

## Wetlands of the Otago Region

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## ***Objective***

Information in this report was compiled by scientists from Manaaki Whenua - Landcare Research and Otago Regional Council, to assist with the implementation of the recent National Policy Statement for Freshwater Management (NPS-FM 2020). The aim is to provide a background document describing the diversity of wetlands across the Otago region. The report places the Otago wetlands in a national context, describes the types and diversity of wetlands in the region, and provides an account of wetlands in each of the Freshwater Management Units and Rohe developed for the Otago Region. These accounts are based primarily on the Regionally Significant Wetlands (RSWs) identified by the Otago Regional Council in the Regional Plan – Water for Otago (listed in Appendix 1 and shown on maps in Appendix 2). This list is not comprehensive, because only wetlands of known extent with adequate information for prioritisation were considered when the RSW list was first compiled. The authors note additional wetlands for consideration and include a list of threatened plant species associated with wetlands in the region. The report is primarily focused on the plants and vegetation associated with wetlands, reflecting the author’s expertise.

### ***Background and national context***

Wetlands are permanently or intermittently wet areas, shallow water, and land-water margins that support a natural ecosystem of plants and animals that are adapted to wet conditions (Resource Management Act 1991). They have historical, cultural, economic, and ecological significance. Wetlands can be reservoirs for mātauranga (knowledge), wellbeing, and utilisation (Taura et al. 2021). They are mahika kai (food and other resource gathering sites) used by marae, hapū, and iwi, and provide significant habitats for plants, fish, birds, reptiles, insects, and micro-organisms (Clarkson et al. 2013). In addition, many wetlands contain a variety of culturally important medicinal plants for rongoā (Māori medicinal use) (Taura et al. 2021). Wetlands also perform important ecosystem functions: storing water; filtering sediment, nutrients, bacteria, and toxic compounds; accumulating carbon; and buffering major flooding events. One further value of wetlands lies in their record of vegetation and climate history as derived from pollen and subfossil records (McGlone 2009).

In New Zealand, wetlands manifest as a variety of forms such as lakes, rivers, streams, dune hollows, estuaries, swamps, bogs, and marshes (Clarkson et al. 2013). Wetlands have long been treated as a “Cinderella” ecosystem, generally destroyed to develop farmland. However, the ecosystem services and intrinsic values of wetland are now widely recognised and these habitats are currently the focus of restoration and protection as more is discovered about how they influence and benefit many human activities.

In the last 150 years, some 90% of wetlands in New Zealand are considered to have been lost, with about 250,000 ha of inland wetlands remaining (Ausseil et al. 2008), and those wetlands surviving are under threat from land modification and other human activities. A study into wetland loss between 1996 and 2018 emphasised that, despite the Resource Management Act, which came into effect in 1991 and legislates for wetland protection, nearly 5500 ha of wetlands have been destroyed (Dymond et al. 2021). Most of this loss occurred between 2008 and 2012, when many wetlands were converted to pastoral farming (Dymond et al. 2021). The condition of wetlands has also continued to degrade, including by habitat loss or modification and invasive alien species (Clarkson et al. 2013). Currently, there is renewed interest in knowing the location and condition of all wetlands, for sustaining, managing, and restoring societal and ecological values (Clarkson et al. 2013; Taura et al. 2021).

The national historical pattern of wetland loss is also evident in Otago, especially in the lowlands, and destruction of wetland habitat continues. A recent study measuring changes in the area of freshwater wetland regionally between 1996 and 2018 showed a 1.4% of loss of wetland extent in Otago (Dymond et al. 2021). The total area estimated in 1996 was 24,456 ha, with 341 hectares lost from 40 patches, averaging 8.5 ha, with the largest lost 76.4 ha (Dymond et al. 2021).

The Regional Plan - Water for Otago (RPW) provided protection for 173 wetlands and wetland management areas known as Schedule 9 Regionally Significant Wetlands (RSWs). These areas are mapped and their values have been assessed against significance criteria defined in the RPW. Additionally, most wetlands above 800m altitude were also defined as RSWs, though these have not all been individually identified. Objectives for RSWs include maintaining and enhancing wetland values, and one monitoring measure has included regular boundary inspection. However, no measures were available in the RPW for protection of wetland ecosystems, other than RSWs. Although boundaries of RSWs were mapped, delineated, and inspected, no framework or programme has been implemented to measure the condition of RSWs or to monitor wetland ecosystem extent or condition throughout Otago. These measures are now required under the NPS - FM (2020).

### ***Otago context***

The Otago region contains many diverse and distinctive wetlands, including types that are rare nationally. Unusually, our wetlands often occur in catchments retaining large areas of natural vegetation and consequently many wetlands retain a significant forest/shrubland component that has been eliminated by fire elsewhere (McGlone 2009). The range of wetland types in Otago is a consequence of the varied climate, especially large temperature and rainfall gradients, the presence of multiple mountain ranges, active tectonic processes and both large- and small-scale river systems. Wetlands occur in diverse habitats, from lowland to alpine areas in the Southern Alps, central parts with continental climates, and along the more temperate eastern coastal areas. These factors create a varied landscape supporting thousands of wetlands, a diversity that is arguably unparalleled in any other region of New Zealand. Of the 9 broad wetland hydrosystems recognised nationally by Johnson and Gerbeaux (2004), eight occur in Otago (Palustrine, Riverine, Lacustrine, Estuarine, Marine, Inland Saline, Plutonic, and Nival – Geothermal is the only type absent).

The number, variety, and types of wetlands in Otago are a major natural asset for the region, providing numerous ecosystem services supporting towns and rural communities. These include maintaining abundant, high-quality water, helping in carbon sequestration for mitigation of climate change, providing habitats for indigenous biodiversity and wildlife, and supporting recreational activities. Otago wetlands support a high biodiversity of native plants, fungi and animals, and includes endemic species, southern and northern distributional limits, and best examples nationally of some wetland types.

Otago is the home of several nationally significant wetland systems, either distinctive to, or extensive within the region.

These include:

- Scroll plain and meander wetlands exemplified by the upper Taieri River scroll plain, and the Fortification Stream and other meander systems at many scales, in the uplands. Here, rivers and streams meander across floodplains creating diverse habitats maintained by variable water flows. These systems capture the regional geomorphic history, tectonic, glacial-periglacial, and erosion processes that impact gene flow and species formation.
- String bog or patterned mire wetlands, usually in uplands on central and eastern mountains where low temperatures and nutrient limitations facilitate peat accumulation on gentle slopes, creating extensive cushion bog and fen communities. Examples include stream headwater stepped bogs on the Lammerlaw Range

(Rapson et al. 2006) and the impressive Nokomai/Nevis patterned mires (Mark et al 1995).

- Saline Wetlands are naturally rare ecosystems where local mineralisation and evaporative processes result in accumulation of soluble salts and formation of alkaline soils. They typically occur in semi-arid climates and support salt-tolerant herbaceous vegetation which would otherwise occur in coastal marshes. Sutton Salt Lake and isolated patches through the inland basins of Central Otago, are well known examples (Allen et al. 1997, Rufaut et al. 2018).
- Ephemeral wetlands variously occupy depressions on glacial moraine, slump deposits, and dune hollows, ponded by rainfall in winter and dry in summer. They support mainly prostrate plants and a specialised group of insects. Moraine examples in Otago include the Von Valley and Dart Valley near Paradise. Otago has its own special form of ephemeral wetland hollows in the peneplain crests of the lower Central Otago Ranges, eg. Nenthorn area on the Taieri Ridge (Johnson and Rogers 2003).

## **Wetlands in Freshwater Management Units and/or Rohe**

An FMU is a water body or multiple water bodies that the Otago Regional Council deemed as the appropriate geographic unit for setting freshwater management objectives and limits. The Otago FMU boundaries have been created using cultural, land-use, geological and hydro-geomorphological maps, and other relevant information to identify areas with commonalities. The larger FMUs are subdivided into smaller rohe (see Appendix 2).

This section provides an overview of the physiography and wetlands in each FMU or Rohe, including notable flora, in the Otago Region. The major wetland types and characteristics are noted, including natural values, their extent and condition. Although most of the major wetlands have some information available, many (likely the majority) are not well documented or understood, especially for native invertebrates.

### **Catlins Freshwater Management Unit**

*Overview:* The Catlins area has a cool, temperate, overcast, maritime climate with regular rain and strong southerly winds that foster forest growth, including silver beech and podocarp-broadleaved forest on the steeply sloping hillsides that reach the montane zone (Mt Pye 720m). The distinctive Southland syncline creates trellis-like drainage patterns strongly associated with the underlying orientation of geological formations. The main rivers (Owaka, Catlins, MacLennan, and Tahakopa) all flow eastward from relatively small and still largely forested catchments less than 50 km long, terminating in estuaries at the coast. Sheep and beef farms, with occasional dairy and plantation forestry, are common land uses on flood plains and rolling hill country in northern and western areas. Southern areas of the FMU retain native forests and numerous wetland habitats across the full elevational range.

The Catlins area is exceptional in New Zealand for retaining examples of natural sequences where forest adjoins swamps, bogs and marsh wetlands, as water-courses cross flood plains or are disrupted behind levees or dunes. Pondered hollows in these landscapes create a range of wetlands reflecting age, type of substrate and water regime and many retain linkages to adjoining beech, hardwood, or conifer-rich forest.

The largest wetlands are found in estuaries and swamps near river mouths, notably in the MacLennan River, Molyneux Bay Swamp and Tahakopa River Bogs. These areas support extensive wire rush and tangle fern, well developed flaxlands, and frequent transitional shrubland communities bordering forest associated with better drained or elevated sites. They are exceptional examples of coastal lacustrine and estuarine systems supporting native biota, now lost from eastern South Island, and much of New Zealand.

The Tahakopa/McLennan wetlands are a nationally significant example of the complex landforms in lower reaches of rivers near the sea with examples of dunelands, estuary sedgeland, extensive pūkiō swamplands, small-leaved shrublands, short and tall conifer woodlands, and various lowland forest types.

In upper parts of major river catchments, copper tussock is more widespread on poorly drained topography. The highest wetland in the region is Ajax Hill, and is part of an undulating peaty plateau at c. 700 m which comprises a mosaic of cushion bog, flush, and scrub-woodland communities. Cushion bog peat, covers the plateau, with scattered bushes of manuka and inaka, and adjacent bog pine and mountain cedar. Where the water table surfaces, copper tussock and sphagnum moss are common. *Astelia subulata*, known from subantarctic islands and Stewart Island, has its only Otago record from this site (Johnson et al. 1977). Ajax Bog is not currently included in the ORC list of significant wetlands.

*Regionally Significant wetlands:* Within the Catlins FMU 26 sites are recognised as Regionally Significant Wetlands. These are classified mainly as swamp (12 sites), marsh (7) and fen (4). It should be noted that these nominated classifications of wetland types to sites do not reflect the diversity of habitats associated with many wetlands as larger areas in particular usually have several wetland types that grade into each other, depending on the variety of substrates and water movement in each system. This is evident in the excellent Catlins examples where estuaries and coastal lagoons (e.g. Molyneux Bay Swamp/ Puerua River; Johnson 1977b) are fringed with saltmarsh, then backed by sedgeland, flaxland, and scrub, nourished by freshwater from the land, upon poorly drained gentle slopes. The soils here are a mixture of river sediments and peat: typical swamps, often with runnels or open areas of slow-moving water. At some Catlins sites shrub swamps extend further into forest swamp, with kahikatea and other tree species tolerant of wet soils, variously on river alluvium or upon old sand dunes (e.g., Tahakopa River Bogs; Ward & Munro, 1989).

While coastal dune lands have been much modified throughout New Zealand, along with their associated dune wetlands, the Catlins area still retains examples of young dune hollows with turf and rush vegetation (e.g., False Islet; Johnson 1977a), and the forest swamp fringing Lake Wilkie.

