidal flats and its interesting range of plants and animals, provides an ideal resource for teaching a wide range of ecological principles in a way that is equalled by few other ecosystems so readily accessible and close to the city. The research studies and theses which have been completed and documented up to the present time are testimony to its value for this purpose. Considerable potential remains for further development of public walkways, nature trails, observation hides and interpretative sign-posting for wildlife appreciation.

Recreation and tourism: The estuary is the primary focus for many of the aquatically-based recreational activities enjoyed by the resident population of the greater Christchurch area, to an extent that there is an acknowledged need for management of activities within the area to minimise conflict and maximise compatibility between birdlife and human uses. The most popular recreational activities on the estuary are wind-surfing, yachting, power-boating, water-skiing, canoeing, kayaking, rowing and walking. Swimming is popular within Moncks Bay during the summer months, and model aeroplane and kite flying enthusiasts are allowed use of the Linwood paddocks which border the western side of the estuary on one day each month.

Management authority: The Department of Conservation (Canterbury Conservancy) is responsible for management of flora and fauna; the Department's Christchurch Field Centre is responsible for day-to-day management. The Ministry of Agriculture and Fisheries (MAF Fisheries) manages the harvest of economically important marine fish species, sets Total Allowable Commercial Catch (TACC) and daily recreational fishing bag limits, and regulates fishing equipment and methods. Christchurch City Council and the Canterbury Regional Council jointly share territorial responsibility for the Avon-Heathcote Estuary and have statutory responsibilities under the Resource Management Act 1991 for the management of water resources and the preparation of coastal plans. The North Canterbury Fish and Game Council manages sport fishing (trout and salmon) and game-bird hunting.

Jurisdiction: Territorial: Christchurch City Council and Canterbury Regional Council. Functional: Department of Conservation (Canterbury Conservancy), North Canterbury Fish and Game Council and Ministry of Agriculture and Fisheries.

References: Baird (1992); Christchurch City Council (1987); Crossland (1992, 1993); Deely (1991); Knox & Kilner (1973); McCombs & Partridge (1992); Owen (1992); Stephenson (1980); Trotter (1975); Webb (1965, 1972).

Reasons for inclusion:

1a The Avon-Heathcote Estuary is the largest tidal wetland within the Canterbury Region, and is one of the most important coastal wetlands in New Zealand, particularly for migratory shorebirds.

2a The estuary is used by significant numbers of three globally threatened species of birds, *Botaurus poiciloptilus*, *Anarhynchus frontalis* and *Chlidonias albostriatus*.

2b The estuary is of special value in maintaining the genetic and ecological diversity of the region because of its relatively large size and high species richness (*e.g.* 34 species of fish representative of both marine and freshwater habitats).

2c The estuary is of special value as the habitat of fish and bird species at critical stages in their biological cycles; it supports the largest concentrations of international and internal migratory shorebirds on the east coast of South Island.

2d The estuary is of special value for its endemic species of birds, notably *Haematopus finschi*, *Anarhynchus frontalis* and *Chlidonias albostriatus*.

3a The estuary and adjacent Bromley oxidation ponds regularly support over 20,000 waterfowl.

3c The estuary and oxidation ponds regularly support over 1% of the regional populations of *Anas rhynchotis variegata* (5-6%), *Aythya novaeseelandiae* (3%) and *Haematopus finschi* (5-6%), and well as over 1% of the New Zealand populations of at least 13 other species (Crossland, 1992).

Source: Dick Hutchinson.

Lake Forsyth (64)

Location: 43°48'S, 172°45'E. In the southeast of Banks Peninsula near the junction of Kaitorete Spit, coastal Canterbury, South Island. The lake is situated at the edge of the Canterbury Plains and the extinct and eroded volcanic cones of the Peninsula, and is adjacent to a major coastal wetland, Lake Ellesmere. The rural settlement of Little River is 2 km from the lake's northern end and inlet. Birdlings Flat settlement is beside the outlet at the coast. Christchurch City is approximately 45 km away by road. The Christchurch to Akaroa Highway passes along the lake's northwestern edge, providing easy public access and viewing. Within Herbert Ecological District.

Area: c.562 ha.

Altitude: Sea level to approximately 3 m.

Overview: Lake Forsyth, alternatively known as Wairewa, is a narrow lake (7.6 km long by 1 km wide) on Banks Peninsula. The lake lies within the steep-sided Little River Valley, an ancient harbour eroded between lava flows. Curved beach ridges at the base of Kaitorete Spit impound the lake. A short channel leads to the sea, but surface discharge is usually blocked by a gravel beach ridge. This barrier is opened using bulldozers whenever high lake levels threaten to flood farmland. The lake is a little over 2 m deep, slightly brackish and highly eutrophic.

Lake Forsyth/Wairewa is a highly significant place for Maori, especially for Ngai Tahu "iwi" (tribe) and Ngati Irakehu "hapu" (a subgroup of Ngai Tahu) (Tau *et al.*, 1990). There are numerous sacred sites around the lake. The lake was, and continues to be, a very important source of traditional foods ("mahinga kai") and fibre, especially waterfowl, marine and freshwater fish, and eels (tuna) *Anguilla australis* and/or *A. dieffenbachii*. The lake is reserved for Maori fisheries.

The lake is used by a variety of Anatidae. It provides additional waterfowl habitat in close proximity to an extensive wetland, Lake Ellesmere. Lake Forsyth is notable as a wintering area for Great Crested Grebes *Podiceps cristatus australis*, a species whose main breeding areas are in inland Canterbury.

Physical features: Lake Forsyth is part of Banks Peninsula, a place of steep eroded volcanoes (extinct) and long valleys incised between lava flows. The lake occupies the base of one of these valleys. Sea cliffs, stranded within dry land, are visible near the southwestern end of the lake. These are relics of a period of high sea level, approximately 6,000 years ago. Since that time, beach gravels have accumulated at the base of the Peninsula and dammed the valley. The lake is fed by the small Takiritawai River from the Okana River (once called Ohiriri) (Tau *et al.*, 1990). Alluvial flats have developed around the lake head. Drainage is via a broad channel which is usually blocked by the beach ridge at Birdlings Flat. In the past, lake levels would have built up behind the beach until the water volume was sufficient to cause a natural breach to the sea. Today, lake levels are controlled by mechanical opening of the mouth. Northerly

drift of beach sediment, especially during storms, closes the outlet again, often within a few days or weeks. In the northwest and southeast, the lake is bounded by steep slopes that rise to about 400 m. There are higher peaks in the upper catchment.

