Australian Government
Department of Sustainability, Environment, Water, Population and Communities





Interlaken Lakeside Reserve

Ramsar Site

Ecological Character Description

September 2012

Ecological Character Description Disclaimer

Introductory Notes
This Ecological Character Description (ECD Publication) has been prepared in accordance with the *National Framework and Guidance for Describing the Ecological Character of Australia's Ramsar Wetlands* (National Framework) (Department of the Environment, Water, Heritage and the Arts, 2008).

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) prohibits actions that are likely to have a significant impact on the ecological character of a Ramsar wetland unless the Commonwealth Environment Minister has approved the taking of the action, or some other provision in the EPBC Act allows the action to be taken. The information in this ECD Publication does not indicate any commitment to a particular course of action, policy position or decision. Further, it does not provide assessment of any particular action within the meaning of the *Environment Protection and Biodiversity Conservation Act 1999* (Cth), nor replace the role of the Minister or his delegate in making an informed decision to approve an action.

The *Water Act 2007* requires that in preparing the [Murray-Darling] Basin Plan, the Murray Darling Basin Authority (MDBA) must take into account Ecological Character Descriptions of declared Ramsar wetlands prepared in accordance with the National Framework.

This ECD Publication is provided without prejudice to any final decision by the Administrative Authority for Ramsar in Australia on change in ecological character in accordance with the requirements of Article 3.2 of the Ramsar Convention.

Disclaimer

Note: There may be differences in the type of information contained in this ECD publication, to those of other Ramsar wetlands.

Images
Cover landscape images by K. Morgan 2009.

Sexually mature Golden Galaxias female from Lake Sorell by Dr Scott Hardie, July 2009.
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Acknowledgements

This work is largely based on a document produced by Dr Helen Dunn in June 2008. Entura was tasked with reviewing and updating the original document produced by Dr Dunn. Thanks to Dr Dunn, and those colleagues at Entura who assisted with this document: Eleni Taylor Wood, Raymond Brereton, Stephen Casey, Johanna Slijkerman, Catherine Walsh, David Ikedife, Anita Wild, Dax Noble, Brad Smith, Ruth Painter, Nita Marcus, Dave Graddon, Jessie Digney, Malcolm McCausland and Carolyn Maxwell at Entura contributed text and made editorial comments on the document.

Thanks to staff of the Commonwealth Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) for their support and advice.

The Tasmanian Department of Primary Industries, Parks, Water and Environment provided invaluable assistance in the preparation of this ECD. Information provided related to the floristic communities of Interlaken Lakeside Reserve, data on rainfall and lake levels, as well as invaluable information on the carp management program and the golden galaxias.

The Tasmanian Aboriginal Land and Sea Council provided an Aboriginal community perspective on the Interlaken area.

Executive summary

Interlaken Lakeside Reserve (ILR) was listed as a Ramsar site in 1982. The 517 hectare site, located on the eastern edge of Tasmania's central highlands, includes the north-western corner of Lake Crescent, its adjacent intermittently inundated wetland and an area of mixed light bush. Lake Crescent is separated from nearby Lake Sorell by a low strip of land varying in width between 300 metres and one kilometre. The lakes are connected by the Interlaken Canal which marks the eastern boundary of the ILR. At the western end of the land separating the lakes, Kermodes Drain has been dug through a low-lying marsh area, connecting Lake Sorell to the north western corner of the ILR. Lake Sorell and Lake Crescent are both shallow lakes and have a long history of use as water supply for settlements downstream on the Clyde River and irrigation, such that the water levels within each lake have been manipulated with weirs, sluice gates and channels since around 1840.

The character and condition of ILR are integrally dependent on the whole context of the Lakes Sorell and Crescent system. Therefore, the physical components and processes described in this Ecological Character Description (ECD) draw upon data for the system as a whole. The description of ecological characteristics and ecosystem processes in the intermittent marshes also draws on information from across the systems (such as factors underlying the distribution of floristic communities and seed bank studies).

Ramsar Criteria

Ramsar Criteria at the time of listing (1982)

The original Ramsar Information Sheet (RIS) described the wetland as meeting the following criteria at the time of listing in 1982 (Tasmanian Department of Environment and Land Management 1998):

Criterion (2a): it supports an appreciable number of rare, vulnerable or endangered species or subspecies of plant or animal (now known as Criterion 2).

Criterion (2b): it is of special value for maintaining the genetic and ecological diversity of a region because of the quality and peculiarities of its flora and fauna (now known as Criterion 3).

There was little justification provided in the original RIS of how or why the ILR met these criteria.

Reassessment of Ramsar Criteria (using updated biogeographic region and current criteria)

A RIS compiled in 2005 assessed ILR against Ramsar criteria in the context of the Central Highlands IBRA bioregion (Department of the Environment and Heritage (DEH) 2004; Department of Primary Industries, Water and Environment (DPIWE) 2005a. The authors of the 2005 RIS claimed that Criteria 1, 2, 3, 4, 7 and 8 were met at the time of listing (DPIWE 2005a).

In 2008, the Australian Government adopted the Australian Drainage Divisions system as the most appropriate biogeographic regionalisation approach for ecosystems at the national level. In this document, the values present in the ILR at the time of listing (1982) have been re-assessed against the current (2005) Ramsar criteria, using the Tasmanian Drainage Division as the biogeographic region.

Criterion 1**:** A wetland should be considered internationally important if it contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.

ILR is a valuable regional representation of two Ramsar wetland types ('O' - Permanent freshwater lakes and 'Ts' - Seasonal/intermittent freshwater marshes) within the Tasmanian Drainage Division.

Analysis of Tasmania's vegetation mapping (TASVEG) indicates that ILR is one of the largest intermittent freshwater marshes present in the Tasmanian Drainage Division and is particularly unusual at this elevation (800 metres). It is considered in good condition relative to other large freshwater wetlands in lowland and coastal Tasmania (Kirkpatrick and Harwood 1983).

This criterion is considered to be met.

Criterion 2**:** A wetland should be considered internationally important if it supports vulnerable, endangered or critically endangered species or threatened ecological communities.

The ILR site is habitat for the Tasmanian endemic freshwater fish, golden galaxias (*Galaxias auratus*) (Fulton 1990; Hardie 2003a). This species is listed as endangered under the Commonwealth EPBC Act and rare under the TSP Act. It is also listed as endangered under the IUCN Red List. Its natural distribution is confined to Lake Sorell, Lake Crescent and associated wetlands and small tributaries. Although there are no quantitative data on total abundance throughout its 76 square kilometre range, it is considered to be locally abundant, particularly in Lake Crescent (Hardie 2003a; Scott Hardie pers. comm., 2010). It occurs at much higher densities (ten times) in Lake Crescent than in Lake Sorell and this is believed to reflect greater predation pressure from the trout population in Lake Sorell (Hardie 2003a). The intermittent marshes adjacent to the lakes are thought to provide an important nursery area for juvenile fish (Hardie 2003a; Jackson 2004). Although it is abundant in these two lakes, the golden galaxias is listed on the *Environment Protection and Biodiversity Conservation Act 1999* because of its limited distribution and potential threats to the species which include habitat degradation and predation by introduced species (trout).

Evidence exists that the green and gold frog (*Litoria raniformis*) was present in the late 1970s and early 1980s in the ILR (R Mawbey and Aquenal, pers. comm., 2009). This species is considered Vulnerable under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* and endangered under the IUCN Red List. Chilcott (1986) listed seven frog species found in the vicinity of Lake Crescent and suggested that the range of green and gold frog would be restricted to the marshes along the margins of Lake Crescent, including within the ILR. Based on recent surveys, it is not clear whether the green and gold frog is still present in the ILR (Heffer 2003a).

Similarly, there is one record for the Australasian bittern (*Botaurus poiciloptilus)* from the Lake Crescent area in the late 1970s (Thomas 1979) and suitable habitat is present in the ILR. However, there are no recent records of this species in this area. The Australasian bittern is listed as endangered under the EPBC Act and on the IUCN Red List (Version 2009.1). T

This criterion is considered to be met

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Criterion 3**:** A wetland should be considered internationally important if it supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region.

Criterion 3 was claimed to be met in the 2005 RIS. The site is an essential element of the maintenance of ecological diversity in the area. It supports several species which are rare and/or poorly reserved. The site supports one flora species listed as threatened in Tasmania; southern swampgrass (*Amphibromus neesii*), rare, *Threatened Species Protection Act 1995* (TSPA). The interesting nature of the phytoplankton community, and its differences from nearby Lake Sorrell, are of scientific value. The wetland provides important habitat for many species of macroinvertebrates, including the hydobiid gastropod (*Austropygus* sp.), which is endemic to Lakes Sorrell and Crescent (Cleary 1997) (RIS).

The ILR site supports a significant proportion of the population of the nationally listed golden galaxias (*Galaxiella auratus*), which is also listed as endangered on the IUCN Red List. The golden galaxias is endemic to Lakes Sorell and Crescent and associated streams and wetlands. Therefore, the ILR site is considered to support a population of a species important for maintaining the biological diversity of the biogeographical region.

ILR is considered to meet this criterion.

Criterion 4**:** A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.

This criterion was claimed to be met in the 2005 RIS, based on the site being a refuge for common waterbirds (ducks and swans) but there is little available supporting information to suggest that the site is critical for mobile or migratory species, or is critical for sustaining non migratory wetland species population in the medium or long term.

However, the site provides habitat for the nationally listed golden galaxias during spawning, with the ILR and intermittent marshes adjacent to the lakes providing important nursery habitat for juveniles. Therefore, the site is considered to support a population of a species during a critical life cycle stage.

ILR is considered to meet this criterion.

Criterion 5**:** A wetland should be considered internationally important if it regularly supports 20 000 or more waterbirds.

ILR is not considered to meet this criterion because the available data suggests that the site does not regularly support 20 000 or more waterbirds.

Criterion 6**:** A wetland should be considered internationally important if it regularly supports one per cent of the individuals in a population of one species or subspecies of waterbird.

ILR is not considered to meet this criterion because the available data suggests that the site does not regularly support one per cent of the individuals in a population of a species or subspecies of water bird.

Criterion 7**:** A wetland should be considered internationally important if it supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity.

This criterion was claimed to be met in the 2005 RIS, however there is little supporting evidence that can be found to justify this claim. It is considered that this criterion was misapplied in that RIS (DPIWE 2005a). This criterion is predominantly about the diversity of fish populations or a fish assemblage that displays a large range of morphologies and reproductive methods.

Criterion 8**:** A wetland should be considered internationally important if it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.

The ILR wetlands provide important breeding habitat for the nationally endangered Tasmanian endemic golden galaxias. This galaxiid's small, adhesive eggs are typically deposited on aquatic vegetation and rocky substrate, and the intermittent marshes adjacent to the lakes are thought to provide an important nursery area for juvenile fish (Hardie 2003a; Jackson 2004). Adult fish prefer rocky lakeshore habitat (Hardie 2003a) and, to a lesser degree, marsh habitat.

Given the high relative abundance of the golden galaxias population within Lake Crescent the ILR is considered to provide important spawning, foraging and refuge (from predations) habitat for the species.

ILR is considered to meet this criterion.

Criterion 9**:** A wetland should be considered internationally important if it regularly supports one per cent of the individuals in a population of one species or subspecies of wetland-dependent non-avian animal species.

The ILR wetlands support a significant proportion of the entire golden galaxias population. The golden galaxias is endemic to Tasmania and only occurs naturally in Lake Sorell, Lake Crescent and associated tributary streams and wetlands. It is much more common in Lake Crescent (ten times the density of Lake Sorell) and habitat critical to its survival is all areas where the species naturally occurs. Lake Crescent (and associated intermittent marshes) is approximately 2285 hectares in size while Lake Sorell (and associated intermittent marshes) is approximately 5212 hectares. Given the higher densities of golden galaxias present, Lake Crescent may contain up to 80 % of the population of this species. Given the ILR wetlands comprise approximately 15 % of suitable habitat wetlands present in Lake Crescent it is expected that ILR could regularly support more than one per cent of the population of this species.

ILR is considered to meet this criterion.

This document provides support for the conclusion that the ILR met Ramsar criteria 1, 2, 3, 4, 8 and 9 at the time of listing.

Wetland types

The wetland types, as defined by Ramsar, present at the ILR Ramsar site are:

O – Permanent freshwater lake over eight hectares in area

Ts – Intermittent marshes on inorganic soils.

Permanent freshwater lake occupies approximately 179 hectares while the intermittent marshes occupy 173 hectares with the balance of the site supporting *Eucalyptus delegatensis* dry forest and woodland (TASVEG Code DDE).

Ecosystem components and processes

Ecosystem components such as geomorphology, hydrology, water quality, plankton, flora and fauna; and ecosystem processes such as trophic interactions, the wetland inundation regime; and provisioning, regulating, cultural and supporting benefits and services can determine, or strongly influence the character of a Ramsar site. These ecosystem components and processes have been investigated for ILR. A brief summary of these ecosystem components and processes at time of listing (1982) is provided below.

Component or process	Summary description
Ecosystem components	
Geomorphology	Shallow mid altitude lakes
Hydrology	Drainage catchment- relatively small 32.8 square kilometres Rainfall - variable local rainfall Lake level variability - variable lake levels, natural and human causes
Water quality	Turbidity- generally high, strongly related to lake levels Nutrients and water chemistry - neutral pH Sediment - re-suspension in shallow lake; affects nutrients, light attenuation and productivity
Plankton	Basis of food chain; dominated by diatoms Interesting assemblages of plankton characterise Lake Crescent
Flora	Species and communities- good representation of mid altitude wetlands; one of largest freshwater intermittent marsh systems in the Tasmanian Drainage Division Important representation of regional biodiversity
Fauna	Macroinvertebrates - important habitat for endemic species Fish - supports habitat critical to survival of endangered fish species golden galaxias (*Galaxias auratus*); supports >1 per cent of total population of golden galaxias Birds - habitat for some migratory and listed bird species Frogs - population of threatened green and gold frog

Ecosystem processes	
Trophic interactions	Light attenuation prevents macrophyte growth in the open water, while diatoms and other phytoplankton flourish; these are consumed by zooplankton; small fish, including golden galaxias, consume plankton, benthic fauna and airborne insects that land on the water surface; trout consume golden galaxias
Wetland inundation regime	Strongly influenced by rainfall; managed (where possible) in conjunction with lake levels in nearby Lake Sorell; trigger for breeding of golden galaxias where sufficient water level is needed to cover spawning habitat Influences- the wetland vegetation; the viability of flora species in intermittent marshes (dormancy, regeneration and dispersal); and overall wetland condition

Ecosystem benefits and services

Ecosystem benefits and services provided by the ILR site are an important part of the ecological character of the ILR. The relationships between the ecological service and the ecosystem components and processes were examined to identify the primary drivers of the ecological character of the site. Some of these services are confined to the standing open water, others to the intermittent marshes. In the case of the golden galaxias and waterfowl, both the wetland and the water body are important for aspects of their ecology. The ecosystem benefits and services provided by the ILR are presented below.

Ecosystem service	Wetland Type	Component	Process
Provisioning services			
Fresh water - water supply	Permanent freshwater lake	Geomorphology Hydrology	Wetland inundation - lake level change and management
Food - commercial eel fishery	Permanent freshwater lake	Geomorphology Fauna - invertebrate and fish communities	Trophic interactions - predation Wetland inundation - lake level change and management
Regulating services			
Sediment deposition and retention - sediment trap	Intermittent freshwater marsh	Flora - wetland vegetation	Wetland inundation - lake level change, sediment transport, deposition and nutrient renewal
Cultural services			
Recreation and tourism -	Permanent	Geomorphology	Trophic interactions -

Ecosystem service	Wetland Type	Component	Process
recreational trout fishing	freshwater lake	Fauna - invertebrate and fish communities	predation of golden galaxias Wetland inundation - lake level change and management
Spiritual and inspirational - Aboriginal associations and education	Intermittent freshwater marsh / Permanent freshwater lake	Geomorphology Flora - wetland vegetation	Wetland inundation - lake level change and management
Supporting services			
Threatened wetland species, habitats and ecosystems - breeding/spawning area for golden galaxias	Intermittent freshwater marsh / Permanent freshwater lake	Fauna - golden galaxias population Geomorphology - inundated rocky shoreline and marshes Hydrology - influencing habitat connectivity Water quality Flora- wetland vegetation	Trophic interactions - predation Wetland inundation - provision of habitat for reproduction
Natural or near-natural wetland ecosystems - regional example of mid-altitude temperate wetland communities and component species	Intermittent freshwater marsh / Permanent freshwater lake	Geomorphology Hydrology - rainfall and connectivity Water quality - nutrients Flora - wetland vegetation	Wetland inundation - lake level change and management, flooding regime, nutrient cycling, provision of habitat for reproduction, dormancy and colonisation
Biodiversity - habitat for endemic and threatened species and ecosystems	Intermittent freshwater marsh / Permanent freshwater lake	Fauna - invertebrate communities Geomorphology - including rocky shorelines for galaxias reproduction Hydrology - habitat connectivity Water quality - dissolved oxygen Plankton communities	Trophic interactions - predation and competition Wetland inundation - lake level change and management, dispersal of species
Biodiversity - plankton dominated aquatic community, including unusual diatom	Permanent freshwater lake	Geomorphology Water quality - turbidity, nutrients,	Trophic interactions - light attenuation, primary production, decomposition

Ecosystem service	Wetland Type	Component	Process
communities		trace elements (silica)	and predation Wetland inundation - lake level change and management, nutrient cycling, reproduction and dispersal of species
Biodiversity – refugia	Intermittent marshes	Golden galaxias, wetland flora	Trophic interactions – predation and competition

Critical ecosystem components, processes and services

Critical ecosystem components, processes and services are those that:

- are important determinants of the site's unique character (e.g. geomorphology and water quality);
- are important for supporting the Ramsar criteria under which the site was listed (e.g. fauna such as the golden galaxias and the wetland vegetation community);
- are reasonably likely to change over the short, medium or long term (<100 years); or
- if change occurs to them, will cause significant negative consequences (e.g. wetland inundation regimes).

Critical ecosystem components and processes

Of the ecosystem components and processes within the ILR at the time of listing in 1982, two components, the golden galaxias and the intermittent marshes, were determined to be 'critical.' As little information exists regarding the occurrence of the green and gold frog and Australasian bittern at the ILR and that they have not been recorded at ILR since the time of listing, it is not considered that they currently contribute to the ILR meeting Criterion 2 and, as such, are not considered to be critical components of the ILR.

<u>Golden galaxias</u>: This species is a critical component as it is one of the primary determinants of the ecological character of the ILR. The species is endemic to Tasmania and found only in Lake Sorell, Lake Crescent and associated tributaries and wetlands. It is found in the highest densities within Lake Crescent. The golden galaxias is a critical component in the justification for meeting five of the Ramsar criteria for which the site was listed. The criteria relate to:

- The ILR supporting vulnerable or endangered species (Criterion 2);
- The ILR being important in that it supports a species at a critical stage in its lifecycle (Criterion 3);
- The ILR being important spawning ground and nursery on which fish depend (Criterion 4);
- The ILR providing important spawning, foraging and refuge habitat for a nationally endangered species, the golden galaxias fish (Criterion 8); and
- The ILR regularly supporting more than one per cent of the individuals in a population of one species of wetland dependent non-avian animal species (Criterion 9).

Given the small catchment of Lake Crescent and the highly variable rainfall of the region, change in the abundance of the species over the short, medium or long term is likely. If a substantial loss were to occur, this would cause considerable negative consequences to the identified character of the ILR.

Intermittent marshes: The intermittent marshes of the ILR are also considered a critical component as they are a part of the defining character of the ILR. The presence of the intermittent marshes is central to the justification for meeting Criterion 1 of the Ramsar criteria for which the site is listed. The intermittent marshes are also important foraging, spawning and nursery area for the golden galaxias as well as a refuge from predation by introduced fish. Due to the highly variable nature of the wetting and drying regime of the marshes and water extraction for downstream use it is possible, in the absence of controls; that changes to the nature of the intermittent marshes could occur that could result in significant negative changes to the site. Such changes could ultimately lead to a change in ecological character.

Critical ecosystem services

The following 'supporting services' were determined to be 'critical' ecosystem services of ILR:

- Threatened wetland species, habitats and ecosystems – ILR is a breeding /spawning area for golden galaxias; and
- Natural or near-natural wetland ecosystem – ILR is a regional example of mid-altitude temperate wetland communities and component species.

Breeding / spawning area and habitat for golden galaxias: The rocky substrate around the shore of Lake Crescent and the intermittent marshes provides spawning areas for golden galaxias (Hardie et al. 2007). The species also uses the open water column and wetland habitats during its life cycle.

Regional example of wetland communities: The ILR intermittent marshes are considered to be the largest freshwater marshes within the Central Highlands and Tasmania. The two wetland communities are adapted to variable climatic conditions but are dependent on periodic inundation to survive. Connectivity to the lake provides important sediment and nutrient cycling, as well as water for germination and dispersal of propagules. The ILR is also a representative example of mid altitude freshwater marshes in the Tasmanian Drainage Division, as many others in Tasmania are at much lower altitude.

Threats to the ILR Ramsar site

The principal threat to the ecological character of Interlaken Lakeside Reserve and the entire Lakes Sorell and Crescent ecosystem is limited water inflows. While fluctuation in water level is characteristic of this system, extreme drying out (or water-logging) over an extended period is a major threat to the site's ecological character. It has the potential to impact wetland vegetation, water quality and fauna habitat, particularly for the golden galaxias. Lake Crescent and Lake Sorell were modelled as part of the Commonwealth Scientific and Industrial Research Organisation (CSIRO) Tasmania Sustainable Yields Project (Ling et al 2009), which investigated water availability in Tasmania under current and future scenarios for climate to 2030. The results show that the level in the lakes is likely to be lower under future climate scenarios due to a decrease in inflows and an increase in evaporation from the lakes. The projected lower inflows and lake level under future climate scenarios would result in longer periods between spill events. The major threats to the ILR Ramsar site are presented in the following table.

Actual or likely threats or threatening activity	Potential impact	Likelihood	Timing
Prolonged high or low lake levels (including impacts of climate change)	Inability of intermittent marshes to reproduce Decline in condition of vegetation Loss of soil seed bank Loss of spawning habitat and triggers for golden galaxias	Almost certain	Immediate
Forestry activities adjacent to wetland such as clearing of native vegetation, partial harvesting or plantation establishment	Sediment deposition and increased turbidity Nutrient enrichment Changes to hydrology Establishment of weeds Reduced habitat quality	Possible	Immediate
Water extraction for human and agricultural use	Low lake levels and associated impacts Inability of intermittent marshes to reproduce Decline in condition of vegetation Loss of soil seed bank Loss of spawning habitat and triggers for golden galaxias	Possible, subject to legislation	Immediate to long term (subject to legislation)
Exotic plants and animals: Increase in terrestrial or exotic flora	Displacement of native wetland species	Almost certain	Immediate
Exotic plants and animals: Increase in trout numbers	Increased predation of galaxias population	Possible	Immediate to long term
Exotic plants and animals: Introduction of/ increase in European carp	Reduced water quality and increased turbidity Impact on native plants	Possible	Immediate to long term
Exotic plants and animals: Introduction of other exotic fish species	Impact on native fish	Possible	Medium to long term
Exotic plants and animals: Presence of chytrid fungus	Impact on frog population	Almost certain	Immediate
Exotic plants and animals: Introduction of didymo (*Didymosphenia geminata*)	Adversely affect water quality, aquatic invertebrates and fish stocks	Possible	Medium to long term

Limits of acceptable change

1. Acceptable change is defined as "the variation that is considered acceptable in a particular measure or feature of the ecological character of the wetland" (Phillips 2006). Limits of Acceptable Change (LAC) are a tool by which ecological change can be measured. However, Ecological Character Descriptions are not management plans and Limits of Acceptable Change do not constitute a management regime for the Ramsar site. Exceeding or not meeting Limits of Acceptable Change does not necessarily indicate that there has been a change in ecological character within the meaning of the Ramsar Convention. However, exceeding or not meeting Limits of Acceptable Change may require investigation to determine whether there has been a change in ecological character. Limits of Acceptable Change can be updated as new information becomes available to ensure they more accurately reflect the natural variability (or normal range for artificial sites) of critical components, processes, benefits or services of the Ramsar wetland.

LACs were developed for each critical ecosystem component and corresponding service. These are summarised in the following table.

Critical component and supporting service	**Baseline condition, range of natural variation where known, supporting evidence**	**Limit of acceptable change (LAC)***	**Basis of LAC**	**Level of Confidence**
Golden galaxias Supporting Service: Threatened wetland species, habitats and ecosystems – ILR is a breeding /spawning area for golden galaxias.	Successful spawning and suitable habitat for golden galaxias (Hardie 2003a).	Loss of two successive cohorts of golden galaxias.	Expert opinion, scientific literature and available data.	High

Critical component and supporting service	Baseline condition, range of natural variation where known, supporting evidence	Limit of acceptable change (LAC)*	Basis of LAC	Level of Confidence
Intermittent marshes Supporting Service: Natural or near-natural wetland ecosystem – ILR is a regional example of mid-altitude temperate wetland communities and component species.	Vegetation surveys and mapping prior to, and since the time of listing (Kirkpatrick and Harwood 1981; Chilcott 1986; Heffer 2003a)	50 % change in area of wetland vegetation for greater than six months based on 53 ha of *Triglochin procerum* dominated vegetation and 121 ha of sedge dominated vegetation (Chilcott 1986).	Expert opinion and available vegetation mapping and survey data.	High
	Evidence from vegetation surveys is inconclusive. It is unclear whether differences in species diversity and composition over time is due to real change or different levels of sampling intensity. Hydrology and its influence on lake and wetland levels is a major factor that can affect these LAC – see Section 7.5 for discussion on loss of connectivity during dry phases.	Loss of 50% of native wetland species[1] recorded in 1981 (ten species) including at least one dominant (*Triglochin procerum , Potamogeton tricarinatus, Myriophyllum simulans, Baumea arthrophylla or Isolepis fluitans*). An increase in woody/non-wetland species.	Baseline species data is based on 1981 data compiled by Kirkpatrick and Harwood (1981), however it is recommended that new reference sites be established in core wetland habitats (away from marginal habitat) to establish a more robust LAC for species composition.	Low

- Exceeding or not meeting a LAC does not automatically indicate that there has been a change in ecological character.

[1] Native wetland species identified in Appendix 4.

Changes since listing

Significant changes have occurred to the wetlands at ILR since the time of listing in 1982, many of which have been attributed to a recent prolonged dry spell and lower lake levels. When the Interlaken Lakeside Reserve was placed on the Ramsar list, the values supporting the listing related to wetland flora and, to a lesser degree, the diverse phytoplankton community of the lake that fell within the boundary. Several years of low rainfall, deliberate lowering of the lake levels as part of a carp management program and water releases for downstream users resulted in lake levels below that required for inundation of the wetlands for much of the period 1998 to mid-2009.

Dry periods are a natural property of intermittent wetlands such as at ILR and the biota is generally adapted to such variation. While the recent dry period at ILR was largely a result of the prolonged period of low rainfall, it is difficult to determine the degree to which water releases for downstream users or the lowering of lake levels for carp management, have impacted on the character of the site. It is clear that water was released from the system during times when the lake level was below the preferred minimum operating level (802.7 metres AHD) but what is unclear is the degree to which such releases exacerbate impacts to the system and whether it has significantly altered the character of the site that has been used as a water reservoir for over 160 years (Mason-Cox 1994).

The degree to which the wetland vegetation will recover given the recent heavy rainfall since mid-2009 is unknown and monitoring will be important to determine this. However, it is likely that due to the natural resilience of these vegetation types, little significant change has occurred. Overall, the evidence suggests that the site still retains its fundamental ecological character and meets the criteria for which it was listed in 1982, although there have been some changes in the condition of the site. Changes during the period 1998-2009 are summarised below.

- Wetland vegetation communities- increased bare ground and exotic flora species;
- Decline in water quality- particularly turbidity, nutrients and algal levels;
- Fauna- introduction of European carp; introduction of common galaxias (*Galaxias maculatus*); loss of golden galaxias habitat due to low lake levels; possible loss of the green and gold frog and Australasian bittern (additional survey effort is required to determine whether losses are actual, or if drought conditions resulted in populations retracting to undetectable numbers from which they may recover under more favourable conditions);
- Loss of connectivity between the intermittent marshes and the water body (due to low lake levels) potentially leading to:
    - isolation of galaxiid population from preferred spawning sites on the rocky lake shores;
    - isolation of galaxiid populations from each other and potential genetic impacts;
    - isolation of benthic and planktonic fauna from wetland habitats;
    - loss of protection from predation amongst macrophytic vegetation for galaxiids;
    - loss of nutrient supply from water column;
    - dewatering of wetland substrates and reduction in groundwater levels; and
    - loss of potential sources of propagules from elsewhere in the wetland system.

Key knowledge gaps and monitoring

Further information is required in order to fully understand some key ecosystem services, components and processes and set meaningful limits of acceptable change for ILR. Knowledge gaps include:

- Wetland invertebrate fauna;
- Role of the wetlands in the ecology of the golden galaxias;
- Ability of wetland vegetation to recover from the prolonged dry period;
- Utilisation of the ILR by migratory and listed bird species;
- Distribution of frogs within the ILR and of the presence of chytrid fungus;
- Presence and relative abundance of exotic fish species;
- Likely impacts of nearby native vegetation clearing and forestry plantation establishment on the hydrology of the Ramsar site; and
- Likely impact from water extraction for all purposes under the 2005 Water Management Plan and effects on long-term sustainability of golden galaxias populations and the system as a whole.

Community and Education Messages

There are currently limited interpretation signs at the Interlaken Lakeside Reserve and the recreational and environmental potential of the site has not been greatly promoted. Signs are required to inform visitors of the:

- status of the area;
- reasons for reservation; and
- reasons it is recognised as a wetland of international importance.