Most RSW sites in the Catlins are either wetlands that occupy valley floors, or the broad fingers of stream headwaters. In the lower reaches of valleys the swamps that occupy strips of relatively fertile floodplain are mainly composed of carex sedges, flax, and toetoe, and the hummocky ground typical of swamps offers sites for with scattered shrubs of manuka, coprosmas, and cabbage trees on the hummock crests (e.g., McLennan River, Lenz Reserve).



In the valley headwaters poorly drained basins of stream tributaries tend to have a main cover of copper tussock and various sedges, as fens (having moderate soil nutrient status, intermediate between that of swamps and bogs), and in many cases now surrounded by developed pasture (e.g., Cairn River Bog, Kuriwao Saddle Complex). A few areas of bog vegetation can occur within these sites, as evidenced by a cover of wire-rush, indicative of peat substrates that have accumulated where nutrient levels are very low, (e.g., Trig Y Bogs).

### **North Otago Freshwater Management Unit**

*Overview:* Extending along the eastern coast from north of Dunedin to the lower Waitaki River and inland to the Kakanui Range, the North Otago FMU comprises small coastal catchments (Kakanui, Waianakarua, Pleasant, Shag, and Waikouaiti Rivers) that arise in rolling uplands having volcanic basalt, schist, limestone, and greywacke rocks, often covered by loess. Warm summers and dry mild winters characterise the climate. Upland areas support extensive areas of native tussock grassland, with native forest and shrubland nowadays limited to isolated refugia from fire in montane and lowland areas nearer the coast. The mild temperate climate facilitates a wide range of land uses, with sheep and beef farming in the uplands, dairy and dairy support concentrated on lowland river flats, and pockets of horticulture on fertile coastal limestone and alluvial soils.

The mild climate and relatively fertile soils from volcanic and limestone substrates in the region have created a distinctive suite of herb-dominated wetlands representing natural eutrophic conditions.

Upland *Schoenus* sedgeland with and without copper tussock, and lowland flaxlands are the most widespread wetland vegetation types in North Otago. Ephemeral wetlands are common, associated with uplands around Nenthorn on the ancient schist peneplain, and largely contained within the Red Bank Wetland Management area (122ha). Elsewhere in this FMU, the largest areas of wetlands are in coastal and estuarine areas, Pleasant River Estuary (84ha), Waikouaiti River Estuary Wetland Complex (71ha), and the Hawksbury Lagoon (43ha).

The Pleasant River Estuary supports an extensive saltmarsh complex with marginal shrublands, a diverse range of bird species and an important poorly described invertebrate fauna. Other estuaries and lagoons along the coast include additional distinctive lagoonal and estuarine habitats, depending on the behaviour of the rivers as they near the coast. Many of these are protected and part of active restoration programmes, while others are subject to regular livestock grazing.

Inland, several nationally rare wetland habitats are found. Ephemeral wetlands with several threatened plant species (e.g. *Isolepis basilaris* and *Myosurus minimus* subsp. *novae zelandiae*) occur on upland plateaux in the south of the region, while limestone sinkholes and depressions with tall-

herbaceous species occur in the northern parts. The upland plateaux on the Kakanui Range have extensive copper tussock wetlands where drainage is impeded.

*Regionally Significant Wetlands:* Within the North Otago FMU, 17 sites are currently recognised as Regionally Significant Wetlands. These are classified as swamp (8 sites), marsh (3), saltmarsh (3), and unclassified (3). With the exception of Red Bank Wetland Management Area in the Macraes area uplands, all other sites are coastal, mainly lagoons and estuaries associated with river and stream mouths. Five sites are grouped close to Karitane and the Waikouaiti Estuary, the largest being Waikouaiti River Estuary Wetland Complex (71 ha) and Hawkesbury Lagoon (43 ha). A further 8 such sites are scattered along the coast to the north, the largest being Pleasant River (84 ha), Shag River (14 ha) and All Day Bay (11 ha).

The lagoon sites, impounded behind coastal dunes, are intermittently open to the sea, and tend to have narrow marginal sedge wetlands, and brackish shallows with productive aquatic plants that sustain large waterfowl populations. The river estuaries have braids and banks with sand and silt beds, constantly renewed and disturbed, and plant community zones from seagrass up to saltmarsh turf of succulent, salt-tolerant herbs, then oioi tall rushland with shrubs of saltmarsh ribbonwood at higher elevations relative to tidal influence, which diminishes both upslope and inland. Fingers of estuarine vegetation extend into lower reaches of lower catchment tributaries, there to merge with inputs of freshwater, or to now end abruptly against farmland.

The only inland RSW, Red Bank Wetland Management Area, has wetlands as part of a mosaic of snow tussock, shorter grassland, and shrubland, the wetter soils having red tussock grassland, schoenus fens, sphagnum mossland, and examples of ephemeral wetlands (Macraes RAP (Recommended Area for Protection; Bibby, 1997).

No RSW sites are identified yet in the Kakanui Mountains. Potential sites for further recognition are several RAP's identified for the Dansey Ecological District (Comrie, 1992), e.g., sites near Mt Stalker and Mt. Dasher. Wetlands in these uplands include copper tussock grasslands and cushion bogs (Allen et al. 1988).

### **Taieri Freshwater Management Unit**

*Overview:* The entire Taieri River catchment is included in a single FMU, extending from Taieri Mouth across the Taieri Plain and into the Strath Taieri and Maniototo Basins. The catchment area comprises all or parts of several block-faulted schist (mostly) and greywacke (in north) mountains: the Rock and Pillar Range (1450m), Lammermoor (1160m) and Lammerlaw (1210) Ranges, eastern slopes of Rough Ridge (950m), southern slopes of the Kakanui Mountains (1600m), the lower crests of Taieri Ridge (660m), and Maungatua (895m). The climate ranges from coastal cool-temperate to

more continental conditions inland, with frequent winter snow on upland plateaux. Outside of urban and rural settlements, beef and sheep farms are common in uplands with expanding dairy and dairy-support predominant in the larger valleys.

The area contains many notable and significant wetlands associated with the flat-topped mountains, meandering streams and rivers, stream-side and valley-floor fens and bogs, and large ponded areas adjoining natural and modified lakes, or associated with past or infrequent river routes to the sea. Copper tussock, mostly in upland areas, and shrub-dominated wetlands are the most widespread (>4000 ha total). Flaxland and herbfield/sedgeland (> 1000 ha total) are also extensive in lowland and uplands respectively.

The Taieri River contains major wetland types throughout the catchment. At Taieri Mouth there are estuarine communities, with local occurrences of wooded wetlands (known as carrs) (Sykes et al. 1991). The Taieri plains support the large Waipori/Waihola Wetland Complex (2090 ha), the relict of more extensive wetlands. The Strath Taieri area is notable for the ephemeral wetlands associated with schist depressions along Taieri Ridge. The Maniototo area supports numerous copper tussock wetlands, mostly associated with seepage areas, and subalpine herbfields on upper mountain slopes. The upper Taieri Basin forms the eastern part of the drier basins of Otago. Broad flood plains have been created by sediment eroded off adjoining mountains and their flanking Tertiary sediments. The scroll plains, reflecting river course changes across areas of low topographic relief, are a major feature of the upper Taieri basin. The upper Taieri Wetland Complex, comprising the Styx Basin Wetlands and the Maniototo Basin Wetlands, contain diverse wildlife and habitats reflecting the age, isolation, sediment regime and frequency of water flows and impoundments. Extensive stock grazing and draining in the past, and now downslope from more intensive agricultural developments, on adjoining fans and interfluves, these nationally important wetlands are currently largely restricted to swamp sites near the current river. The upper areas of the catchment contain several substantial reservoirs with adjoining wetlands (e.g. Great Moss Swamp/Loganburn Reservoir).

Naturally uncommon wetlands also feature in the Taieri FMU, with saline ecosystems (e.g., Sutton Salt Lake Wetland), ephemeral wetlands (e.g., Styx area), and streamside string bogs (e.g., Lammermoor and Lammerlaw Ranges). Although relatively small in total extent, these types all support specialized plants and animals. The narrow subalpine streamside mires in these ranges, along with their tussock grassland interfluves are key sites for securing water that feeds into streams draining the drier upper Taieri catchment.

*Regionally significant wetlands:* Within the Taieri FMU 39 sites are recognised as Regionally Significant Wetlands. These are presently classified mainly as swamp (13 sites), marsh (8), fen (7), and inland saline (5). These figures include Swampy Summit (bog) which is actually in Dunedin and Coast FMU. (The transfer requires the '39 sites' to be changed to 38).

These sites are here considered under five groupings, based on landscape setting and habitat: the Taieri Plain area, Taieri scroll plains, uplands, ephemeral wetlands, and inland saline sites.

The lowermost Taieri Gorge has two small recognised sites (Governors Point and Rocky Hill) where marsh of the tidal river runs back to limited areas of forest swamp. Takitōa Swamp (68 ha), with flax, shrubland, and carex sedgeland, occupies the bed of a side valley at the top of the gorge. The Taieri Plain would once have been one large wetland system, waterbird paradise and mahika kai garden, of shallow lakes and oxbow pools, overlying many metres depth of silt and peat layers, with swamp forest on the river channel levees, sedge and raupo swamps in the backswamps. The extant wetlands of Lakes Waihola and Waipori are what remain, their 2089 hectares embracing both shallow lakes, linked to the Waipori River by a birds-foot delta of channels, the result of downstream river movement alternating with the reverse current as the lowermost Taieri backs up with each high tide. The character, values, and management of the complex, including Te Nohoaka o Tukiauau/Sinclair Wetlands are well known. Six much smaller RSW sites are recognised on the Taieri Plain: ponds with swamp and willow margins.

Of very different origin and character are the scroll plains of the upper Taieri, wetland systems that are still present on a grand scale, comprising the broad river meanders of the present river course as it wanders across the floodplains, along with ponded oxbows and paleomeanders that represent the river history. These scroll plains, recognised as being special to Otago, are already being further understood towards their ongoing management.

A suite of upland wetlands that occupy mid-altitude hill crests and gentle valley heads are here considered in a sequence running inland. Maungatua Summit Wetland Management Area (1213 ha), including the Maungatua Scientific Reserve, has cushion bogs, tarns, and tussock tops surrounded by subalpine shrublands then beech forest remnants in gulley heads on the east side of the range. To the west of Maungatua, at slightly lower elevation, gentle headwater fingers of the Pioneer Stream area, drain north to the arms of the Lake Mahinerangi reservoir, and contain the Loch Luella and Loch Loudon fen complexes (871 and 33 ha), having a cover of copper tussock and sphagnum bogs and fens, now with developed pasture surrounds. Comparable remnants occur in the Black Rock marshes on slopes rising to the Lammermoors. To the north, on somewhat drier rolling hills generally west of the Silverpeaks, red tussock and moss wetlands are less extensive, being present

on the Peat Moss Hills (36 ha) and Lamb Hill (37 ha) wetlands. West again, several smaller wetlands are present in the Clarks Junction vicinity.

Named evocatively by miners traipsing inland to the goldfields, the Great Moss Swamp offered the challenge of crossing numerous fingers of soft moss bogs. This broad basin between the Lammermoors and the Rock and Pillar Range proved ideal for impoundment as the Loganburn Reservoir, serving irrigation on the Maniototo Plain. With the damming and raising of reservoir levels the nature of the peat substrate was revealed as large buoyant pads of peat became floating islets, to be wind-piled against down-wind shores. Notwithstanding the inundation of the main basin, tributary gulleys still retain wetland gradients of moss-, sedge-, and tussock bogs and fens, and the remnants of stream meanders remain in the Loganburn head. Surrounding country has been steadily developed for pastoral farming.