Ecological features: Lake Forsyth and its surroundings have been surveyed and described by Wilson (1992) in a report for the New Zealand Protected Natural Areas Programme. The vegetation of the lake margins includes both freshwater and saltmarsh plants, indicators of slightly brackish water.

Conspicuous emergent plants of note include Raupo *Typha orientalis*, *Bulboschoenus caldwellii*, *Schoenoplectus pungens* and Saltmarsh Ribbonwood *Plagianthus divaricatus*. There is also a diverse saltmarsh turf flora (Wilson, 1992). Fully aquatic species include abundant *Potamogeton pectinatus*, the charophyte *Lamprothamnium papulosum*, plus *Myriophyllum triphyllum*, *Lepilaena bilocularis*, *Zannichellia palustris*, *Ruppia polycarpa*, *Potamogeton cheesemanii* and the alga *Enteromorpha*. Toxic algal blooms, mainly of *Nodularia spumigena*, occur periodically, possibly in response to nutrient-rich run-off from farmland.

Coastal flats and hills around Lake Forsyth also include plant communities of note. Shady slopes and an amphitheatre-like gully on Forsyth Spur, to the northwest of the lake, support rich shrubland and regenerating forest (Wilson, 1992). Birdlings Flat, a stony semi-arid area between Lake Forsyth and Lake Ellesmere, supports an interesting example of dry coastal shrubland, as well as many naturalised species. This area is under threat because it continues to be treated as a wasteland.

Prior to European settlement, much of the catchment was vegetated in thick podocarp forest. Deforestation, farm development and the introduction of new plant and animal species have no doubt caused major changes to the lake ecosystem.

Land tenure: The lake is Crown land and Maori Fishing Reserve under Fisheries Regulations, 1986. Surrounding areas are a mixture of freehold land and Maori Reserve land, with small areas of Crown land, including Conservation area and Recreation Reserve.

Conservation measures taken: None. Although the Maori Fishery Reserve status over Lake Forsyth is not intended as a habitat conservation measure, the lake (but not the tributaries) gains some protection from over-exploitation.

Conservation measures proposed: After a detailed survey of Banks Peninsula, Wilson (1992) recommended areas worthy of protection. (Survey results were written up as a Protected Natural Areas Programme report). Lake Forsyth is a "recommended area for protection" (RAP). Other RAPs in the vicinity are 180 ha of native vegetation on Forsyth Spur, above the lake, and 100 ha of dry shrubland and lake shore at Birdlings Flat.

Land use: Non-commercial fishing by Maori people and recreational activities, including boating and duck shooting. The principal land use in surrounding areas is pastoral farming, with limited areas of intensive farming on alluvial soils near Little River. Rural housing settlements at Little River and Birdlings Flat have a mixture of permanent residents and holiday or weekend-only residents.

Maori are thought to have occupied Banks Peninsula for one thousand years (Wilson, 1992). The Lake Forsyth/Wairewa area remains an important settlement area for Maori people. There are several "pa" (village) sites, sacred and historically important sites, and "marae" (meeting places) near the lake.

Possible changes in land use: None known at the lake. Because of the cultural significance of the lake, it is unlikely that local Maori will support any new activities detrimental to the health of the lake. Probable changes in the catchment area include expansion of plantation forestry, farm development and land subdivision for holiday or cottage industry housing. There is growing interest in re-vegetation of parts of Banks Peninsula.

Disturbances and threats: The lake is in a highly eutrophic state, probably as a result of

deforestation and soil and fertiliser run-off from nearby farms. Warm, de-oxygenated water conditions can occur when the lake level is kept low. These conditions lead to an increased risk of toxic algal blooms. In the past, *Nodularia spumigena* blooms have only been toxic to mammals. Future blooms may be toxic to fish and/or birdlife. Eutrophication and commercial eel fishing in tributary rivers are cited as key reasons for reduced eel catches at the lake (Tau *et al*., 1990).

Other ecological disturbances are the use of motor-boats, duck shooting and mechanical opening of the lake outlet, without consideration of impacts on fish, water quality or birds. Water quality may deteriorate further as a result of point source discharges, leaching from a landfill near the lake, and effluent discharge from new houses and existing settlements (Canterbury Regional Council, in prep.).

Hydrological and biophysical values: Wilson (1992) concludes that the lake is a major part of the landscape and biota of the Herbert and Akaroa Ecological Districts, and should not be allowed to deteriorate further.

Social and cultural values: Lake Forsyth/Wairewa is a highly significant place for Maori, especially those of Ngai Tahu "iwi" (tribe). The sub-group Ngati Irakehu is the principal guardian "hapu" (extended family group) of this lake (Tau *et al*., 1990). There are numerous sacred sites around the lake, although few are discussed in public. The lake was, and continues to be, a very important source of traditional foods ("mahinga kai") and fibre, especially waterfowl, marine and freshwater fish, and eels (tuna) *Anguilla australis* and/or A. *dieffenbachii*.

Eels are caught in large numbers during the annual "whakaheke", the season and process of migration to the sea. The value of the kale to Maori has been acknowledged in law since at least 1896. The Treaty of Waitangi (1840) also confirmed unimpeded Maori rights to their fisheries and other resources. Lake Forsyth/Waiwera is the only Maori Fishing Reserve set aside for fin-fish (Tau et al., 1990).

Noteworthy fauna: Lake Forsyth is an important wintering area for the Great Crested Grebe *Podiceps cristatus australis* and the only coastal location regularly used by this species (the grebe is usually found on high country lakes in inland Canterbury). Over 20 grebes have been recorded on the lake in some winters. The lake also supports many other common waterfowl, particularly Anatidae. However, unlike nearby Lake Ellesmere, Lake Forsyth is not a major site for migratory shorebirds.