Following on from the identified threats to the ecological character of the ILR Ramsar site, a number of communication and education messages could be given priority in addition to the programs listed above. These include:

- Informing visitors of appropriate minimal impact use of the reserve including walking, boating, recreational vehicles and domestic pets;
- Integration of management authorities including Parks and Wildlife Service, Inland Fisheries Service etc to encourage cross tenure management of relevant issues;
- Liaison with teachers and organisations such as Waterwatch and Landcare to encourage educational programs in the reserve;
- Threats associated with use – chytrid, didymo, vehicle use, fire etc;
- Seeking a special relationship with the local school in developing educational programs and activities based on the particular values of the reserve;
- Considering the reserve in the context of all parks and reserves within the Central Highlands and their particular values, in developing an interpretation and education strategy;
- Education of angling groups and surrounding landholders regarding the values and threats present at ILR;
- Development of good working relationships with adjacent land managers and the community including the Aboriginal community, to ensue cross tenure management issues can be effectively and cooperatively addressed; and
- Working closely with Local Government to ensure consistency between management plans, site plans and the municipal planning scheme.

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Nomenclature and terminology

Interlaken Lakeside Reserve[2] is the name of the site used in this ECD, in accordance with the designation at the time of listing (1982). This term remains in use on the Ramsar organisation website. However, the tenure and reserve status of the site is in the process of changing and in the 2005 Ramsar Information Sheet and on the Tasmanian Government website the site is simply referred to as 'Interlaken'. In the interests of clarity, the Ramsar site is referred to in this ECD by its original listing title of 'Interlaken Lakeside Reserve' and as 'ILR' for brevity and readability. This name will be used in the updated RIS that has been prepared as part of this ECD.

Lake Crescent is used in this ECD for the permanent body of water, only part of which lies within the Ramsar site. Data from the entire water body are considered relevant to the understanding of that area of open water lying within the Ramsar boundary.

The Lakes Sorell and Crescent system is the term used to include the two bodies of water, associated wetlands, drainage channels, Clyde River outflow and creeks in the catchment.

Wetlands consistent with the definition provided by Ramsar (DEWHA 2008a) refers to areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres.

Intermittent Marshes refers particularly to the periodically inundated vegetated areas on the shoreline of Lakes Sorell and Crescent. These areas may, at times, be dry and are therefore described as temporary wetlands.

ILR wetlands are specifically those wetlands lying within the Ramsar boundary including open water and intermittent marshes.

2 Other names for the site include 'Interlaken (Lake Crescent)' and 'Interlaken'.

Abbreviations

AHD - Australian Height Datum

Chla – Chlorophyll *a*

CLAC – Crown Land Assessment and Classification

CSIRO – Commonwealth Scientific and Industrial Research Organisation (CSIRO)

DEH – Commonwealth Department of the Environment and Heritage

DEWHA – Commonwealth Department of the Environment, Water, Heritage and the Arts (formerly DEWR)

DEWR – Commonwealth Department of the Environment and Water Resources (formerly DEH)

DPIW – Tasmanian Department of Primary Industries and Water (formerly DPIWE)

DPIWE – Tasmanian Department of Primary Industries, Water and Environment

DPIPWE – Tasmanian Department of Primary Industries, Parks, Water and Environment (formerly DPIW)

DSEWPaC – Commonwealth Department of Sustainability, Environment, Water, Population and Communities (formerly DEWHA)

EC – Electrical conductivity

ECD – Ecological Character Description

EPBC Act – Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*

FSL – Full Supply Level

IFS – Tasmanian Inland Fisheries Service

ILR – Interlaken Lakeside Reserve

IUCN – International Union for Conservation of Nature

NRM – Natural Resource Management

PWS – Tasmanian Parks and Wildlife Service

RIS – Ramsar Information Sheet

TSP Act – Tasmanian *Threatened Species Protection Act 1995*

Units

km – kilometres

m – metres

NTU – Nephelometric Turbidity Units

PSU – Practical Salinity Units

µS/cm – microSiemens per centimetre

1. Introduction

1.1 Site details

Site Name	**Interlaken Lakeside Reserve**
Location in coordinates	42º 09' 00"S, 147º 09' 00E
General location of site	Interlaken Lakeside Reserve lies at the north west corner of Lake Crescent, approximately 20 kilometres west of the Tunbridge township at an altitude of about 800 metres.
Area	517 hectares
Date of Ramsar designation	1982
Ramsar criteria met by the wetland	1, 2, 3, 4, 8, 9
Management Authority	Department of Primary Industries, Parks, Water and Environment GPO Box 44 Hobart Tasmania 7000
Date the ecological character description applies	1982
Date of compilation	March 2008 and reviewed December 2011
Names of Compilers	Dr Helen Dunn and Entura
Reference for Ramsar Information Sheet	Ramsar Information Sheet prepared by Department of Primary Industries and Water 2005 http://www.environment.gov.au/cgi-bin/wetlands/ramsardetails.pl?refcode=11#
Reference to the Management Plan	Heffer DK (2003b). Interlaken Lakeside Reserve Ramsar Wetland Management Plan. Rehabilitation of Lakes Sorell and Crescent report series no. 6/2 Inland Fisheries Service, Hobart. http://www.ifs.tas.gov.au/ifs/fisherymanagement/publications/pdf-s-for-publications/wetlands-report-2-ramsar-management-plan.pdf

1.2 Purpose of the ecological character description

This Statement of Purpose originates from the *National Framework and Guidance for Describing the Ecological Character of Australia's Ramsar Wetlands: Module 2 of the National Guidelines for Ramsar Wetlands – Implementing the Ramsar Convention in Australia* (DEWHA 2008a). These purposes are fulfilled for the Interlaken Lakeside Reserve Ramsar site by analysis of data particular to the site and the presentation of conceptual models for its ecological character at the time of its Ramsar listing.

It is intended that the Ecological Character Description (ECD) will be used to:

1. Assist in implementing Australia's obligations under the Ramsar Convention, as stated in Schedule 6 (Managing wetlands of international importance) of the Environment Protection and Biodiversity Conservation Regulations 2000 (Commonwealth):
   - (a) to describe and maintain the ecological character of declared Ramsar wetlands in Australia; and
   - (b) to formulate and implement planning that promotes:
     - (i) conservation of the wetland; and
     - (ii) wise and sustainable use of the wetland for the benefit of humanity in a way that is compatible with maintenance of the natural properties of the ecosystem.
2. Assist in fulfilling Australia's obligation under the Ramsar Convention, to arrange to be informed at the earliest possible time if the ecological character of any wetland in its territory and included in the Ramsar List has changed, is changing or is likely to change as the result of technological developments, pollution or other human interference.
3. Supplement the description of the ecological character contained in the Ramsar Information Sheet submitted under the Ramsar Convention for each listed wetland and, collectively, form an official record of the ecological character of the site.
4. Assist the administration of the Commonwealth *Environment Protection and Biodiversity Conservation Act* (EPBC Act), particularly:
   - (a) to determine whether an action has, will have or is likely to have a significant impact on a declared Ramsar wetland in contravention of sections 16 and 17B of the EPBC Act; or
   - (b) to assess the impacts that actions referred to the Minister under Part 7 of the EPBC Act have had, will have or are likely to have on a declared Ramsar wetland.
5. Assist any person considering taking an action that may impact on a declared Ramsar wetland whether to refer the action to the Minister under Part 7 of the EPBC Act for assessment and approval.
6. Inform members of the public who are interested generally in declared Ramsar wetlands to understand and value the wetlands.
7. Develop a dynamic model of the Interlaken system integrating descriptive data from the time of listing with more recent and extensive data, including predictive modelling of climate change.

1.3 Ecological Character Description methodology

This ECD has been prepared in accordance with the *National Framework and Guidance for Describing the Ecological Character of Australia's Ramsar Wetlands: Module 2 of the National Guidelines for Ramsar Wetlands – Implementing the Ramsar Convention in Australia*, (DEWHA 2008a). The ECD has been compiled with reference to the character and condition of the wetland at the time of listing (1982), although much of the data are drawn from more recent research and documentation.

At the time of listing (1982) the values noted arose from the wetland flora, with some reference to the phytoplankton of the lakes in the area. The following two decades saw considerable research interest in the site, firstly with reference to the species of particular conservation significance (notably phytoplankton, galaxiid fish and aquatic snails) and, more recently, as the basis for the rehabilitation of Lakes Sorell and Crescent after the discovery of carp in these two interconnected lakes.

Research was conducted by the Inland Fisheries Service between 2000-2003, through the Lakes Sorell and Crescent Rehabilitation Project, following drastic measures to reduce and control the carp population of the two lakes. Data from this work provided the foundation for the preparation of a Water Management Plan for Lakes Sorell and Crescent. The suite of studies undertaken as part of the Lakes Sorell and Crescent Rehabilitation Project has been used extensively in preparing this ECD[3]. These data provide rich description and analysis of the ecological character of Lakes Sorell and Crescent and indicators of the natural variability of Lake Crescent and its associated marshes, including the Interlaken Lakeside Reserve Ramsar site. Although conducted up to two decades after Ramsar listing, these surveys are considered relevant to provide data appropriate to the services, components and processes at the time of listing. These data are integrated with available earlier information on vegetation communities, providing a richer interpretation of the dynamics of this ecosystem.

As the Ramsar site is part of a larger wetlands ecosystem (Lake Crescent water body, its catchment and its associated marshes), the scope of this ECD reflects that integral relationship. The conceptual models, ecosystem services and management issues bring together the physical and biotic components and processes showing the integral relationship between the Ramsar site and the wider ecosystem of Lake Crescent and its catchment, notably Lake Sorell.

The components and processes fundamental to the character of the Ramsar site are essentially the same as at the time of listing, although the site has experienced drier phases since 1982. Evidence of change in condition and the factors underlying these changes are presented in Section 7.

1.4 Treaties, legislation and regulations

A number of Treaties, Legislation and Regulations are relevant to the ecological character of the ILR Ramsar site.

1.4.1 International

1.4.1.1 Treaties

Australia is party to a number of bilateral agreements, initiatives and conventions for the conservation of migratory birds which are relevant to the ILR Ramsar site. The bilateral agreements are:

- *The Convention on Wetlands of International Importan*ce *(Ramsar Convention)* –an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. Negotiated through the 1960s by countries and non-governmental organisations that were concerned at the increasing loss and degradation of wetland habitat for migratory waterbirds, the treaty was adopted in the Iranian city of Ramsar in 1971 and came into force in 1975. It is the only global environmental treaty that deals with a particular ecosystem, and the Convention's member countries cover all geographic regions of the planet (Ramsar Secretariat 2009)

[3] The full reports are available on the Inland Fisheries Service website, www.ifs.tas.gov.au

- The *Agreement between the Government of Australia and the Government of Japan for the Protection of Migratory Birds in Danger of Extinction and their Environment* (JAMBA) (1974)
- The *Agreement between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and their Environment* (CAMBA) (1986)
  The JAMBA and CAMBA are bilateral agreements relating to the conservation of migratory birds and were formed with the Government of Japan in 1974, and the People's Republic of China in 1986. They list terrestrial, water and shorebird species which migrate between Australia and the respective countries. In both cases the majority of listed species are shorebirds. Both agreements require the parties to protect migratory birds by:
  - limiting the circumstances under which migratory birds are taken or traded;
  - protecting and conserving important habitats;
  - exchanging information; and
  - building cooperative relationships.

  The JAMBA agreement also includes provisions for cooperation on the conservation of threatened birds. Australian Government and non-government representatives meet every two years with Japanese and Chinese counterparts to review progress in implementing the agreements and to explore new initiatives to conserve migratory birds (DEWHA 2009a).
- *The Agreement between the Government of Australia and the Republic of Korea for the Protection of Migratory Birds and their Environment (ROKAMBA) (2006)*
  A bilateral migratory bird agreement similar to the JAMBA and CAMBA. In April 2002, Australia and the Republic of Korea agreed to develop ROKAMBA and the agreement was signed in Canberra on 6 December 2006. It came into force on 13 July 2007. The ROKAMBA formalises Australia's relationship with the Republic of Korea in respect to migratory bird conservation and provides a basis for collaboration on the protection of migratory shorebirds and their habitat (DEWHA 2009a)
- *Convention on the Conservation of Migratory species of Wild Animals* (Bonn Convention) - a framework in which countries with jurisdiction over any part of the range of a particular species co-operate to prevent migratory species becoming endangered. For Australian purposes, many of the species are migratory birds.

1.4.2 National

1.4.2.1 Legislation

- *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) - The Australian Government's central piece of environmental legislation. It provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places which are defined in the Act as matters of national environmental significance. The EPBC Act enhances the management and protection of Australia's Ramsar wetlands. Ramsar wetlands are recognised as a matter of national environmental significance under the EPBC Act. A 'declared Ramsar wetland' is an area that has been designated under Article 2 of the Ramsar Convention or declared by the Minister to be a declared Ramsar wetland under the EPBC Act. The EPBC Act also establishes a process for identifying Ramsar wetlands and encourages best practice management through nationally consistent management principles.

1.4.2.2 Guidelines and policies

- *National Framework and Guidance for Describing the Ecological Character of Australian Ramsar Wetlands.* Module 2 of the National Guidelines for Ramsar Wetlands. DEWHA (2008) provides background information on ecological character, guidance on interpreting terms, the essential elements of an ecological character description, and a step-by-step guide to developing a description of ecological character for wetlands.
- *Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000* - provides a framework for water resource management and water quality guidelines for environmental values and the context within which they should be applied.
- *EPBC Act Policy Statement 1.1: Significant Impact Guidelines 2006* - provides overarching guidance on determining whether an action is likely to have a significant impact on a matter of national environmental significance protected by the EPBC Act.

1.4.3 State

1.4.3.1 Legislation

- *National Parks and Reserves Management Act 2002* (NPRM Act)- provides for the management of national parks and other reserved land. The *National Parks and Wildlife Act 1970* was repealed on the enactment of the NPRM Act.
- National Parks and Reserved Land Regulations 1999 - provides regulations under the *National Parks and Reserves Management Act 2002*.
- *Nature Conservation Act 2002* - makes provision with respect to the conservation and protection of the fauna, flora and geological diversity of the State, to provide for the declaration of national parks and other reserved land and for related purposes.
- Wildlife Regulations 1999 - provides for regulations under the *Nature Conservation Act 2002*.
- *Threatened Species Protection Act 1995* - provides for the protection and management of threatened native flora and fauna and to enable and promote the conservation of native flora and fauna.
- *Forest Practices Act 1985* - ensures that all forest practices are conducted in accordance with the Forest Practices Code, to provide for the issue of that Code, to provide for the creation of private timber reserves, to provide for the constitution of the Forest Practices Tribunal and to provide for incidental and consequential matters.
- *Aboriginal Relics Act 1975* - provides for the preservation of Aboriginal relics.
- *Aboriginal Lands Act 1995* - promotes reconciliation with the Tasmanian Aboriginal community by granting to Aboriginal people certain parcels of land of historic or cultural significance.
- *Inland Fisheries Act 1995* - consolidates the law relating to inland fisheries.
- *Water Management Act 1999* - provides for the management of Tasmania’s water resources. In particular the Act provides for the use and management of freshwater resources in Tasmania, including:
  - Promote sustainable use and facilitate economic development of water resources;
  - Recognise and foster the significant social and economic benefits resulting from the sustainable use and development of water resources for the generation of hydro-

electricity and for the supply of water for human consumption and commercial activities dependent on water;

- Maintain ecological processes and genetic diversity for aquatic and riparian ecosystems;
- Provide for the fair, orderly and efficient allocation of water resources to meet the community's needs;
- Increase the community's understanding of aquatic ecosystems and the need to use and manage water in a sustainable and cost-efficient manner; and
- Encourage community involvement in water resources management.

1.4.3.2 Policies and plans

- *State Policy on Water Quality Management* 1997 - provides for the sustainable management of Tasmania's surface water and groundwater resources by protecting or enhancing their qualities while allowing for sustainable development in accordance with the objectives of Tasmania's Resource Management and Planning System.
- *Lakes Sorell and Crescent Water Management Plan* 2005- provides a framework for managing the lakes' catchment's water resources in accordance with the objectives of the Plan, the *Water Management Act 1999* and the *State Policy on Water Quality Management 1997*.

2. Site description

2.1 Site location

Interlaken Lakeside Reserve Ramsar site lies at the north-western corner of Lake Crescent (Figure 2-1), approximately 20 kilometres west of the township of Tunbridge at an altitude of about 800 metres on the eastern limit of the Tasmanian Central Highlands. Lake Crescent is separated from Lake Sorell to its immediate north by a low strip of land varying in width from 300 metres to one kilometre. The lakes are connected by the Interlaken Canal (Figure 2-2). At the western end of the land separating the lakes, Kermodes Drain has been dug through the low-lying marsh area (Figure 2-2). The Ramsar site is 517 hectares in area consisting of 179 hectares of open water, 165 hectares dry land and 173 hectares of shallow, intermittent marsh.

Lakes Sorell and Crescent are both shallow lakes which lie in an area of flat land on the eastern edge of the Central Plateau below the treeline. They are surrounded by eucalypt forest and open paddocks cleared for rough grazing. Lake Crescent is a permanent water body, with a maximum depth of 3.8 metres at full supply (803.8 metres AHD). The pH of the lake is approximately seven and conductivity about 200 µS/cm and average annual rainfall[4] is 699 millimetres. Lake Crescent is particularly exposed and wind-blown, so there is complete mixing of its waters. Depending on the season and the water levels, the intermittent marshes on the perimeter of the lakes may be dried out or partially inundated. The water in Lake Crescent is invariably turbid and noticeably tinted by suspended sediment.

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[4] An annual rainfall figure of 726mm has been used in the ILR Ramsar Information Sheet based on the nearest Bureau of Meteorology (BoM) recording site. The figure of 699mm for the immediate area was calculated for the Lake Sorell and Crescent Rehabilitation project using a range of sources and modeling by a hydrologist.

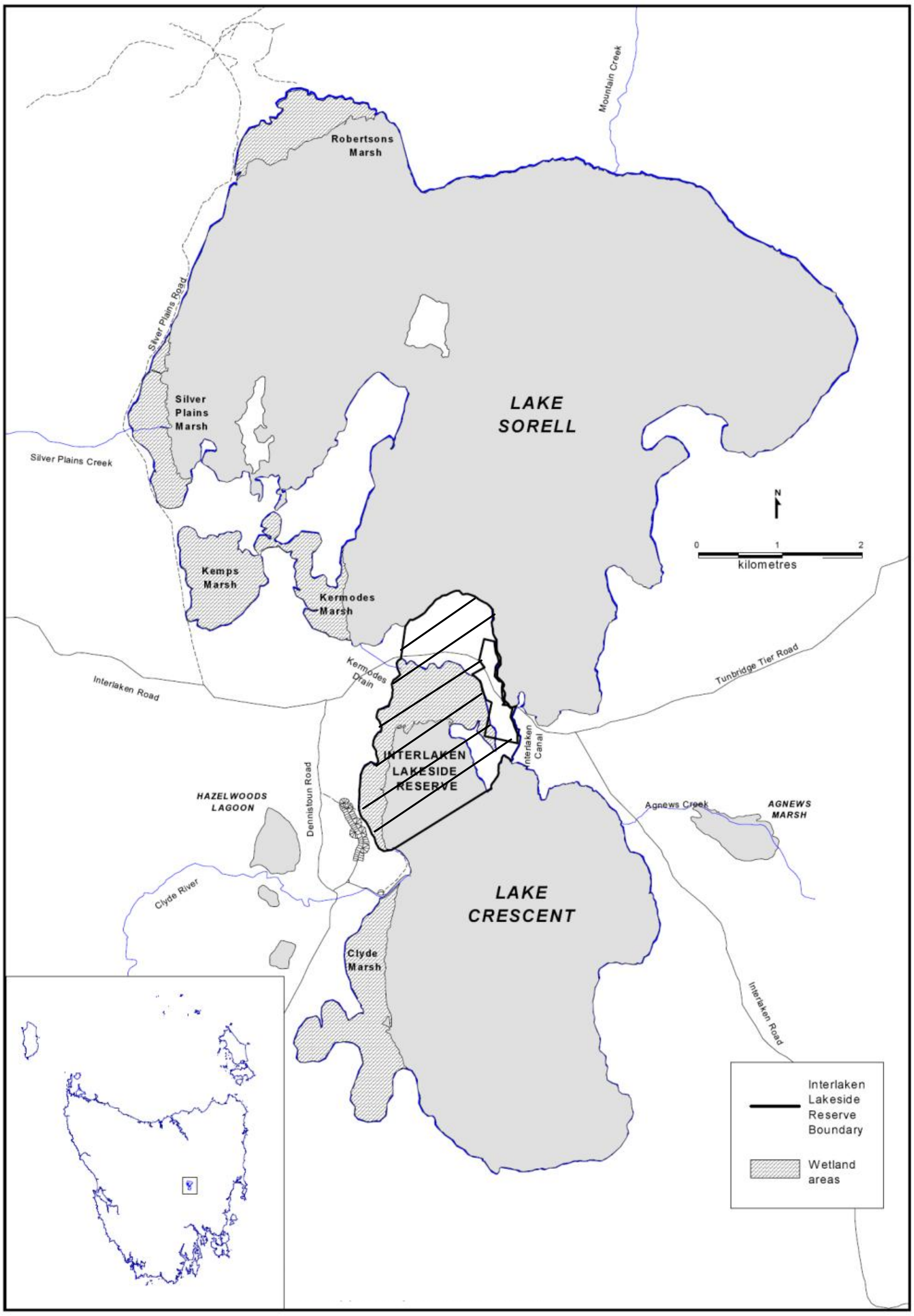

Figure 2-1
Lakes Sorell and Crescent showing drainage. Inset: location of the Lakes on the eastern edge of the central highlands in Tasmania (Heffer 2003a)

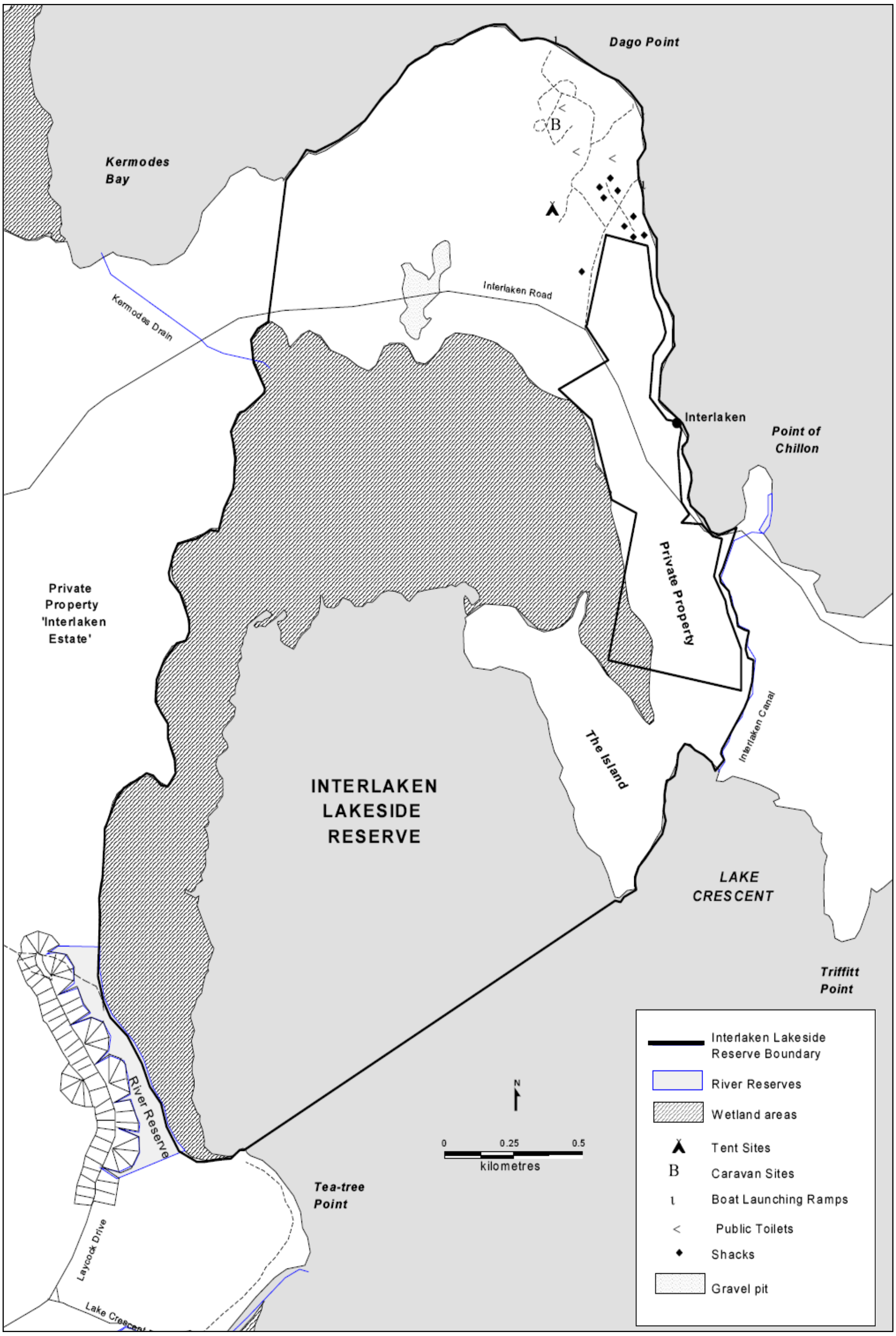

Figure 2-2
Interlaken Lakeside Reserve (Heffer 2003a)

2.2 Site History

An aerial photograph taken in 1984 (Figure 2-3) suggests that around the time of listing in 1982, the ILR intermittent marshes were inundated and the water level was almost at full supply level within Lake Crescent.

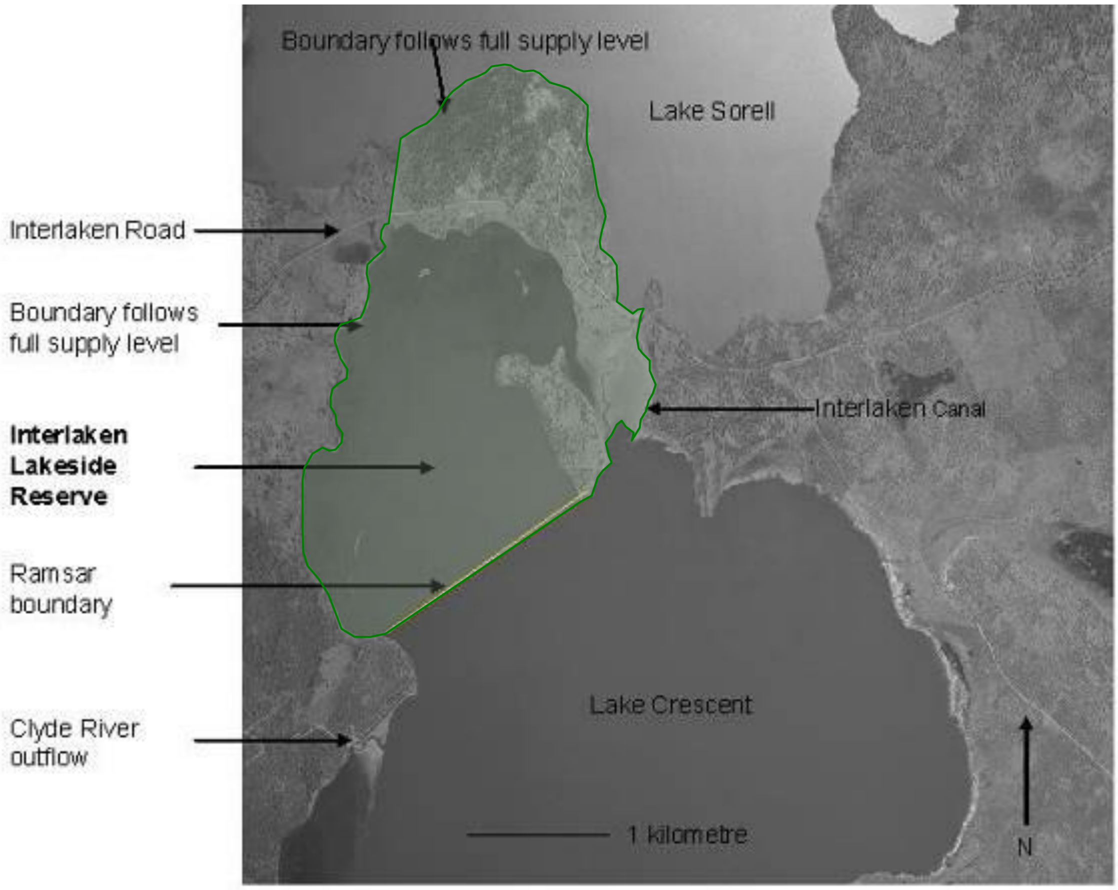

Figure 2-3
Aerial image of Interlaken Lakeside Reserve in 1984 when the marshes were inundated

2.2 Site history

Lakes Sorell and Crescent have a long history of use as water supply for settlements downstream on the Clyde River and for irrigation. Water levels have been manipulated with weirs and channels since around 1840. Surrounding land was used for timber harvesting and grazing from the early 19th century and was sold off by the turn of the 20th century (Mason-Cox 1994). The two lakes have also been popular with anglers in the past. Prior to 2004 they were stocked with brown trout (*Salmo trutta*) and Lake Crescent was known as a fishery for large 'trophy' trout (C. Wisniewski, pers. comm. 2010).

2.3 Climate

The mean annual rainfall at Interlaken has been estimated as 699 millimetres based on data for a period of over 100 years (J. Deakin, pers. comm. 2008). The rainfall is spread quite evenly through the year with generally higher falls in late winter and lower falls in late summer (Figure 2-4).

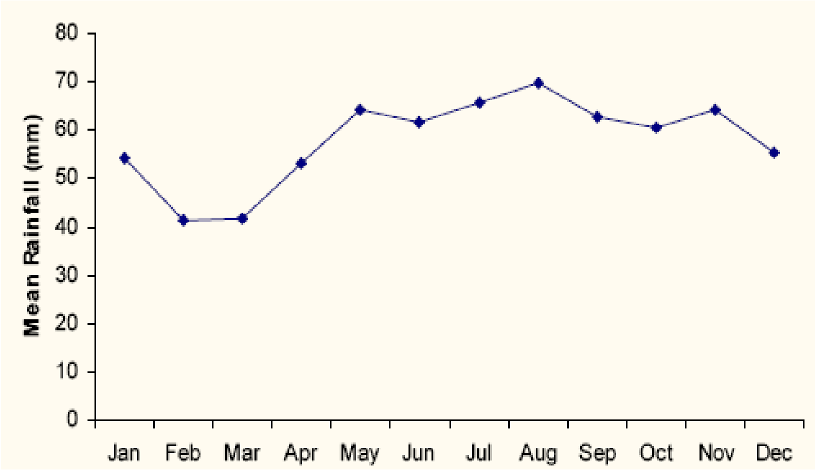

Figure 2-4
Mean monthly rainfall for Interlaken (1900 – 2002) (Heffer 2003a; J. Deakin unpublished data)

Lakes Sorell and Crescent are located in an area of Tasmania with the highest relative variability of annual rainfall, estimated as 20 % of average annual rainfall (Langford 1965). The lakes also lie in a lower rainfall area of the State, as the predominantly westerly rain-bearing winds have generally dropped their load on the mountain ranges to the west.