The uppermost tributaries of the Taieri have wetlands not currently listed, including the large fen of Teviot Swamp, having sphagnum and sedge communities, and numerous small string bogs in the upper gullies of the Lammerlaw and Lammermoor Ranges, partly within Te Papanui Conservation Park (Johnson 1986b; Johnson & Lee 1988).

Ephemeral wetland is a term embracing landforms of various origin – glacial moraines, dune hollows, oxbows, sink holes – but with a type characteristic of inland Otago: surface depressions on the plateau crests of rolling schist country. Such hollows lack a surface outlet, such that they pond in winter and spring from rain, groundwater and snow melt, yet dry out, often completely in the drier months, encouraging a specific wetland flora and fauna for part of the year, typically as a low-growing turf vegetation. Such ephemeral wetlands are, by nature scattered and local across the landscape, their biota very diverse but also naturally rare, and often nationally threatened. The Taieri FMU has scattered examples, both singly and in groups, notably Nenthorn Ridge (67 ha; Johnson 1993), Red Bank (122 ha), and Styx (11 ha) Wetland Management Areas.

‘Inland saline’ describes a broad, hydrosystem level of wetland classification, even though of very localised sites in New Zealand, yet almost exclusively in inland Otago basins, where evaporation in the semi-arid climate concentrates soluble salts from groundwater. Whether as shallow salt pans upon inland plains and terraces, or hill-scarp seepages from ancient sediments fringing the basins, the saline and alkaline substrates can be ephemeral in their seasonal or periodic wetness, yet display a set of halophytic, salt-tolerant plants otherwise typical of coastal marshes, and associated, distinctive invertebrates. Most notable of sites is Sutton Salt Lake (131 ha), the only such in New Zealand. Within Taieri FMU the other large sites are Totara Creek (88 ha), (Belmont (20 ha), and

Patearoa (4.5 ha). Saline sites occur also on the margins of the Upper Taieri Scroll Plains (Johnson 1995b).

### **Dunedin and Coast Freshwater Management Unit**

*Overview:* The Dunedin and Coast FMU has two units, split by the Taieri River FMU. In the south, around Milton it includes the Tokomairiro River catchment, and several smaller streams, while in Dunedin City it encompasses the Kaikorai, Leith, and Waitati streams, and smaller catchments on Otago Peninsula. The highest peak is Swampy Summit (739m). Geologically diverse, the hilly topography is a legacy of past volcanic activity. The climate is cool temperate with mild summers and winters and consistent rain. Prior to human arrival the area was covered in dense hardwood – podocarp forest and significant areas remain, mainly towards the coast and to the north of Dunedin. Secondary native tussock grassland occupies summits around Dunedin and recovering forest is common on the lower slopes. The Milton area and parts of the Otago Peninsula are primarily sheep and beef farms with local dairy farming on the Taieri Plains. The urban centre, Dunedin City, is surrounded by lifestyle blocks and small industries.

The wetlands are mainly associated with estuaries and lower reaches of rivers and streams. Flaxlands are the most common wetland vegetation type in this FMU, with oioi restiad rushland widespread in coastal wetlands and carex in upland areas. The wetlands are generally small and scattered along water courses and around the coast. The Okia Flat wetland and the Tokomairiro River Swamp are the largest wetland systems, both over 170ha.

*Regionally Significant Wetlands:* Within the Dunedin and Coast FMU 16 sites are recognised as Regionally Significant Wetlands. These are presently classified mainly as swamp (8 sites), several grading to saltmarsh (2), marsh (4) and bog (1).

Starting with the bog site, the flat crest of Swampy Summit (48 ha) holds several tarns with margins of sphagnum bog grading to tussock and shrubland, The substrate is peat, which in places is exposed as dried, wind-eroded surfaces that reveal subfossil stumps of a former pink pine woodland, as well as quartz pebbles derived from moa gizzard stones: two indications of bog history and change over time, in both flora and fauna. Additional bog communities occur in stream heads to the east of Swampy Summit, in basins having peat to 6m depth, variously with communities of sphagnum, carex sedgeland, mountain flax, with surroundings of subalpine scrub and regenerating cedar cloud forest. Part of this system has been documented by Walker et al. (2001) and its peat types by Johnson & Gerbeaux (2004).

One other bog site is recognised: Black Swamp, an isolated 6 ha dome of peat on a ridge crest inland from Milton, having wire rush, sphagnum, and sedge communities, and heath scrub including manuka and dracophyllum, within surrounding farmland Johnson 1985).

Identified wetlands in the Dunedin and Coast FMU are otherwise all close to the coast, but with varying degrees of coastal, tidal, and saltwater influence. The sites can be grouped into three broad landform settings, their general character described below for sites ordered from south to north.

A. Lowland stream valleys, mainly freshwater marshes and swamps, as small compact sites or with tributary fingers. Small sites tend to be juncus marshes on damp mineral soils. The vegetation of larger sites may have a component of saltmarsh, with a gradation to oioi rushland, then a predominance of swamp with saltmarsh ribbonwood, carex sedgelands, flax, manuka, and cabbage trees. Such sites are Measly Beach Wetland Complex (46 ha.), Tokomairiro River Swamp (175 ha), Akatore Creek (69 ha.), Lower Coutts Gulley Swamp (33 ha.; SW of Taieri Mouth), Te Matai Marsh (1 ha.; near Okia Flat), Jennings Creek Marsh (8 ha.), and Whareakeake Marsh, (2 ha.; near Murdering Beach).

B. Stream-mouth lagoons, infrequently open to the sea, with brackish water. These have expanses of shallow, open water, typically fringed with oioi rushland then saltmarsh ribbonwood and local areas of more freshwater swamp in the beds of feeder streams and seepages: Lower Otokia Creek (3 ha.; behind Brighton), Kaikorai Lagoon (63 ha.), and Tomahawk Lagoon (31 ha.).

C. Larger tidal embayments, saline, of Otago Peninsula and Otago Harbour. Hoopers Inlet has patches of saltmarsh and oioi rushland around its perimeter, while at the Hoopers Inlet Swamp site (32 ha.), saltmarsh on the inlet margin runs back to various sedgelands, areas of turf vegetation on old sand flats behind Allans Beach, and a small area of bog. Papanui Inlet Saltmarsh (5 ha.) is a covenanted area of saltmarsh communities persisting despite former partial drainage. Okia Flat (222 ha.) is an extensive undulating sand flat where some of the dune hollows are small bogs and others ephemeral wetlands with turf vegetation, carex sedgeland, and juncus rushland. Aramoana Saltmarsh notable for its size (75 ha.), is a readily accessible site, with access track and boardwalk, illustrating a sequence from seagrass mudflats to halophytic saltmarsh, then oioi rushland, shrubland, and flax upslope.

Coastal wetland sites that do not appear to have yet been identified within the Dunedin and Coast FMU are those of Purakaunui Inlet and Blueskin Bay (including the Orokonui arm).

One aspect of wetland botanical interest lies in the latitudinal distribution limits of plants, for example species that are more common in northern New Zealand come south only as far as their

cold-tolerance may allow, hence sea rush (*Juncus kraussii*), reaching a southern limit in Purakaunui Inlet, and the tall sedge *Bolboschoenus caldwellii* at Tomahawk Lagoon.

### **Clutha Matau-au Freshwater Management Unit**

Otago's major river, indeed New Zealand's largest, stretching from the Southern Alps to the sea, is further divided into five Rohe.

#### **Lower Clutha Rohe**

*Overview:* The Lower Clutha Rohe includes the Clutha River downstream from Beaumont and its major tributary, the Pomahaka River, which drains the slopes of the Blue Mountains (1019m) and the Umbrella Range (1455m). Smaller rivers include the Waipahi whose catchment drains the area south of Clinton, and the Waitahuna and Tuapeka rivers with catchments to the north on the Lammerlaw Range. The area supports native tussock grasslands in the uplands with substantial areas of beech forest in the Blue Mountains and recovering shrublands in gullies. Originally largely forested, nearly all the conifers, and much of the beech and hardwood forest was eliminated by early fires. The area combines coastal and continental climate influences with generally mild winters and cool temperate summers with periodic dry spells. Sheep and beef farming, dairy in lowlands and flood plains and forestry in hinterlands, are the dominant land uses.

The most widespread wetland type in the rohe is upland sedgeland with rushland and flaxland common in lowland areas. The largest wetlands include the Loch Luella Fen Complex, an extensive network of copper tussock/sphagnum on valley floors near Lake Mahinuragi, the Lake Tuakitoto Wetlands near Kaitangata, and the Molyneux Bay Swamp, coastal foredune and associated wetlands around the Koau mouth of the Clutha River.

*Regionally significant wetlands:* Within the Lower Clutha Rohe 28 sites are recognised as Regionally Significant Wetlands. These are classified mainly as swamp (12 sites), marsh (7), fen (6), and bog (2). One list for Lower Clutha includes Cairn Road Bog (60ha) and Kuriwao which are in Catlins FMU list (and properly sits there) and Loch Luella Fen Complex (873 ha) which is listed, properly, in Taieri FMU.

Within the Lower Clutha Rohe 25 sites are recognised as Regionally Significant Wetlands. These are classified mainly as swamp (12 sites), marsh (7), fen (5), and bog (1).

The sites discussed are here grouped within five geographical areas: Inch Clutha, Kaitangata, Clinton, Tapanui, and Lawrence.

On the seaward end of the island of Inch Clutha, between the Matau and Koau branches of the lowermost Clutha River the Molyneux Bay Swamp (150 ha.), south of the Matau mouth, is a lagoon



with swamp-edged fingers; the Clutha River Mouth Lagoon (29 ha.) an elongated water body with marsh margins; and the Clutha Matau Wetlands (21 ha.) a river-margin swamp. Further up-river the Culcairn Oxbow Marsh (8 ha.) is a curved pond of a former oxbow channel, marsh-fringed, in a farmland. Finegand Lagoon Marsh (6ha.), south of Balclutha is a stream pond with willows and juncus marsh.

In the Kaitangata area the largest site is Lake Tuakitoto Wetland (546 ha.), a shallow lowland lake bordered by sedge and rush swamp, but much colonised with crack willows. Smaller wetlands in this area occupy fingers of stream valleys, as juncus marshes, some with ponds and willows, or swamps with flax, shrubs, and red tussock: Frasers Stream Headwaters Marsh Complex (26 ha.); Stirling Marsh Complex (11 ha.); Camp Stream Swamp (8 ha.); Two Stone Hill Stream Swamp (5 ha.); and East Benhar Swamp (2 ha.).

Wetland sites in the Clinton district are remnants of former broad swathes of copper tussock country, these being the most boggy sites, typically with copper tussock, wire rush, sphagnum, sedges, and some heathland and coprosma shrubland. The sites are all in farmland settings: Dunvegan Fen Complex (87 ha.); Three Stones Fen Complex (58 ha.); Hazeldale Fens (10 ha.); and Willowburn Bog (4 ha) where silver birch trees show an ability to behave as weeds in peatland substrates. Macfarlane Road Oxbow Swamp (2 ha.) and Marana Swamp (2 ha.) are small isolated hollows, with ponds and willows.

To the east of the Blue Mountains John O'Groats Hill Fen (22 ha.) and Blackcleugh Burn Swamp (3 ha.) have red tussock wetlands on valley flats. The tops of the Blue Mountains, at c. 900m altitude, have sphagnum and cushion bogs, not currently listed. Near Tapanui are three small marsh sites within farmland: Clifton Hill Marshes (4 ha.) with copper tussock, and Pomahaka River Oxbow Marsh (Dalvey) (4 ha.), and Pomahaka River Oxbow Marsh (Koi Creek) (2 ha.) both with ponds and willows.

North of Lawrence, Bungtown Bog (28 ha., and partly Scientific Reserve) is a bog with sphagnum, wire rush, and bog pine. Glendhu Swamp (22 ha.) has valley floor copper tussock, while Malones Dam Margins (2 ha.) has a small swamp at one end.