Birds recorded at the lake include Black Shag *Phalacrocorax carbo*, Little Shag P. *melanoleucos*, Cattle Egret *Bubulcus ibis*, White-faced Heron *Egretta novaehollandiae*, Great Egret or White Heron *E. alba*, Royal Spoonbill *Platalea regia*, Black Swan *Cygnus atratus*, Canada Goose *Branta canadensis*, Paradise Shelduck *Tadorna variegata*, Grey Teal *Anas gracilis*, Mallard *A. platyrhynchos*, Grey Duck *A. superciliosa*, New Zealand Shoveler *A. rhynchotis variegata*, Australasian Harrier *Circus approximans*, Pukeko *Porphyrio porphyrio melanotus*, South Island Pied Oystercatcher *Haematopus finschi*, Pied Stilt *Himantopus leucocephalus*, Banded Dotterel *Charadrius bicinctus*, Spur-winged Plover *Vanellus miles*, Southern Black-backed Gull *Larus dominicanus*, Black-billed Gull *L. bulleri*, Caspian Tern *Sterna caspia*, White-fronted Tern *S. striata*, Black-fronted Tern *Chlidonias albostriatus*, New Zealand Kingfisher *Halcyon sancta vagans* and Welcome Swallow *Hirundo tahitica neoxena* (Wilson, 1992). The Australasian Bittern *Botaurus poiciloptilus* is probably no longer present at the lake.

Lake Forsyth is renowned for its eels *Anguilla australis* and/or A. *dieffenbachii* which migrate from the lake and its tributaries to the sea in late summer to spawn. The lake and streams also contain whitebait (immatures of Galaxiid species) and a range of estuarine and freshwater fin-fish.

The invertebrate fauna is not well known. Most obvious are huge breeding swarms of the lake midge *Chironomus zealandicus* (Wilson, 1992).

Noteworthy fauna: There are no records of rare or unusual plants at Lake Forsyth. The regionally rare, sand-binding plant Pingao *Desmoschoenus spiralis* occurs on coastal dunes near the outlet of Lake Forsyth. The wetlands and dry lake margins support good examples of local plant communities.

Scientific research and facilities: There are no research facilities at the lake. Early research into water quality and productivity is listed in Livingston *et al*., (1986b).

Conservation education: None.

Recreation and tourism: Water sports such as boating and water-skiing have declined at Lake Forsyth because of the loss of water quality. The waters are not clean enough for swimming. The lake remains an important local recreation area for trout fishing, game-bird shooting and boating. The lake and steep hills form a scenic landscape, highly visible from a main road.

Management authority: The Department of Conservation (Canterbury Conservancy) is responsible for the management of wildlife; on-site management, such as Great Crested Grebe monitoring, is undertaken by the Department's Christchurch Field Centre. Ngai Tahu "iwi" and local "runanga" (management committees) are responsible for the management of Wairewa Maori Fisheries Reserve. Banks Peninsula District Council is responsible for resource consents, district planning and day-to-day management of lake levels and opening of the lake outlet. Canterbury Regional Council is responsible for management of water, soil, gravel and other natural resources, as well as pollution and flood control. The North Canterbury Fish and Game Council manages sport fishing (trout) and game-bird hunting.

Jurisdiction: Functional: North Canterbury Fish and Game Council and Department of Conservation. Territorial: Banks Peninsula District Council Canterbury Regional Council.

References: Canterbury Regional Council (in prep.); Livingston *et al*. (1986b); Tau et al. (1990); Wilson (1992).

Reasons for inclusion:

2a Lake Forsyth is used by significant numbers of a globally threatened species of bird, *Chlidonias albostriatus*.

2c The lake is of special value as the habitat of fish (notably Anguilla spp.) and birds (notably *Podiceps cristatus*) at critical stages in their biological cycles.

2d The lake is of special value for its endemic species of birds, notably *Tadorna variegata, Haematopus finschi, Larus bulleri* and *Chlidonias albostriatus*.

Source: Jenny Steven

Lake Ellesmere (65)

Location: 43°47'S, 172°28'E. 20 km south of Christchurch City and Banks Peninsula, South Island.

Area: c.20,000 ha, but significant variation in surface area, depending upon water level. Length of shoreline c.58 km.Altitude: Sea level to 2 m.

Overview: Lake Ellesmere (Te Waihora) is a large, bar-type lagoon, once the estuary of the Waimakariri River. The brackish lake water is separated from the Pacific Ocean by a shingle barrier, the Kaitorete Spit. Water levels vary by up to 3.6 m with season, and daily

fluctuations occur in response to changes in wind direction. Due to periodic flooding of surrounding farmland, the lake is opened to the sea two or three times a year to lower the water levels. Lake Ellesmere is the largest brackish lagoon habitat in New Zealand, a habitat type which in itself is uncommon in this country. Approximately 80 species of birds regularly inhabit the catchment, and species richness is greater than that recorded for any other locality in New Zealand. The wetland is also particularly noteworthy for the extensive saltmarsh plant communities and rushlands which separately dominate large segments of the lake shore.

Physical features: Lake Ellesmere is enclosed by a barrier, the Kaitorete Spit, which was formed as a result of long-shore drift. The spit abuts the southern boundary of Banks Peninsula and borders the Canterbury Plains which extend west to the foothills of the Southern Alps. A total of thirty seven rivers, streams and artificial drains flow into the lake. Five of these are major waterways: the Selwyn, Irwell, LII and Halswell Rivers and Harts Creek. With low rainfall, groundwater supply is an important contributor to the lake, and artesian water sources are within a few metres of the surface everywhere around the lake. Annual rainfall is approximately 650 mm, evenly distributed throughout the year, but can be highly variable seasonally. The climate is mild, but frequent droughts occur in summer and early autumn. Soils around the lake are weakly developed, with ill-defined top soils and undeveloped sub-soil. There are significant areas of saline soils around the lake, with the most extensive area adjoining the northern shoreline. The lake is polytrophic and contains high levels of sodium, magnesium, sulphate and chloride. The average depth ranges from 2.5 to 4.5 m, and water levels continually change throughout the year because of seasonal changes in rainfall, catchment inputs and evaporation rates, and because of mechanical opening of the lake to the sea. Strong prevailing winds result in the lake waters being permanently turbid.