There is wide variability of annual totals between years. The highest recorded rainfall in the period between 1901 and 2003 was 1,157 millimetres in 1956, with the lowest 274 millimetres in 1913. Since the inception of irrigation in the Clyde River area in the mid 1830s, several dry periods have been observed (Mason-Cox 1994). This suggests that there is evidence, from over 170 years, that periodic years with low water yields are normal for these lakes.

Temperature

The continental effect on the generally temperate maritime climate of Tasmania is apparent in the central highland area. Interlaken can be extremely cold in winter, yet reach high temperatures in summer (Langford 1965). Snow can occur in any month of the year and frosts are common. Figure 2-5 provides an estimate of the temperature patterns in the Lake Crescent area. The mean daily maximum ranges from 4°C in winter to 20°C in summer (Heffer 2003a).

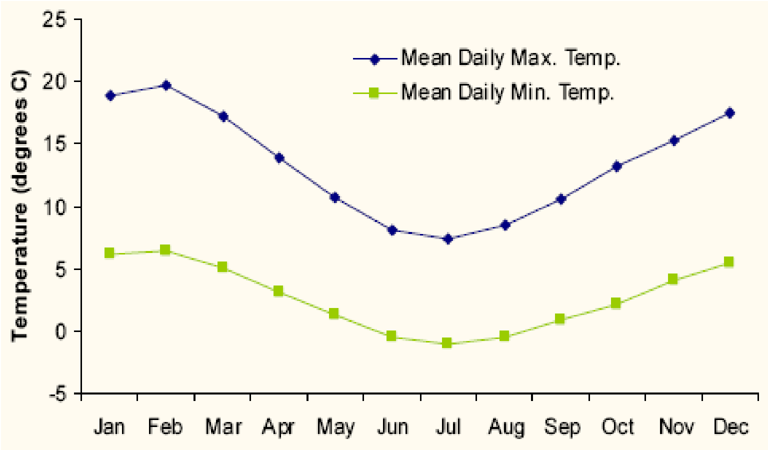

Figure 2-5
Mean daily temperature for the Lake Sorell and Lake Crescent area (average between values at Bothwell and Miena), 1900 – 2002 (BoM data shown in Heffer 2003a)

Predominant winds are from the west, south-west and north-west (Heffer 2003a). The strongest winds occur mostly during the autumn and spring. Wind causes turbulence and increases evaporation in the lakes, influencing their characteristics and functions.

2.4 Bioregion

The representativeness of the ILR Ramsar site within a bioregional setting was evaluated in the context of the Tasmanian Drainage Division (Bureau of Meteorology 2009).

2.4.1 Drainage division and river basin

The Tasmanian Drainage Division encompasses all of Tasmania, including the Bass Strait Islands to the north (Figure 2-6). The Tasmanian Drainage Division has a total area of 68 363 square kilometres encompassing 19 river basins with areas covering between 678 – 11 344 square kilometres (DEWHA 2009b). The climate is wet temperate in the west and north east with a mainly mild to cool summer and low rainfall in the central midlands (DEWHA 2009b). The main rivers in Tasmania consist of the South-Esk, Derwent, Gordon-Franklin, Arthur, Pieman, Huon, Mersey, Ringarooma and North-Esk. These have large catchment sizes, with the South-Esk and Gordon-Franklin reaching 8 907 and 5 893 square kilometres respectively.

Areas of poorest ecosystem condition occur mainly in the two most intensively developed river basins in the Tasmanian midlands, the Derwent and Tamar (DEWHA 2009c). The ILR falls within the Tasmanian Drainage Division and is part of the upper catchment of the Derwent River Basin (Figure 2-6).

The Derwent River Basin covers approximately 8800 square kilometres in south-east and central Tasmania with the major land uses being agriculture and forestry, with National Parks and other wilderness reservations in highland regions of the catchment (DEWHA 2009c). The Derwent River, and a number of its main tributaries, have been dammed and diverted in over 20 storages for the generation of hydro-electricity (DEWHA 2009c). The estimated average annual rainfall for the catchment is variable, ranging from around 500 millimetres up to 1200 millimetres in the mountainous areas of the upper catchment (DEWHA 2009c).

Figure 2-6
The Tasmanian Drainage Division and river basins

2.5 Land tenure

The ILR is Crown Land. Part of the area of dry land at the northern end of the ILR is a Public Reserve under the *Crown Lands Act 1976.* A block of private land that lies within the Crown Land is not part of the site (Figure 2-2). The recent Crown Land Assessment and Classification (CLAC) project recommended that the ILR be declared a Conservation Area under the *Nature Conservation Act 2002.* (CLAC 2006). Lake Crescent and Lake Sorell are managed by the Department of Primary Industries, Parks, Water and Environment. Council zoning is ‘Rural’ for all adjacent freehold land and ‘Water Conservation’ for the lakes and Crown land at the northern end of Lake Sorell (Gudde 2004).

2.6 Ramsar criteria

2.6.1 Ramsar listing of the Interlaken Lakeside Reserve in 1982

The ILR was listed as a result of a state-wide study of flora of wetlands in Tasmania (Kirkpatrick and Harwood 1981) that highlighted the importance of the wetland on the north-west corner of Lake Crescent as a good example of freshwater wetland floristic communities. Ramsar listing recognised these values in an international context. The recognition of the importance of Lake Crescent as habitat for the threatened golden galaxias subsequently complemented the original values.

2.6.2 Ramsar criteria at the time of listing (1982)

The original Ramsar Information Sheet (RIS) described the site as meeting the following criteria at the time of listing (1982):

Criterion (2a): it supports an appreciable number of rare, vulnerable or endangered species or subspecies of plant or animal (equivalent to Criterion 2 in 2010).

Criterion (2b): it is of special value for maintaining the genetic and ecological diversity of a region because of the quality and peculiarities of its flora and fauna (equivalent to Criterion 3 in 2010).

There is little justification in the original RIS of how or why it met these criteria.

2.6.3 Ramsar criteria as described in the Ramsar Information Sheet (2005)

The RIS compiled in 2005 assessed ILR against Ramsar criteria in the context of the Central Highlands IBRA bioregion (Department of the Environment and Heritage (DEH) 2004; Department of Primary Industries, Water and Environment (DPIWE) 2005a). The criteria and justification is presented below.

Criteria 1- **A wetland should be considered internationally important if it contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.**

> Lake Crescent is a valuable representative of a permanent shallow freshwater lake and intermittent freshwater marsh in the Central Highlands Biogeographic Region of Tasmania. In Tasmania the site is assessed as a wetland in good condition (Dunn 2005).

Criterion 2 –A wetland should be considered internationally important if it supports vulnerable, endangered or critically endangered species or threatened ecological communities.

> The site supports the golden galaxias (*Galaxias auratus*) which is listed as endangered on the International Union for Conservation of Nature and Natural Resources (IUCN) Red List (Jackson 2004).

Criterion 3 – **A wetland should be considered internationally important if it supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region.**

The site is an essential element of the maintenance of ecological diversity in the area. It supports several species which are rare and/or poorly reserved. The site supports one flora species, southern swampgrass *(Amphibromus neesii)*, which is listed as *rare* under the *Threatened Species Protection Act 1995* (TSP Act). The interesting nature of the phytoplankton community, and its differences from nearby Lake Sorell, are of scientific value. The wetland provides important habitat for many species of macroinvertebrates, including the hydrobiid gastropod (*Austropyrgus* sp.), which is endemic to lakes Sorell and Crescent (Cleary 1997).

Criterion 4 - A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.

When inundated the marshy areas of the wetland are important for waterbirds as a feeding, resting and breeding area, and as a drought refuge. When water levels are high in Lake Crescent and the adjoining Lake Sorell, it is believed that waterbirds such as ducks, swans and cormorants use these wetlands when nearby wetlands in the Midlands periodically dry out (S. Blackhall, pers. comm., 2009).

Criterion 7 – A wetland should be considered internationally important if it supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity.

The site supports a significant proportion of the population of golden galaxias. This small, native freshwater fish is endemic to Tasmania and is restricted to Lakes Sorell and Crescent and their associated streams and wetlands. The golden galaxias is listed as rare in Tasmania (TSP Act) as well as endangered on the IUCN Red List.

Criterion 8 – A wetland should be considered internationally important if it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.

When inundated, marshland areas of Lakes Crescent and Sorell are thought to provide important nursery areas for juvenile golden galaxias (Hardie 2003a).

2.6.4 Reassessment of Ramsar criteria (using updated biogeographic region)

In 2008, the Australian Government adopted the Australian Drainage Divisions system as the most appropriate biogeographic regionalisation approach for ecosystems at the national level. As a result, the values present in the ILR at the time of listing (1982) have been re-assessed against the current Ramsar criteria, using the Tasmanian Drainage Division as the biogeographic region. The results are described below:

Criterion 1: A wetland should be considered internationally important if it contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.

ILR is a valuable regional representation of two Ramsar wetland types ‘O’ (Permanent freshwater lakes >8ha) and ‘Ts’ (Seasonal/intermittent freshwater marshes) within the Tasmanian Drainage Division. *Triglochin procerum - Baumea arthrophylla* marsh community is present at this site. Freshwater intermittent marshes and all freshwater wetland vegetation communities are considered rare in the Tasmanian biogeographic region and are listed on the Tasmanian *Nature Conservation Act 2002;* therefore this large wetland contains important habitat that supports a suite of species important in the bioregion.

Analysis of Tasmania's vegetation mapping (TASVEG) indicates that this is one of the largest intermittent freshwater marshes present in the Tasmanian Drainage Division and is particularly unusual at this elevation (800 metres). It is considered in good condition relative to other large freshwater wetlands in lowland and coastal Tasmania (Kirkpatrick and Harwood 1983).

This criterion, equivalent to Ramsar Criteria 1a, 1b, 1c and 1d prior to 1999 (DEWHA 2008a), was not met in 1982 according to the original RIS for ILR (Tasmanian Department of Environment and Land Management 1998). However, it was listed as being met in 2005 in the RIS and is still considered to be valid in 2010.

Criterion 2: A wetland should be considered internationally important if it supports vulnerable, endangered or critically endangered species or threatened ecological communities.

ILR is habitat for the endemic freshwater fish, golden galaxias (Fulton 1990; Hardie 2003a). The golden galaxias is considered one of the primary determinants of the unique ecological character of ILR. This species is listed as endangered under the EPBC Act and rare under the TSP Act. It is also listed as endangered on the IUCN Red List. Its natural distribution is confined to Lakes Sorell and Crescent and associated wetlands and small tributaries. Although there is no quantitative data on its abundance throughout its 76 square kilometre range, it is considered to be locally abundant, particularly in Lake Crescent (Hardie 2003a). It occurs at much higher densities (ten times) in Lake Crescent than in Lake Sorell and this is believed to reflect greater predation pressure of the trout population in Lake Sorell (Hardie 2003a). The intermittent marshes adjacent to the lakes are thought to provide an important nursery area for juvenile fish (Hardie 2003a; Jackson 2004). Although it is abundant in these two lakes, its limited distribution and threats from introduced species (carp, trout) and habitat degradation has caused it to be listed as threatened.

Evidence exists that the green and gold frog (*Litoria raniformis*) was common in the late 1970s and early 1980s in the ILR (R. Mawbey, pers. comm., 2009). This species is considered Vulnerable under the EPBC Act and endangered under the IUCN Red List. A study by Chilcott (1986) listed seven frog species found in the vicinity of Lake Crescent and suggested that the range of green and gold frog would be restricted to the marshes along the margins of Lake Crescent, including ILR. Based on recent surveys, it is not clear whether the green and gold frog is still present in the ILR (Heffer 2003a).

Similarly, there is one record for the Australasian bittern (*Botaurus poiciloptilus)* from the Lake Crescent area in the late 1970s (Thomas 1979) and suitable habitat is present in the ILR. However, no recent records of this species exist. The Australasian bittern is listed as endangered on the IUCN Red List (Version 2009.1).

As little information on the presence of the green and gold frog and Australasian bittern exists for the ILR and that they have not been recorded since the time of listing, it is not considered that they currently contribute to the ILR meeting this criterion.

This criterion, equivalent to Ramsar Criteria 2a prior to 1999 (DEWHA 2008a), was met in 1982 according to the original RIS for ILR. It was also met in 2005 and is still considered to be valid in 2010.

Criterion 3: A wetland should be considered internationally important if it supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region.

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The site is an essential element of the maintenance of ecological diversity in the area. It supports several species which are rare and/or poorly reserved. The site supports one flora species listed as threatened in Tasmania; Swamp Wallaby Grass *(Amphibromus neesii*, rare, *Threatened Species Protection Act 1995* (TSPA)). The interesting nature of the phytoplankton community, and its differences from nearby Lake Sorell, are of scientific value. The wetland provides important habitat for many species of macroinvertebrates, including the hydrobiid gastropod (*Austropyrgus* sp.), which is endemic to lakes Sorell and Crescent (Cleary 1997).

The site also provides habitat for the nationally listed golden galaxias. The golden galaxias is considered one of the primary determinants of the unique ecological character of ILR. Therefore, ILR is considered to support populations of an internationally important species during a critical life stage.

ILR is considered to meet this criterion.

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Criterion 4: A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.

The site provides habitat for the nationally listed golden galaxias during spawning and the intermittent marshes adjacent to the lakes provide important nursery habitat for juveniles. Therefore, ILR is considered to support populations of an internationally important species during a critical life stage.

ILR is considered to meet this criterion.

Criterion 5: A wetland should be considered internationally important if it regularly supports 20 000 or more waterbirds.

The available data, although limited, suggests that ILR is not likely to regularly support 20 000 or more waterbirds.

ILR is not considered to meet this criterion.

Criterion 6: A wetland should be considered internationally important if it regularly supports one per cent of the individuals in a population of one species or subspecies of water bird.

The available data, although limited, suggests that ILR is not likely to regularly support one per cent of the individuals in a population of a species or subspecies of water bird.

ILR is not considered to meet this criterion.

Criterion 7 – A wetland should be considered internationally important if it supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species

interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity.

This criterion was claimed to be met in the 2005 RIS, however there is little supporting evidence that can be found to justify this claim. It is considered that this criterion was misapplied in that RIS (DPIWE 2005a). This criterion is predominantly about the diversity of fish populations or a fish assemblage that displays a large range of morphologies and reproductive methods.

It is considered that the ILR does not meet this criterion.

Criterion 8: A wetland should be considered internationally important if it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.

The wetlands in ILR provide important breeding habitat for the nationally endangered endemic golden galaxias. The galaxiid's small, adhesive eggs are typically deposited on aquatic vegetation and rocky substrate, and the intermittent marshes adjacent to the lakes are thought to provide an important nursery area for juvenile fish (Hardie 2003a; Jackson 2004). Adult fish prefer rocky lakeshore habitat (Hardie 2003a) and, to a lesser degree, marsh habitat.

Given the high relative abundance of the Lake Crescent golden galaxias population , the Interlaken site is considered to provide important spawning, foraging and refuge (from predations) habitat for the species.

ILR is still considered to meet this criterion.

Criterion 9: A wetland should be considered internationally important if it regularly supports one per cent of the individuals in a population of one species or subspecies of wetland-dependent non-avian animal species.

The ILR wetlands support a significant proportion of the entire golden galaxias population. The golden galaxias is endemic to Tasmania and only occurs naturally in Lakes Sorell and Crescent and associated streams and wetlands. It is much more common in Lake Crescent (ten times the density of Lake Sorell) and habitat critical to its survival is all areas where the species naturally occurs. Lake Crescent (and associated intermittent marshes) is approximately 2,285 hectares in size while Lake Sorell (and associated intermittent marshes) is approximately 5,212 hectares. Given the higher densities of golden galaxias present, Lake Crescent may contain up to 80 % of the population of this species. Further, as the ILR wetlands comprise approximately 15 % of the wetlands present in Lake Crescent, it is expected that ILR could regularly support one per cent or more of the population of this species.

This criterion was added to the Ramsar criteria after 1999, and so was not identified as being met in the original 1982 RIS. It was not listed as being met in the 2005 RIS.

However, re-assessment indicates that ILR does meet this criterion.

2.7 Wetland types

Wetland types as defined by Ramsar which are present at the Interlaken Lakeside Reserve Ramsar site are:

O – Permanent freshwater lake over eight hectares in area

Ts – Intermittent marshes on inorganic soils

Permanent freshwater lake occupies approximately 180 hectares while the intermittent marshes occupy 174 hectares, with the balance of the site supporting light bush and forest (Figure 2-7).

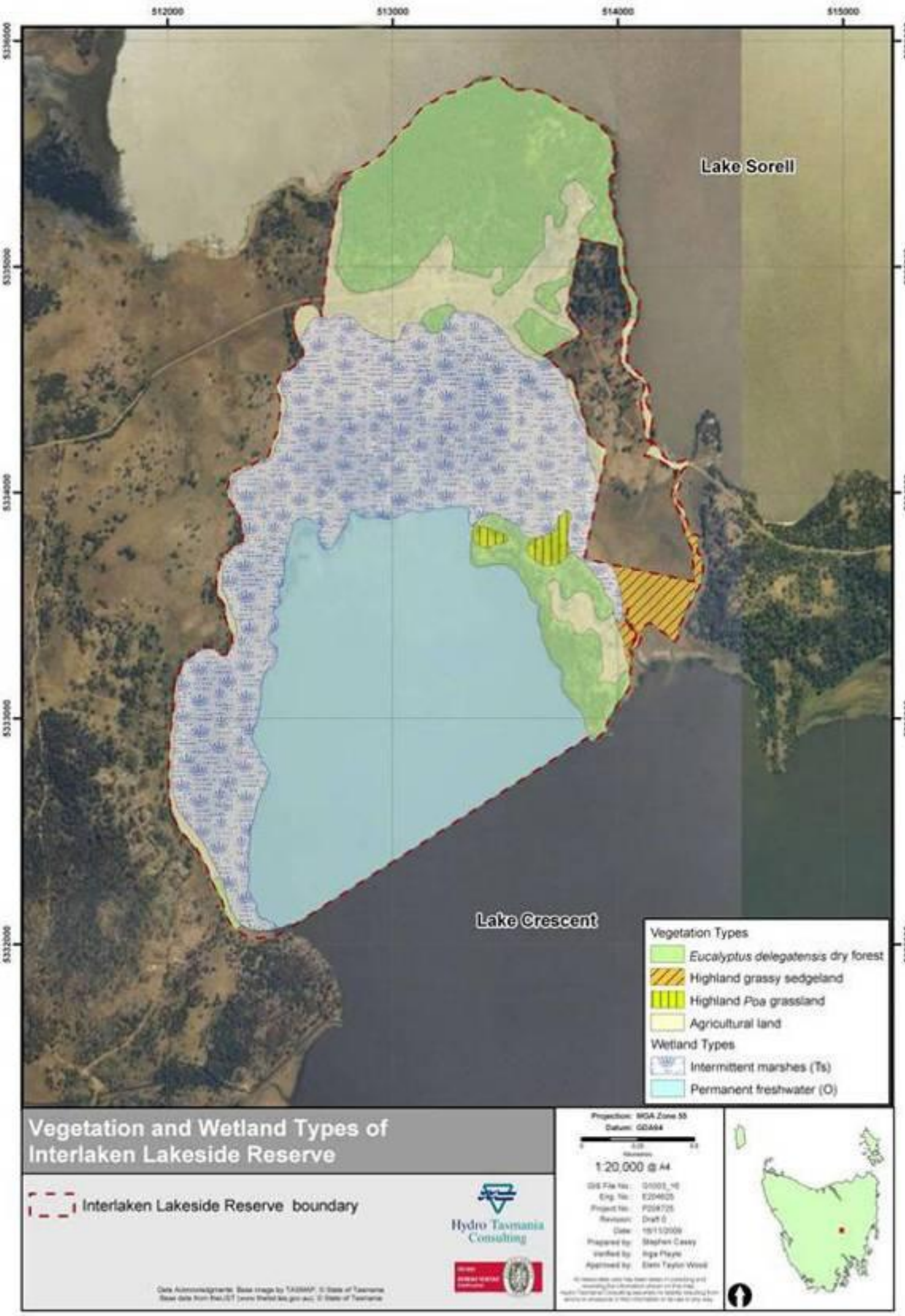

Figure 2-7
Distribution of wetland types within the ILR

3. Ecosystem components, processes, benefits and services

This chapter describes the major components processes, benefits and services of the ILR Ramsar site at the time of listing in 1982.

3.1 Ecosystem components

Geomorphology, hydrology, water quality, plankton, flora and fauna are important components of the ecological character of the ILR and are described below. The golden galaxias and the intermittent marshes on site are considered to be 'critical' components of the ILR. The selection and justification of critical components and processes are described in more detail in Section 3.2.

3.1.1 Geomorphology

Lakes Sorell and Crescent lie in an area underlain by Jurassic dolerite, Tertiary basalt and Triassic sandstone, with alluvial deposits common on flats and swampy ground. Lakes Sorell and Crescent lie outside the areas of highland Tasmania known to have been glaciated and their origin is unclear (Davies 1965). They may have evolved from low gradient stream systems on old erosion surfaces on a dolerite cap. The two lakes may exist as a result of a slight tilting or subsidence (Davies 1965), or by backfilling of the basin at the outlet to the Clyde River due to deposition of fine organic particulates (I. Houshold pers. comm. 2008), or a combination of both.

The geomorphology of the site has lead to the creation of the two shallow lakes with limited stream inflows, small catchments and a high surface area to depth ratio, exposing the water to relatively high levels of evaporation. There is no evidence of any supplementary ground-water feeding into the lakes. Lake Crescent lies at an altitude of 804 metres AHD, with a surface area of 23 square kilometres and shoreline length of about 30 kilometres. Bathymetry of Lake Crescent at full supply level is shown in Figure 3-1. Wetlands level is assessed at 803 metres AHD and full supply at 803.8 metres AHD.

Additional geoscientific data and information on the substrate, landform material and geomorphic processes of the wetland is required to better define its ecological character and inform conceptual models for the wetland system.

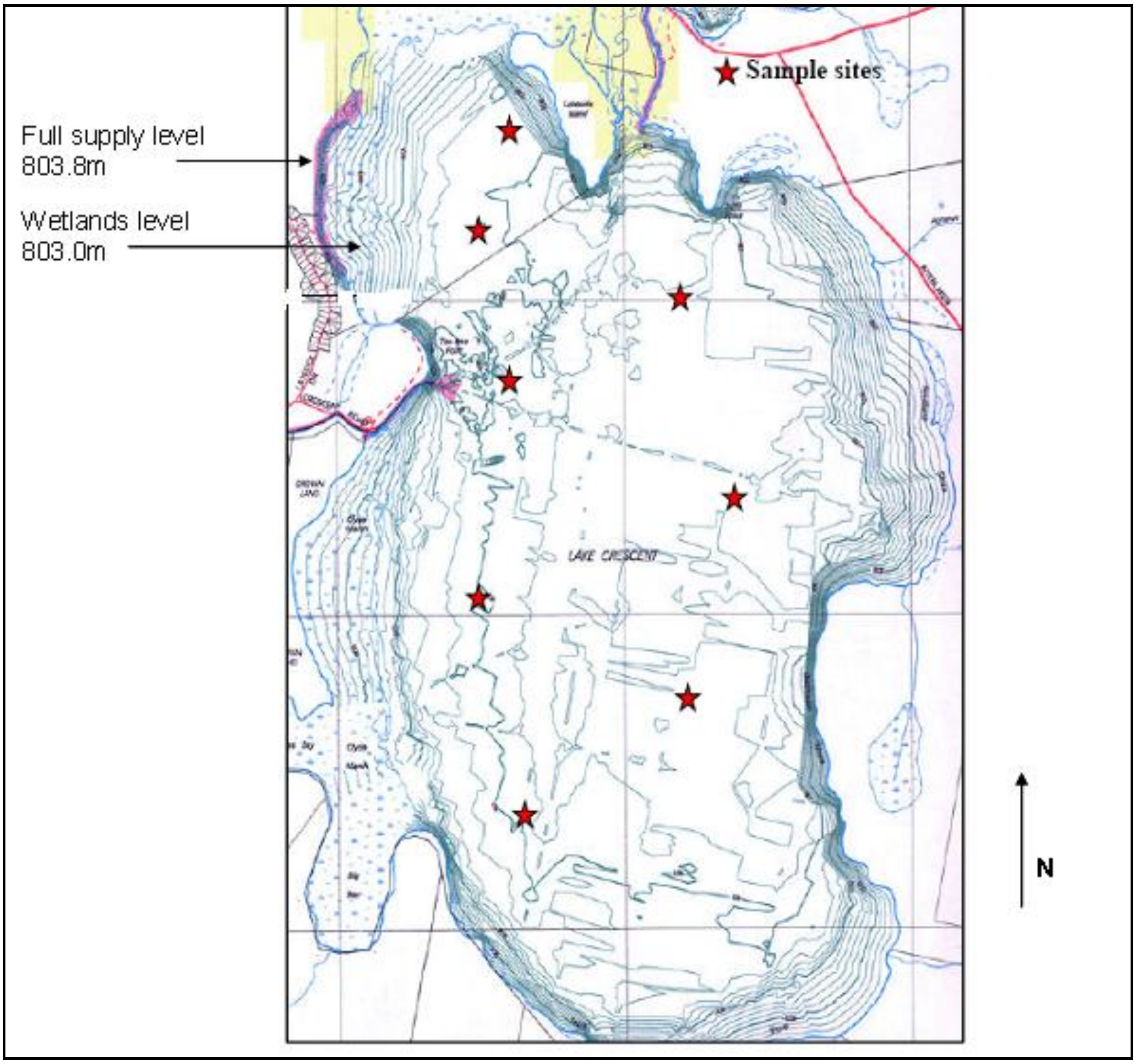

Figure 3-1
A bathymetric map of Lake Crescent (main isopleths at one metre intervals) (Uytendaal *et al* 2003)

Wetlands occur on the western side of Lake Crescent: Interlaken Lakeside Reserve in the north-west and Clyde Marsh south of the outflow of the Clyde River (Figure 3-2). The wetlands have a low gradient (around only 2 metres from backing terrestrial vegetation to water's edge) and are subject to differing periods and depth of inundation. At times of extreme low water levels, the intermittent marshes, including those in the ILR, may be separated from the water body by the exposed dry lake bed.

The lake bed is comprised of fine inorganic sediments of local origin. The lake shoreline is made up of sections with the lake bed sediments grading into adjacent marshes, an open sandy shoreline backed by low dunes on the eastern shore and several cobble shorelines.

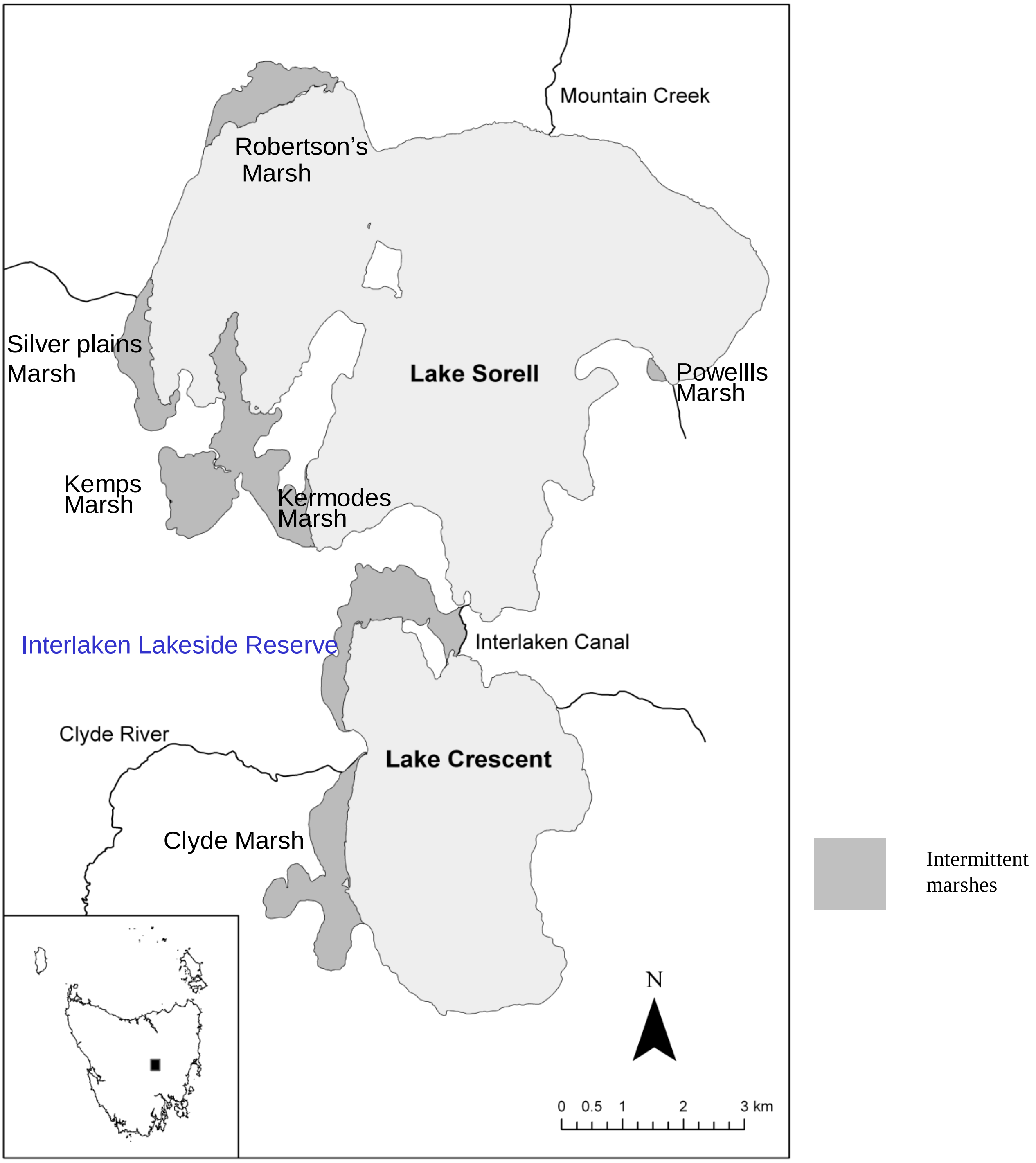

Figure 3-2
Location of the intermittent marshes at Lake Sorell and Lake Crescent (D Hardie, pers comm., 2008)

3.1.2 Hydrology

3.1.2.1 Drainage catchments

Lake Crescent has a catchment area of 32.8 square kilometres, a surface area of 23.1 square kilometres, and holds an estimated volume of 49 386 megalitres (Uytendaal 2003a). At times of high water level, water passes from Lake Sorell (catchment area of 94.8 square kilometres; Uytendaal 2003a), into Lake Crescent via the Interlaken canal (originally the Interlaken Rivulet) and Kermodes Drain (Figure 2-2). The flow from Lake Sorell into Lake Crescent is controlled by a weir. Both lakes are supplied by a few small watercourses and gain catchment run-off, but there is little evidence of any ground-water contributions (J. Deakin, pers. comm., 2008). Both lakes are heavily reliant upon local rainfall as the main water input. Outflow from Lake Crescent is through a short canal and a weir, which controls flows into the Clyde River.