In the northern portion of Lower Clutha Rohe, the headwaters of the Pomahaka against the Umbrella Range have upland wetlands (cushion bogs, snowbanks, sedge fens), not currently listed, but described in the PNA report for the Umbrella Ecological District (Dickinson,1988).

### **Roxburgh Rohe**

*Overview:* The Roxburgh Rohe spans the Clutha River catchment area from Clyde to Beamont. Along the western side numerous small catchments drain the Umbrella Range (1455m) and the Old

Man Range (1695m). The eastern margin contains the small Teviot River catchment with Lake Onslow at its source, and drains parts of the Lammerlaw Range (1210m). The climate becomes more continental with cold winters, snow at higher elevations, and warm dry summers, compared with areas further downstream. Apart from urban areas, sheep and beef farming are the major land uses. Plantation forestry, mostly in the south, is now being attempted on the uplands.

Herbfield, tussock grassland, and shrubland represent the major native vegetation types remaining. Isolated beech and conifer trees are remnants of an extensive forest depleted by early fires.

Wetlands are common in upland areas, with copper tussock, sedgeland and herbfield the most widespread types.

The streams draining into Lake Onslow from the south (Boundary and Fortification Creek) are arguably the most distinctive and impressive upland wetlands in Otago, if not nationally, representing scroll plain ecosystems with numerous meander channels and oxbows, and supporting extensive areas of copper tussock sedgeland. The northern parts of the rohe, on the margins of the Manuherikia, support several saline wetlands.

*Regionally significant wetlands:* Within the Roxburgh Rohe 12 sites are recognised as Regionally Significant Wetlands. These are classified as inland saline (4 sites) ephemeral wetland (1), fen (3), and marsh (4).

The inland saline sites, all in the Conroys Gulley area, are mainly hillside toe slopes, intermittently wet with seepage from groundwater, having saline and alkaline soils, a flora of salt-tolerant plants that otherwise occur in coastal saltmarshes, along with species that are dormant in dry seasons, being annuals which is unusual in native plants. The sites are Conroys Dam Inland Saline Wetland Management Area (18 ha.), Conroys Road Inland Saline Wetland Complex (7 ha.), Chapman Road Inland Saline Area (7 ha.), and Blackmans Inland Saline Wetland Management Area (12 ha.).

Flat Top Hill Ephemeral Wetlands (5 ha.) contain surface depressions on hill-crest plateau, not saline, but again with native annual plants that tolerate both ponding and drought.

The largest wetlands in the Roxburgh Rohe occupy valleys feeding Lake Onslow, from the south: Fortification Creek Wetland Management Area (526 ha., a site that includes the wetlands of Teviot River South Branch), Boundary Creek Fen (94 ha.), and Middle Swamp (67 ha.). In each of these, valley floors of gentle gradient have developed meander systems, on a smaller scale and at higher altitude than the broad scroll plains of the upper Taieri, with complex patterns of sinuous stream channels, cutoffs, oxbows, and paleochannels. Copper tussock grassland occupies the hummocky alluvial flats, along with sedgelands, turf communities in the hollows, aquatic plants, and valley-side

sphagnum fens (Johnson 1986b). The origin and development of these meander systems have been described by Hayward (2022).

A notable wetland, not currently listed, is Teviot Swamp, so-named, but better described as a large fen complex, in a basin at the head of Teviot River South Branch, at 1000 m altitude. Fed by groundwater and seepages from Lammerlaw Top, sphagnum moss is the principal peat-forming plant on the wettest ground, and as water movement changes with time across the fen fans, cyclical changes take place towards fen and bog vegetation of cushion plants. In uppermost tributaries the moss and cushion communities are part of small string bog systems, with pools in terrace sequences. These habitats extend into the adjacent uppermost Taieri catchment, notably in MacKay Creek, and the Taieri FMU (Johnson & Lee 1988).

Further fingers of valley wetlands at upper altitudes, the sites not presently recognised, occur in the heads of the Fraser River, west of Alexandra. Four small marsh sites are identified in the Ettrick to Roxburgh area: Island Block Pond Marshes (4 ha.), Upper Black Stream Marshes (3 ha.), Rigney Pond Marshes (0.5 ha.), and Gilmour Road Marsh (1 ha.).

### **Manuherikia Rohe**

*Overview:* The Manuherikia Rohe has the most extreme temperature and rainfall regime in New Zealand, reflecting its position in the rain shadow of the Southern Alps. The catchment of the Manuherikia River includes the Ida Valley, which drains the western slopes of Rough Ridge; and the eastern slopes of the Dunstan Mountains (1683m), and parts of the Hawkdun (1691m) and St Bathans (2087m) Ranges. The predominantly schist block-faulted mountains extend into the alpine zone, while the eastern boundary comprises the low-relief hills of Rough Ridge. The broad valleys of both the Manuherikia and Ida Basins are flanked by Tertiary deposits, being partly eroded remnants from the ancient Lake Manuherikia, and these have spread outwash terraces and fans adjoining flood plain areas along streams and rivers.

Like much of Central Otago, the climate is typically continental in character with very dry lowland areas in summer. Prior to human burning, the natural vegetation would have been more woody with forested slopes, mostly beech and conifers. However these are long gone, and the shrublands and grasslands present today likely reflect the species that previously may have dominated frosted valley-floors in the broad basins. Nowadays, tussock grasslands and shrublands are widespread, with alpine herbfields along wide summit ridges.

The dominant wetland type is copper tussock grassland, located across a broad elevation zone extending from motane to subalpine areas, with alpine sedgeland, fens and bogs common at higher

altitudes. Numerous dams and expanded ponds also contain turf and swamp wetlands, and saline wetlands occur in the lower Manuherika area around Galloway.

*Regionally significant wetlands:* Within the Manuherikia Rohe 11 sites are recognised as Regionally Significant Wetlands. These are classified as inland saline (5 sites), marsh (4), swamp (1), and fen (1).

At the head of the Manuherikia valley Kirkwoods Creek Wetland Management Area (256 ha.) spans an altitudinal range from stream valley fens of copper tussock, sedgelands, and sphagnum, up to the crest of the Hawkdun Range. Comparable stream valley wetlands are identified in the Hut Creek Swamps (12 ha., north of Falls Dam, and Hawkduns Runs Road Marsh (51 ha., north of St Bathans).

Inland saline sites to the north of Alexandra, mainly on salty and alkaline toe slopes are centred on the Galloway area: Galloway No 1 Inland Saline Wetland Complex (3 ha.), Galloway No 2 Inland Saline Wetland Management Area (6 ha.). Also in this vicinity, Long Gully Marsh (1 ha.) is a pond with raupo and carex margins.

Two further saline sites, north of Alexandra are Dunard Inland Saline Wetland Management Area (3 ha., on Moutere Station) and Rockdale Inland Saline Wetland Management Area (3 ha., near Chatto Creek). At the south end of the Ida Valley basin, a further saline site is the Moa Creek Inland Saline Wetland (3 ha.), and the copper tussock/ carex wetland of the Kirk Creek Headwaters Marsh Complex (7 ha.) .

The Lower Manorburn Dam Margins (18 ha.) are a marsh and swamp fringe of raupo and willows.

Other wetland sites, not yet listed for the Manuherikia rohe include periodically submerged turf vegetation of reservoir margins e.g. Greenland Reservoir (Johnson 1986a), Poolburn Reservoir, and Falls Dam, and various streamside and oxbow communities of copper tussock, sedgelands, and sphagnum mosslands in the Little Valley and Hopes Creek tributaries of the Manorburn (Johnson 1986a, 1994b, 1995a).

### **Dunstan Rohe**

*Overview:* The Dunstan Rohe extends upstream from Clyde to include all catchments independent of those draining directly into the Otago lakes, and contains the large hydro-electricity reservoir, Lake Dunstan. The Nevis, Shotover, Kawarau, Cardrona, and Lindis catchments are all within the Rohe, surrounded by mountains to 1600 m elevation in the east (Garvie and Dunstan Ranges), rising to 2500 m in the west (Richardson Mountains) towards the edge of the Southern Alps. The landforms reflect the regions glacial history with steep-sided valleys, extensive glacial deposits, peri-glacial features, and alluvial surfaces.

The climate is continental with cold winters and dry summers, especially in the lowlands. Above treeline, shrubland and grassland give way to herbfields. The natural vegetation below the alpine zone is forest, mostly beech with scattered conifers throughout in the montane zone and on poorer soils. The forested valley floors have always supported tall and short tussock grassland with pockets of small-leaved shrubs and conifer woodlands. All these communities were modified by early fires which removed forests and expanded tussock grasslands on lower and mid-slopes in eastern mountains.

Sheep and beef farming are the most extensive land uses with local expanding areas of viticulture, horticulture, and dairy support in the basins. Seasonal tourism is a major activity. The most extensive wetlands are copper tussock grasslands with sedgeland on upland areas and herbfields in the alpine zone. Bendigo wetlands, at the head of Lake Dunstan are the largest wetlands in the Rohe, comprising the Upper Clutha River delta and marginal swamps and lagoons. These provide habitat for diverse wildlife in Central Otago. Small lakes in the Rohe such as Hayes and Johnson also support different wetland types. The Churchhill wetland complex in the upper Shotover catchment, includes bog, fen, shallow water (tarn) and ephemeral wetlands. There are also widespread copper tussock wetland fens on valley floors in the Nevis catchment.

*Regionally significant wetlands:* Within the Dunstan Rohe 10 sites are recognised as Regionally Significant Wetlands. These are swamp (4 sites), fen (3), marsh (2), and bog (1).

On the delta where the Upper Clutha runs into Lake Dunstan, the Bendigo Wetland (244 ha.) has developed swampy, willow-edged river margins, a wetland with values especially for birds and angling. Further upstream, above Luggate, the Campbells Reserve Pond Margins (1 ha.) is a small marsh, spring-fed from terrace scarp seepage, while Butterfield Wetland (2 ha.), on an old Hawea River terrace is of similar origin, with a raupo-edged pond.

Two sites in the Nevis Valley, Nevis Red Tussock Fen (44 ha.) and Schoolhouse Flat Red Tussock Fen (9 ha.) are broad alluvial fans entering the main valley, with communities of red tussock and various carex species, patterned according to degrees of soil wetness.

Notable, but not yet listed, at the head of the Nevis, in its Roaring Lion catchment is New Zealand's largest string bog system, which extends also into the Nokomai catchment, Southland, a patterned mixture of terraced tarns, fens, bogs, and snowbanks (Mark et al 1995).

In the Queenstown area Lake Hayes Margins (17 ha.) has lake fringes of raupo, crack- and grey-willows, and some carex swamp (Johnson 1981). Moke Creek Swamp (1 ha.) and Moke Lake Bog (12 ha.) have both bog and swamp types. No details are to hand for the Shotover River Confluence Swamp (15 ha.).

In one of the heads of the Shotover, the Polnoon, the Church Hill Wetland Complex (103 ha.) occupies a fault-derived basin, with glacial moraines, and a representation of bogs, fens, tarns, and ephemeral wetlands.

Two further sites, not so far identified are Queenstown Hill, where a Conservation Covenant has cushion bog and tarn communities on the gentle hill crest (Ward & Munro 1989); and the head of Pisa Range Roaring Meg head, sedge and cushion bogs and tarns (Johnson, 1989).

Additional wetlands, not yet listed for Dunstan Rohe are:

Arrow River headwaters: meanders, fens, bogs.

Remarkables, Rastus Burn: fens, seepages.

Doolans Creek Right Branch head: tarns, fens, seepages.

Doolans Creek, South Branch head: tarns, fens, seepages.

Nevis Valley, Nevis Burn, southern tributary: stream finger fens.