Ecological features: The extensive freshwater swamplands which once surrounded Lake Ellesmere have been almost entirely drained and developed into farmland since European colonisation, and little now remains except for some tiny areas scattered around the lake shoreline at Yarr's Flat, Hart's Creek and Lakeside. At present, the main habitat types are the extensive rushlands (*Juncus, Carex, Scirpus and Leptocarpus* spp.) which dominate the lake shore and semi-developed farmlands inland from Yarr’s Flat and around the Halswell River, the Shore Ribbonwood *Plagianthus divaricatus* which extends over much of Kaitorete Spit, and three broad types of saltmarsh progressing from *Mimulus repens/Lilaeopsis novaeselandise* communities through *Salicornia australis, Cotula coronopifolia* and *Triglochin striata* to *Hardeum marinum* and *Agrostis stobonifera* on the basis of decreasing inundation frequency. The main areas of these latter plant communities are along the Greenpark Sands from the Halswell River to Kaituna Lagoon and at the tip of Kaitorete Spit.

Monocultures of Raupo *Typha orientalis* occur as narrow strips around Kaituna Lagoon and the Halswell River, and as extensive beds around Harts Creek. An extensive area of willow *Salix* spp. is located at Harts Creek, and smaller areas are present near the mouth of the Irwell River and Taumutu. Two inlet rivers, the Selwyn and LII, are fringed with large overhanging willows for several kilometres upstream. The dominant submerged plant species are *Ruppia megacarpa* and *Potamogeton pectinatus*.

Land tenure: The bed of Lake Ellesmere is controlled by a variety of Government, ad hoc and local public agencies. Leases in Perpetuity (LIPs) are the major "private" land tenure around the lake, and include large areas of lake bed and wetlands, notably around the Kaituna Lagoon and the area from Harts Creek to Yarr’s Flat. Most land adjoining the lake to the south, west and north is freehold farmland in various stages of development. There is an area of Maori land at Taumutu, and a substantial part of Kaitorete Spit which borders the

lake is local authority or Crown land leased for grazing. All Crown land lake bed is presently subject to a Treaty of Waitangi claim by Ngai Tahu.

Conservation measures taken: Six separate but relatively small land areas adjoining the lake have been designated as Wildlife Refuges and Wildlife Management Reserves, and one Scientific Reserve has been established primarily for botanical values. Other small areas of lake shore land have been designated as reserves for river protection and other purposes. A National Water Conservation Order was granted in February 1988; this designates the range of water levels within which the lake is to be managed. Constraints are placed on the stop-banking of leasehold lands adjoining the lake.

Conservation measures proposed: In 1987, there was a proposal for the designation, under a Crown land (Ellesmere wetlands) policy statement, of approximately 19,700 ha of Crown land lake shore and lake bed to be subject to management which gives emphasis to protection of wetlands. This proposal has now been overtaken by the Ngai Tahu Maori land claim which includes all remaining Crown land lake shore and lake bed. The claim is concerned with management of the wetland. A proposal to establish a number of observation facilities from which to view the resident wildlife remains under consideration.

Land use: Lake Ellesmere and its major inflows constitute a locally and regionally important recreational fishery for trout, perch, flounder and whitebait, and a major national commercial fishery for eels and flounder. Lake Ellesmere is also the most important game-bird shooting area in the region. The lake attracts and can cater for most boating activities. A number of public domains and informal areas are used for picnics and passive recreation, and there is considerable potential for walkways, nature and historic trails and wildlife appreciation.

Most LIPs and private land adjoining the lake have been subject to extensive drainage and some degree of development for farming purposes. With the exception of Kaitorete Spit, the major portion of the land area within the immediate vicinity of the lake is subject to intensive management for dairy, sheep and beef farming and arable cropping purposes. Several distinctive hut settlements have been established in close proximity to the lake, and these are intensively utilised as bases from which to pursue a variety of recreational activities on and around the lake.

Substantial volumes of water are drawn off from both inflowing rivers and streams and from groundwater reservoirs to satisfy irrigation demands for cropping and grazing on farmland in the catchment of the lake and adjacent to it. This practice accentuates the extremely low inflows which prevail during the summer and autumn months, and contributes to the process of nutrient runoff which accumulates within the lake basin.

Possible changes in land use: Changes in the immediate vicinity of the lake include selective removal and control of willow from within the Harts Creek Wildlife Refuge, development of the underlying aquifer in the Yarr's Flat Wildlife Management Reserve, and selective creation of water retention sills on the Greenpark Sands to enhance and retain wetland values through drought periods. It is not possible to predict the outcome of the Treaty of Waitangi claim by Ngai Tahu; however, the outcome is likely to affect management of the wetland. Ngai Tahu are concerned about water quality and the fisheries in-282A Directory of Wetlands in New Zealand particular.

There is likely to be a gradual change to more intensive and varied land use patterns in the catchment area, particularly involving horticulture, pip and other fruit production.

Disturbances and threats: Land management practices are continually impacting on wetland habitat values as a consequence of regular livestock grazing within the rushlands, saltmarsh and shore ribbonwood areas. Nutrient run-off and accumulation within the lake basin are a major and increasing threat to water quality. Continuation of the

eutrophication process will see further progressive degradation of the floral and faunal values of the lake. Ongoing clearance of lake shore and adjacent rushlands reduces landscape and waterfowl habitat values.

Hydrological and biophysical values: Lake Ellesmere traps and ponds the discharge from groundwater, inflowing drains, streams and rivers within the catchment. The extent and quality of the wetland is thus influenced by inflow volumes, quality of inflowing water, and timing and duration of lake openings. The average inflow has been calculated to be 9 cubic metres per second, with flood peaks as high as 476 cubic metres per second. Groundwater is an important contributor to the lake, but availability and flow is dependent upon lake level, inflow drains, soil moisture and amounts of groundwater usage for seasonal irrigation. Evaporation often exceeds catchment inputs through the summer. Wind-lash has a significant influence on water depth over shallow lake margins and adjacent saltmarsh and farmland.