3.1.2.2 Rainfall

ILR lies on the eastern edge of the highland area of Tasmania and, as such, is on the furthest edge of a strong precipitation gradient from the high rainfall carried by the predominant rain-bearing westerly winds (Davies 1965). It also falls within an area of high variability of annual rainfall with an estimated 20 % mean deviation of average rainfall (Davies 1965). Local rainfall is a significant component of the water supply to the lakes.

Anecdotal evidence of the actual historic rainfall of the area confirms occurrences of periods of dry years through the 19th and early 20th century (Mason-Cox 1994). Estimated annual rainfall since 1900, compiled from a number of sources, shows such inter-annual variation and periods of dry years (J. Deakin, pers. comm., 2008) (Figure 3-3). Based on these data, mean annual rainfall is 699 millimetres with a range from a low of 274 millimetres in 1913 to a high of 1157 millimetres in 1956. Drawing on these data, wet and dry years have, over the last century, been in random sequence. At the time of listing in 1982, several preceding years had been above the median rainfall of 671 millimetres, maintaining the wetlands in damp or an inundated condition. In 2007 and 2008 after several years of low rainfall (beyond the 2001 data provided in Figure 3-3) the wetlands were dry and lake levels low. The wetlands have been inundated since late 2009 following substantial rainfall. It is not possible to extrapolate with certainty a trend towards decreasing rainfall since listing. Such a trend could be possible under conditions of climate change.

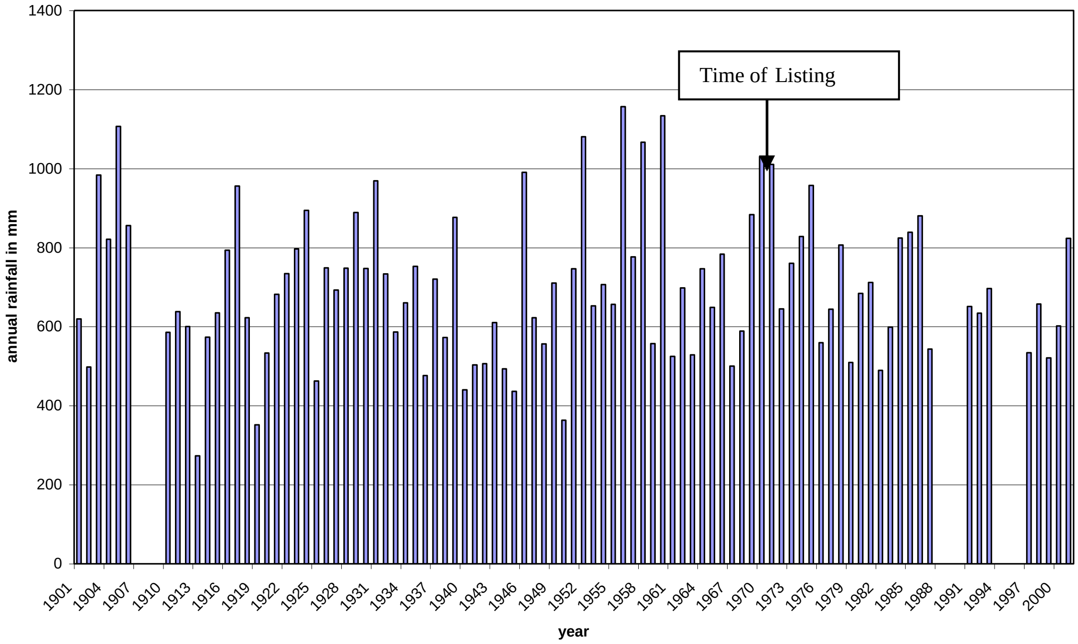

Figure 3-3
Estimated and actual annual rainfall for Interlaken. Note: there is no data for 1907-09, 1989-91, 1995-97 (Jenny Deakin, unpublished data)

3.1.2.3 Lake level variability

The water levels in Lake Crescent (along with Lake Sorell) have a history of variability. The sources of variability are both natural and man-made. Figure 3-4 shows the recent water level history of Lake Crescent. There is a low level of confidence in the data for the early 1990s. In late 1996/early 1997 approximately 22 000 megalitres was released from the lakes for carp management purposes. Influx at that time from Lake Sorell, by manipulating the weir at Interlaken canal, caused a spike in water level in Lake Crescent Lake levels are influenced by a number of factors, principally rainfall, draw-down for irrigation and town uses, and evaporation. The estimated rainfall data (Figure 3-3) over the last 100 years suggests lake level fluctuations have been typical following years with low rainfall. The lake levels affect the inundation of the wetlands and are crucial in the health and long-term integrity of the wetlands (see Section 3.3.2).

See Appendix 7 for lake levels from January 2000 to October 2011.

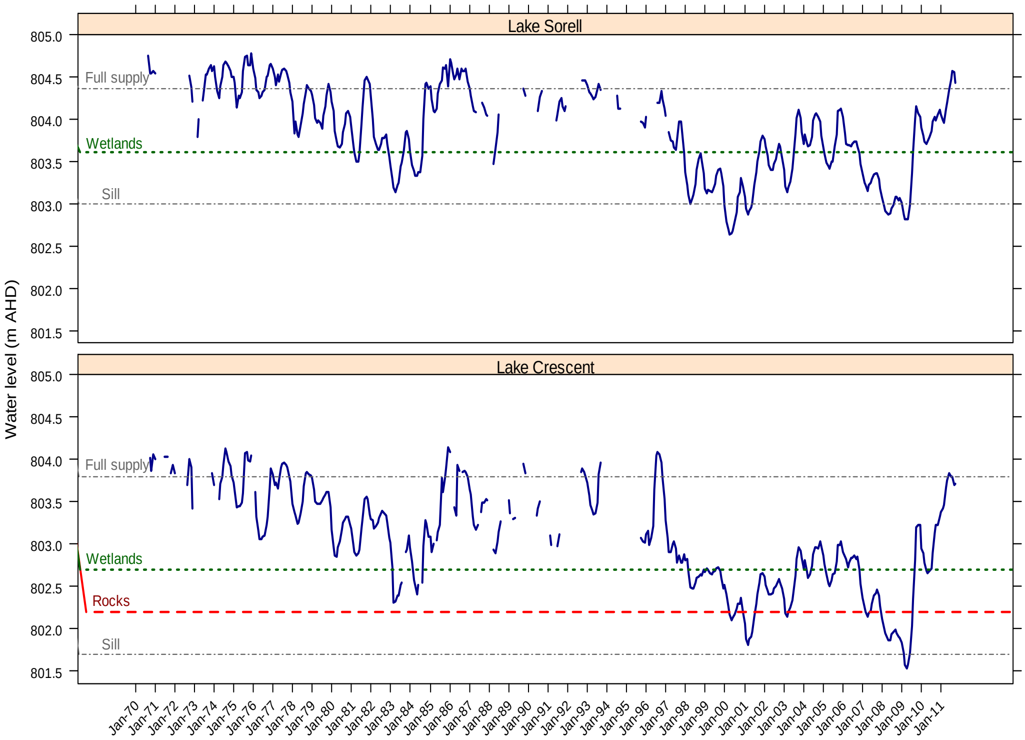

Figure 3-4
Water level history of Lake Crescent and Lake Sorell from September 1970 to October 2011. Levels measured in metres Australian Height Datum

3.1.3 Water quality

3.1.3.1 Overview

Lake Crescent is a shallow, polymictic (continuously mixed) body of water draining from a small catchment in the highlands of Tasmania. The underlying rock is dolerite and soils tend to be neutral to acidic with a build-up of litter and peat beneath the vegetation. Temperature within the lake is homogeneous in all seasons and it demonstrates diurnal variation during calm periods (Cheng and Tyler 1973). Dissolved oxygen was found to be at saturation (Cheng and Tyler 1973).

3.1.3.2 Turbidity

The water in Lake Crescent has, since observations began, been notably turbid. Cheng and Tyler (1973) noted that the very low transparency in the lake was due to biotic and physical factors. As Lake Crescent is shallow it is subject to frequent disturbance of the sediments through wind and wave action. In addition to suspension of inorganic lake bed sediments (‘tripton’), detritus and plant debris contribute to the turbidity of the water column. Lake Crescent also has a high standing crop of plankton, making it more turbid than neighbouring Lake Sorell (Cheng and Tyler 1973). The turbidity of the lake limits the euphotic layer in which photosynthesis occurs; therefore, macrophytes do not flourish in Lake Crescent.

The primary mechanism for reducing colloidal turbidity in Lake Crescent is export from the lake through water releases, which are small compared with the volume of the lake. Therefore a significant reduction in colloidal turbidity is expected to take decades. The primary mechanism influencing turbidity in Lake Crescent is wind re-suspension resulting from low water levels, therefore the preferred minimum levels recommended in the water management plan are an appropriate trigger (Uytendaal 2003a).

Water within the wetlands is considered to be relatively clear in comparison to the main lake. This is likely to be a consequence of the vegetation dampening wave action and allowing the wetlands to act as a sink to trap nutrients and settle out sediments.

3.1.3.3 Nutrients and water chemistry

Nutrients enter Lake Crescent via run-off from streams and overflow from Lake Sorell. Cheng and Tyler (1973) showed that in Lake Crescent nutrient levels and ionic composition were generally consistent with those of Tasmanian highland lakes flowing over dolerite. The main lake water body has low conductivity (67.6 µS/cm) and more or less neutral pH, although contributing streams varied somewhat from these levels. The dominance order of major cations, measured over 40 sampling events, was most often Ca>Na>Mg>K[5] or Na>Ca>Mg>K (Cheng and Tyler 1973). Uytendaal (2003a) concluded that the water quality of Lake Crescent inflows was generally (with the exception of nitrogen in Agnews Creek which is approximately two kilometres from the boundary of the ILR) of high quality, with most inflows being relatively ‘pristine’ and that internal nutrient loading, driven by wind re-suspension, is the most significant mechanism influencing water quality in the lakes. Uytendaal (2003a) also concluded that at the time of writing, local agricultural and forestry practices were not having a measurable detrimental impact on the water quality of tributaries entering Lake Crescent.

3.1.3.4 Sediment

The lake bed sediment is a key component in determining the ecological character of ILR and the Lake Crescent ecosystem. Sediment re-suspension controls turbidity, nutrient cycling, light attenuation and lake productivity (Uytendaal 2003a). The majority of the sediment in Lake Crescent continually cycles through re-suspension rather than being derived from external sources draining into the lake (Uytendaal 2003a). The exposed, shallow water is prone to wind effects. At higher wind speeds and lower lake levels, the sheer stress increases causing greater re-suspension of the sediment material, resulting in increased turbidity.

With reference to lake-wide nutrient and sediment budgets, Uytendaal (2003a) concluded that internal loading, driven by re-suspension, was the most significant mechanism influencing water quality in the lakes and estimated that inputs into Lake Sorell amounted to 0.2 % of the total flux of internal suspended sediment, two per cent of the internal flux in nitrogen and one per cent of the internal flux in phosphorus.

3.1.4 Plankton

Phytoplankton forms the basis of the food chain within the open water component of the ILR. Zooplankton graze on the phytoplankton and in turn become a food source for larger invertebrates. Zooplankton such as Cladocerans of the genus *Daphnia* are the preferred prey item of the golden galaxias (Hardie 2003a).

[5] Ca>Na>Mg>K = Calcium, Sodium, Magnesium, Potassium.

Lake Crescent and Lake Sorell are mesotrophic systems (Uytendaal 2003b). Diatoms dominate the phytoplankton biomass in Lake Crescent, in both absolute and relative abundance, while filamentous green algae dominate the phytoplankton biomass in Lake Sorell (Uytendaal 2003a). Few macrophytes occur in the open water of Lake Crescent as they are limited by light attenuation caused by high levels of turbidity. Changes in the light climate of a shallow lake have a strong influence on algal growth and sediment re-suspension dynamics have an impact on algal biomass and community composition (Uytendaal 2003a). Sediment re-suspension has also been shown to influence phosphorus concentration in the water column (Uytendaal 2003a).

The earliest data on the phytoplankton of the lakes (Cheng and Tyler 1973) documented an extensive species list for Lake Crescent. Surveys were repeated in 1987 and 2000-2001 (Appendix 3). The original surveys identified a high diversity and abundance of phytoplankton in Lake Crescent, in contrast to Lake Sorell where the clearer water enabled macrophytes to flourish. Phytoplankton surveys were not undertaken at the time of listing (1982), although the importance of the phytoplankton was noted in the criteria for listing and the turbid conditions favouring phytoplankton growth continued. Uytendaal (2003), on analysing the survey results from 2000-2001, noted that species diversity and dominance had not changed significantly since the work carried out between 1969 and 1972 by Cheng and Tyler (1973) and that this was similar to the conclusions of Cutler et al (1990). Uytendaal (2003) asserted that species diversity remained comparable and the trends of diatom dominance in Lake Crescent and green 'filament' dominance in Lake Sorell reported in 1973 were still valid in 2003.

The zooplankton community is dominated by small (<500 µm) cladocerans (*Daphnia, Bosmina*), calanoid copepods and cyclopoid copepods and abundance varies seasonally (Uytendaal 2003).

3.1.5 Flora

The intermittent marshes on the perimeter of Lakes Sorell and Crescent are typical of temporary wetlands in temperate Australia. Kirkpatrick and Tyler (1988) described the ILR wetlands as the largest area of shallow freshwater marshes in Tasmania. Detailed data on the flora were collected, along with experimental studies, in the Lakes Sorell and Crescent Rehabilitation Project (Heffer 2003a).

3.1.5.1 Flora communities and species

Two distinct floristic communities are found in the intermittent marshes of the ILR. These communities – *Baumea arthrophylla* sedgeland and a mixed herbfield – were recorded just prior to the Ramsar listing in a statewide study by Kirkpatrick and Harwood (1981) and confirmed by Chilcott (1986). These studies indicated concentric bands of the two wetland types, a herbfield at the outer edges and sedgeland adjacent to the open water (Figure 3-5). These two wetland types are equivalent to TASVEG communities Freshwater aquatic herbland (AHF) and Freshwater aquatic sedgeland (ASF) respectively. Both AHF and ASF are listed as threatened native vegetation communities under the *Nature Conservation Act 2002*.

At the time of listing floating club-rush (*Isolepis fluitans*) was the most common species, with the highest level of cover (Kirkpatrick and Harwood 1981). Other dominant species included water ribbons (*Triglochin procerum*) and common milfoil (*Myriophyllum simulans*). These herbaceous species formed the outermost zone of the wetland, while soft twig-rush (*Baumea arthrophylla*) formed a sedgeland closer to the water's edge. In 1986, water ribbons was one of the most abundant plants and floating pondweed *(Potamogeton tricarinatus*) was quite widespread (Chilcott 1986). This latter species was more abundant in 1986 than in the 1981 survey, possibly reflecting changes in inundation during that period. *Baumea arthrophylla* was not recorded in 1986 but was widespread in both 1981 and 2003 but it is thought to have been due to a misrecording as *Chorizandra australis* during the 1986 survey (Heffer 2003a). The dominant species tolerate a range of degrees of inundation and have strategies to enable survival during periods of drying out of the wetlands. Distribution of the dominant species may reflect the differential drainage and tendency to ponding (Figure 3-6 and Figure 3-7). The ponding effect is visible in aerial images taken under moderate flooding conditions (Figure 3-7).

Two species of conservation interest were recorded in the 1979 survey, southern swampgrass (*Amphibromus neesii*) and mountain isolepis (*Isolepis montivaga*) (Kirkpatrick and Harwood 1981). Plants resembling southern swampgrass were observed in the 2000-2001 survey but failed to flower owing to the dry conditions (Heffer 2003a), so the continued presence of this species at the site is yet to be confirmed. *Amphibromus* species have a limited distribution and southern swampgrass is listed as rare under the Tasmanian *Threatened Species Protection Act 1995*.

Mountain isolepis occurs in low abundance in ILR: it was not recorded in the 2000-2001 survey quadrats but was seen during other field work (Heffer 2003a). Although this species is uncommon in Tasmania, it is not listed under the TSP Act (Heffer 2003a). *Carex longbrachiata* and *Calocephalus lacteus* have been recorded at the north western corner of the ILR near the mouth of Kermodes drain (DPIPWE Natural Values Atlas). None of the species observed on site are listed under the EPBC Act.

The three vegetation surveys (Kirkpatrick and Harwood 1981, Chilcott 1986 and Heffer 2003a) provide evidence of the response of the wetland plants to different levels of inundation. The survey at the time of listing is a snapshot of wetland vegetation under particular conditions. The two later surveys add to our understanding of the dynamics of these wetlands and the processes that maintain their ecological character (as discussed further in Chapter 7).

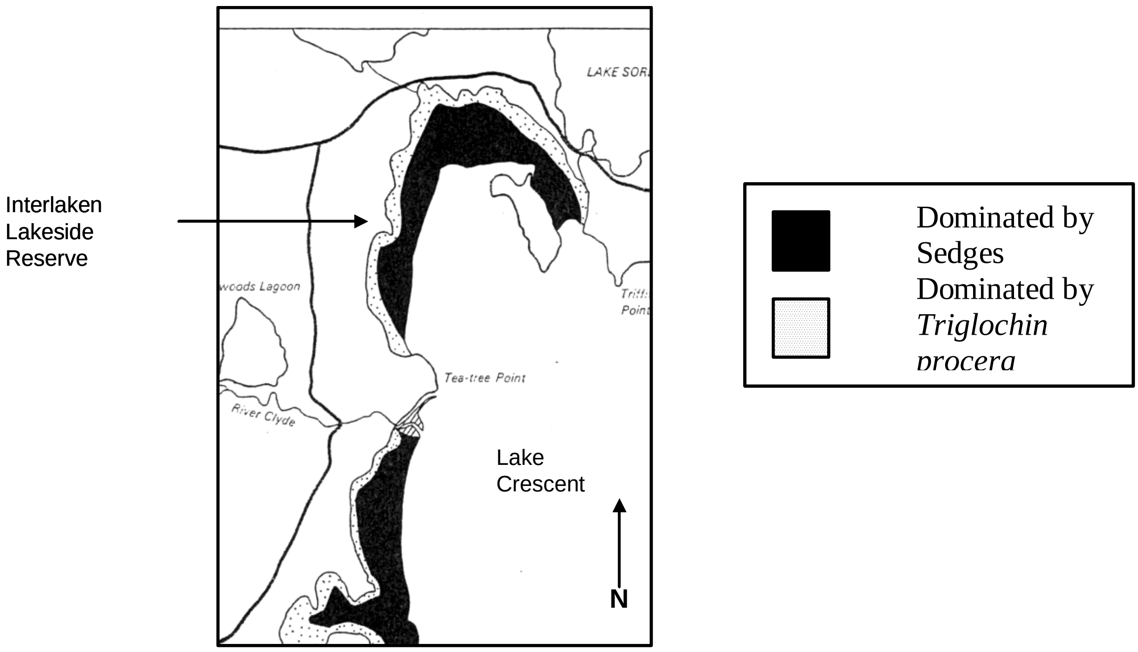

Figure 3-5
The distribution of vegetation communities in ILR wetlands around the time of listing. Source: Chilcott 1986.

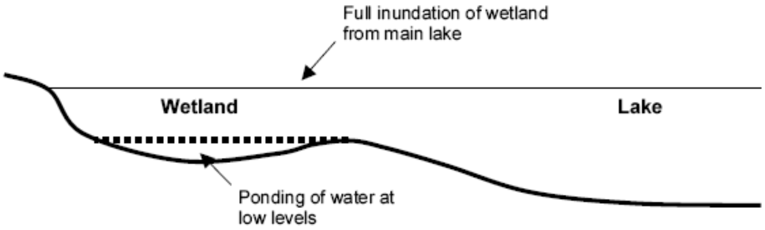

Figure 3-6
Diagrammatic representation of wetland profile showing development of ponding (Heffer 2003a)

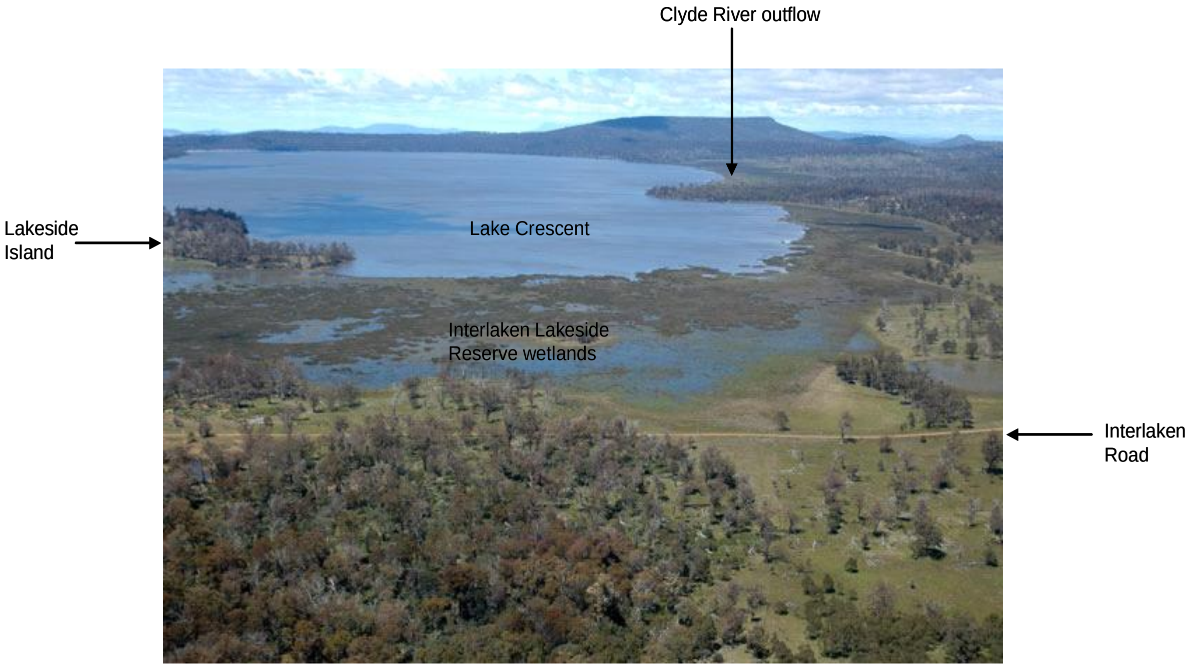

Figure 3-7
Aerial view of ILR, looking south, taken in December 2006 showing ponding and different vegetation communities (Jenny Davis, Murdoch University, scale not defined)

3.1.6 Fauna

3.1.6.1 Macroinvertebrates

Invertebrates are an important food source for golden galaxias, other fish, waterbirds, platypus and other invertebrates within ILR. The diatom-rich plankton community and detritus form part of the food source of the invertebrate fauna within the ILR (Hardie 2003b). A number of surveys relating to macroinvertebrates were undertaken around the time of the Ramsar listing (Leonard and Timms 1974; Timms 1978; and Chilcott 1986) (Appendix 5). Leonard and Timms (1974) surveyed the littoral rocky habitat fauna along the steeper lake margins; Timms (1978) surveyed benthic fauna within Lake Crescent; while Chilcott (1986) extended the types of habitats surveyed to include the littoral macrophyte habitat fauna of Clyde Marsh. In combination, these three surveys provide a reasonable estimation of the macroinvertebrate fauna at the time of the Ramsar listing.

Following examination of the water levels shown in Hardie (2003b), it seems that these surveys were conducted during times when the water level was high and close to FSL. These studies targeted particular habitats using a variety of sampling methods and were conducted within the deeper water habitats (indicative of Ramsar wetland type 'O', permanent freshwater lake over eight hectares in area). These early studies did not sample the associated wetland area in the ILR (indicative of Ramsar wetland type 'Ts', intermittent marshes on inorganic soils) (Figure 2-7). However, the invertebrate fauna of such areas can be inferred from a survey of the nearby Clyde Marsh conducted by Chilcott (1986), which is situated approximately two kilometres south of the ILR. Given that the vegetation communities of Clyde Marsh were similar to those of ILR, it may be assumed that similar taxa might be expected to inhabit these wetlands (Chilcott 1986).

Timms (1978) recorded 19 species from five sites within the benthos of Lake Crescent using an Eckmann grab sampler. The habitat was described as consolidated mud with overlying detritus in the shallower margins. Timms (1978) did not demonstrate dominance in any species; however, lower taxa such as Oligochaetes were present in high numbers at each site, whilst some species such as the molluscs (*Potamopyrgus* spp. and *Pisidium* sp.) were locally abundant. Chilcott (1986) recorded 38 species from five sites within the lake benthos using an Eckmann grab sampler. The fauna was numerically dominated by chironomid midge larvae and oligochaete worms, with the greatest diversity within this habitat at depths between 1.2 and 2.4 metres. Mollusc fauna was not particularly abundant and demonstrated a depth gradient with a single bivalve species, *Pisidium fultoni*, restricted to shallow margins, while three gastropod species were more dominant in deeper water. It is not possible to ascertain why the Timms (1978) and Chilcott (1986) survey results varied with any degree of confidence considering the similarities with the survey methods and effort. However, differences may be attributed to Timms (1978) conducting the survey during spring and Chilcott (1986) conducting the survey during autumn.

Chilcott (1986) also sampled 26 species at a single site in Clyde Marsh (Figure 2-1) using a sweep net for two minutes in and around the dominant macrophyte species. The fauna was numerically dominated by crustaceans including the amphipod *Austrochiltonia australis* and the common shrimp (*Paratya australiensis)*. The mollusc group was also numerically dominant and was dominated by *Gyraulus scottiatus* and *Physastra gibbosa*.

Leonard and Timms (1974) sampled 20 species within the littoral rocky margin habitat north of the Clyde River outflow (presumably Tea-Tree Point, Figure 2-2), the southern-most boundary of the ILR by randomly selecting five cobble/boulders and washing the surface with ethanol into a net with a 0.8 millimetres mesh diameter. They found that the insect fauna represented eight out of 20 species, which is lower than that found in other Tasmanian highland lakes and is probably due to the trophic status of Lake Crescent. Crustaceans and molluscs were also numerically dominant and represented four and three out of 20 species respectively. They also found that both abundance and biomass varied considerably between rocks sampled and was probably due to a number of factors including water depth, wave fetch impacts and the underlying substrate (i.e. detritus versus more rocks).

Of the invertebrate fauna, an endemic hydrobiid snail *Austropyrgus* sp. was recorded within the ILR after the time of listing. This species is only found in Lakes Sorell and Crescent and is of high conservation value (Cleary 1997 in Hardie 2003b). It prefers lotic freshwater environments and is generally found on weeds, leaves, roots and stones (DEWHA 2008b). The species was not detected in studies conducted around the time of listing. However, this may have been due to a change in the taxonomy of the species.

3.1.6.2 Fish

A total of four fish species are thought to have been present at the time of listing: the introduced species brown trout (*Salmo trutta)* and rainbow trout (*Oncorynchus mykiss)*; and the native species, golden galaxias, (*Galaxias auratus)* and short-finned eel (*Anguilla australis)*. Golden galaxias occurred in substantial numbers as a robust population, despite the presence of introduced predatory brown trout. The other native species, the short-finned eel, occurred in numbers sufficient to allow commercial harvesting from the canal between Lakes Sorell and Crescent. The degree of harvesting was dependent on the commercial demand for eels and lake levels.

The golden galaxias is listed as endangered and rare under Commonwealth and Tasmanian legislation, respectively. Tasmania has 11 species of endemic galaxiid fish, mostly limited in geographic distribution. The golden galaxias is one of the larger sized galaxiids although it is a relatively small-size fish, usually around 150 millimetres. Its natural distribution is confined to the upper Clyde River catchment, specifically Lakes Sorell and Crescent and associated wetlands and small tributaries (two translocated populations of this species occur in farm dams the Clyde River catchment; Hardie *et al*. 2004). It forms a major constituent of the diet of brown trout (Hardie 2003a; Stuart-Smith *et al*. 2004) (Figure 3-8), but it appears that, at the time of listing, it was able to maintain a stable population in Lake Crescent. Lake Crescent sustains a more abundant population of golden galaxias than Lake Sorell, due to the difference in abundance in salmonid fish for which the galaxiid forms the major prey species.

The golden galaxias uses the open water column, rocky shorelines and inundated wetlands at various stages in its life cycle. Spawning takes place in rocky substrate around the shorelines of the lake and in suitable wetland habitat during late autumn/winter (Hardie *et al*. 2007). An extensive area of rocky shoreline of Lake Crescent at Island Shore within the Ramsar boundary (Figure 3-9 and Figure 3-12) becomes inundated at a level of about 802.2 metres AHD (Hardie *et al.* 2007).