South of Nevis Burn: tarns, string bogs.

Schoolhouse Creek, mid to upper reaches: meanders, pools, fens, bogs.

### **Upper Lakes Rohe**

*Overview:* This most western Rohe contains the catchments of Otago's great lakes (Wakatipu, Wanaka, Hawea) and includes the high rainfall areas along the Southern Alps that are the sources for the large volume of water in the Clutha River. Heavily glaciated during the Pleistocene, oversteepened valley sides coupled with frequent earthquakes and storm events create a dynamic landscape where changing water courses, locally impeded flows, and cool climates produce a variety of generally small wetlands. The metres of rain annually in these mountains maintain lake levels and the flows in the Clutha River, benefitting the now-irrigated drier inland areas of Otago. Much of these catchments retain natural vegetation with grassland/shrubland on the regularly disturbed river flats giving way to forest, mostly *Nothofagus*, on the lower and mid-slopes. Treeline is around 1050m asl, with alpine shrubland, grassland and herbfield, respectively, dominating at higher elevations. Mount Aspiring (3033m) is the highest point close to the Main Divide, but many peaks extend above 2000m on the mountains surrounding the lakes.

Sheep and beef farming are the main land uses, with concentrated tourism, mainly ski-fields, on several mountains, and expanding eco-tourism in and around urban areas.

In these environments most wetlands are small, with copper tussock sedgeland and carex sedgelands the most widespread types.

*Regionally significant wetlands:* Within the Upper Lakes Rohe 18 sites are recognised as Regionally Significant Wetlands. These are swamps (4 sites); swamps associated with lagoons (10); or systems having ephemeral wetlands (2).

The sites are here outlined in approximately north-to-south order. On the east side of Lake Hawea, the shallow Dingle Lagoon (25 ha.) is fringed with carex swamp, juncus marshes, and willows. Makarora Flat Swamp Complex (60-70 ha.) is mainly marsh with carex sedgeland, juncus marshes, and willows where the Makarora delta meets the head of Lake Wanaka. Across the low saddle between Lakes Hawea and Wanaka, The Neck Wetlands (11 ha.) are a group of bedrock depressions with carex and raupo swamps (Ward & Munro 1989). On the west side of Lake Wanaka, Minaret Bay Swamp (23 ha.) has marsh and swamp on stream deltas at the bay head.

The lower Matukituki Valley/ West Wanaka area has several wetlands, the largest being the Matukituki Valley Wetland Management Area (76 ha.) on the true left of the flood plain with a mixture of carex and raupo swamps, and open waters. Also fed by seepage from alluvial fans, Big Boggy Swamp (13 ha.), adjacent to the valley road, has a mix of lagoon ponds, with raupo and tall sedge swamps and some woody vegetation. On a smaller scale Little Boggy Swamp (0.2 ha.) has a raupo-fringed pond.

Scaifes Lagoon (5 ha.), alongside the Glendhu Bay road is likewise mainly raupo swamp. The Matukituki Bluff Ephemeral Wetland Management Area (23 ha.) is less swampy, and includes ephemeral wetlands, occupying a river terrace.

At the head of Lake Wakatipu, near Paradise, the Diamond Lake Wetland (49 ha.) and nearby Lake Reid Wetland (40 ha.) are shallow lakes, stream-fed, with aquatic vegetation and fringes of sedge swamps.

Kinloch Wetland (11 ha.) is mainly marshes, on the west side of the Dart River delta, while the Rees River delta is associated with the Glenorchy Lagoon Wetland (128 ha.), a DoC Wildlife Management Area having lagoons with swampy shores, islands, and willows. Just south of Glenorchy, Little Stoney Bog (7 ha.) / 'Lake Fyfe' is a small lake in a bench hollow with margins of turf, fen, and rushland.

Close behind Queenstown, along Gorge Road, the Matakauri Wetland (11 ha.) is a swamp with carex sedgeland. On the west side of Lake Wakatipu, to the south of the Von River mouth, Mt Nicholas Lagoon (91 ha.) has swamp margins and islands, while the much smaller Signal Hill Swamp (2 ha.), is located just to the east. The much larger wetland system of the Von Valley Wetland Management Area (545 ha.) is one of valley heads and once-glaciated hill crests with a scattering of depressions holding, tarns, kettles, and swamp communities.

Many wetlands of the Upper Lakes Rohe have not yet been identified. These include the following, again listed in approximately north-to south order:

Lake Hawea head, Hunter Valley, Lake Creek head, stream braids with marshes and fens.

Hunter Forks Flats, and further down valley: river braids with, marshes.

Makarora Valley head: copper tussock and sphagnum types.

Wilkin Valley, Wonderland: river flat fens and ponds.

Young Valley, South Branch: river flat fens and ponds.

Albert Burn top flats: string bogs.

Lake Wanaka, Snag Bay, south of Albert Burn: lagoon, ponds.

Buchanan Peaks, south side: tarns and fens in two stream headwaters.

West Wanaka, Diamond Lake, willow and carex swamp fringe, fens upslope.

South of Lake Wanaka, End Peak: tarns, fens, bogs.

Motatapu Valley head: stream meanders, fens, bogs.

Dart Valley, Lake Sylvan, bogs to north, east, and south of lake, beech forest surrounding.

Paradise, on old moraines between Dart Valley and Diamond Lake: kettles with turf margins.

Caples Valley head, McKellar Saddle: tarns, bogs.

Greenstone Valley: copper tussock fens (Johnson & Lee 1993).

Lochy Valley head, above Lake Nigel: valley floor fens.

Remarkables, Wye Creek, both branches: valley head fens.

South of Wye Creek and Staircase Creek head: tarns and small string bogs.

Hector Mts many tarns, including Lake Hope.

### ***Notable flora and fauna in Otago wetlands***

The flora and fauna found in wetland ecosystems include birds, fish, skinks, geckos, invertebrates and plants. Compared with other natural ecosystems, wetlands support a disproportionately high number of threatened flora and fauna (Clarkson et al. 2013). Wetlands are home to 22% of New Zealand's bird species and 30% of native freshwater fish. The proportion of New Zealand's invertebrates is not known, but similar numbers of different invertebrates are found in wetlands as



in rivers and streams (Clarkson et al. 2013). Notable flora and fauna in wetlands found in Otago include some rare and threatened species, and others that are naturally uncommon. Although rare and threatened species have been recorded in wetlands, there have not been systematic inventories compiled for most Otago wetlands to date.

A list of nationally threatened indigenous plant species likely or known to occur in Otago wetlands is presented in Table 1 compiled from a range of sources. We are unaware of any threatened endemic or native plant species solely restricted to the Otago Region, a pattern reflecting the strong compositional linkages between wetlands in southern New Zealand and the dispersal ability of most plants occupying specialised habitats limited in time and space.

*Table 1: Nationally threatened plants known or likely to be present in Otago wetlands.*

This list is based on a NIWA Stocktake of nationally threatened freshwater dependent plants (June 2021), concerning plant taxa in the higher threat categories of Nationally Critical (C in table below), Nationally Endangered (E), and Nationally Vulnerable (V). The table includes plants that are known to occur in Otago wetlands (based on Johnson & Rogers 2003, Johnson 1994a, and unpublished records, New Zealand Plant Conservation Network website (NZPCN), and iNaturalist website, or likely to occur in Otago based on their broader distribution. Note that this list does not include plants of the lesser 'At Risk' national status (Declining, Recovering, Relict, and Naturally Uncommon) for which there would be many more Otago records.

Taxa	Threatened Status	General Location
<i>Brachyscome linearis</i>	C	Fiordland, also Von Valley, Otago
<i>Crassula peduncularis</i>	C	Near Alexandra (J. Barkla)
<i>Isolepis lenticularis</i>	C	(as <i>I. fluitans</i> ) Otago locations uncertain
<i>Lagenophora montana</i>	C	(now <i>L. schmidiae</i> ). North and South Islands, including Otago alpine wetlands
<i>Ourisia modesta</i>	C	Tahakopa Valley, Otago (J. Barkla)
<i>Pseudognaphalium ephemerum</i>	C	Marlborough to Southland, likely Central Otago reservoir margins.
<i>Triglochin palustris</i>	C	North and South Islands, including Central Otago, e.g. Moke Lake (NZPCN).
<i>Carex cirrhosa</i>	E	North and South Island, throughout.
<i>Carex strictissima</i>	E	North and South Island, including Canterbury and Otago.
<i>Chaerophyllum colensoi</i> var. <i>delicatulum</i>	E	North and South Island, including ephemeral wetlands in Von catchment.
<i>Crassula multicaulis</i>	E	Extends to Otago, in tarn and ephemeral wetlands in the Upper Clutha catchments
<i>Gratiola concinna</i>	E	Extends to Otago, at McRaes in ephemeral wetlands.
<i>Hypericum rubicundulum</i>	E	From Canterbury to Southland.
<i>Mazus novaezeelandiae</i> subsp. <i>impolitus</i> f. <i>impolitus</i>	E	Upper Clutha, turf, riverbank.
<i>Ranunculus brevis</i>	E	Dunstan Range in tarn and lake edge habitats (D. Lyttle).

<i>Trithuria inconspicua</i> subsp. <i>brevistyla</i>	E	now <i>T. brevistyla</i> , Lake Sylvan, otherwise Fiordland lakes
<i>Wurmbea novae-zelandiae</i>	E	Including near Waikouaiti (CD Meurk).
<i>Althenia bilocularis</i>	V	( <i>Lepilaena</i> ) Tomahawk Lagoon, Lake Waihola.
<i>Carex capillacea</i>	V	North and South Islands, including Greenstone Valley, in cushion bogs.
<i>Carex rubicunda</i>	V	North and South Islands, including L. Manapouri, L Wanaka and Shotover catchment.
<i>Carex uncifolia</i>	V	North and South Islands, including Central Otago.
<i>Juncus pauciflorus</i>	V	North and South Islands, uncertain distribution.
<i>Myosurus minimus</i> subsp. <i>novae-zelandiae</i>	V	North and South Islands, including Central Otago.
<i>Pittosporum obcordatum</i>	V	North and South Islands, including the Catlins.
<i>Ranunculus ternatifolius</i>	V	Damp sites incl Otago, Fortification Ck., Manorburn
<i>Tetrachondra hamiltonii</i>	V	Fiordland, Southland, including Otago but localities uncertain

### **Threats to the ecological integrity of wetlands**

The ecological integrity of wetlands in Otago depends on maintaining the full range of types across representative environments in a condition that fosters the dominance of indigenous plants and animals. The impacts of past extinctions and widespread modifications cannot easily be reversed, and environmental and landuse changes make it even more difficult to restore any putative historic states. Instead, our objectives in the future should focus on maintaining and creating wetlands in a healthy condition for the spectrum of indigenous species specialised for these habitats. Restoring indigenous woody and herbaceous elements in suitable hydrological environments will ensure the persistence of habitats sustaining native biota.

In the past fire, drainage, invasive non-native species, and intensive stock grazing were the major drivers of wetland modification and depletion in Otago and these factors continue to be significant threats to the persistence of wetland habitats to sustain the full range of indigenous biodiversity.

Fire in New Zealand has long been a major driver of vegetation change in wetlands. While fire is a threat, some wetland types have a prehistory of periodic burning, and many species are adapted to recover quite quickly, usually resprouting and otherwise from seed banks. For example, manuka populations on many Otago wetlands have serotinous capsules that require fire to release seeds. However, fire destroys indigenous conifers and other woody species and provides an opportunity for weed invasion and consolidation, and species such as gorse also have extensive seed banks. Fire provides pulses of nutrients that may temporarily assist establishment of weeds. The cessation of

fire on wetlands will promote a natural succession towards more diverse and native-dominated communities, depending on the availability of seed sources and the local abundance of weeds.