Social and cultural values: The lake is close to the city of Christchurch and is of considerable social significance to the region for participation in a variety of outdoor activities. There are five hut settlements scattered around the lake, most of which are fully occupied during weekends and other holiday periods. Peak activity occurs during the summer and autumn seasons, and is aquatically oriented, focusing strongly on the major inflowing rivers and the open waters of the lake.

Known to Maoris as Te Waihora ("water spread out"), Lake Ellesmere is of very considerable significance to the Ngai Tahu tribe. In pre-European times, the lake and surrounding wetlands were of great importance as a source of food and materials for transport, home and industry. Little Maori land remains in the area today, but the remnants of "pa" (settlements), "kainga" (homes), camp sites and "urupa" (burial sites) found around the lake indicate that the shoreline must, at one time, have carried a considerable permanent population. In response to the Ngai Tahu claim for the return of Waihora, the Waitangi Tribunal has recommended two alternatives for vesting ownership of the lake in Ngai Tahu and for its ongoing joint management.

Many archaeological sites and Maori and European cultural features have been identified in close proximity to the lake and along Kaitorete Spit. Four Maori "pa" sites existed close to the lake, while early European activities were concerned with the extraction of timber from Banks Peninsula for use by the construction industry in Christchurch and railway development to link Christchurch with Akaroa harbour.

Noteworthy fauna: Twenty-six species of fish, including both freshwater and marine species, have been recorded in the lake, although some (e.g. basking shark) are only visitors when the lake is open to the sea. Sixteen fish species are resident, including the Short-finned Eel *Anguilla australis*, Longfinned Eel *A. dieffenbachii*, flounder *Rhombosolea* spp., whitebait *Galaxias* spp., Brown Trout *Salmo trutta*, Perch *Perca fluviatilis*, Common Smelt *Retropinna retropinna*, Common Bully *Gobiomorphus cotidianus* and Giant Bully *G. gobioides*. Six of the fish species inhabiting the lake are commercially significant.

One hundred and fifty-eight species of birds (including 133 native species) have been recorded at the lake or in peripheral habitats, or as stragglers along Kaitorete Spit. About 80 species occur as regular users of the lake. Species richness is greater than that recorded for any other locality in New Zealand. During 1981/82, the lake generally held between 17,600 and 30,100 ducks, geese and swans at any one time. It has been estimated that 75% of the total population of New Zealand Shoveler *Anas rhynchotis variegata* pass through Ellesmere annually. The lake supports a sizeable proportion of the New Zealand populations of at least 17 species of waterfowl, including two species of herons, six species of swans, geese and ducks, five species of international migratory shorebirds, four species of

indigenous shorebirds and one endemic species of gull. Notable species include Cattle Egret *Bubulcus ibis* (20% of the New Zealand population), Mute Swan *Cygnus olor* (25%), Black *Swan C. atratus* (10%), Canada Goose *Branta canadensis* (30%), Grey Teal *Anas gracilis* (20%), Pied Stilt *Himantopus leucocephalus* (up to 50%), Banded Dotterel *Charadrius bicinctus* (25%), Wrybill *Anarhynchus frontalis* (10%), Pacific Golden Plover *Pluvialis fulva* (up to 17%), Pectoral Sandpiper *Calidris melanotos* (up to 33%), Sharp-tailed Sandpiper *C. acuminata* (up to 28%), Rednecked Stint *C. ruficollis* (up to 68%), Curlew Sandpiper *C. ferruginea* (up to 58%) and Black-billed Gull *Larus bulleri* (up to 20%).

Noteworthy flora: The predominant vegetation types around the shoreline of Lake Ellesmere are:

- the extensive saltmarsh plant communities which extend generally along the Greenpark Sands, from the Halswell River to the Kaituna Lagoon and at the tip of Kaitorete Spit;
- the rushlands which dominate the shore of the lake and surrounding semi-developed farmlands, dominated by *Juncus maritimus,* with *J. pallidus, J. gregiflorus* and *Carex* spp. also scattered throughout, along with areas of Shore Ribbonwood *Plagianthus divaricatus*;-the extensive beds of Raupo *Typha orientalis* which occur around Harts Creek, the LII River mouth and Taumutu Lagoon and as narrow strips around Kaituna Lagoon and the Halswell River mouth;
- the extensive area of willows *Salix* spp. at Harts Creek.

Scientific research and facilities: More than fifty scientific papers and reports dealing with a wide range of ecological studies within the Lake Ellesmere catchment have been completed. These studies have included studies of the flora, invertebrates, eel fishery, fish stocks, birdlife, groundwater, lake level stabilisation, drainage, reclamation and soils. various past symposia have focused on different ecological issues of concern within the catchment. The Lincoln University campus is situated within 5 km of the Selwyn River mouth, and the Ilam campus of the University of Christchurch is situated within the city, approximately 20 km northeast of the lake.

Conservation education: While no formal programmes apply to Lake Ellesmere, the fauna and flora, wildlife habitats and ecological issues of concern are regionally important to academic institutions at all levels for conservation education and training. The lake is readily accessible from Christchurch City, and there is considerable potential for walkways, nature and historic trails, and wildlife appreciation.

Recreation and tourism: Lake Ellesmere is the most important game-bird shooting area within the Canterbury Region, and is locally important as a recreational fishery for trout and flounder. The lake attracts and can cater for most boating activities, and land-yachting is a popular activity on farmland bordering the Greenpark Sands. The five hut settlements around the lake are heavily utilised by holiday-makers during the peak summer months and by game-bird shooters during autumn and winter.

Management authority: The Department of Conservation (Canterbury Conservancy) is responsible for management of flora and fauna, Wildlife Refuges, Wildlife Management Reserves and Scientific Reserves; the Department's Christchurch Field Centre is responsible for day-to-day management. Selwyn District Council and Banks Peninsula District Council, which jointly share territorial responsibility for Lake Ellesmere, have statutory responsibilities under the Resource Management Act 1991 for water resources and the preparation of coastal plans. The North Canterbury Fish and Game Council manages sport fishing (trout and perch) and game-bird hunting.

Jurisdiction: Territorial: Selwyn District Council and Banks Peninsula District Council. Functional: Department of Conservation (Canterbury Conservancy) and North Canterbury Fish and Game Council.