Figure 3-8
Fish stomach contents. Left: Golden galaxias stomach contents, including juvenile golden galaxias, small beetles from the water surface and plankton fragments. Right: Brown trout stomach contents showing numerous golden galaxias, the preferred food source (C Wisniewski, Inland Fisheries Service)

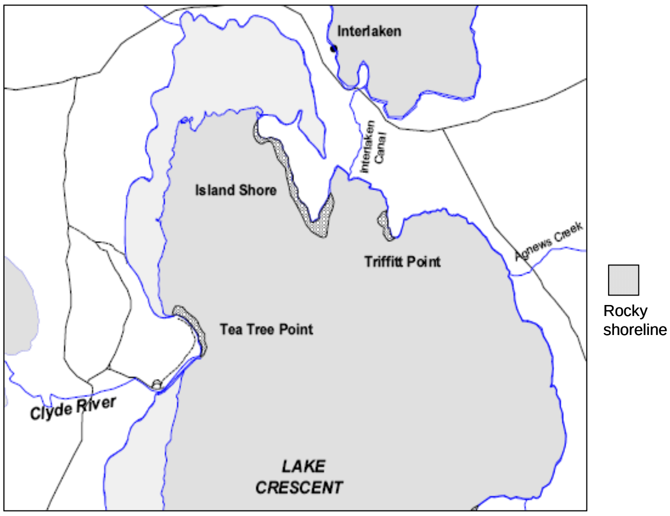

Figure 3-9
Rocky shorelines of Lake Crescent (Hardie 2003a)

Spawning occurs at a water temperature of about 4 °C and appears to be triggered by rising water levels (Hardie *et al* 2007). The fertilized eggs adhere to rocky substrate, or aquatic vegetation if available. The newly hatched larvae are pelagic, feeding on plankton and small insect larvae in the mid to upper water column. Once the juvenile fish reach a size of about 40 millimetres they begin to move inshore to benthic habitats, utilising the inundated wetlands if available, growing to about 60 millimetres in their first year. Adult fish are more benthic and prefer rocky shorelines though they will use both substrate and water column to find the aquatic insects, small crustaceans and molluscs that are their preferred food (Figure 3-8). The population is dominated by female fish that are usually larger in size (Hardie *et al* 2007).

At times of low water level, the ILR wetlands habitat is unsuitable for fish, reducing the extent and diversity of habitats and food resources available to the golden galaxias. Unlike some species of galaxiid fish, the golden galaxias is non-diadromous, i.e. it does not migrate between sea and freshwater during its life cycle. Thus, whilst the migratory and reproductive cycles of this species are not directly controlled by low water levels, these conditions create significant stress on golden galaxias populations as rocky shore breeding sites and preferred littoral habitats of both juvenile and adult fish are lost and water quality declines. Adult galaxiids can adapt to feeding in the water column and surface based prey, but this makes them more vulnerable to predation by trout.

Lakes Sorell and Crescent are important localities for recreational fishers. Brown trout grow to a large size in Lake Crescent although numbers are lower than in Lake Sorell. This is thought to be due to poor recruitment of trout in Lake Crescent and the abundant galaxiid population which provides an abundant food resource for larger individuals. There has been a moratorium on stocking of trout in Lake Crescent since 2005 and a program to remove trout from the lake was implemented during January-March 2009 (S. Hardie, pers. comm., 2009).

3.1.6.3 Birds

Lakes Sorell and Crescent were regarded as refuges for waterfowl and other birdlife in dry periods at the time of listing, but there is little systematic data to support this assertion. When the lake is full and standing water extends into the wetlands, Lake Crescent becomes an important habitat and food source for black swans, (several species of duck including musk duck, hardhead, Australasian shoveler, grey teal, chestnut teal, black duck and Australian shelduck; Figure 3-10), and other waterbirds such as cormorant, grebe, coots, swamp hens and herons (a full list of species can be found in Appendices 1 and 2). Some of these species are known to breed in the wetlands when they are inundated. The lake, associated wetlands, and adjacent forest provide feeding and roosting habitat for a number of migratory birds that undertake movements within Tasmania and south-east Australia.

Systematic summer (February) counts of waterfowl have been undertaken by DPIPWE since 2002, prior to which information was collected in an opportunistic manner and there is an absence of any data for the period 1992 to 2001. The highest number of waterfowl was observed in 1986, (Figure 3-10). Black ducks were the most numerous species in that year, followed by chestnut teal. Few black swans were recorded in 1986, despite it being a higher rainfall year with higher water level in the lakes. One explanation is that rainfall was widespread in Tasmania in 1986; therefore, there were suitable areas of wetland habitat in lowland areas. Bird observations carried out at Lake Crescent and the surrounds in the period between 1983 and 1986 (Appendices 1 and 2) also recorded chestnut teal and black duck in good numbers in 1986 (Chilcott 1986).

Chestnut teal are the most consistently recorded bird species and are present in most years for which data are available. At the time of listing, it is believed that the lakes supported sufficient numbers of ducks to attract shooters during the duck hunting season (generally from March to June).

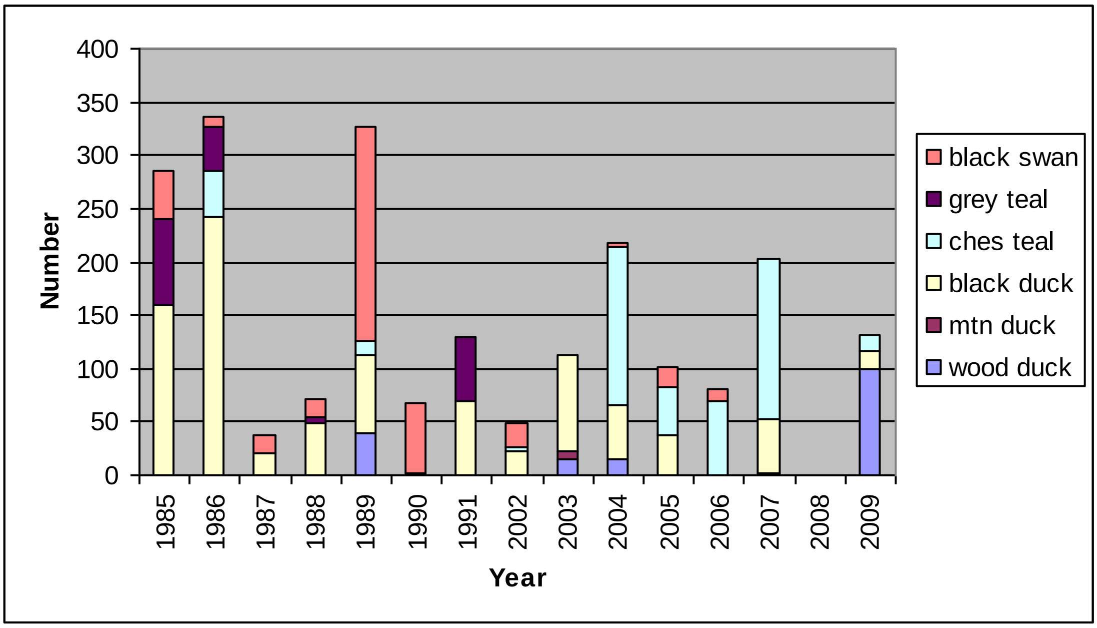

Figure 3-10
Waterfowl recorded in the north-west corner of Lake Crescent 1985 – 2009. Note: data was not recorded from 1992 – 2001 (S. Blackhall, pers. comm., 2009; data provided by DPIPWE)

An extensive list of bird species has been compiled from records of sightings over several years from the Lake Crescent area (Heffer 2003a, Appendices 1 and 2). Five species listed as migratory on the EPBC Act[6], the cattle egret (*Ardea ibis)*, Latham's snipe (*Gallinago hardwickii),* white-bellied sea eagle (*Haliaeetus leucogaster),* Caspian tern (*Sterna caspia)* and the white throated needle-tail *(Hirundapus*

[6] These species are listed on one or more of the migratory bird agreements, the Bonn Convention, JAMBA, CAMBA and ROKAMBA

caudacutus), have been recorded within the ILR at or around the time of listing (Heffer 2003a, Thomas 1979, R. Mawbey, pers. comm., 2009). The cattle egret and Latham's snipe have been observed feeding and roosting within the intermittent marsh habitats at the Ramsar site. While these bird species are notable there is no evidence that they occur in large enough numbers to meet Ramsar criteria and no evidence is available to determine the frequency with which they utilise the ILR.

There is a record for the Australasian bittern from the Lake Crescent area (Thomas 1979) and there is suitable habitat present in the ILR but no recent records of this species exist. The Australasian bittern is listed as Endangered under the EPBC Act and on the IUCN Red List (Version 2009.1).

The great crested grebe (*Podiceps cristatus)*, which is listed vulnerable on the Tasmanian TSP Act, has been recorded from the open water and emergent vegetation wetland habitats within the ILR while the white-bellied sea eagle (*Haliaeetus leucogaster)* (TSP Act vulnerable) has also been recorded in the area (Heffer 2003a).

Although not wetland dependent, the swift parrot (*Lathamus discolor)* which is listed as endangered on the EPBC Act and the Tasmanian TSP Act, has also been recorded from the forested portion of the ILR around the time of listing (Heffer 2003a). Two other species listed as endangered on the TSP Act have also been recorded in the area: the wedge-tailed eagle (*Aquila audax fleayi)* (also listed as endangered under the EPBC Act) and grey goshawk (*Accipiter novae-hollandiae*; Heffer 2003a).

3.1.6.4 Frogs

Seven species of frogs were found in the vicinity of Lake Crescent around the time of listing (Chilcott 1986). These were the brown tree frog *(Litoria ewingi)*, green and gold frog *(Litoria raniformis)*, common froglet *(Crinia signifera)*, Tasmanian smooth frog *(Geocrinia laevis)*, southern toadlet *(Pseudophryne semimarmorata)*, spotted marsh frog (*Limnodynastes tasmaniensis)* and bull frog (*Limnodynastes dumerili)*. All of these species are considered likely to have utilised the intermittent marshes of the lake margins of Lake Crescent, although green and gold frog would have been restricted to these habitats (Chilcott 1986). Other species may move into the marshes to breed and lay their eggs.

Green and gold frog was listed as vulnerable on the EPBC Act and TSP Act following a widespread decline in sightings across its range in south east Australia and Tasmania. It was reported to be common and widespread within the ILR within the intermittent marsh habitat in the late 1970s and early 1980s around the time of listing (R. Mawbey, pers. comm., 2009). R. Mawbey reported finding up to 40 individual green and gold frogs under woody debris at Lake Crescent in the early 1980s and breeding events were common with numbers of juveniles regularly recorded (R. Mawbey, pers. comm. 2009).

3.1.6.5 Other fauna

The platypus (*Ornithorhynchus anatinus)* is known to inhabit Lake Crescent, where it feeds on the abundant invertebrate fauna. Much of the shoreline is not considered suitable for burrows and breeding, though the Interlaken canal and adjacent swamps are though to be used (T. Byard pers. comm., 2008). Retreat of the water level from certain parts of the shoreline may adversely affect access to platypus burrows and impact upon breeding. Up to 2008, no evidence has been observed of the fungal disease mucormycosis, which is affecting platypus in other parts of Tasmania (T. Byard pers. comm., 2008).

3.2 Critical ecosystem components

This section describes what are considered to be the critical components of the ILR at the time of listing in 1982. Critical components are those that:

- are important determinants of the site's unique character (e.g. geomorphology, hydrology and water quality);
- are important for supporting the Ramsar criteria under which the site was listed (e.g. fauna such as the golden galaxias and the wetland vegetation community);
- change is reasonably likely to occur over the short, medium or long term (<100 years); or
- if change occurs to them, they will cause significant negative consequences (e.g. wetland inundation regimes).

Of the ecosystem components and processes within the ILR at the time of listing in 1982, two components, the golden galaxias and the intermittent marshes, have been determined to be 'critical' in defining the character of the ILR. As very little information exists regarding the presence of the green and gold frog and Australasian bittern at the time of listing and as they have not been recorded at ILR since, it is not considered that they contribute to the ILR meeting Criterion 2 or are important determinants of the sites character and, as such, are not considered to be critical components of the ILR.

3.2.1 Golden galaxias

This species is one of the primary determinants of the unique ecological character of the ILR. Golden galaxias is endemic to Tasmania and only found in Lakes Crescent and Sorell. It is found in the highest densities within Lake Crescent. The golden galaxias is a critical component in the justification for meeting five of the Ramsar criteria for which the site was listed. The criteria relate to the site:

- supporting vulnerable or endangered species (Criterion 2);
- contributes to the biodiversity of the region (Criterion 3)
- supporting internationally important species during a critical life stage (Criterion 4);
- being important spawning ground and nursery on which fish depend (Criterion 8); and
- regularly supporting one per cent of the individuals in a population of one species of wetland dependent non-avian animal species (Criterion 9).

Given the small catchment of Lake Crescent and highly variable rainfall of the region, changes in abundance over the short medium or long term are likely and if they were to occur would cause considerable negative consequences to the ecological character of the ILR. It is for these reasons the golden galaxias is considered to be a critical component of the ILR.

3.2.2 Intermittent marshes

The intermittent marshes of the ILR are also considered a critical component as they are a part of the defining character of the ILR. The presence of the intermittent marshes is central to the justification for meeting Criterion 1 of the Ramsar criteria for which the site is listed. The intermittent marshes are also important foraging, spawning and nursery areas for the golden galaxias as well as a refuge from predation. Due to the highly variable nature of the wetting and drying regime of the marshes and water extraction for downstream use it is possible, in the absence of controls, that changes to the nature of the intermittent marshes could occur which could cause significant negative changes to the site.

3.3 Ecosystem processes

Trophic interactions and the wetland inundation regime are the major ecosystem processes at ILR. No 'critical' ecosystem processes have been identified.

3.3.1 Trophic interactions in Lake Crescent

Light attenuation effectively prevents macrophyte growth in the open water, but diatoms and other phytoplankton flourish in the nutrient–rich shallow water. These are consumed by zooplankton comprised of micro-crustacea such as *Daphnia* (water flea), ostracods (seed shrimps) and copepods (freshwater shrimps). Small fish consume plankton, benthic fauna and airborne insects that land on the water surface incidentally. The golden galaxias is the main food source for large trout (Figure 3-8). Predation pressure appears not to have a detrimental impact on populations of golden galaxias in Lake Crescent with the current stocking levels (D. Jarvis and C. Wisniewski, pers. comm., 2008). The lake holds mainly large trout in relatively small numbers and the galaxiid population generally remains abundant under normal spawning cycles. Increasing turbidity leads to a change in prey choices by large trout from insects, fish and larger crustaceans to almost exclusively zooplankton (Stuart-Smith *et al* 2004). Figure 3-11 summarises trophic interactions in the Lake Crescent water body. The considerable annual variation in plankton biomass or the impact of zooplankton grazing on plankton biomass does not appear to be a limiting factor on fish population sizes.

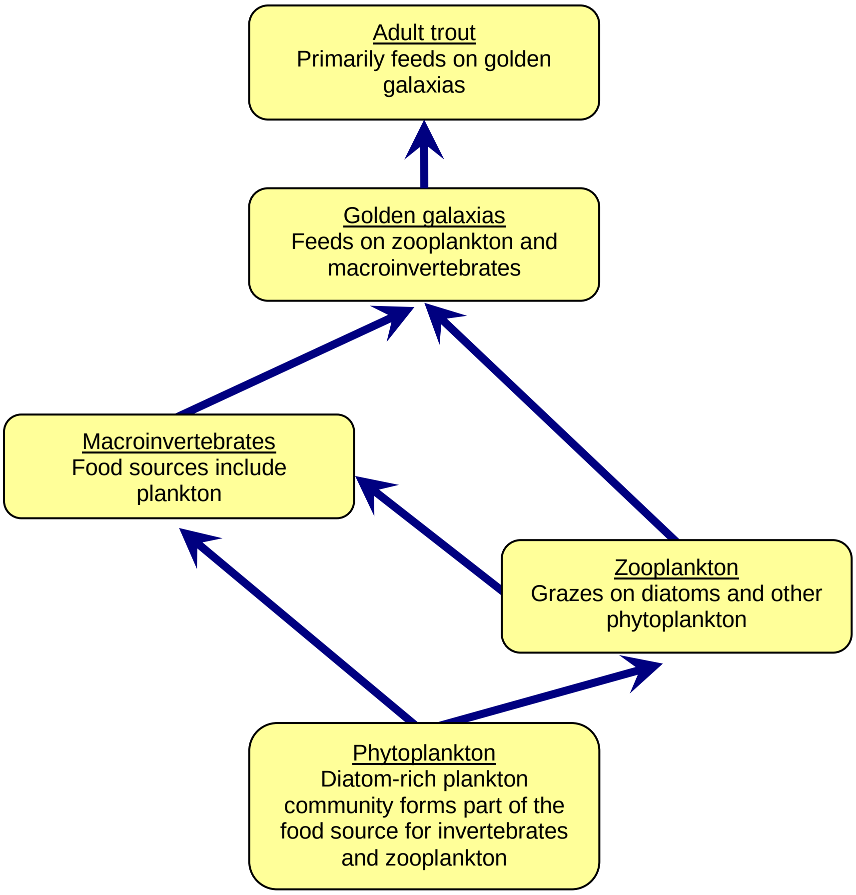

Figure 3-11
Primary trophic interactions in Lake Crescent

3.3.2 Wetland inundation regime

Section 3.1.2 (Hydrology) provides evidence of differing water levels and the consequences for wetland inundation. The ILR has a very low gradient, generally less than 0.5 metres (Figure 3-12). If an increase in lake level of 20 centimetres occurs, large areas of the wetland become inundated. A small fall from full inundation of the marshes of 20 centimetres to 802.8 metres can expose a large proportion of the intermittent marshes to drying out.

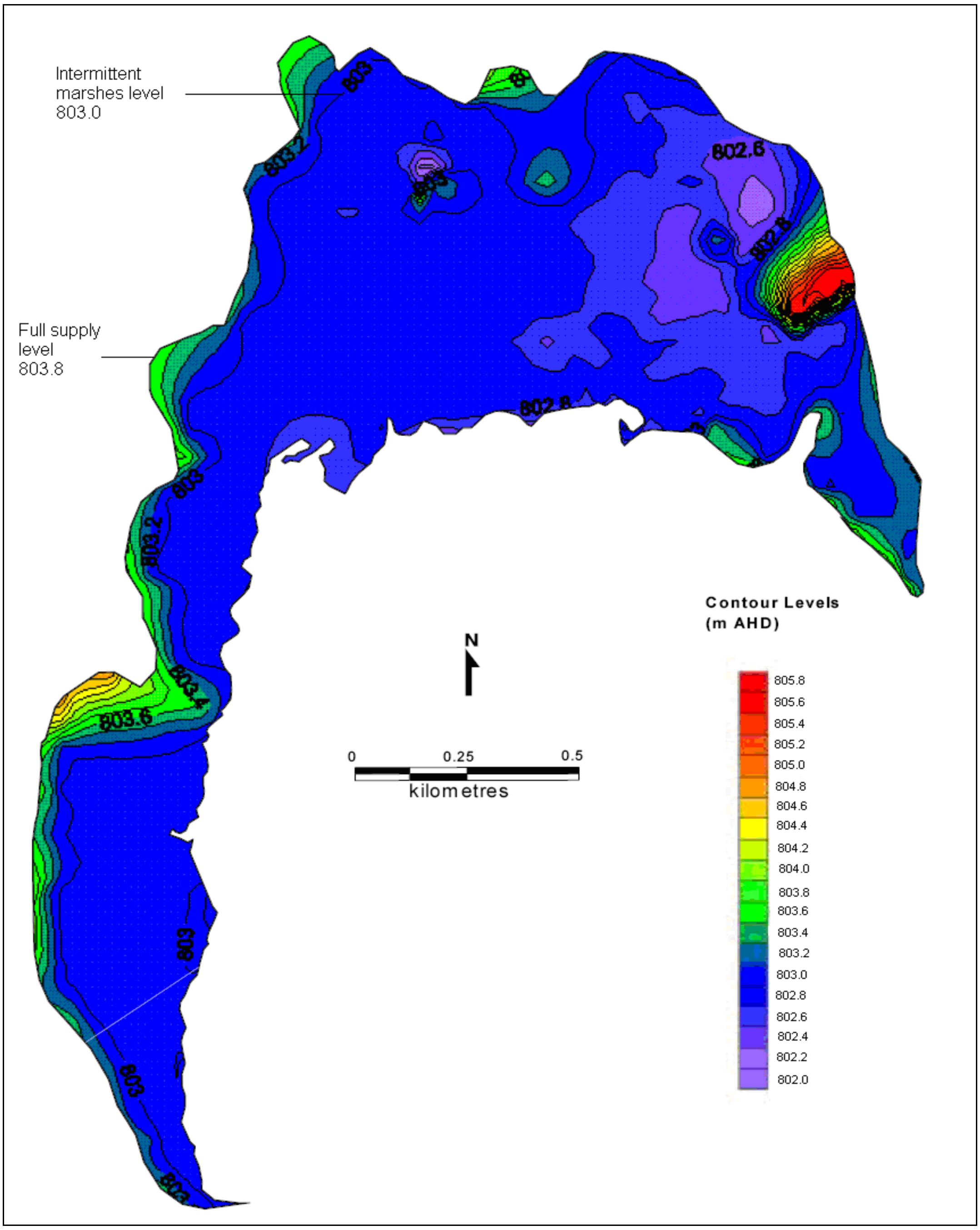

Figure 3-12
Interlaken Lakeside Reserve survey height levels (metres AHD). The contours of the full supply lake level (803.8 metres AHD) and the level of the wetlands (803 metres AHD) are indicated (Heffer 2003a)

Rainfall and water level data over time indicates that the wetland varies in extent of inundation in an irregular fashion, unrelated to seasonal patterns (Section 3.1.2 Hydrology). Factors such as incidence, rates of filling/drying, depth and duration all influence the intermittent inundation and degree of water-logging at ILR which are drivers of the wetland's ecology and character. Estimates of lake levels for phases of wet and dry are provided in Section 3.1.2.

The 2005 Lakes Sorell and Crescent Water Management Plan dictates how the water levels in both lakes are to be managed. For Lake Crescent, the operating rules and guidelines identify Full Supply

Level (803.8 metres AHD), a Preferred Operating Range (802.7 to 803.8 metres AHD) and a Critical Minimum Level (802.2 metres AHD). The Water Management Plan, recognising the importance of the wetting and drying regimes on maintaining wetland health, has set guidelines which the Water Manager should follow as far as practicable. These include:

- Lake Crescent should not be maintained above 803.3 metres AHD or below 803.0 metres AHD for more than five consecutive years in order to reduce the impacts of the wetlands being wet or dry for too long.
- Lake Crescent should be allowed to reach 803.3 metres AHD at least once in every five years to allow the intermittent marshes to be inundated and encourage aquatic plant growth and regeneration.
- Sudden large changes in water levels inconsistent with climatic changes should be avoided particularly within the inundation zone of the intermittent marshes (803.0-803.3 metres AHD). Additionally decreases in water levels of greater than 600 millimetres should not occur in either lake between June and September to reduce the risk of dewatering golden galaxias eggs.

3.3.2.1 The impact of inundation on wetland vegetation

The wetlands of ILR are adapted to intermittent inundation. They can withstand periods of drying out and both seasonal and intermittent changes in water level. The various plant species have different adaptations and requirements in order to maintain viability and to reproduce. Heffer (2003a) identified species associated with different habitat types according to submersion and form. Species commonly found in the ILR fall into the categories ‘amphibious, emergent’ e.g. *Baumea arthrophylla*, *Lilaeopsis polyantha;* and ‘amphibious, responds to changing water level’, e.g. *Isolepis fluitans*, *Villarsia reniformis* and *Triglochin procerum.* All the species tolerate, or are dependent upon, varying water levels and degrees of inundation, at least for some period of time.

Some of the species occurring within ILR require standing water in order to flower and set seed. Heffer (2003a) found, under experimental conditions, some species quickly achieved greater stem height when inundated. Many wetland species have both sexual and vegetative reproductive strategies, the latter being advantageous in drier periods when a full reproductive cycle cannot be completed. The low level of relief of ILR wetlands and absence of small-scale drainage features means that as water level rises, it spreads evenly across the wetland. Conversely, the water may recede quickly, leaving germinating seedlings unable to establish (Heffer 2003a).

3.3.2.2 Viability of wetland species

Heffer (2003a) found that the soil seed bank at ILR was species poor. Following experimentation, she concluded that different species required different conditions to germinate, grow and reproduce. Herbaceous species respond more quickly to changing water depths. Even if watering results in germination, there is a risk that subsequent drying may destroy the propagules and diminish the capacity of the species to flourish. The degree to which the wetland flora can withstand periods of drying out is an important component of the Water Management Plan for Lakes Sorell and Crescent (DPIW 2005). The Plan recommends a water regime that fluctuates annually and has a dry phase every few years is necessary for the maintenance of the health and diversity of the wetlands (Heffer 2003a).

When the wetland is watered, it brings the potential for species dispersal and re-colonisation of both plants and animals. Many wetland invertebrate species require standing water and macrophyte growth to provide suitable habitat for breeding. Golden galaxias and frogs use the watered wetlands for breeding.

3.3.2.3 Impacts on wetland condition

At high water levels, the continuity between the open water and the wetlands at ILR brings nutrients into the wetlands system and renewal of sediments. Aquatic species can move between the water column and wetlands, and dissemination and recolonisation can occur. Trophic interactions in the wetlands become more complex, involving a wider range of biota.

At times when the water level is low, the connection between wetlands and their major water supply is lost. At very low levels and continuous exposure, the wetlands and the open water may be separated by an extensive perimeter of dry lake bed mud. Patches of exposed, dried mud between stands of vegetation isolate the vegetation patches and their associated fauna. Nutrients are not renewed. The drier conditions encourage plant species that are more ubiquitous in their requirements, including some largely terrestrial species, and wetland taxon diversity is reduced. Dry conditions also allow invasive exotic species, especially those associated with pasture, to become established and potentially displace wetland species, at least in the short term. Their spread is exacerbated by dry conditions which enable easy access to the lake shore by vehicles and occasional wandering stock. Compaction of soils by vehicles occurs particularly when the wetlands begin to dry out.

3.4 Ecosystem benefits and services

The ecosystem benefits and services provided by the ILR site are important in describing the ecological character of ILR. The provisioning, regulating, cultural and supporting benefits and services of ILR are presented in Table 3-1. The relationships between the ecological service and the components and processes have also been examined to identify the primary drivers of the ecological character of the site (Table 3-1). Some of these services are confined to the standing open water, others to the intermittent marshes. In the case of the golden galaxias and waterfowl, both wetland and water body are important for aspects of their ecology.

ILR as a breeding / spawning area for golden galaxias and a regional example of wetland communities, are considered to be 'critical' ecosystem services. These are described in more detail in Section 3.5.

Table 3-1 Ecosystem services and related components and processes at ILR

Ecosystem service	**Wetland Type**	**Component**	**Process**
Provisioning services			
Fresh water - water supply	Permanent freshwater lake	Geomorphology Hydrology	Wetland inundation - lake level change and management
Food - commercial eel fishery	Permanent freshwater lake	Geomorphology Fauna - invertebrate and fish communities	Trophic interactions - predation Wetland inundation - lake level change and management
Regulating services			

Ecosystem service	Wetland Type	Component	Process
Sediment deposition and retention - sediment trap	Intermittent freshwater marsh	Flora - wetland vegetation	Wetland inundation - lake level change, sediment transport, deposition and nutrient renewal
Cultural services			
Recreation and tourism - recreational trout fishing	Permanent freshwater lake	Geomorphology Fauna - invertebrate and fish communities	Trophic interactions - predation of golden galaxias Wetland inundation - lake level change and management
Spiritual and inspirational - Aboriginal associations and education	Intermittent freshwater marsh / Permanent freshwater lake	Geomorphology Flora - wetland vegetation	Wetland inundation - lake level change and management
Supporting services			
Threatened wetland species, habitats and ecosystems - breeding/spawning area for golden galaxias	Intermittent freshwater marsh / Permanent freshwater lake	Fauna - golden galaxias population Geomorphology - inundated rocky shoreline and marshes Hydrology - influencing habitat connectivity Water quality Flora- wetland vegetation	Trophic interactions - predation Wetland inundation - provision of habitat for reproduction
Natural or near-natural wetland ecosystems - regional example of mid-altitude temperate wetland communities and component species	Intermittent freshwater marsh / Permanent freshwater lake	Geomorphology Hydrology - rainfall and connectivity Water quality - nutrients Flora - wetland vegetation	Wetland inundation - lake level change and management, flooding regime, nutrient cycling, provision of habitat for reproduction, dormancy and colonisation
Biodiversity - habitat for endemic and threatened species	Intermittent freshwater marsh / Permanent freshwater lake	Fauna - invertebrate communities Geomorphology - including rocky shorelines for galaxias reproduction Hydrology - habitat connectivity Water quality - dissolved oxygen Plankton communities	Trophic interactions - predation and competition Wetland inundation - lake level change and management, dispersal of species

Ecosystem service	Wetland Type	Component	Process
Biodiversity - plankton dominated aquatic community, including unusual diatom communities	Permanent freshwater lake	Geomorphology Water quality - turbidity, nutrients, trace elements (silica)	Trophic interactions - light attenuation, primary production, decomposition and predation Wetland inundation - lake level change and management, nutrient cycling, reproduction and dispersal of species

3.4.1 Provisioning services

3.4.1.1 The lakes as a water supply system

The Lakes Sorell and Crescent system was among the first targeted for use in irrigation in Tasmania (Mason-Cox 1994). This in itself suggests an annual rainfall less than required levels to satisfy demands to serve pasture and crop growth downstream in the Clyde valley. From around 1820, landowners began pressuring for control of the two lakes for water supply. Lake Sorell, with its larger capacity, was seen as the main supply source with Lake Crescent as the 'holding tank'. This position is still in evidence today (J. Deakin, pers. comm., 2009).