Changes in the hydrological regime are a common cause for the demise of wetlands, usually from increased drainage on adjoining land or, over longer time periods, shifts in land use upslope that deprive the wetlands of water. Traditionally, widespread drainage of flat land in Otago basins and flood plains, for the spread of agriculture, severely reduced wetland extent as water flows were generally reduced and concentrated in artificial water courses. More recently, water abstraction in lowland and montane areas is a new threat for wetlands, depending on the water source and the spillover area from irrigation and more intensive farming. Land use also alters local evapotranspiration and water runoff patterns, potentially impacting downslope wetlands. Plantation forestry is a notable example in Central and Eastern Otago, where extensive upland planting may reduce catchment flows and water reliability downstream while also providing a seed source for invasion onto and around wetland margins. Maintaining hydrological regimes is critical for the long-term persistence of wetland habitats. Individual wetlands will adjust and change in response to natural fluctuations in water availability but continued declines in water entering wetlands over several decades will inevitably cause their demise.

Invasive exotic plants, especially shrubs and trees, but also grasses and sedges, and invasive mammals also modify wetland ecosystems, changing the indigenous biota and often making the environment more suitable for non-native biodiversity. An influx of exotic weeds, especially species that potentially decrease the habitat available for indigenous biota, is a major issue in wetlands, and even remote sites may have numerous exotic species present. Major weeds in Otago are gorse, willows, and introduced conifers which displace indigenous species, alter water regimes, facilitate dominance of other non-native flora and fauna, and increase the risk of major disturbances such as fire. Herbaceous weeds can also be problematic. These include *Carex ovalis*, *Nardus stricta*, and *Glyceria maxima*, all grazing resistant and dominant in patches in many wetlands. The problem with invasive species is that they capture wetland ecosystems, reducing indigenous dominance and creating wetlands that are compositionally similar to those common in northern hemisphere countries.

Introduced mammals (possum, mustelids, and rodents) are widespread across most wetlands in Otago and the recently established Predator Free 2050 programme is seeing the establishment of extensive networks of control activities that is reducing the abundance and current impacts of predators.

Stock grazing has frequently occurred around and on numerous undrained wetlands in Otago, creating in many places an herbaceous vegetation of mixed indigenous and introduced species. In these situations all plants are either partially tolerant or highly resistant to grazing by sheep and cattle. However these peculiar plant assemblages represent grazing-induced communities, structurally and compositionally different from the indigenous communities likely to occur in the absence of grazing mammals. The often prostrate indigenous species occurring in grazing-induced habitats are usually found in wetland patches adjoining permanent or seasonal water bodies where there is concentrated grazing by birds (Korsten et al. 2013). Ongoing stock grazing is clearly relevant for sustaining grazing-induced communities, but grazing will prevent these habitats from supporting the full range of potential indigenous plants and animals in the longer term, while also maintaining the local presence and abundance of many pasture species. The challenge for management is that cessation of grazing in wetlands frequently facilitates prolific growth of established introduced herbaceous grasses and sedges, effectively reducing establishment options for indigenous taxa. However, in our experience, depending on the wetland system, re-establishment of taller indigenous taxa will occur, over several decades, often facilitated by restoration plantings.

Direct human impacts on wetlands in recent decades have increased as roads have extended access to remote places. This has seen increasing recreational use of uplands with expansion of ski-fields and slope grooming, regular trail-bike and 4 wheel-driven vehicle touring in fragile environments, and major infrastructural activities associated with the drive towards greater alternative electricity developments (e.g. wind farming, hydro-electricity).

Climate change is a potential threat for wetlands, primarily in eastern areas where increased temperatures, reduced overall rainfall, and yet more frequent storm events are predicted. These will alter water availability, especially in small catchments. Wetlands in western regions, along the Southern Alps, will continue to receive regular and abundant rainfall. In eastern upland areas, precipitation may become more limiting, reducing water flows in small catchments. Warming temperatures may also increase fire risk, although most fires nowadays are ignited by humans. However, the regional protection of wetland habitats and types across the broad elevation, geological and climate gradients in Otago will provide the greatest range of options for the persistence of the specialised indigenous plants and animals occurring in wetland areas in the region.

## Conclusion

Wetlands are complex ecosystems formed from past and present water flows, climates, and sedimentation patterns. Although broad types are recognised, most sites contain diverse habitats representing different ages, stages, features, and processes. They are also dynamic ecosystems, with changes driven by shifts in topography, accumulation of peat, flooding events, and other disturbances.

In our view, the Otago region contains the most diverse representation of wetlands in New Zealand. Nearly all are likely to be less than 10,000 years old, forming after the last glacial period as conditions became warmer. These ecosystems support a specialised biota and numerous endemic species. They also provide ecosystem benefits for sustaining many cultural, agricultural, and recreational activities across Otago.

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## Appendix 1.

Regionally Significant Wetlands in Otago, grouped according to Freshwater Management Units/Rohe. Names and area (hectares) provided by the Otago Regional Council (February, 2022).

### *Catlins Freshwater Management Unit*

Blair Fen	14.3
Blair Swamp	1
Cairn Road Bog	60.2
Cannibal Bay Road Swamp	7.9
Catlins River Wetland	44.3
Cheetwood Road Wetlands	29.6
False Islet Wetland Management Area	40.1
Harrington Mill Road Swamp	1.4
Hukihuki Swamp	18.7
Hungerford Point Saltmarsh	7.2
Kuriwao Saddle Fen Complex	79.8
Lake Wilkie Swamp	2.1
Lenz Reserve Wetlands	68.4
Maclennan River Podocarp Swamp Complex	118.1
Molyneux Bay Swamp	140.5
Otanomomo Tuatiki Reserve	37.6
Ratanui Swamp	5.4
Samson Hill Marshes	8.5
Stuarts Marsh	20.8
Tahakopa Bay Podocarp Swamp	4.9
Tahakopa Marsh Complex	4
Tahakopa River Bogs	186.6
Tautuku River Mouth Marsh	50.3
Trig Y Bogs	16.3
Upper Tahakopa Swamps	23.4
Wairepo Creek Marsh Complex	45.9

### *North Otago Freshwater Management Unit*

All Day Bay Lagoon	11.2
Devils Bridge Wetland	7.6
Ellison Saltmarsh	8.2
Hawksbury Lagoon	43.4
Kakaho Creek Swamp	0.6
Kemp Road Lagoon	9.5
McGregor Swamp	2.9
McLachlan Road Marsh	10.2
PleasantRiverEstuary	84.3
Red Bank Wetland Management Area	122.1
Shag Point Dam Margins	0.6
Shag River Estuary Swamp	14.5

Tavora Wetland	2.2
Te Hua Taki Wetland	6.9
Upper Waiareka Creek Swamp	0.4
Waianakarua River Estuary Swamp	2.8
Waikouaiti River Estuary Wetland Complex	71.6

*Taieri Freshwater Management Unit*

Andersons Pond Margins	2.6
Belmont Inland Saline Wetland Management Area	20.5
Black Rock Marshes	63.2
Braeside Swamp	2.6
Clachanburn Marsh	3.0
Cross Eden Creek Marsh Complex	8.8
Fernhill Marsh	0.7
Fortification Stream Headwaters Swamp	26.0
Glyn Wye Wetland Management Area	43.3
Governors Point Swamp	2.5
Great Moss Swamp	422.7
Henley Swamp	9.4
Lamb Hill Fen Complex	37.7
Laws Road Swamp	1.4
Loch Loudon Fen Complex	33.4
Loch Luella Fen Complex	873.6
Maungatua Summit Wetland Management Area	556.4
McKays Triangle Wetland	41.6
Murrays Road Inland Saline Wetland Management Area	1.5
Nenthorn Ridge Wetland Management Area	67.1
Office Creek Seepage	2.8
Old Dunstan Road Swamp	5.7
Otokia Swamp	9.4
Paddys Rock Ephemeral Tarn	0.7
Patearoa Inland Saline Wetland	4.5
Peat Moss Hills Fen Complex	36.0
Red Bank Wetland Management Area	122.1
Reefs Pond Margins	0.7
Rocky Hill Tidal Marshes	3.2
Styx Ephemeral Wetland Management Area	10.9
Sutton Salt Lake Wetland Management Area	131.6
Swampy Summit Swamp	48.5
Takitoa Swamp	67.9
Timber Creek Seepage	1.0
Totara Creek Inland Saline Wetland	8.8
Trig Q Ephemeral Pool	0.5
Upper Taieri Wetlands Complex	2734.6
Waipori Boot Swamp	11.4
Waipori/Waihola Wetland Complex	2089.6

### *Dunedin and Coast Freshwater Management Unit*

Akatore Creek Swamp	55.2
Aramoana Saltmarsh	74.6
Black Swamp	5.9
Coutts Gully Swamp	33
Hoopers Inlet Swamp	32.1
Jennings Creek Marsh	2.6
Kaikorai Lagoon Swamp	63.7
Lower Otokia Creek Marsh	3
Measly Beach Wetland Complex	46.1
Okia Flat Wetland Management Area	221.8
Papanui Inlet Saltmarsh	5
Swampy Summit Swamp	48.5
Te Matai Marsh Complex	1.1
Tokomairiro River Swamp	175
Tomahawk Lagoon	31.5
Whareakeake Marsh	1.8

### *Clutha Matau-au Freshwater Management Unit - Lower Clutha Rohe*

Blackcleugh Burn Swamp	3.5
Bungtown Bog	28.5
Cairn Road Bog	60.2
Camp Stream Swamp	7.6
Clifton Hill Marshes	4.2
Clutha Matau Wetlands	21.0
Clutha River Mouth Lagoon	29.5
Culcairn Oxbow Marsh	8.5
Dunvegan Fen Complex	81.6
East Benhar Swamp	1.9
Finegand Lagoon Marsh	5.8
Frasers Stream Headwaters Marsh Complex	26.2
Glendhu Swamp	22.1
Hazeldale Fens	9.6
John O'Groats Hill Fen	11.6
Kuriwao Saddle Fen Complex	79.8
Lake Tuakitoto Wetland	545.8
Loch Luella Fen Complex	873.6
Macfarlane Road Oxbow Swamp	2.1
Malones Dam Margins	2.1
Marana Swamp	2.5
Molyneux Bay Swamp	140.5
Pomahaka River Oxbow Marsh (Dalvey School Road)	3.6

Pomahaka River Oxbow Marsh (Koi Creek)	2.0
Stirling Marsh Complex	11.2
Three Stones Fen Complex	58.1
Two Stone Hill Stream Swamp	5.2
Willowburn Bog	4.3

*Clutha Matau-au Freshwater Management Unit - Roxburgh Rohe*

Blackmans Inland Saline Wetland Management Area	12.3
Boundary Creek Fen	94.2
Chapman Road Inland Saline Wetland	7.1
Conroys Dam Inland Saline Wetland Management Area	17.6
Conroys Road Inland Saline Wetland Complex	6.0
Flat Top Hill Ephemeral Wetlands	5.3
Fortification Creek Wetland Management Area	527.6
Gilmour Road Marsh	0.9
Island Block Pond Marshes	3.6
Middle Swamp	66.6
Rigney Pond Margins	0.5
Upper Black Stream Marshes	3.5

*Clutha Matau-au Freshwater Management Unit - Dunstan Rohe*

Bendigo Wetland	243.7
Butterfield Wetland	1.6
Campbells Reserve Pond Margins	1.4
Church Hill Wetland Complex	102.6
Lake Hayes Margins	17
Moke Creek Swamp	1.2
Moke Lake Bog	12.5
Nevis Red Tussock Fen	43.7
Schoolhouse Flat Red Tussock Fen	9.1
Shotover River Confluence Swamp	15.2