References: Burrows (1970); Dalmer (1980); Graynoth & Skrzynski (1973); O'Donnell (1985); Palmer (1982, 1986); Ryan (1974).

Reasons for inclusion:

1d Lake Ellesmere is the only very large area of brackish lagoon habitat in New Zealand. This habitat type is uncommon in New Zealand, and most brackish lagoons are very small.-284A Directory of Wetlands in New Zealand

2a The lake is used by significant numbers of three globally threatened species of birds, *Botaurus poiciloptilus*, *Himantopus novaezelandiae* and *Anarhynchus frontalis*.

2b The lake is of special value in maintaining the genetic and ecological diversity of the region because of its large size, diversity of microhabitats and high species richness (e.g. 47% of all bird species recorded in New Zealand).

2c The lake and associated wetlands are of special value as the habitat of bird species at critical stages in their biological cycles. They provide wintering habitat for migratory shorebirds form the Arctic (during the New Zealand summer) and very important wintering habitat for a variety of indigenous bird species. The lake is also important habitat for a wide variety of fish species.

2d The lake is of special value for its endemic species of fish and birds, notably fish such as *Anguilla dieffenbachii*, *Retropinna retropinna*, *Gobiomorphus cotidianus* and *G. gobioides*, and birds such as *Anas rhynchotis variegata*, *Himantopus novaezelandiae*, *Anarhynchus frontalis* and *Larus bulleri*.

3a The lake regularly supports over 20,000 waterfowl.

3c The lake regularly supports over 1% of the regional populations of *Cygnus atratus* (10%), *Anas gracilis* (20%), *A. rhynchotis variegata* (75%), *Charadrius bicinctus* (25%), *Anarhynchus frontalis* (10%) and *Larus bulleri* (20%).

Source: Dick Hutchinson and John Andrew.

Te Whanga Lagoon and Lake Wharemanu (66)

Location: 43°50'S, 176°37'E. In the Chatham Islands. The site extends over the greater portion of the northeastern sector of the main Chatham Island, and covers the major part of the area between the settlements of Kaingaroa in the northeast, Owenga in the southeast and Waitangi in the southwest. Lake Wharemanu is centrally located immediately adjoining the northern border of the lagoon.

Area: c.18,600 ha, comprising about 20% of the total area of the island.

Altitude: Sea level to 2 m.

Overview: A very large bar-type lagoon separated from Hanson Bay and the Pacific Ocean to the east by a narrow sandspit and associated sand dune system. The lagoon waters are strongly brackish, to the extent that typically marine species of fish and shellfish which gain access to the lagoon are able to survive for very long periods of time. There is relatively little seasonal variation in water levels, and the natural opening and closing cycle of the lagoon outlet to the Pacific Ocean is approximately seven years, although it is artificially opened periodically to regulate water levels. The lagoon is important habitat for a wide variety of species of shags, swans, ducks, migratory shorebirds and gulls. Floral communities of note on the land adjoining the lagoon include some significant stands of mixed broadleaf forest on the steeper western shore and expanses of short saltmarsh turf

intermixed with stands of taller native rush on the broad, gently tapering shores adjoining the lagoon to the north, east and south.

Physical features: Te Whanga Lagoon is barrier-enclosed to the east by a long sandspit forming the coastline of Hanson Bay which extends southward from Okawa Point to the settlement of Owenga. The lagoon extends for approximately 24 km from north to south and is about 16 km wide at its widest point. The water body is comprised of three basins, separated by very extensive areas of sandy shallows which also continue along the entire length of the eastern shore. Principal inflows are the 19 named and unnamed creeks and the Te Awainanga River which drain the lands to the west and south of the lagoon. There are six islands of varying size scattered throughout the lagoon, most of which are accessible to sheep and cattle.Most of the western shore of the lagoon is characterised by the presence of limestone which in places forms low cliffs immediately adjoining the shoreline. Elsewhere, the sandy beach and narrow plain are backed by limestone banks and thence rolling peatland or rich mineral soils, while in other portions, the shore plain leads directly to peatland. The northern, eastern and southern shores are frequently peat slopes with shallow coverings of sand. The climate is strongly maritime, being characterised as cool, cloudy and windswept with air temperatures ranging between a low of 5°C in winter and a high of 18°C in summer.

Ecological features: The Chatham Islands group are known to be a centre of endemism for both flora and fauna. The original vegetation cover of Karaka **Corynocarpus laevigatus** and swamp forest, scrub and rushlands once surrounding Te Whanga Lagoon has been substantially modified under the influence of Maori and European settlement, and most of the original plant cover has now been replaced by introduced pasture grasses or bracken and umbrella fern. Periodically inundated areas of shore to the west of the lagoon support small native saltmarsh species including Shore Pimpernel **Samolus repens, Selliera radicans** and *Triglochin striata*, mixed with introduced grass species, Buck's Horn Plantain *Plantago coronopus* and scattered taller rushes and sedges including Three-square *Schoenoplectus pungens*. Bracken fern communities in association with native herbs (species *of Libertia, Pratia, Lobelia, Gunnera, Drosera, Thelmitra* and *Gentiana*, and *Cyathodes robusta*) are common where peats extend to or adjoin the shoreline, and some significant stands of mixed broadleaf forest, dominated by Kopi or Karaka *Corynocarpus laevigatus* with Hoho, Kowhai *Sophora* spp. and Akeake *Dodonaea viscosa*, adjoin the western shores to the south of Moutapu Point. Elsewhere along the northern, eastern and southern boundaries of the lagoon, broad, gently tapering and intermittently flooded shores support expanses of short saltmarsh turf (including species of *Selliera, Samolus, Leptinella* and *Triglochin*) and stands of the taller Jointed Rush *Leptocarpus similis* and Sea Rush *Juncus maritimus*. A valuable expanse of the endemic Chatham Island Aster *Sporodanthus traversii* habitat is supported on the reserve land adjoining the saltmarsh at Ocean Mail.