The Clyde River was first dammed in 1833 through the installation of a dam and sluice gate at the head of the Clyde River in Lake Crescent. A few years later, a dam was constructed across Interlaken Rivulet (Mason-Cox 1994). For the rest of the 19^{th} century, the use, management and access to water from the lakes was controversial. Poor water quality lead to outbreaks of diphtheria and typhoid, user disputes were common and many unauthorised alterations to weirs and drainage channels were made. Legislation to control the water in the Clyde eventuated, resulting in the *Clyde Water Act 1898* that provided for the river to be managed by a Trust, largely comprised of local landowners. These responsibilities have now been subsumed under the *Water Management Act 1999* (T. Byard, pers. comm., 2009).

Lakes Sorell and Crescent still provide town water for Bothwell and Hamilton as well as irrigation water. Water in the system is now managed under the *Lakes Sorell and Crescent Water Management Plan 2005* and the *River Clyde Water Management Plan 2005*, under the jurisdiction of DPIPWE. The level of Lake Crescent is manipulated by release of water from Lake Sorell via Interlaken canal.

The Lakes Sorell and Crescent system has a small catchment. Dry seasons and periods of low water with associated poor water quality have been reported over the last 150 years. As such, the function of the lake as a water supply reservoir is dependent upon constant top-up and the entire system has limited capacity. Climatic factors are the core driver to the adequacy of the system as a water supply. Although only a small proportion of water would come from the ILR component of Lake Crescent, small changes in the volume of water in the lake can have a significant effect on the water levels within the ILR.

3.4.1.2 Commercial eel fishery

Lake Crescent has been used as a commercial eel fishery based on the short-finned eel (*Anguilla australis*), since 1965 (Chilcott 1986 *in* Heffer 2003b). Prior to the installation of carp screens at the Clyde River outflow in 1995, the eel fishery was restricted to the capture of downstream migrating eels with a trap installed at the Clyde River outflow (Heffer 2003b). Following the installation of the fine mesh screens (1.1 millimetres), the fishery was operated using fyke nets within the lake itself and later through an eel trap installed at the Lake Sorell gate to capture eels moving from Lake Sorell to Lake Crescent (Heffer 2003b). However this trap cannot be used when water levels are low (Frijlink 2000 *in* Heffer 2003b). The eel population in Lake Crescent has historically been maintained by the stocking of elvers by the IFS as carp screens block the natural spawning migration of eels between the lake and the ocean (Heffer 2003b).

3.4.2 Regulating services

3.4.2.1 Sediment trap

When the wetlands at ILR are filled, the plant architecture facilitates reduction in wind driven re-suspension as well as slowing water movement which allows the trapping and settlement of sediments, resulting in clearer water in the wetland areas. This then mixes with water in the whole system, reducing turbidity. At high water levels, nutrients also cycle in and out of the wetlands into the open water.

In shallow lake systems such as at ILR, wind strength and fetch can cause re-suspension of sediment in the water column leading to a decline in water quality. At ILR, water quality influences the plankton in the lake and the success of golden galaxias spawning. Hardie (2003a) suggests that at high turbidity levels, an influx of sediment particles at spawning sites in Lake Crescent can pose the threat of smothering spawning habitat. This process however, is likely to provide nutrients for the wetland vegetation communities within ILR.

3.4.3 Cultural services

3.4.3.1 Recreational trout fishing

Brown trout were introduced to Lake Crescent over a century ago and the adult trout are known to feed largely on abundant golden galaxias. In Lake Crescent, the conditions favour growth of a relatively small number of large trout, known to anglers as 'trophy trout'. These provided a particular challenge enjoyed by experienced fishers and the lake attracted fishers worldwide. In recent years, conditions in the Lakes Sorell and Crescent system have deteriorated. Low lake levels have left anglers 'high and dry' from access to the open water and the challenge of trout fishing has become much less attractive in this area (T. Byard, pers. comm., 2009). While trout are an introduced species, recreational fishing is considered an important service due to the significant interaction this activity has on the functioning of the ILR. These interactions include the trophic relationship between trout and the golden galaxias, the recreational use of the wetland and the management of the trout fishery potentially impacting on water level management.

3.4.3.2 Aboriginal associations with Lake Crescent

Aboriginal people are known to have inhabited the Lake Crescent area. A brief archaeological survey was undertaken at Lake Crescent in 1986 (Thomas and Associates 1986 cited in Heffer 2003b) as part of an environmental impact study to determine the impacts of raising the water level of the lake (Chilcott 1986 *in* Heffer 2003b). Eight Aboriginal sites were identified along the shoreline of Lake

Crescent. Three of the sites were located along the shoreline of the ILR (Thomas and Associates 1986 cited in Heffer 2003b).

Clashes between Aboriginal people and European settlers in the Lakes Crescent and Sorell area between the 1820s and 1830s have been documented (Heffer 2003b). George Augustus Robinson, in his journeys across Tasmania, noted when he visited in the early 1830s that it was country of the Big River tribe (known as the Lairmairrener people) (Plomley 1966). The Lairmairrener people had names for the nearby hills and the Clyde River, and used the resources of the lakes for food, including eels and birdlife. Robinson noted that ‘Crescent Lake has a very monotonous appearance (and) saw plenty of wild ducks’. He recorded that the lake and Clyde River ‘abounded in eels’. While at his encampment near the lake, Robinson observed that there were ‘numerous flocks of wild ducks at the mouth of the (Clyde) River and the natives killed several young ones in the marshes with their waddies’. At this point he noted that the Clyde River at its source flowing from Lake Crescent was a small stream that he ‘crossed … by stepping from one rock to another’.

These brief notes from the journals of George Augustus Robinson were made at a time when he suggested that he was ‘convinced that natives would not long sojourn in this place, and moreover there are white people here also and soldiers’. However, the naming of features in the area by the Big River tribe (Lairmairrener people) and knowledge of the food resources available suggests that the area was regularly used by Aboriginal bands, at least in the summer seasons.

Today’s Aboriginal community undertakes access trips to view the sites in the area and to re connect with the land and its values (through the Tasmanian Aboriginal Land and Sea Council). These trips are important to today’s community as the sites in these areas show that the old people regularly used these areas, and through returning to and explaining the importance of these areas, this allows Aboriginal people to continue their long association with the land (C. Hughes, pers. comm., 2008).

3.4.4 Supporting services

3.4.4.1 Breeding/spawning area for golden galaxias

The rocky substrate around the shore of Lake Crescent provides spawning areas for golden galaxias (Hardie *et al* 2007). The species also utilises the open water column and wetland habitats at various stages of its life cycle (Section 3.1.6.2).

3.4.4.2 Regional example of wetland communities

ILR encompasses two typical wetland communities for highland Tasmania. Each can tolerate slightly different conditions: the sedgeland is found in areas that are better drained and its tough stems are resistant to desiccation, while the herbfield is more diverse, with some annual species and others which require standing water to support the stems and achieve flowering and seed dispersal.

The wetland communities are adapted to variable climatic conditions but are dependent on at least intermittent connection with the lake to survive. Connectivity provides important sediment and nutrient cycling, as well as water for germination and dispersal of propagules. These intermittent marshes are considered to be the largest freshwater marshes within the Central Highlands bioregion and Tasmania as a whole. The ILR is also representative of mid altitude freshwater marshes in the Tasmanian Drainage Division, as many others in Tasmania are at much lower altitude. Thus, the ILR represents a genetic resource for many wetland species. For instance, ILR supports southern swampgrass, a plant listed on Tasmania's *Threatened Species Protection Act 1995,* which is generally found in lowland areas.

3.4.4.3 Habitat for endemic and threatened Species

The ILR wetlands support several endemic and threatened species. An endemic snail, a hydrobiid gastropod (*Austropyrgus* sp.) has been recorded at ILR, the distribution of which is limited only to Lakes Sorell and Crescent (Cleary 1997 *in* Hardie 2003b). ILR also supports the golden galaxias, which is listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. The golden galaxias is endemic to Tasmania where its natural distribution is limited to the Lake Sorell and Crescent system. The fish uses the habitat of Lake Crescent for its complete life cycle. It feeds in the open areas of the water body and along shorelines on abundant zooplankton and invertebrates. It moves to shallow water to breed, using rocky shorelines and wetland macrophyte vegetation as a spawning area, to attach its eggs. The rocky shores and wetlands also provide cover from trout.

The green and gold frog has also been observed within ILR. The species was reported to be common and widespread within the ILR in the intermittent marsh habitat in the late 1970s and early 1980s around the time of listing (R. Mawbey, pers. comm., 2009). This species was listed as vulnerable on the EPBC Act in 2000 and the TSP Act in 2001, following a widespread decline in sightings across its range in south east Australia and in Tasmania. The green and gold frog depends upon permanent freshwater for breeding and the intermittent marshes of the ILR (when inundated) provide ideal breeding habitat including shallow water with a complex vegetation structure dominated by emergent plants such as water ribbons (*Triglochin procerum*) and spike rush (*Eleocharis* sp.), and submerged plants such as watermilfoil (*Myriophyllum simulans*), marsh-flower (*Villarsia* sp.) and pondweed (*Potamogeton* sp.) (DPIWE 2001).

3.4.4.4 Plankton-dominated Lake System, including Unusual Diatom Communities

In combination, the configuration of the lake, the nature of the sediments, colloidal inputs from Lake Sorell, and the weather conditions, create an environment which favours a plankton–dominated trophic system. The plankton assemblages in ILR and Lake Crescent as a whole are unique and depend on the specific morphology of the lake. Unlike neighbouring Lake Sorell where the water is historically clear, Lake Crescent is very turbid and light cannot penetrate even its shallow depths to allow for growth of in-lake macrophytes. Primary production is therefore primarily comprised of planktonic forms, which occur in vast numbers and a variety of taxa, dominated by diatoms. The plankton assemblages in Lake Crescent differ from the nearby Lake Sorell markedly in terms of species composition, population structure, population stability and total biomass. Lake Crescent has a standing crop ten times that of Lake Sorell (Cheng and Tyler 1976). The rich phytoplankton sustains a zooplankton community that provides food for the large population of golden galaxias.

3.5 Critical ecosystem benefits and services

This section describes what are considered to be the critical services for the ILR at the time of listing in 1982. Critical services are those that:

- are important determinants of the site's unique character (e.g. geomorphology, hydrology and water quality);
- are important for supporting the Ramsar criteria under which the site was listed (e.g. fauna such as the golden galaxias and the wetland vegetation community);

- change is reasonably likely to occur over the short, medium or long term (<100 years); or
- if change occurs to them, they will cause significant negative consequences (e.g. wetland inundation regimes).

The following ‘supporting services’ were determined to be ‘critical’ ecosystem services of ILR:

- Threatened wetland species, habitats and ecosystems – ILR is a breeding /spawning area for golden galaxias; and
- Natural or near-natural wetland ecosystem – ILR is a regional example of mid-altitude temperate wetland communities and component species.

These services support the critical components of ILR and are therefore essential in defining the character of the ILR. Loss of any of the other services would not fundamentally alter the ecological character of the ILR.

3.5.1 Breeding/spawning area for golden galaxias

The rocky substrate around the shore of Lake Crescent and the intermittent marshes provides spawning areas for golden galaxias (Hardie *et al*. 2007). The species also utilises the open water column and wetland habitats at various stages of its life cycle (Section 3.1.6.2).

3.5.2 Regional example of wetland communities

The ILR intermittent marshes are considered to be the largest freshwater marshes within the Central Highlands and Tasmania. The two wetland communities present are adapted to variable climatic conditions but are dependent on periodic inundation to survive. Connectivity to the lake provides important sediment and nutrient cycling, as well as water for germination and dispersal of propagules. The ILR is also a representative example of mid altitude freshwater marshes in the Tasmanian Drainage Division, as many others in Tasmania are at much lower altitude.

4. Interactions and conceptual models

The links between biotic and abiotic components and processes present in the ILR are shown in Figure 4-1. This conceptual model represents, in a simplified way, the character of the two major habitats of the ILR: open water and the intermittent marshes. Change in level of inundation and degree of water logging is a defining process of this ecosystem. Under conditions of full supply, connectivity between the two systems is maintained, allowing for a flow of water and nutrients between the open water and the intermittent marshes. Under such conditions there is also continuity of access throughout the lake ecosystem for flora and fauna components.

Figure 4-1 shows how the wetland processes are changed by changes in water level. When the water level is low many wetland plants are unable to flower and set seed, with some species reduced to vegetative stages lying within the soil, and golden galaxias can no longer move into the rocky shores and inundated macrophytes in order to spawn. At low lake levels, wetland herbfield communities are not recognizable, water ribbons (*Triglochin* sp.) having been reduced to a short dry form or underground tubers, and non-wetland forbs and grasses (some exotic) have invaded. Patches of dry mud are interspersed with the remaining stands of sedgeland dominated by tall sedge (*Baumea arthrophylla).* Low lake levels affect the distribution of the rocky shorelines that are critical spawning habitat for the golden galaxias. The golden galaxias also spawn among the macrophytes and use the plant vegetative structures as places to secure their eggs. Despite other important spawning stimuli (rising water levels and suitable water temperatures) spawning is delayed until suitable spawning substrata are sufficiently inundated (Hardie 2003a).

Low water levels also lead to increased turbidity, a greater proportion of nutrients in the system as a result of wind re-suspension of bottom sediments, and decreased light penetration.

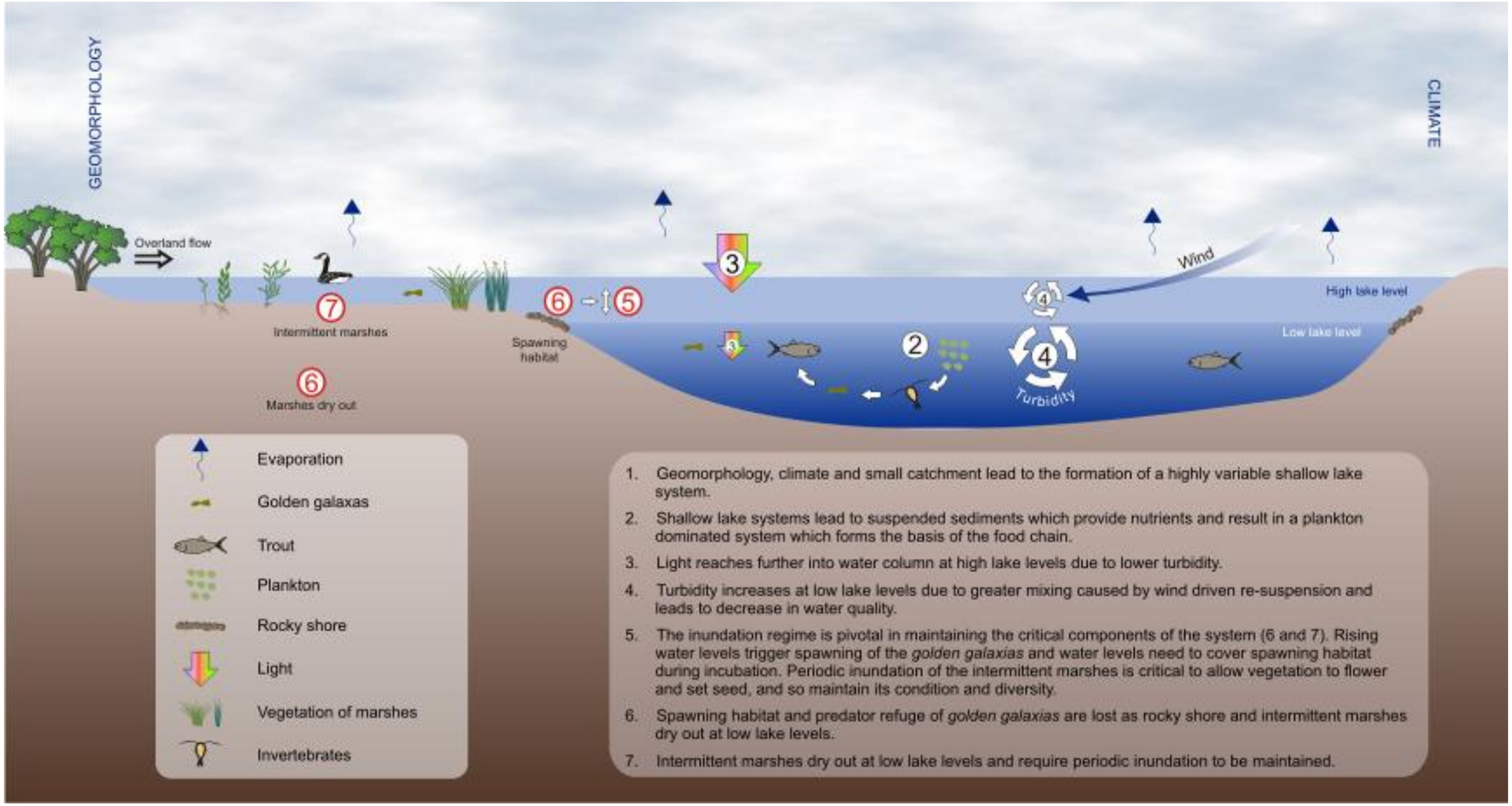

Figure 4-1
A stylized cross section of the Interlaken Lakeside Reserve interface between the water body and wetlands, showing key drivers and biological interactions

5. Threats to ecological character

5.1 Identification of threats

Major threatening activities that could impact on the ILR are summarised in Table 5-1. Note that this table only includes those threats which have the potential to affect the ecological character. For each threat identified, the likelihood (probability) of the threat occurring and timing of the threat (i.e. when the threat will actually result in an adverse impact to the ecological character of the wetland) is also included. The following categories have been used to define the likelihood of a threat occurring:

- Already occurring – threat is currently known to occur
- Almost certain – threat is expected to occur in the short term (one to two years)
- Possible - threat may occur in the short term (one to two years)
- Unlikely - threat not expected in the short term but may occur in medium (three to five years) or long term (greater than five years)
- Rare - Threat may only occur in extreme and/or exceptional circumstances

Table 5-1
Major threatening activities to the ILR

Actual or likely threats or threatening activity	Potential impact	Likelihood	Timing
Prolonged high or low lake levels (including impacts of climate change)	Inability of intermittent marshes to reproduce Decline in condition of vegetation Loss of soil seed bank Loss of spawning habitat and triggers for golden galaxias	Almost certain	Immediate
Forestry activities adjacent to wetland such as clearing of native vegetation, partial harvesting or plantation establishment	Sediment deposition and increased turbidity Nutrient enrichment Changes to hydrology Establishment of weeds Reduced habitat quality	Possible	Immediate

Actual or likely threats or threatening activity	Potential impact	Likelihood	Timing
Water extraction for human and agricultural use	Low lake levels and associated impacts Inability of intermittent marshes to reproduce Decline in condition of vegetation Loss of soil seed bank Loss of spawning habitat and triggers for golden galaxias	Possible, subject to legislation	Immediate to long term (subject to legislation)
Exotic plants and animals: Increase in terrestrial or exotic flora	Displacement of native wetland species.	Almost certain	Immediate
Exotic plants and animals: Increase in trout numbers	Increased predation of galaxias population	Possible	Immediate to long term
Exotic plants and animals: Introduction of/ increase in european carp	Reduced water quality and increased turbidity Impact on native plants	Possible	Immediate to long term
Exotic plants and animals: Introduction of other exotic fish species	Impact on native fish	Possible	Medium to Long term
Exotic plants and animals: Presence of chytrid fungus	Impact on frog population	Almost certain	Immediate
Exotic plants and animals: Introduction of didymo (*Didymosphenia germinata*)	Adversely affect water quality, aquatic invertebrates and fish stocks	Possible	Medium to long term, 5 years to decades

5.2 Prolonged high or low lake levels

The principal threat to the ecological character of ILR and the entire Lake Sorell and Crescent ecosystem is limited inflows. The impacts of change in water levels have been demonstrated. While fluctuation in water level is characteristic of this system, extreme drying out (or water-logging) over an extended period is a major threat to the site's ecological character.

Lakes Crescent and Sorell were modelled as part of the CSIRO Tasmania Sustainable Yields Project (Ling *et al* 2009), which investigated water availability in Tasmania under current and future climate to 2030. In the Sustainable Yields project, fifteen global climate models with three estimates of temperature changes due to global warming were used to provide a spectrum of possible 2030 climates. From this spectrum, three were selected for reporting, representing a wet extreme, median and dry extreme future climate. Lakes Crescent and Sorell were modelled as a storage within this project. The results show that the level in the lakes is likely to be lower under future climates due to a decrease in inflows and increase in evaporation from the lakes. This is shown in Figure 5-1 which graphs the volume of Lakes Crescent and Sorell for a representative ten year period from the 84 years of modelling. The projected lower inflows and lake level under future climate shown in Figure 5-1 would result in longer periods between spill events, as shown in Table 5-2.

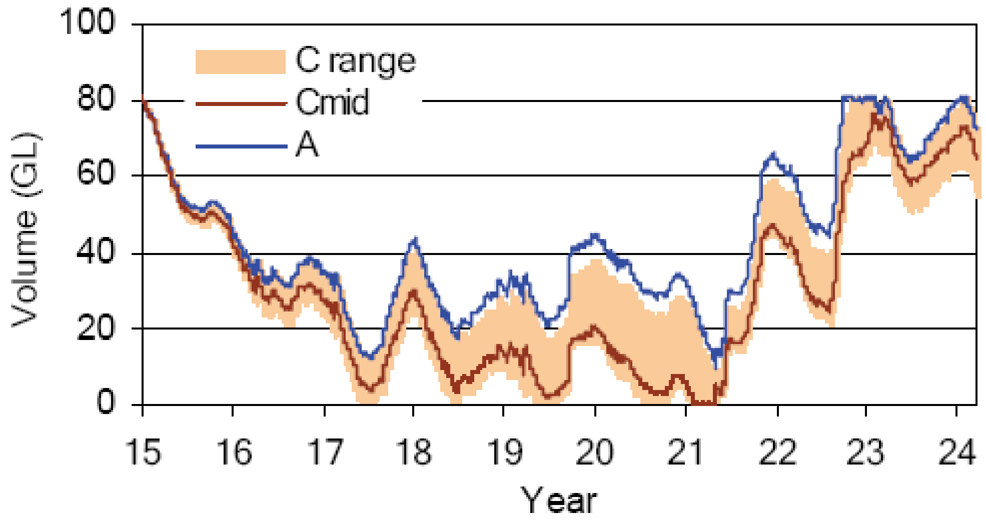

Figure 5-1
Lakes Crescent and Sorell storage behaviour over a ten year period under (A) historical climate and (Cmid) future climate. 'C range' represents a range of future climates from dry to wet, whilst C mid represents a median scenario of future climate. Note that the active storage volume is shown on the y-axis (Ling *et al* 2009)

Table 5-2
Storage behaviour for Lakes Crescent and Sorell over an 84 year period under historical climate (A) and future climate (C) (Ling *et al* 2009)

Days	**Historical climate**	**Future climate: wet climate scenario**	**Future climate: median climate scenario**	**Future climate: dry climate scenario**
Mean days between spills	129	149	247	321
Maximum days between spills	7,736	7,736	9,612	11,722

Historically, low rainfall periods have been experienced and the ecological character of the wetlands and their flora confirm that this is a natural condition to which the biota is generally adapted. However, the evidence provided by the recent dry spell, and research on the ability of the wetland flora to remain viable over extended periods of drying out, may indicate that there is a limit to the time beyond which the wetlands are difficult to restore to their original condition.

Lake level data for the last 35 years shows a trend towards lower rainfall in the area.

Extended periods with lower rainfall have a further effect of drying out the soils therefore requiring greater rainfall to restore the wetland system. Climate change predictions suggest that the long-term prognosis for the Lakes Sorell and Crescent system is marginal in sustaining the supply and quality of water in the lakes. Additionally, if rainfall patterns become modified to the extent that the late winter seasonal increases disappear, this will be detrimental to the spawning of the galaxiids.

Prolonged high lake levels could negatively impact on the ILR. This is not seen as a likely threat as water levels are more easily managed at high water levels than at low but it could potentially be an issue. Little work has been undertaken on the likely impacts of prolonged high water levels but they could include:

- Changes to the vegetation communities and species diversity;
- Impacts on spawning habitat for and population dynamics of golden galaxias;
- Change in phytoplankton communities;
- Changes to the trophic interactions; and
- Increases in exotic fish populations.

Low lake levels also deprive the golden galaxias of key spawning habitat amongst the rocky shoreline and macrophyte beds of the wetland vegetation. This species typically has a life-span of three to four years (with many males only living for one to two years; Hardie 2007), indicating that if spawning sites are very limited, there will be inadequate recruitment to sustain the population. The galaxiids also depend on seasonal rainfall, and hence water level fluctuations that usually occur in late winter - early spring. These cause the lake level to rise, which acts as a spawning trigger for the adult fish (Hardie *et al* 2007). Recent studies show that, given appropriate water levels in both lakes (i.e. levels that are above the sill in Sorell and close to or above the edge of the rocky shores in Crescent), water level manipulations can be used to aid spawning of the golden galaxias population in Lake Crescent (DPIW 2008).

Critical water levels have been estimated with reference to the effects of wind on sediment re-suspension. When the lake levels are low, the effects of wind will result in wave orbital motion reaching the bed of the lake resulting in high rates of re-suspension and, hence, higher turbidity. This level has been determined (Uytendaal 2003a) at 802.7 metres AHD and acts as a preferred minimum level while a critical operating level is set at 802.2 metres AHD as shown in Figure 5-2.

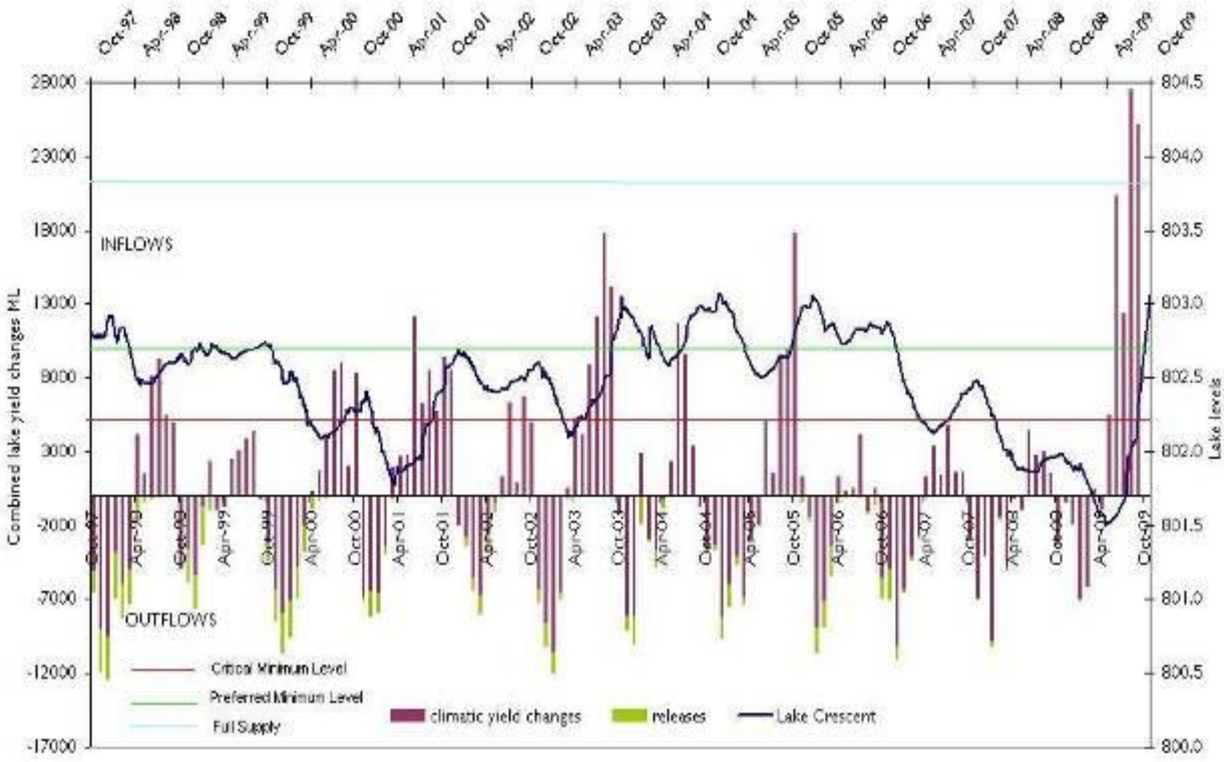

Figure 5-2
Lake levels and water releases for downstream use for Lake Crescent 1997 – 2009 (Data provided by Inland Fisheries Service)

5.3 Forestry activities

Forestry activities have the potential to impact on the hydrology of Lakes Crescent and Sorell. Changes in hydrology have the potential to impact on the whole system including biota such as the golden galaxias and its habitat. Harvesting and conversion of native forest in the catchments surrounding Lakes Crescent and Sorell are likely to result in altered catchment water yields. Following deforestation, catchment yields typically increase. This lasts for 10 to 30 years until understorey vegetation establishes and leaf area index and sapwood area per hectare increase (Eamus 2009). It can take up to 100 years for the catchment water yield to return to normal (Eamus 2009). This change to the water balance, characterised by increased base flows and storm flows, can lead to scouring, erosion and downstream deposition of sediments.

Forestry activities such as the use of heavy machinery can also impact sediment balances by creating changes to topography and increasing the amount of bare soil, causing soil compaction leading to increased run off, or by changing drainage patterns through creation of roads and skidding tracks (Moasaghii *et al*. 1999). This in turn can lead to increases in turbidity in the lake systems and potentially affect water quality and the biota. Another impact that potentially could occur due to forestry activities is increased nutrient input through the use of fertilizers or regeneration burns.

The Forest Practices Authority implements endorsed management actions for threatened species, such as the golden galaxias, which are delivered though the Threatened Fauna Advisor (TFA). The TFA was developed through consultation with landowners, Forest Practices Officers and relevant specialists and has been endorsed by the Forest Practices Advisory Council. The TFA delivers a recommendation for the golden galaxias, and the strategic part of this recommendation states:

> *"Planning should aim to ensure maintenance of water quality and other aspects of habitat quality such as shading, snags and food input. Planning should also aim to avoid any changes in hydrology, fragmentation of suitable habitat and catchment wide disturbance to populations of these species"*

"To achieve these aims the following is recommended:

> *To maintain undisturbed levels and patterns of stream flow, any strategic plans for these species should aim to ensure that not more than 15 % of the basal area of the forest within a catchment, upstream of where the species occurs, is harvested in ten years. This means that in the forested portion of a catchment (excluding cleared land) 85 % of the forested area must not have been harvested in the last ten years. Note that work is in progress to further develop and implement this aim.*
>
> *Where possible coupe boundaries should be planned to minimise the number of internal streams* (Forest Practices Board 2001)".