*Clutha Matau-au Freshwater Management Unit - Manuherikia Rohe*

Dunard Inland Saline Wetland Management Area	3.1
Galloway No 1 Inland Saline Wetland Complex	3.5
Galloway No 2 Inland Saline Wetland Management Area	6.2
Hawkdun Runs Road Marsh	51
Hut Creek Swamps	12.5
Kirk Creek Headwaters Marsh Complex	6.6
Kirkwoods Creek Wetland Management Area	256.4

Long Gully Marsh	1.3
Lower Manorburn Dam Margins	18.5
Moa Creek Inland Saline Wetland	3.4
Rockdale Inland Saline Wetland Management Area	2.8

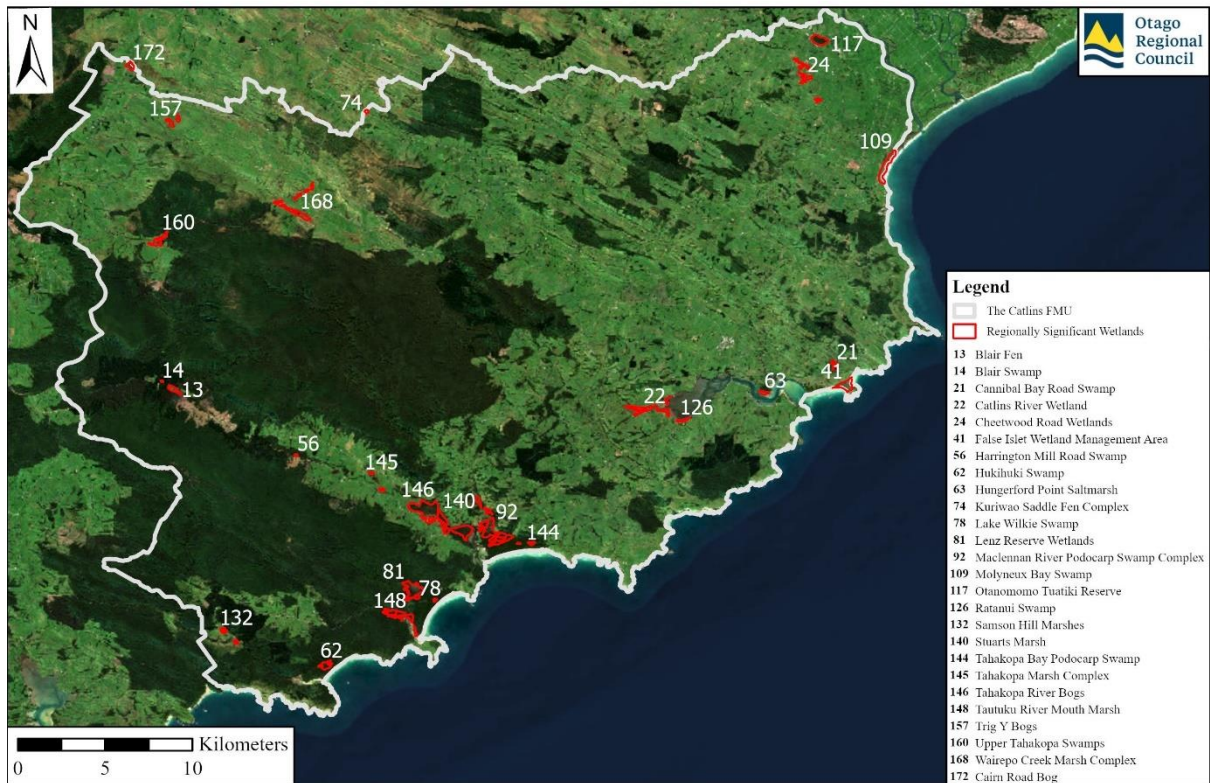
*Clutha Matau-au Freshwater Management Unit - Upper Lakes Rohe*

Big Boggy Swamp	13.4
Diamond Lake Wetland	48.9
Dingle Lagoon	24.7
Glenorchy Lagoon Wetland	128.2
Kinloch Wetland	11.3
Lake Reid Wetland	39.9
Little Boggy Swamp	0.2
Little Stoney Bog	6.8
Makarora Flat Swamp Complex	72.8
Matakauri Wetland	10.8
Matukituki Bluff Ephemeral Wetland Management Area	23.1
Matukituki Valley Wetland Management Area	75.9
Minaret Bay Swamp	23.3
Mount Nicholas Lagoon	91.4
Scaifes Lagoon	5.5
Signal Hill Swamp	1.7
The Neck Wetlands	11.4
Von Valley Wetland Management Area	544.6

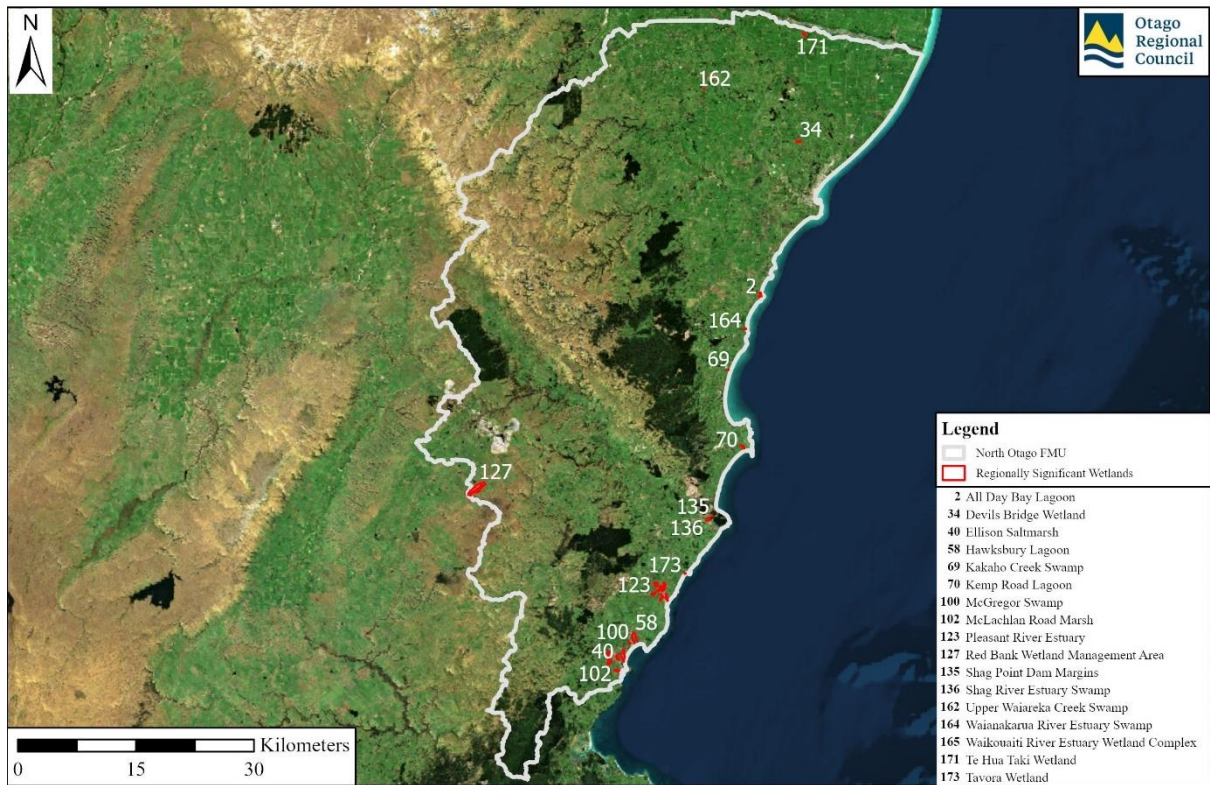
**Appendix 2.**

Maps of Freshwater Management Units/Rohe showing Regionally Significant Wetlands in Otago .  
 Provided by the Otago Regional Council (February, 2022).