Land tenure: With the exception of an area in the northeast corner of the lagoon owned by the Land Corporation of New Zealand, the bed of Te Whanga is Crown land. The excluded area identified above totals 829.6 ha; it is subject to varying degrees of periodic flooding, and is leased for grazing purposes under Licence to Graze No. 151. The land adjoining the lagoon is almost all privately-owned, most being currently utilised for farming and grazing purposes. Exceptions are a 20-metre wide strip of land reserved from sale under Section 58 of the Land Act 1948, which extends along the eastern shore from Rangiauria at the end of the true right bank of the Te Awainanga River to the Waitangi Wharf-Owenga Road bridge, identical reserve strips around the perimeters of Waikawa and Te Awapatiki islands, a Local Purpose (Esplanade) Reserve of 0.992 ha adjacent to Waikato Point, the Chudley Recreation Reserve of 37.4 ha immediately to the northwest of Tokonewa Creek outfall, and the Ocean

Mail Scenic Reserve of 831 ha which in part borders the lagoon and Lake Wharemanu immediately south of Ocean Point.

Conservation measures taken: Ocean Mail Scenic Reserve was established in 1990, primarily to protect botanical values within the area adjoining the lagoon and Lake Wharemanu, and extending northward to Ocean Mail Point on the island's north coast. Various areas of native forest situated on private land bordering or in the near vicinity of the lagoon at Te Awapatiki, Wairoa, Rangatira and Big Bush are protected under Forest Heritage Fund and Nga Whenua Rahui covenants.

A substantial amount of fencing has been erected during recent times to secure the boundaries of the Ocean Mail Scenic Reserve and several of the Forest Heritage and Nga Whenua Rahui covenanted areas against intrusion by domestic livestock.

Conservation measures proposed: None known.

Land use: Limited harvesting of whitebait Galaxias spp., juvenile smelt Retropinna retropinna, eels Anguilla spp., flounder Rhombosolea spp. and other marine fish is undertaken in the lagoon by residents of Chatham Island. A low level of game-bird hunting occurs during a two-month season (May and June) for Grey Duck *Anas superciliosa*, Mallard *A. platyrhynchos* and Pukeko *Porphyrio porphyrio melanotus*, and during an eleven-month season (May to March) for Black Swan *Cygnus atratus*. Black Swan eggs are selectively harvested by some island residents throughout the nesting period, and Eastern Buff Weka *Gallirallus australis hectori* are hunted irregularly, although they may legally be hunted throughout the year.

Most of the private land surrounding both Te Whanga Lagoon and Lake Wharemanu has been subject to some degree of clearance and development for farming of sheep and/or cattle. Development culminating in established pasture is most pronounced and extensive on those lands bordering the western shores of the central and southern basins of Te Whanga, where the highest stocking densities for sheep and cattle are manifest. Elsewhere around the lagoon, the land is utilised for rough grazing at lower stocking densities, primarily for beef cattle.

Possible changes in land use: There is potential for the development of commercial harvesting of fish stocks within the lagoon, particularly targeting flounder and eels. There is a possibility of progressive development of the remaining scrublands within the catchment area for more intensive farming, or alternatively, increased plantings for exotic forestry development, particularly over that portion of the southern tablelands draining to the lagoon. Eco-tourism is a small but growing industry on the island; this, in part, focuses on the lagoon. Harvesting of sphagnum moss is a recent development within the lagoon catchment.

Disturbances and threats: Uncontrolled grazing by domestic livestock within the reserves adjoining the lagoon and on the islands adjacent to Kahupiri Point and Te Awapatiki is damaging the existing wetland habitat values. Gamebird hunting and other recreational activities are a primary source of disturbance to protected fauna inhabiting these wetlands, particularly the migratory shorebirds.

Commercial fishing and aquaculture are potential threats to the lagoon ecosystem. A similar threat is posed by changes to rates of nutrient run-off within the catchment area and their accumulation within the lagoon, which may result from changes to or intensification of farming practices, sphagnum moss harvesting and peat mining. The spread of weeds (Gorse and Himalayan Honeysuckle) is a potential threat to shoreline habitat values and the indigenous flora bordering the lagoon and Lake Wharemanu. Increased ecotourism on Chatham Island may threaten archaeological sites adjacent to the wetland. Development of the hydro-electric generating potential existing within the Te Awainanga River catchment would adversely impact on the migratory life cycle of resident freshwater fish species.

Hydrological and biophysical values: Te Whanga Lagoon is important for the support of food chains upon which a considerable range of fish, shellfish and waterfowl species depend. The lagoon plays a general role in the maintenance of water quality.

Social and cultural values: Readily accessible at a number of locations around its perimeter, the lagoon is of some importance to the residents of Chatham Island as an area for food gathering and recreational activities. Harvesting of a variety of fish species, including whitebait Galaxias spp., smelt, flounder, eels etc., and waterfowl, such as Black Swan, Grey Duck and Mallard, is important to many residents, as is the collecting of Black Swan eggs and the hunting of Weka Galbrallus australis hectori. The lagoon is also important to the growing eco-tourism industry on the Chatham Islands, as a major wetland habitat around which a number of rare species of wildlife, many of which are unique to the island group, can be observed.

The Chatham Islands were first settled by Moriori and later by Maori (of Ngati Mutunga and Ngati Tama tribes), and the lagoon undoubtedly assumed considerable significance to those original inhabitants, as an alternative food source to the surrounding ocean, particularly during times when adverse sea conditions prevented food gathering from coastal sites. Both the name of the lagoon (Te Whanga: "the sheltering place" or "inner bay") and place names such as Te Awapatiki ("path of the flounder") in the vicinity of the natural outlet to the lagoon are to an extent indicative of that importance.

Various important archaeological sites have been identified in a number of different locations around the lagoon. Te Awapatiki holds deep cultural and spiritual significance for the descendants of the original Moriori inhabitants of the island; it was a highly "tapu" (sacred) place and venue for the most solemn Moriori deliberations. "Ana kowhati" (petroglyphs or rock drawings) adorn the limestone cliffs bordering the western shore of the lagoon, "rakau whakapahoho" (Moriori tree carvings) exist in a number of adjoining remnant patches of forest, and there are a number of "parahanga" (middens) and "urupa" (burial places) on the lands bordering the lagoon.