Whether these prescriptions result in the identified goals in protection of water quality is unknown, as is the impact on hydrology in the catchment. The recommendations delivered through the TFA are currently under review (A. Chuter, pers. comm., 2010).

5.4 Water extraction for human and agricultural use

Releases of water for irrigation and other downstream uses (stock and human consumption) have also added to low lake levels in the past and can be seen in Figure 5-2. Since the introduction of the *Lakes Sorell and Crescent Water Management Plan 2005*, there have been two instances where releases of water downstream were considered when lake levels were below the prescribed management levels outlined in the Plan. On these occasions, the proposed releases could not be considered in regard to Sections 2.6.6 and 2.6.7 of the Plan; hence the Minister declared a Water Supply Emergency under Tasmanian legislation to override the Plan.

Referrals were made under the EPBC Act with regard to these releases. The first referral was for the release of 3,300 megalitres of water for irrigation purposes in 2007/08. This action was refused in consideration of the 'relevant controlling provisions: wetlands of international importance; and listed threatened species and communities'. The second referral was for the release of up to five megalitres a day for essential purposes (town water, stock and domestic) in 2008/09. It was determined that the proposed 2008/2009 release was 'clearly unacceptable' on the basis of potential impacts to golden galaxias and ILR Ramsar site. Again the action was refused and no release of water occurred.

Recent heavy rains (winter - spring 2009 to present) mean that water levels rose quickly and inundation of the intermittent marshes has occured (803.29 metres AHD on 4 November 2009). This was the highest the water level had been (apart from brief release from Lake Sorell as part of the carp management) since the mid 1980s (Figure 3-4 and Figure 5-2).

Water levels were measured manually the by IFS on a daily basis at the Lake Sorell and Lake Crescent outlets. An automated gauging station managed by DPIPWE commenced operation on 31 July 2010.

IFS also have an automatic gauging station to monitor releases for town water on the Clyde River below the Lake Crescent outlet weir.

5.5 Exotic plants and animals

Exotic plant and animal species threaten the ecological character of the ILR. The introduction of terrestrial and/or exotic flora species into the ILR could potentially change the vegetation composition of the communities on site. However, the species present in the wetlands when dry are likely to be out-competed by adaptable wetland species once the area is re-wetted. Thus, introduced terrestrial/exotic flora species can generally be managed through the inundation regime at ILR. Exotic fauna species and pathogens such as brown trout, European carp, Canadian pondweed (*Elodea canadensis),* chytrid fungus and didymo *(Didymosphenia geminata*) may require other forms of management.

Trout pose a threat to golden galaxias through competing for habitat and food resources, as well as predation. Brown trout were introduced to the lake in 1868 and rainbow trout in 1922 (Cutler *et al* 1991). Juvenile brown trout compete with adult galaxias for both habitat and food resources (Hardie 2003a). Both species have a preference for rocky shorelines, although it seems that they have somewhat different food preferences, and golden galaxias appear to have greater flexibility in its food sources. The preferred food of adult brown trout is the golden galaxias. Recruitment of brown trout is believed to be lower in Lake Crescent than in Lake Sorell, leading to less predation pressure in Crescent and hence a more abundant galaxiid population.

European carp (*Cyprinus carpio)* were first discovered in a number of dams in northern Tasmania in the early 1970s and posed a potential threat to ILR at the time of listing in 1982. They were subsequently discovered in Lake Crescent in 1995 (Inland Fisheries Service 2004). Carp is listed as a noxious species in Tasmania because of its ability to dominate fish communities and its destructive bottom feeding behaviour. This behaviour destroys aquatic habitats through damaging wetland plants and degrades water quality through sediment disturbance.

Given the role of sediments in the Lake Crescent ecosystem and the ecology of the important golden galaxias population, carp have the potential to cause catastrophic impacts on the ecological character of ILR. Carp were also seen as a threat to the highly valued trout fishery in the lakes. European carp have the potential to impact upon galaxiid populations by competing for food and damaging wetland macrophytes. As a non-piscivorous (non fish-eating) species, however, they do not directly prey upon the golden galaxias. The IFS has undertaken an eradication program in Lake Crescent and is of the view that European carp have now been eradicated from the lake, including the ILR. As a result, there is no active work on carp in Lake Crescent (T Byard, pers. comm., 2012). Work on eradicating carp from Lake Sorell is continuing.

The introduction of additional species, particularly exotic piscivorous species such as redfin perch, would also constitute an additional, significant threat to golden galaxias.

The installation of fine-meshed screens at the outlets of both lakes (to prevent carp moving between the lakes and downstream into the Clyde River), has reduced the capacity of the galaxiid populations in Lake Crescent and Lake Sorell to interbreed. While the long-term impacts on the genetic diversity of the golden galaxias population are not known (Hardie 2003a) and the inter-population genetics of this species have not been examined, it is considered unlikely that the screens will affect the genetic structure of the populations in the short- to medium-term (S. Hardie pers. comm. 2009). However, this barrier to their movement does mean that the two galaxiid populations are effectively isolated; and this will need to be considered in terms of their management in the long term. Recruitment of fish from Lake Sorell to Lake Crescent (which is mostly likely to be the direction the movement would occur; top to bottom lake) is not occurring anymore, so breeding success within Lake Crescent is very important for the viability of the population in that lake. This requires further investigation (S. Hardie pers. comm. 2009).

Introduced aquatic plants are a risk to Tasmania's inland waters. Canadian pondweed (*Elodea canadensis)* was recorded in Lake Sorell in an early survey but has not been recorded recently. Despite the lack of recent records, the species is still expected to exist in the lake as it is difficult to eradicate once it is introduced. This species is just one of many potential aquatic invaders.

Chytrid fungus potentially poses a threat to frog populations within the ILR. Although there is no published data on testing for chytrid within the ILR, the decline of green and gold frog within Tasmania has generally been linked with the spread of the chytrid fungus (Obendorf and Dalton 2006, Obendorf 2005). Obendorf (2005) reported that at wetland sites where green and gold frog had been recorded historically but not recently, chytrid is present. Chytrid fungus was not found at sites where green and gold frog was still common (Obendorf 2005). The occurrence of chytrid is generally associated with wetlands where there are high levels of human disturbance and visitation (Pauza and Driessen 2008). Given that Lake Crescent has been a popular fishing spot in the past, it is possible that chytrid has been introduced to the ILR.

Another significant threat to the ILR is didymo *(Didymosphenia geminata*), commonly called rock snot. It is a freshwater alga that is widespread in the Northern Hemisphere and New Zealand. It has also recently been recorded in Chile. Although not present in Tasmania, it is considered a significant pest as it is highly invasive. Didymo consists of microscopic diatom cells and it takes just one cell in a single drop of water to be spread between waterways. It can multiply quickly to form massive blooms that completely smother the stream or lake bed. The blooms affect water quality, aquatic invertebrates and fish stocks as well as being a problem for irrigation and recreation. Didymo was recently discovered in New Zealand and is causing a major concern for fisheries managers and anglers. It poses a significant threat in Tasmania because of the potential transfer from New Zealand via fishing and other equipment.

6. Limits of acceptable change

The “limits of acceptable change” (LAC) are defined in the ECD Framework (DEWHA 2008a) broadly as the upper and lower bounds of variability for a measure of a particular ecosystem component, process or service. If the particular measure exceeds these bounds (i.e. moves outside the limits of acceptable change) this may indicate a significant change in ecological character that could lead to a decline or loss of the values for which the site was listed. LACs are not considered to be management triggers. Management triggers should occur before the LACs are reached to allow management actions to occur, thus limiting any change in ecological character. As such, management triggers are not dealt with in the ECD as they will form part of any management plan developed for the site.

Additional LAC explanatory notes

2. Limits of Acceptable Change are a tool by which ecological change can be measured. However, Ecological Character Descriptions are not management plans and Limits of Acceptable Change do not constitute a management regime for the Ramsar site.
3. Exceeding or not meeting Limits of Acceptable Change does not necessarily indicate that there has been a change in ecological character within the meaning of the Ramsar Convention. However, exceeding or not meeting Limits of Acceptable Change may require investigation to determine whether there has been a change in ecological character.
4. While the best available information has been used to prepare this Ecological Character Description and define Limits of Acceptable Change for the site, a comprehensive understanding of site character may not be possible as in many cases only limited information and data is available for these purposes. The Limits of Acceptable Change may not accurately represent the variability of the critical components, processes, benefits or services under the management regime and natural conditions that prevailed at the time the site was listed as a Ramsar wetland.
5. Users should exercise their own skill and care with respect to their use of the information in this Ecological Character Description and carefully evaluate the suitability of the information for their own purposes.
6. Limits of Acceptable Change can be updated as new information becomes available to ensure they more accurately reflect the natural variability (or normal range for artificial sites) of critical components, processes, benefits or services of the Ramsar wetland.

Limits of acceptable change have been developed for the critical components and services that were identified in Chapter 3, as required by the ECD Framework (DEWHA 2008a). They are presented in Table 6-1.

It is expected that where the limits of acceptable change for these critical components and services are exceeded, this could indicate a change in the ecological character of the ILR Ramsar site. It is noted that for one critical component and process, there is limited baseline information with which to develop quantitative LACs (e.g. species composition of wetland communities). In this case a conservative LAC has been set however it should be noted that this is based on limited data and that a more robust LAC with a higher level of confidence could be set if reference sites were established. The absence of a robust baseline for native wetland flora species is considered to be a key knowledge gap (see Section 8).

Table 6-1
Limits of acceptable change for the ILR

Critical component and supporting service	Baseline condition, range of natural variation where known, supporting evidence	Limit of acceptable change (LAC)	Basis of LAC	Level of Confidence
Golden galaxias Supporting Service: Threatened wetland species, habitats and ecosystems – ILR is a breeding /spawning area for golden galaxias.	Successful spawning and suitable habitat for golden galaxias (Hardie 2003a).	Loss of two successive cohorts of golden galaxias.	Expert opinion, scientific literature and available data.	High

Critical component and supporting service	Baseline condition, range of natural variation where known, supporting evidence	Limit of acceptable change (LAC)	Basis of LAC	Level of Confidence
Intermittent marshes Supporting Service: Natural or near-natural wetland ecosystem – ILR is a regional example of mid-altitude temperate wetland communities and component species.	Vegetation surveys and mapping prior to, and since the time of listing (Kirkpatrick and Harwood 1981; Chilcott 1986; Heffer 2003a) Evidence of the number of wetland flora species from vegetation surveys is inconclusive. It is unclear whether differences in species diversity and composition over time is due to real change or different levels of sampling intensity. NOTE: Hydrology and its influence on lake and wetland levels is a major factor that can affect these LAC - see Section 7.5 for discussion on loss of connectivity during dry phases.	50 % change in area of wetland vegetation for greater than six months based on 53 ha of *Triglochin procer*umdominated vegetation and 121 ha of sedge dominated vegetation (Chilcott 1986). Loss of 50% of native wetland species[7] recorded in 1981 (ten species) including at least one dominant (*Triglochin proceraum , Potamogeton tricarinatus, Myriophyllum simulans, Baumea arthrophylla or Isolepis fluitans*).	Expert opinion and available vegetation mapping and survey data. Baseline species data is based on 1981 data compiled by Kirkpatrcik and Harwood (1981) however the sampling methodology is not robust enough to have a high confidence in setting a baseline from this data. It is recommended that new reference sites be established in core wetland habitats (away from marginal habitat) to establish new more robust LAC for species composition.	High Low

[7] Native wetland species identified in Appendix 4.

7. Current ecological condition

7.1 Changes and trends since 1982

Significant changes have occurred to the wetlands at ILR since the time of listing in 1982, many of which have been attributed to the recent prolonged dry spell and lower lake levels. When the ILR was placed on the Ramsar list, the values supporting the listing related to wetland flora and, to a lesser degree, the diverse phytoplankton community of the lake that fell within the boundary. Several years of low rainfall, deliberate lowering of lake levels as part of a carp management program and water releases for downstream users have resulted in lake levels below that required for inundation of the wetlands for much of the period 1998 to 2009.

Dry periods are a natural property of intermittent wetlands such as at ILR and the biota is generally adapted to such variation. While the recent dry period at ILR was largely a result of the prolonged period of low rainfall, it is difficult to determine the degree to which water releases for downstream users, or the lowering of lake levels for carp management, have impacted on the character of the site. It is clear that water has been released from the system during times when the lake level was below the preferred minimum operating level (802.7 metres AHD) (Figure 5-2) but what is unclear is the degree to which such releases exacerbated impacts on the system and whether it significantly altered the character of the site which has been used a water reservoir for over 160 years.

The degree to which the wetland will recover given the heavy rainfall since mid- 2009 is unknown and monitoring will be important to determine this. Overall, the evidence suggests that the site still retains its fundamental ecological character and meets the criteria for which it was listed in 1982, although there have been some significant changes in the condition of the site. At present it is thought that these changes are within the limits of acceptable change identified in Section 6. Changes to ILR since the time of listing are described further in the following sections.

7.2 Wetland vegetation communities

The two wetland flora communities dominated by *Triglochin procerum* and *Baumea arthrophylla* continue to define the vegetation of the wetland area. The most recent survey of wetland vegetation (Heffer 2003a) provided a more detailed species list and the dominant wetland communities were again mapped (Figure 7-1). The overall matrix of wetland is vegetated with a mixed aquatic herbfield community (red) with isolated areas of sedgeland dominated by *Baumea arthrophylla* (blue) and a very small patch of *Juncus* sp rushland (green) on the inner margin of Lakeside Island.

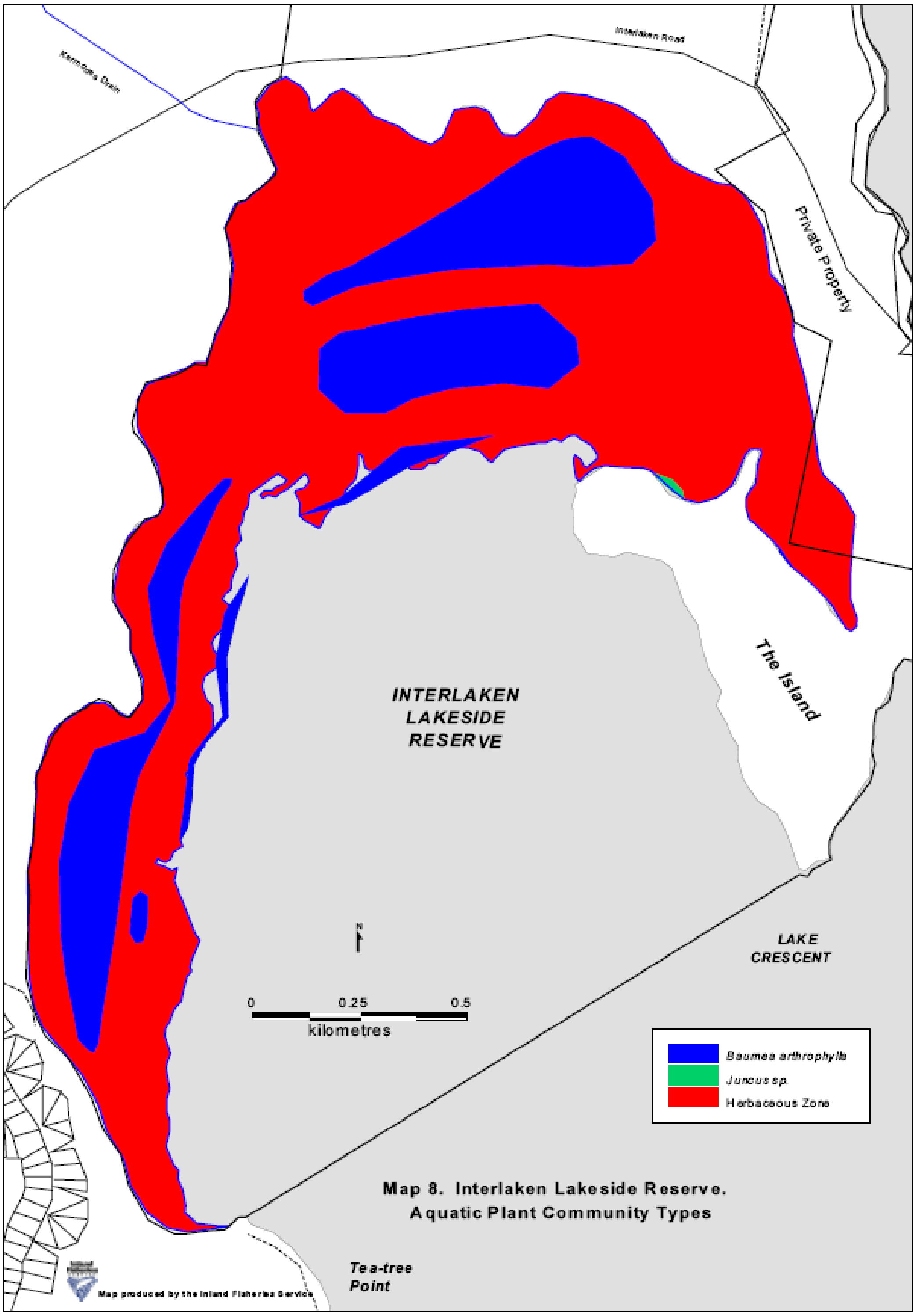

Figure 7-1
Distribution of aquatic plant communities at ILR in 2001 (Heffer 2003a)

Heffer (2003a) reported a decrease in plant abundance compared with the earlier surveys and also found a depauperate pool of species in the soil seed bank. However, it was not possible to determine whether this was a result of change or different survey technique/effort. While a number of the wetland species have vegetative stages that can withstand drying out and re-colonisation can occur from other wetlands, it remains to be seen whether the reduction in diversity of the wetland communities is long-term and irreversible.

When surveyed in 2000 and 2001 (Figure 7-2), extensive areas of bare ground (approximately 35 % cover) occupied much of the wetlands. The dominant plant species were *Agrostis avenacea, Baumea arthrophylla*, *Isolepis fluitans*, *Villarsia reniformis* and *Lilaeopsis polyantha*, all of which had an abundance of 6-25 % cover, assessed on the Braun-Blanquet scale.

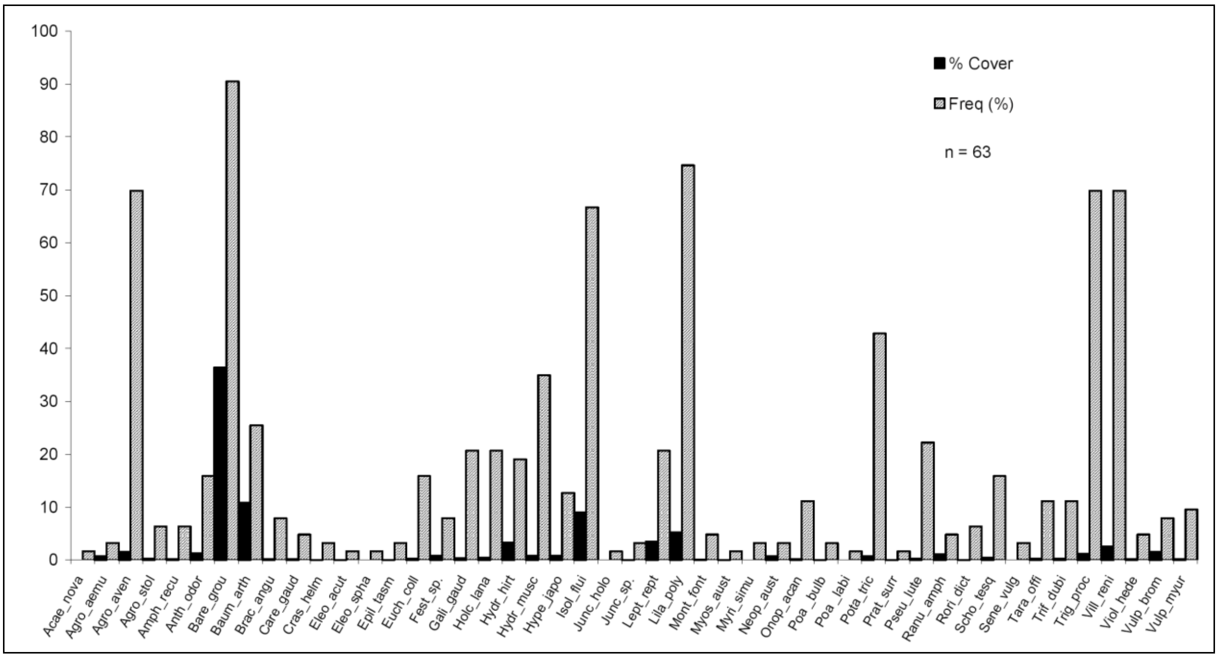

Figure 7-2
Species abundance (% cover) and frequency of occurrence at ILR. N = number of quadrats; plant codes can be found Appendix 4 (Heffer 2003a)

Species lists gathered from 1981, 1986 and 2003 are not easily comparable as they are confounded by potentially differing sampling intensity as well as potentially sampling different habitats and under differing water levels. For instance, species lists for the ILR from 1981 (Kirkpatrick and Harwood 1981) identified 10 wetland species, while Chilcot (1986) identified a comparable number (13). However, Heffer (2003a) recorded 24 wetland species, only 12 of which were also recorded in 1986 and only 6 species (7 if including misrecorded *Baumea*) common to all three sampling events (Appendix 4). The change in dominance of different herbfield species in 2003 compared with 1981 and 1986 data is likely a result of earlier surveys being undertaken during wetter conditions. This is supported by hydrological records and the presence of species of the Asteraceae (daisy) family which are species typical of the terrestrial edge of wetlands (M. Brock pers. comm., 2008). The greater number of wetland species recorded in the drier years is also likely to be the result of more intensive survey effort.

A total of 43 plant species were recorded in the most recent survey (Heffer 2003a). Three quarters of these, including nine introduced species, were low in abundance and found in few quadrats. Heffer (2003a) surveyed vegetation in over 60 quadrats, sited at 100 metre intervals along 16 transects over a period of time. This may explain the discrepancy with the number of taxa (13) recorded in Kirkpatrick and Harwood's (1981) statewide survey in which the focus lay in recording the broad categories of wetland communities.

Images taken in March 2007 (Figure 7-3) show where the lake shoreline retreated beyond the wetlands, leaving exposed lake mud. In the exposed areas of ILR, the soil layer was dry, leaving 'posts' with deep fissures. These images reflect the condition of the wetlands during an extended dry period, characterised by two distinct vegetation communities and extensive areas of bare ground and pasture grass. Apart from three brief periods in the mid 1970s and 1980s and since mid-2009 to present, the lake has not reached full supply level since the time of listing (Figure 3-4).

Despite the recent prolonged drought, it is unlikely that the vegetation communities of the intermittent marshes have changed significantly. While a change in area of occupancy of the vegetation types occurred, the LAC for area of vegetation communities has not been exceeded. As discussed above, there have been changes in species composition but these are likely to be artefacts of sampling techniques or sampling under differing water levels. The LAC set for species diversity are conservative given the low confidence in the data but the most recent surveys indicate that they have not been exceeded. However, it cannot be determined conclusively that finer-level changes have not occurred as monitoring techniques have been inconsistent between surveys. It is recommended that reference sites and a standardised monitoring technique be established to determine a LAC for species composition which is more robust (see Section 8).

7.2.1 Exotic species

At the time of listing, only three exotic flora species were recorded from the Lakes Sorell and Crescent wetlands (Kirkpatrick and Harwood 1981). Two species likely to have been accidentally introduced as a result of grazing were present in ILR: creeping bent grass (*Agrostis stolonifera)* and dandelion (*Taraxacum officinale)*. More recent surveys indicated that the number of exotic flora species has risen to thirteen (mostly pasture grasses and pasture weeds). Again, it is unknown whether this is a real change or a result of more intensive survey effort (Heffer 2003a). Such invasion, however, would not be unexpected given the drier conditions up to mid-2009, proximity of grazing areas and public use. It has been suggested that these introduced species would largely die out in the wetlands once these areas are again inundated (J. Kirkpatrick pers. comm., 2008). While minor changes have occurred in relation to the cover and extent of exotic species, it is likely that these will be well within the natural variability of the system such that no real change in relation to the ecological character of the site has taken place since listing.

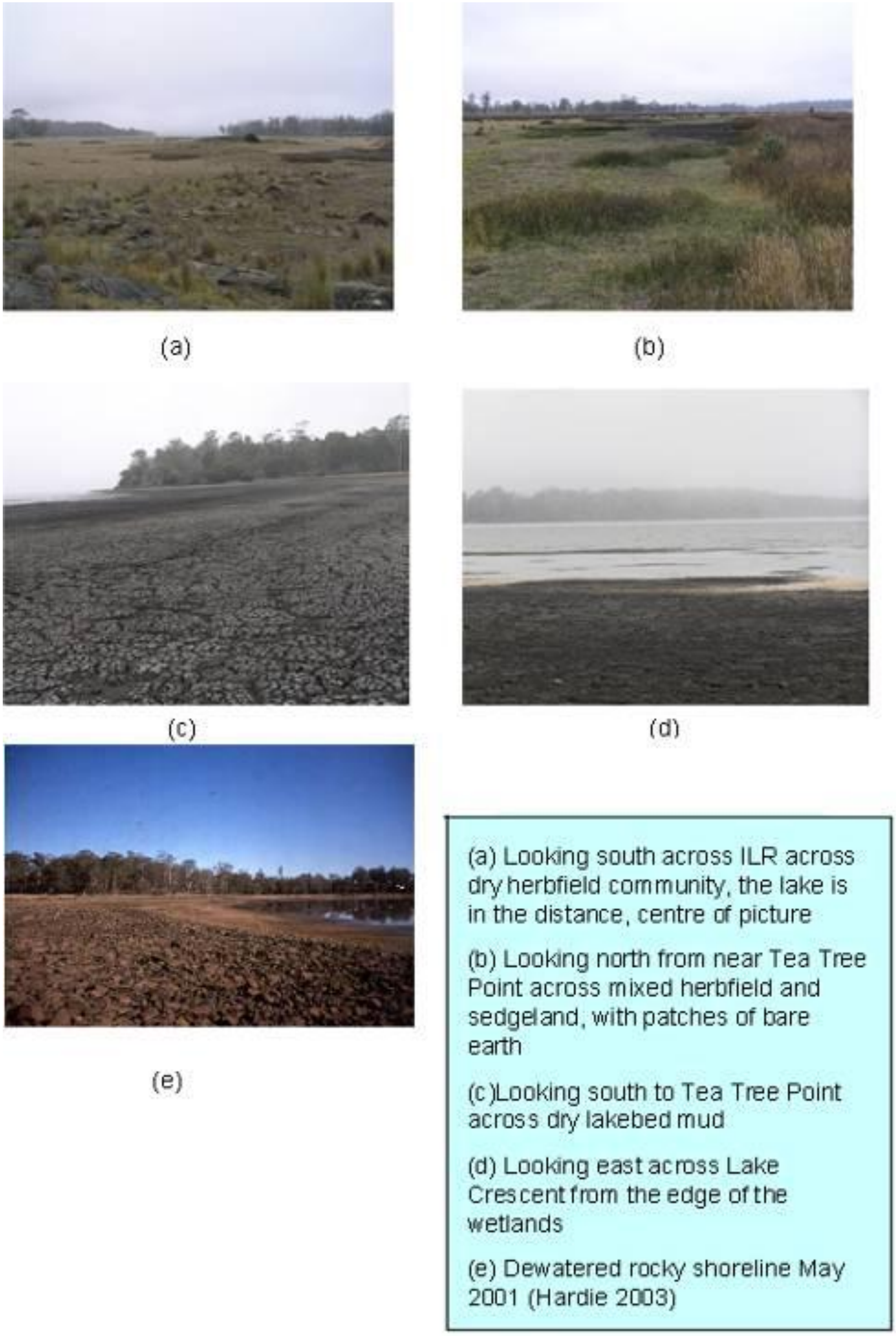

Figure 7-3
The ILR wetlands when the lake level is low (photographs a, b, c, and d were taken by Helen Dunn, March 2007; photograph e is from Hardie 2003a)

7.3 Decline in water quality

Uytendaal (2003a) noted that, as a result of detailed analysis of water quality parameters, a 'highly significant decline in major water quality components such as turbidity, nutrients and algal levels' occurred over his three years of study. The decline in water quality was the result of a complex interaction between water levels and the consequent increase in wind-induced sediment re-suspension; particularly the effect on colloidal turbidity (Uytendaal 2003a). Uytendaal (2003a) has shown that turbidity increases logarithmically with decreasing lake level, thus a small drop in lake level can cause a rapid and dramatic increase in turbidity. A strong interaction between low water levels and increased sediment entrainment occurs, with the highest recorded turbidity coinciding with the lowest recorded water levels. Further evidence of the prevalence of wind re-suspension is the increased hysteresis in turbidity as lake levels decrease (Figure 7-4).

Prior to 1999, turbidity in Lake Crescent ranged between 20 and 40 NTU. From 1999 to 2008, turbidity in Lake Crescent exceeded the level previously recommended for Lake Crescent (70 NTU; Uytendaal 2003a). From 1999 to 2002 turbidity ranged between 50 and 250 NTU (Figure 7-4). More recently (June 2006-February 2009), turbidity ranging between 109 NTU and 780 NTU have been recorded in Lake Crescent with the highest recording taken in October 2008 (C. Wisniewski, pers. comm., 2008). Increased turbidity results in poor photic depth within the lake and is likely to affect growth, recruitment and germination of macrophyte species in the littoral zone of the Interlaken Lakeside Reserve as well as plankton assemblages within Lake Crescent.