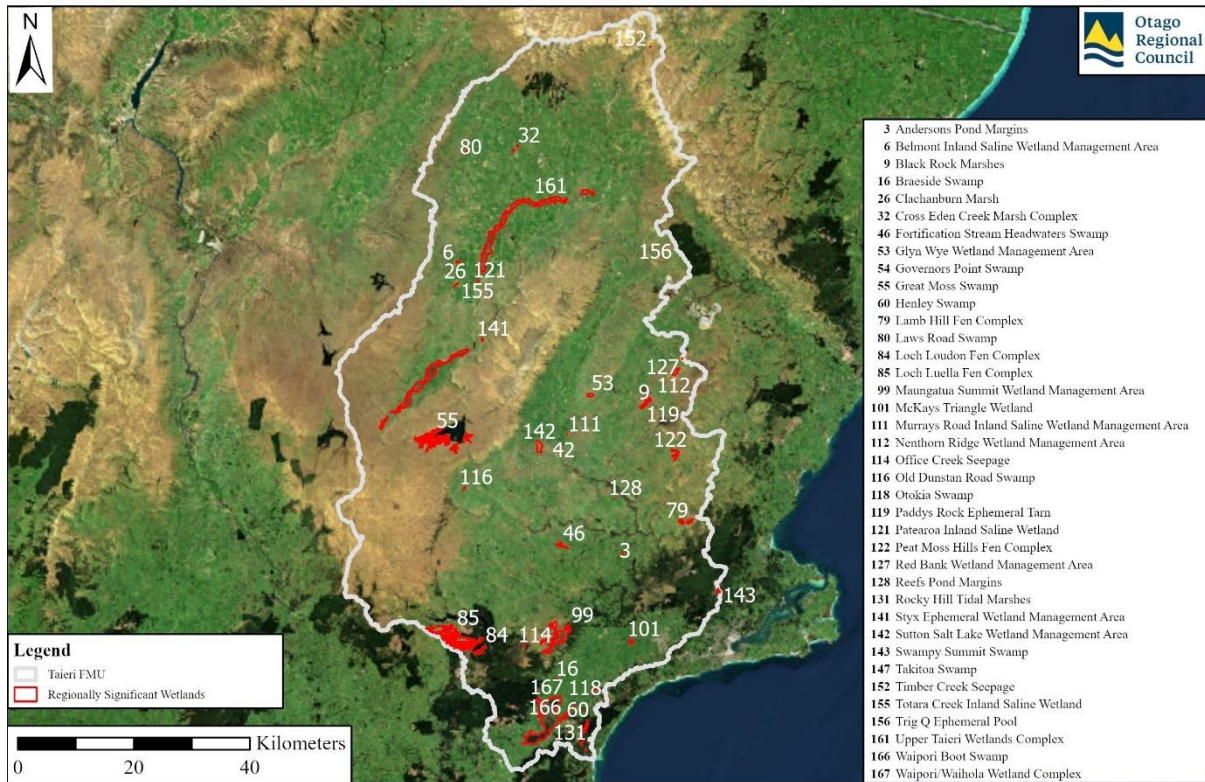
*Catlins Freshwater Management Unit*



# North Otago Freshwater Management Unit

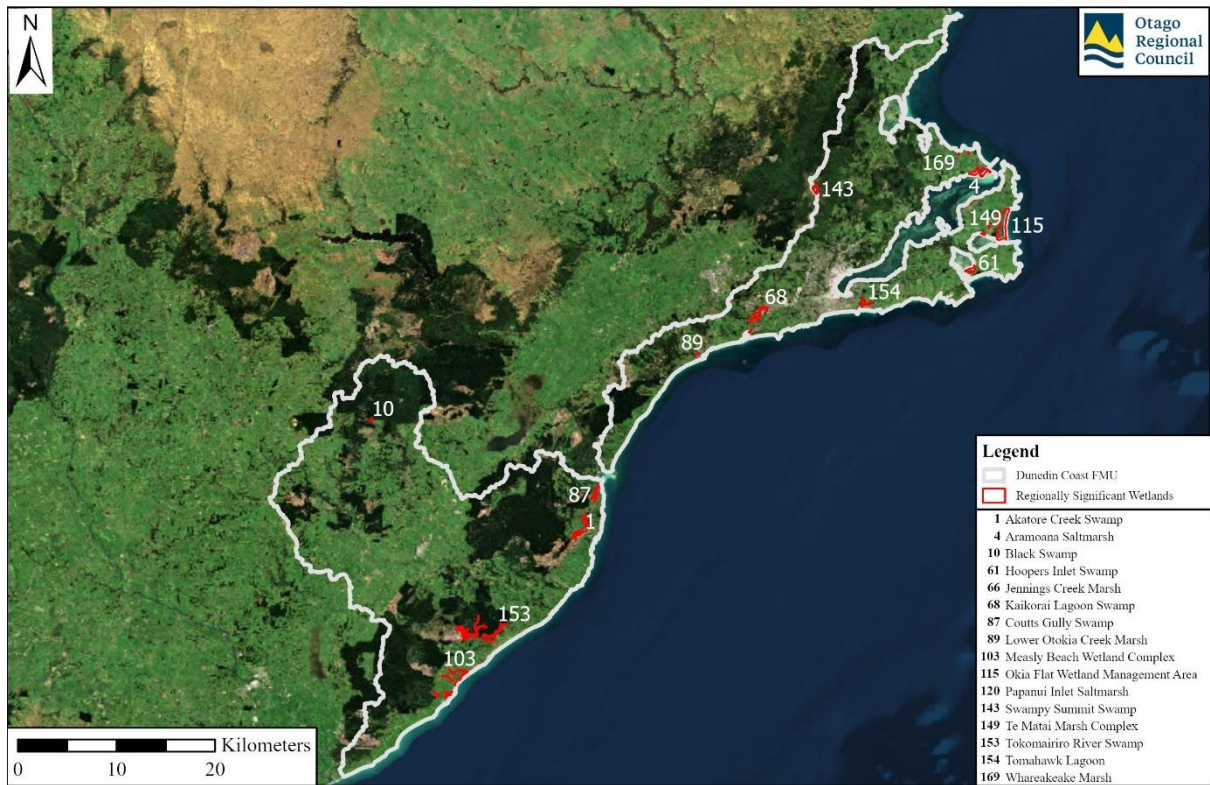


# Taiari Freshwater Management Unit



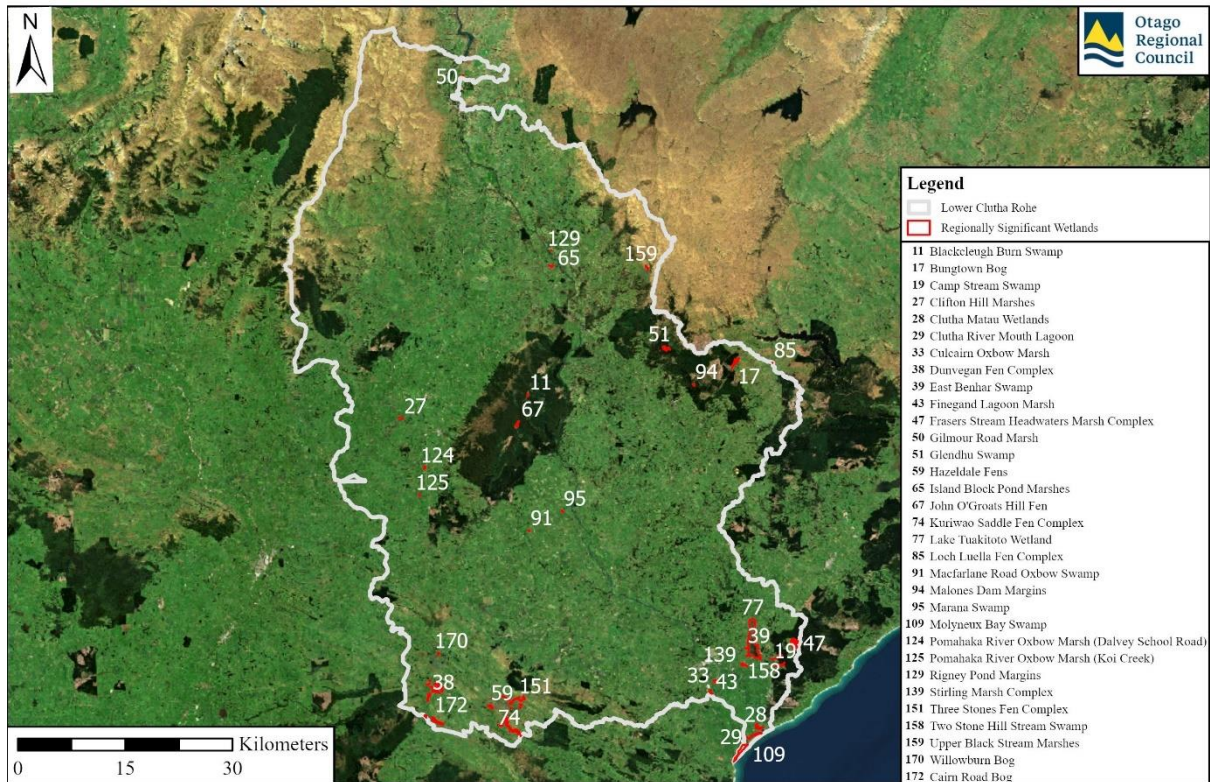


Dunedin Coast Freshwater Management Unit

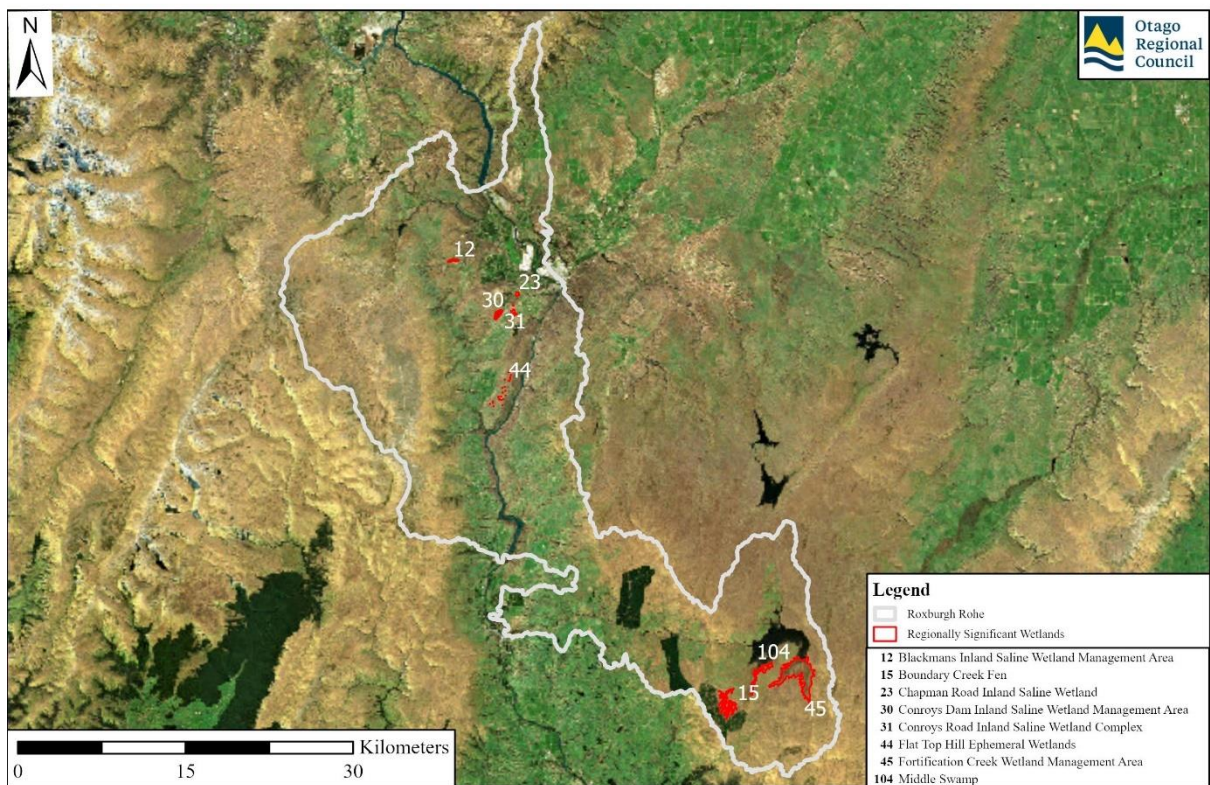


# Clutha Mata -au Freshwater Management Unit

## Lower Clutha Rohe



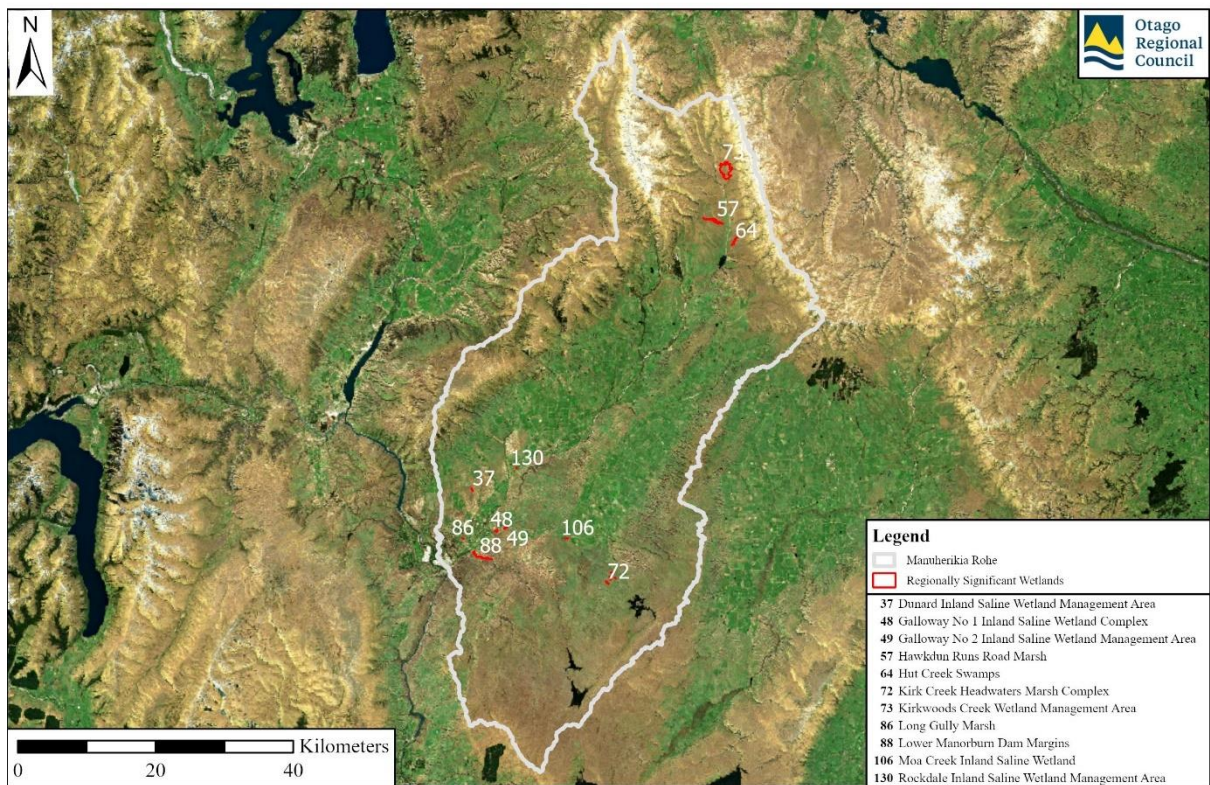
## Roxburgh Rohe



## Dunstan Rohe



## Manuherikia Rohe



Upper Lakes Rohe