Noteworthy fauna: Because of its high salinity and relationship to the adjacent Pacific Ocean, Te Whanga lagoon contains an abundant and diverse fish fauna, including Long-finned Eel *Anguilla dieffenbachii*, Short-finned Eel *A. australis*, Giant Kokopu *Galaxias argenteus*, Banded Kokopu *G. fasciatus*, Koaro *G. brevipinnis*, Inanga *G. maculatus*, Red-finned Bully *Gobiomorphus huttoni*, Common Smelt *Retropinna retropinna*, Yellow-eyed Mullet *Aldrichetta forsteri*, flounders *Rhombosolea* spp. and Kahawai *Arripis trutta*. The Giant Kokopu is also resident in one or more of the freshwater catchments draining into the lagoon.

The wetland is also a very productive habitat for many species of waterfowl, the most abundant of which is a local population of approximately 8, 000 Black Swan *Cygnus atratus*. Other species recorded include Chatham Island Shag *Leucocarbo onslowi*, Pitt Island Shag *Stictocarbo featherstoni*, Chatham Island Oystercatcher *Haematopus chathamensis*, Banded Dotterel *Charadrius bicinctus*, Bar-tailed Godwit *Limosa lapponica*, Red Knot *Calidris canutus*, Sharp-tailed Sandpiper *C. acuminata* and Ruddy Turnstone *Arenaria interpres*. A number of other more common species of waterfowl have also been recorded around the lagoon (A. Grant, pers. comm.).Noteworthy flora: The broad, intermittently flooded shores bordering the northern, eastern and southern boundaries of the lagoon support expanses of short saltmarsh turf, with native species of *Selliera, Samolus, Leptinella* and *Triglochin*, and stands of the taller native Jointed Rush *Leptocarpus similis* and Sea Rush *Uncus maritimus*. An expanse of Chatham Island Aster *Sporodanthus traversii* is included within the Ocean Mail Scenic Reserve where it borders the lagoon and Lake Wharemanu. Along the western shore of the lagoon, areas that are periodically inundated support Shore *Pimpernel Salmolus repens, Selliera radicans* and *Triglochin*

striata, which are intermixed with introduced grass species and Buck's Horn Plantain Plantago coronopus.

Areas of peat generally support bracken fern communities which may also have a relatively rich association of other native herbs (species of *Libertia*, *Pratia*, *Lobelia*, *Gunnera*, *Drosera*, *Thelymitra* and *Gentiana*, and *Cyathodes robusta*), and in some cases are showing signs of regenerating some of the original forest species such as Kowhai *Sophora* spp. and Hoho *Pseudopanax chathamicum*. South of Karewa Point, some significant stands of Kopi Corynocarpus laevigatus dominated-mixed broadleaf forest adjoin the lagoon. Lake Wharemanu is a peat lake with steep banks, and is almost surrounded by a band of tall dense New Zealand Flax *Phormium tenax* in association with other species such as Jointed Rush, Spike Rush, Club Rush, the fern *Blechnum minus*, *Carex* sp. and the shrub *Coprosma propinqua* var. *martini* (Amanda Baird, pers. comm.).

Scientific research and facilities: There are no facilities for scientific investigation around the lagoon, and although limited accommodation is available on the island, the remoteness of the Chatham Islands from mainland New Zealand plus the high cost of transport are significant obstacles in the way of any research of the lagoon, Lake Wharemanu and/or their associated fauna and flora. At least three general surveys of the Chatham Islands freshwater fish fauna have been completed since 1957. Some field work undertaken since 1987 by the Department of Conservation, in cooperation with members of the Royal Forest and Bird Protection Society, has been directed toward updating and improving information on the fauna and flora of the lagoon and adjacent wetlands.

Very limited to date and applicable largely to the resident population of Chatham Island. The conservation values of these two wetlands are of some importance to the eco-tourism industry which is growing on the islands.Recreation and tourism: Current use is minimal and largely restricted to the small resident community. Potential future use for these purposes is similarly limited due to the remoteness of the Chatham Islands from the major population centres on mainland New Zealand and the comparative high cost of air transport from Christchurch, Wellington or Napier.

Management authority: The Department of Conservation (Canterbury Conservancy) is responsible for management of flora and fauna and management of game-bird hunting seasons; the Department's Chatham Islands Field Centre in the Chatham Islands is responsible for day-to-day management. Chatham Island County Council has statutory responsibilities under the Resource Management Act 1991 for water resources and development proposals.

Jurisdiction: Territorial: Chatham Island County Council. Functional: Department of Conservation (Canterbury Conservancy).References: Hay et al. (1976); Moreland (1957); Rutledge (1992); Skrzynski (1967); Stokell (1949); Thompson (1983).

Reasons for inclusion:

1a Te Whanga Lagoon is an excellent example of a very large brackish lagoon, the largest example of this type of wetland in the Chatham Islands. Lake Wharemanu is one of the best, largely unmodified examples of a peat lake on Chatham Island.

2a The wetlands support populations of two threatened species of fish, *Galaxias fasciatus* and *G. argenteus*, and three globally threatened species of birds, *Leucocarbo onslowi*, *Stictocarbo featherstoni* and *Haematopus chathamensis*.

2b The wetlands are of special value for maintaining the genetic and ecological diversity of the region because of their diverse flora and fauna and presence of a number of endemic and threatened species. The large size of Te Whanga Lagoon (approximately 20% of the total area of Chatham Island) contributes to the high value of this wetland for a wide variety of sea-birds, *Anatidae* and shorebirds. At

least eleven species of fish representative of both freshwater and marine habitats have been recorded from the lagoon.

2c The wetlands are of special value as the habitat of fish and bird species at critical stages of their biological cycles.

2d The wetlands are of special value for their endemic plant, fish and bird species, notably the plants *Leptocarpus similis, Sporodanthus traversii* and *Pseudopanax chathamicum*, the fish *Galaxias fasciatus* and *G. argenteus*, and the birds *Leucocarbo onslowi*, *Stictocarbo featherstoni* and *Haematopus chathamensis*.

3c The wetlands regularly support over 1% of the regional population of *Cygnus atratus*.

Source: Dick Hutchinson. Also personal communication from A. Baird and A. Grant, Department of Conservation, Christchurch..