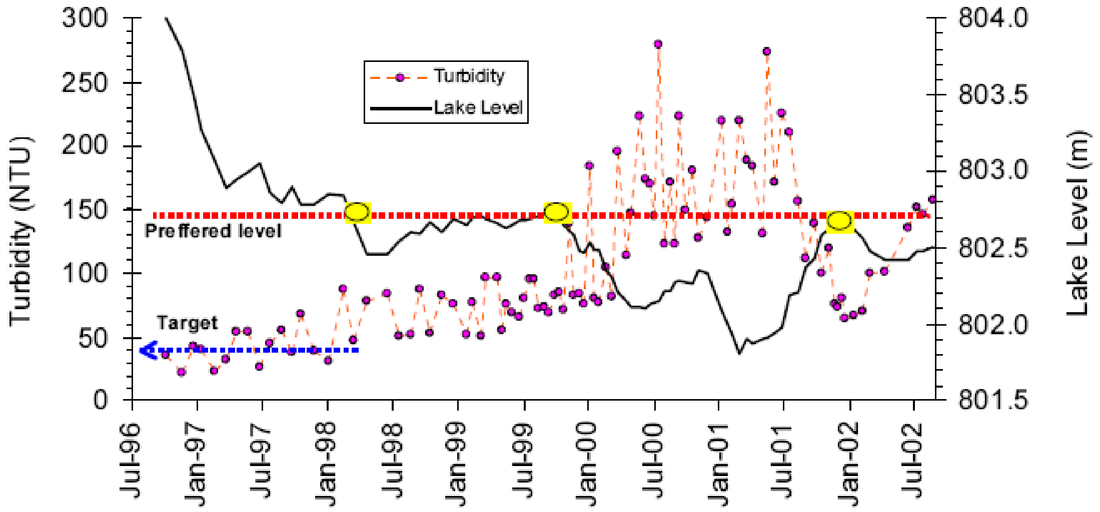

Figure 7-4
Changes in turbidity and lake level changes in Lake Crescent from mid 1996 to August 2002. The management target for turbidity is also shown. Open circles correspond to lake levels approaching and falling below 802.7metres AHD (Uytendaal 2003a)

The phytoplankton community of Lake Crescent has maintained the broad profile of diatom dominance observed by Cheng and Tyler (1973), suggesting that the processes that control the phytoplankton community have continued, despite the decline in water quality.

In recent years large portions of the Lakes Crescent and Sorell catchment have been subject to increased forestry activities and plantation establishment and it is unknown whether these have resulted in any decline in water quality or yield. Uytendaal (2003a) concluded that local agricultural and forestry practices were not having a measurable detrimental impact on the water quality of tributaries entering Lake Crescent at that time and water quality was largely driven by water levels.

The decrease in water quality since the time of listing is therefore largely influenced by low lake level. Turbidity fluctuates when water levels fall below a critical threshold but recovers quickly once levels increase. Given the ability of the system to recover and the lack of long term impacts from high turbidity in the past, it is not expected that the recent decline in water quality within Lake Crescent will have a long term impact on the ecological character of the ILR.

7.4 Fauna

7.4.1 Macroinvertebrates

The macroinvertebrate community within the ILR at the time of listing would have experienced some impact from surrounding land uses such as the draining and grazing of associated wetlands (Hardie 2003b) and the community of shacks which exists near Tea-Tree Point. The current status of macroinvertebrate communities in Lakes Crescent and Sorell was assessed in 2003; but this did not include the ILR due to low water levels (Hardie 2003b). However, Kemps Marsh adjacent to Lake Sorell was sampled on a single occasion as indicative of adjacent marsh areas. Hardie (2003a) acknowledges the difficulty comparing this survey with surveys conducted around the time of listing. However, it was broadly concluded that macroinvertebrate diversity had remained stable despite the extended period of low water levels but there had been a reduction in the abundance of certain species, most probably as a result of a reduction in inundated habitat.

Examination of the data collected in Kemps Marsh by Hardie (2003a) and the littoral habitat in Clyde Marsh by Chilcott (1986) cannot provide any broad comparisons of the change of condition in the ILR marsh areas since the time of listing. Whilst many of the same orders were sampled on both occasions at each site, the species differ markedly. This difference cannot be specifically attributed to a change since listing and requires further investigation. Given the ambiguity associated with the taxonomy at the species level since the time of listing, it is difficult to ascertain the variability in the taxa that were observed compared to the current taxonomic classifications that are used more recently (Hardie 2003b).

7.4.2 Fish

One very obvious change since the time of listing is the presence of European carp. Carp were discovered in Lake Crescent in 1995 (Inland Fisheries Service 2004). An intensive and well-funded program has been conducted to reduce the carp population and restrict its spread into other waterways in Tasmania. Recent surveys indicate that there has not been any new recruitment despite ideal conditions in spring 2009. No adult female carp have been caught from this lake for the past two years and only five females were caught in the previous four years (as at 2009). The lack of spawning behaviour combined with a zero capture of carp suggests the population of carp has been successfully eradicated from Lake Crescent. However, this result must be validated over the coming seasons with continued monitoring during favourable spawning conditions.

The native common galaxias or jollytail (*Galaxias maculatus*) is thought to have been introduced accidentally into the lake after listing in 1982: It was found in the lake in the 2003 study (Hardie 2003a). This species has not been recorded since 2003 and as it is a species which usually inhabits coastal river systems it is not believed to have established a viable population in Lake Crescent (S. Hardie, pers. comm., 2009).

Recent low water levels (up to mid-2009) in Lakes Crescent and Sorell, and the Ramsar wetland, significantly reduced the availability of preferred spawning and refuge habitats of the golden galaxias (Hardie 2003a). Low water levels completely dewatered and disconnected areas of wetland habitat from the main body of Lake Crescent and reduced access to rocky shores, until the inflows in late 2009. Low water levels had also increased the amount of suspended sediment in the water column of both lakes. This sediment appeared to smother some of the remaining areas of rocky shore habitat in Lake Crescent (S. Hardie, pers. comm., 2008), thus decreasing the suitability of these areas for spawning. Collectively, these changes were likely to have reduced the breeding capacity of the golden galaxias population in Lake Crescent and forced galaxiids (juveniles and adults) to use open water habitats, which are non-preferred areas for feeding and refuge (Stuart-Smith *et al* 2007). The impact of these changes on the golden galaxias population is unknown and ongoing monitoring will be required to assess whether there is a lasting effect on the population. Increased water levels since 2009 may have reduced some of these impacts.

Monitoring of recruitment during the 2009 breeding season was undertaken by DPIPWE and found that recruitment in the golden galaxias populations in both lakes (observed at the larval stage) appeared to have been reasonably successful in 2009 (DPIPWE, 2010). This is encouraging for the long-term viability of these populations, especially given the recent extreme drought conditions which caused very low water levels and poor habitat conditions in both lakes (particularly in Lake Crescent). In fact, in Lake Crescent, two out of the last three breeding seasons before 2009 had very poor recruitment (DPIPWE, unpublished data). However, the LAC for golden galaxias has not been exceeded. Given the poor recruitment in past years, the abundance of the 2009 juvenile cohort is likely to be critical for that population in the short-term. Sampling undertaken in September 2011 found that the fish have moved en masse into the wetlands after the high levels of inundation, and that spawning activity had taken place. Eggs were found within the Ramsar site, and also in wetlands in Lake Sorell. Larvae have also been found in Lake Sorell wetlands and a similar result is expected for the ILR (T. Byard, pers. comm., 2011).

7.4.3 Birds

In recent years, there has been a trend indicating fewer ducks using the ILR (Figure 3-8). Terry Byard (pers. comm., Feb 2008) observed reasonable numbers of ducks and some juveniles in the season 2007-8. There is an absence of data on any of the migratory or listed species of birds using the ILR.

7.4.4 Frogs

Hardie (2003a) reports that no specimens of green and gold frog have been observed in recent years during other surveys in the area, although frogs have not been specifically targeted in these surveys. It is likely that given the amount of research completed in the Lake Sorell and Crescent wetlands between 2000 and 2001, the frogs would have been observed if they were present. It is considered that green and gold frog is highly unlikely to be currently present in the ILR as it has not been recorded in this region for many years (J. Ashworth, pers. comm., 2009). Its decline may be linked to the chytrid fungus; however there has been no testing for chytrid in ILR to confirm whether it is present within the system.

There are recent records of other frog species within the ILR, *Crinia signifera*, *Limnodynastes dumerili*, *Litoria ewingi*, and *Pseudophryne semimarmorata* (Heffer 2003a). These species have been assessed as being less susceptible to the effects of chytrid infection (Obendorf 2005).

7.5 Loss of connectivity between the intermittent marshes and water body

At the time of listing, the Lake Crescent water level was sufficient to support a diversity of wetland environments ranging from open water and water with emergent vegetation; to variably waterlogged areas and better drained grassy or wooded wetland edges. These environments supported a range of aquatic biota that was connected to the resources of the water body.

As at 2008, and for several years prior, the wetland was disconnected from the body of open water. Likely impacts of these low lake levels were:

- isolation of galaxiid population from preferred spawning sites on the rocky lake shores;
- isolation of galaxiid populations from each other and potential genetic impacts;
- isolation of benthic and planktonic fauna from wetland habitats;
- loss of protection from predation amongst macrophytic vegetation for galaxiids;
- loss of nutrient supply from water column;
- dewatering of wetland substrates and reduction in groundwater levels; and
- loss of potential sources of propagules from elsewhere in the wetland system.

It is believed that any changes which may have occurred due to low lake levels, and the loss of connectivity between the intermittent marshes and the water body, would not have resulted in significant changes to the ecological character of the site.

7.6 Inundation of the ILR since 2009

Following inflows during 2009-2012, the wetlands, including the ILR, were inundated and both lakes have remained at near full water levels. The degree to which the wetlands will recover given the heavy rainfall of 2009-12 is unknown and monitoring will be important to determine this. Overall, the evidence suggest that the site still retains its fundamental ecological character and meets the criteria for which it was listed in 1982, although there had been some significant changes in the condition of the site during the recent dry phase. At present it is thought that these changes are within the limits of acceptable change identified in Section 6.

Photographs in Figure 7-5 depict the same general view as the photographs in Figure 7-3, and demonstrate the marked change in wetland hydrology of the Ramsar site from a rise of only 300-400mm in lake water levels.

A

B

C

D

E

Figure 7-5
The ILR wetlands when the water level is high (photograph *A* by J Mollison 2009; photographs *B* to *E* by K Morgan 2009)

8. Knowledge gaps

Despite the data available from the Lake Sorell and Crescent Rehabilitation Project, published in 2003, there are several fields where further information is required to fully understand key ecosystem services, components and processes. These are outlined below in order of importance (high to low).

8.1 Role of the wetlands in the ecology of the golden galaxias

The role of the intermittent wetlands in ecology of the golden galaxias is poorly understood. Schools of juveniles have been reported in the wetlands of the Crescent-Sorell system during periods of high water levels (C. Wisniewski, pers. comm., 2009) and juveniles and adults have been found to use littoral aquatic vegetation for feeding and refuge in a translocated population of this species (Hardie *et al* 2006). Additionally, the golden galaxias has also been found to use submerged aquatic vegetation for spawning when it is available (Hardie *et al* 2007). Given this information, the wetlands of the Crescent-Sorell system are likely to provide substantial areas of refuge, feeding and spawning habitat for galaxiids when they are inundated.

8.2 Recovery of wetland vegetation

The viability of the soil seed bank and conditions for germination and survival are critical factors in the ability of the wetlands to withstand prolonged periods of drought. Seed survival is one factor in the ability of the wetlands to withstand drying out but accurate information about seed longevity is lacking. It is believed to be, for most species, between five and ten years (M. Brock, pers. comm., 2009).

Heffer (2003a) undertook studies of the soil seed bank particularly focusing on wetting regimes for germination. Only a limited proportion of the range of species expected in the seed bank was present in the sampled soils, but sufficient propagules emerged to indicate variation between species in the rewetting requirements. It is likely that different species have different rewetting requirements, a factor important for maintaining the diversity of species in the wetlands.

Much of the information required to determine the ability of the wetland vegetation to recover from varying inundation regimes can be derived from regular monitoring of the vegetation communities and the component species. These requirements need to be better understood as a basis for managing water levels and artificial inundation regimes and need to be consistent with the spawning requirements of the golden galaxias.

To detect change in wetland flora species composition (including threatened species) within the ILR, it is recommended that reference sites are set up and monitored regularly so that a LAC with a greater confidence can be set.

8.3 Frogs and chytrid fungus

There is little information available on the distribution of frogs within the ILR or of the presence of chytrid fungus from the ILR. Monitoring frog species present may give information on the health of the ILR system and determine whether or not the green and gold frog still occurs in the ILR.

Monitoring for the presence of chytrid would be useful in determining the cause of decline or loss of the green and gold frog from the ILR. Similarly it would be valuable to determine the level of threat that may exist to other frog species occurring in the ILR.

8.4 Exotic fish species

Given the importance of the site to the golden galaxias, ongoing monitoring of the presence and relative abundance of exotic fish species is important to set benchmarks for limits of acceptable change and identify and mitigate potential threats.

8.5 Birds

Information is lacking on regular counts of bird numbers utilising the ILR site. Given the lack of data it is difficult to argue whether ILR meets the Ramsar criteria related to birds. While a record for the Australasian bittern in the late 1970s exists for the Lake Crescent area and suitable habitat occurs in the ILR no recent sightings have been recorded. If this species were to occur in the ILR, it would be significant and strengthen the justification against Criterion 2. Therefore it would be of importance to better document the utilisation of ILR by waterbirds including the nationally endangered Australasian bittern.

8.6 Wetland invertebrate fauna

Little information on the invertebrate fauna of the intermittent marshes is available from the time of listing (Hardie 2003b), although some inferences can be made using data collected by Chilcott (1986) from the nearby Clyde Marsh. This fauna is a component of the diet of golden galaxias. Without knowledge of the species and communities that inhabit the vegetated wetlands, it is not possible to ascertain if, or how, these taxa withstand periods of drying-out. As in the case of the flora, there may be a temporal limit to their ability to lie dormant or in diapause under dry conditions.

In addition, the impact of low water levels on the macroinvertebrate communities within the in-lake, rocky littoral margins and intermittent marshes is poorly understood and requires further investigation. This is particularly important as aquatic invertebrates are important indicators of water quality and health of the ecosystem.

8.7 Potential impact of adjacent land uses

Adjacent land uses, such as semi-urban development (shacks), agriculture and forestry, have the potential to impact on the hydrology and water quality of the ILR system. Despite the imposition of thresholds and limits on forestry activities (land clearing, partial harvesting and plantation establishment) in the surrounding catchments of Lakes Crescent and Sorell, no information is available on their efficacy as a management tool. The impact of these activities on inflows, sediment balances, groundwater influences, nutrient input or pollution on the ILR is unknown. Modelling or monitoring is essential to determine the likely impacts on the ILR from all adjacent land uses as well as determining the suitability of the threshold levels.

8.8 Geomorphology

Additional geoscientific data and information on the substrate, landform and geomorphic processes of the wetland is required to better define its ecological character and inform conceptual models for the wetland system.

9. Monitoring needs

Recommendations for monitoring the ecological character of ILR and associated threats, is provided in Table 9-1. The aims of the monitoring are to evaluate the current ecological character of ILR to identify whether limits of acceptable change are being exceeded; and to provide baseline information, where it is currently not available, to help set limits of acceptable change for critical components, processes or services. Monitoring is aimed at capturing changes in components, processes or threats that link to the critical services provided by the ILR and its ecological character.

Table 9-1
Monitoring requirements relevant to Interlaken Lakeside Reserve

Overarching component, process or service	Specific component, process or service	Monitoring objective	Indicator/measure	Frequency	Priority
Hydrology	Lake levels and permitted draw downs	Ongoing wetland condition and threat to condition	depth gauges/inflows	Weekly during the release period/monthly at all other times	High
	Adjacent land use: impact on hydrology	Impact on, and threats to, surface and groundwater flows	inflows	Annually	High
Water quality	Physiochemical parameters	Ongoing condition	turbidity nutrients	Monthly (or Ideally automatic data logging at 15 minute to 1 hourly intervals)	High
	Adjacent land use: impact on water quality	Benchmark and detection of change	sediment pollution	At least every two years	High
Biota	Wetland vegetation (recovery and change)	Detection of change	mapping of vegetation types Species composition, including threatened	Five yearly	Medium

Overarching component, process or service	Specific component, process or service	Monitoring objective	Indicator/measure	Frequency	Priority
			species		
	Wetland vegetation- exotic species invasion	Detection of change and threat to wetland vegetation	extent or rate of spread of exotic species present	At lease once every five years	Medium
	Fish (golden galaxias ecology)	Detection of change	golden galaxias population, size and recruitment success	Annually	High
	Exotic Fish	Detection of change and threat posed to native fish population	presence and relative abundance of exotic species	Annually	High
	Birds- including migratory and waders	Benchmarks and detection of change	presence/absence of waterbird species and migratory and rare species	Annually	Medium
	Invertebrates	Benchmarks and detection of change	presence/absence of families total number of families presence of endemics	Five yearly or following large fluctuations of the water level in Lake Crescent	Medium
	Frogs- species surveys	Ecosystem condition	presence and abundance of frogs	Five yearly	Medium
	Frogs- chytrid fungus	Detection of change and threat to frog population	presence/absence	Five yearly	Medium
	Plankton	Detection of change	composition and structure of plankton	Five yearly	Medium

9.1 Lake levels and permitted drawdowns

The most significant issue affecting the ILR has been low water levels. This can be attributed to:

- a naturally low and variable rainfall pattern;
- lakes which are very shallow and hence subject to high loss by evaporation;
- an unusually long period of low rainfall lasting over several years and without any high rainfall years to restore the supply until 2009;
- potential change in hydrology, sediment or nutrient input associated with forestry activities in the lake system's small catchment; and
- increased demand for water for town supplies and irrigation with changing expectations and new cropping strategies.

It is clear that water level plays the central role in maintaining the integrity of the ecological character of the ILR and the intrinsically related Lakes Sorell and Crescent system. Therefore, the most cost-effective monitoring program should focus upon water levels.

Lake levels and permitted drawdowns at Lakes Crescent and Sorell should be monitored at least weekly during the release period and monthly at all other times.

9.2 Adjacent land use impacts

Adjacent land uses such as semi-urban development (shacks), forestry and agriculture have the potential to impact on the hydrology and water quality of the ILR system. Increased demands for water are likely to reduce inflows to the ILR while development and catchment disturbance may increase sediment and pollution inputs to ILR. Modelling or monitoring of inflows, sediment balances, groundwater, nutrient and pollution inputs are required to determine the likely impacts on the ILR as well as determining the suitability of the current thresholds. Baseline condition should be established and change in condition monitored regularly as land uses intensify.

9.3 Physicochemical parameters

Turbidity (colloidal and total) and nutrients should be monitored to assess the effects of the lake level regime on water quality, with specific reference to the preferred minimum levels in both lakes and the critical minimum levels in Lake Sorell and Lake Crescent, as specified in the Lakes Sorell and Crescent Water Management Plan (DPIWE 2005b). Frequency should be monthly, or seasonally as required, with monitoring the responsibility of the water manager or IFS while carp are present (DPIWE 2005b). The long-term target to improve the light climate is 70 NTU for the majority of the time (i.e. 80 % of the time) in the pelagic zone of Lake Crescent (Uytendaal 2003a).

9.4 Survey of wetland flora

The monitoring requirements for wetland flora are consistent with the Lakes Sorell and Crescent Water Management Plan (DPIWE 2005b). Wetland flora, including exotic species, should be monitored to assess the effects of the wetland inundation regime on the abundance and diversity of plant species. The recommended frequency of monitoring is once every five years or as required, such as after large fluctuations in water level.

To adequately detect change and remove the confounding effects of past surveys using different sampling techniques mentioned above, reference sites should be established in core wetland habitats (away from edge effects) and monitored for species composition and change.

9.5 Fish

Golden galaxias recruitment (eggs and larvae) should be monitored to assess the effects of the lake level regime on this population with specific reference to the critical minimum level in Lake Crescent. Monitoring should be conducted annually, or as required if the risks to the galaxiid population are determined by IFS to be high. Monitoring for exotic fish should also be completed at the same frequency. Monitoring is the responsibility of DPIPWE/IFS (DPIWE 2005b).

9.6 Birds

Birds, particularly the presence of migratory, wading or rare birds, should be monitored annually. This information will help to establish benchmarks from which change in bird populations can be measured.

9.7 Invertebrates

The monitoring needs for invertebrates are consistent with the water management plan for Lake Crescent (DPIWE 2005b). Monitoring of abundance and diversity of wetland species should occur every five years or following large, l fluctuations of the water level in Lake Crescent. The sampling method should be consistent with those described by Hardie (2003a) to allow statistical comparison and should include the rocky shoreline littoral, the in-lake benthos and the intermittent macrophyte dominated marsh habitats. The wetland sampling conducted in Kemps Marsh by Hardie (2003a) and Clyde Marsh by Chilcott (1986) should be replicated initially to allow historical and water-level management comparison with similar sites or habitat types within the ILR.

9.8 Frogs

Monitoring of frog species, particularly green and gold frog, should be conducted once every five years. Monitoring for the presence of chytrid fungus should also be undertaken to establish whether the fungus is present or not and whether it has contributed to the loss of green and gold frogs from the site. Any consideration of reintroduction of the species must take into account the viability of the population in the presence of this disease.

9.9 Plankton

Given the interest of the plankton assemblages in the site and the degree to which water quality and other factors can influence the structure and composition of the plankton communities, periodic monitoring of the composition and relative abundance of the plankton communities is required.

10. Communication and education messages

The Ramsar Convention established a Program on Communication, Education Participation and Awareness (CEPA) 2009-2015 of the Convention on Wetlands (Ramsar 2008) to raise awareness of wetland values and functions. The program calls for coordinated international and national wetland education, public awareness and communication. Australia has established the Wetland Communication, Education and Public Awareness (CEPA) National Action Plan 2001-2005. Australia's National Action Plan provides an umbrella for coordinated activities across Australia.

There are currently limited interpretation signs at the ILR and the recreational and environmental potential has not been greatly promoted. Signs are required to inform visitors of the:

- status of the area;
- reasons for reservation of this area; and
- reasons it is recognised as a wetland of international importance.

Signage has been erected on the Interlaken Road at each end of the reserve to identify the Interlaken Lakeside Reserve area and promote the Ramsar site. There is potential for this area to be used for environmental education as primary and secondary schools are located at Bothwell approximately 28 kilometres away. Valuable information could be gained from field trips to the wetland or from classroom projects based on lifecycles and ecological relationships evident in the area.

Following on from the identified threats to the ecological character of the ILR Ramsar site (see Section 5 above,) a number of communication and education messages could be given priority in addition to the programs listed above. These include:

- Informing visitors of appropriate minimal impact use of the reserve including walking, boating, recreational vehicles and domestic pets;
- Close integration of management authorities including Parks and Wildlife Service, Inland Fisheries Service etc to encourage cross tenure management of relevant issues;
- Liaison with teachers and organisations such as Waterwatch and Landcare to encourage educational programs in the reserve;
- Public education around threats associated with use – such as chytrid, didymo, vehicle use and fire;
- Seeking a special relationship with local schools in developing educational programs and activities based on the particular values of the reserve;
- Considering the reserve in the context of all parks and reserves within the Central Highlands and their particular values, in developing an interpretation and education strategy; and
- Education of angling groups and surrounding landholders regarding the values of and threats to ILR.

10.1 Community involvement

Community support is critical to good management of the reserve. Angling groups who regularly use the reserve and surrounding areas have been active in conservation management and have assisted in the erection of a boundary fence for the ILR. It is also desirable to develop and encourage good working relations with adjacent land managers, the local community and the Aboriginal community in matters of mutual interest. It is also important to work closely with Local Government to ensure consistency between management plans, site plans and the municipal planning scheme. Adjacent agricultural land owners who have properties to west and east of the ILR also need to be engaged to ensure cross tenure management issues can be effectively and cooperatively addressed.

11. Glossary

Acceptable change	**The variation that is considered 'acceptable' in a particular measure or feature of the ecological character of a wetland. Acceptable variation is that variation that will sustain the component or process to which it refers. See "Limits of Acceptable Change".**
Alluvial	Pertaining to alluvium, or material transported by flowing water
Baseline	Evidence at a starting point.
Biogeographic region	A scientifically rigorous determination of regions as established using biological and physical parameters such as climate, soil type, vegetation cover, or Drainage Division
Biological diversity	The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species (genetic diversity), between species (species diversity), of ecosystems (ecosystem diversity), and of ecological processes.
Catchment	The total area draining into a river, reservoir, or other body of water
Change in ecological character	The human-induced adverse alteration of any ecosystem component, process, and/or ecosystem benefit/service (Ramsar Convention (2005), Resolution IX.1 Annex A).
Chironomid	Chironomidae is a family of small flies (midges) with aquatic larval forms, common in fresh and brackish water.
Chytrid	A fungus, *Batrachochytrium dendrobatidis,* which infects the skin of frogs destroying its structure and function. Sporadic deaths occur in some frog populations, and 100 % mortality occurs in other populations.
Cohort	A group of individuals identified by a common characteristic (such as age) or experience.
Community	An assemblage of organisms characterised by a distinctive combination of species occupying a common environment and interacting with one another (ANZECC and ARMCANZ 2000a).
Community Structure	All the types of taxa present in a community and their relative abundances (ANZECC and ARMCANZ 2000a).
Conceptual model	A summary, often diagrammatic, to express ideas about components and processes and their interrelationships
Deposition	The dropping of material which has been picked up and transported by wind, water, or other processes (Ryan et al. 2003)
Didymo	*Didymosphenia geminata*, also called rock snot, is a freshwater alga.
Ecological	The combination of the ecosystem components, processes and

character	benefits/services that characterise the wetland at a given point in time.
Ecological communities	Any naturally occurring group of species inhabiting a common environment, interacting with each other especially through food relationships and relatively independent of other groups. Ecological communities may be of varying sizes, and larger ones may contain smaller ones (Ramsar Convention 2005b).
Ecosystem components	The separate physical, chemical and biological parts of a wetland ecosystem
Ecosystem processes	The changes, reactions and interactions which occur naturally within ecosystems
Ecosystem services	The benefits that people receive or obtain, directly or indirectly, from an ecosystem
Endemic species	A species that originates and occurs naturally in a particular limited area.
Eutrophic	In reference to lakes: lakes that are rich in organic and mineral nutrients and support abundant plant life
Groundwater	Water occupying cracks, pores and other spaces below the surface
Introduced (non-native) species	A species that does not originate or occur naturally in a particular area.
Intermittent marshes	A Ramsar wetland type which includes seasonal freshwater wetland areas or pools on inorganic soils; includes sloughs, potholes, seasonally flooded meadows, sedge marshes. The Ramsar code for 'intermittent marshes' is 'Ts'.
Inundation	The condition of water occurring above the surface, (Brinson 1993)
Limits of acceptable change	The variation that is considered acceptable in a particular measure or feature of the ecological character of the wetland without indicating change in ecological character which may lead to a reduction or loss of the values for which the site was Ramsar listed.
Limnology	Study of chemical, physical and biological features of lakes and waterways
Macroinvertebrate	Multi-cellular organisms and insects without a backbone, that are visible without a microscope.
Macrophyte	An aquatic or semi-aquatic plant that grows in or near water; and is emergent, submergent, or floating.
Mesotrophic	In reference to lakes: lakes with an intermediate level of productivity i.e. greater than oligotrophic lakes, but less than eutrophic lakes
Monitoring	The systematic collection of information over time intervals to provide evidence of any change.
Oligotrophic	In reference to lakes: lakes that are poor in nutrients and plant life and rich in oxygen
Permanent freshwater lakes	A Ramsar wetland type characterised by large expanses of open water that are over eight hectares in area. The Ramsar code for 'Permanent freshwater lakes' is 'O'.

Planktonic species	Very small plants and animals that dwell in the water column
Practical Salinity Units	An expression of salinity based on water temperature and conductivity
Ramsar convention	Convention on Wetlands of International Importance especially as Waterfowl Habitat. Ramsar (Iran), 2 February 1971. UN Treaty Series No. 14583. As amended by the Paris Protocol, 3 December 1982, and Regina Amendments, 28 May 1987. The abbreviated names "Convention on Wetlands (Ramsar, Iran, 1971)" or "Ramsar Convention" are more commonly used [http://www.ramsar.org/].
Ramsar criteria	Criteria for Identifying Wetlands of International Importance, used by Contracting Parties and advisory bodies to identify wetlands as qualifying for the Ramsar List on the basis of representativeness or uniqueness or of biodiversity values. [http://www.ramsar.org/
Ramsar information sheet (RIS)	The form upon which Contracting Parties record relevant data on proposed Wetlands of International Importance for inclusion in the Ramsar Database; covers identifying details like geographical coordinates and surface area, criteria for inclusion in the Ramsar List and wetland types present, hydrological, ecological, and socioeconomic issues among others, ownership and jurisdictions, and conservation measures taken and needed (http://www.ramsar.org/about/about_glossary.htm).
Ramsar list	The List of Wetlands of International Importance [http://ramsar.wetlands.org/
Ramsar site	A wetland designated by the Contracting Parties for inclusion in the List of Wetlands of International Importance because they meet one or more of the Ramsar Criteria [http://ramsar.wetlands.org/]
Sedge	Grass-like or rushlike plants that often grow in wet places.
TASVEG	Classification and mapping of vegetation communities in Tasmania
Threatened species	A species that is scheduled under legislation according to established criteria of status or risk
Wetlands	are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres (Ramsar Convention 1987).

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Appendix 1: Avifauna species list of the Lakes Sorell and Crescent area (from Heffer 2003a)

i introduced to Tasmania

t listed in the schedules of the *Threatened Species Protection Act 1995*

u listed on the IUCN Red List (Version 2009.1)

v vulnerable

e endangered

r rare

m migratory species

J listed on the Japan-Australia Migratory Bird Agreement (JAMBA)

C listed on the China-Australia Migratory Bird Agreement (CAMBA)

Sightings (B. Mawbey & R. Mawbey, pers. comm.): 'Recent' sightings are observations made since 2000. 'Past' sightings were from approximately 1980 to 1999.

Common name	Scientific name	Sightings	Code
Black swan	*Cygnus atratus*	Recent wetlands/lakes	
Australian shelduck	*Tadorna tadornoides*	Recent wetlands/lakes	
Pacific black duck	*Anas superciliosa*	Recent wetlands/lakes	
Grey teal	*Anas gracilis*	Recent wetlands/lakes	
Chestnut teal	*Anas castanea*	Recent wetlands/lakes	
Little pied cormorant	*Phalacrocorax melanoleucos*	Recent lakes	
Great cormorant	*Phalacrocorax carbo*	Recent lakes	
Australian wood duck	*Chenonetta jubata*	Recent wetland/lakes	
Great crested grebe	*Podiceps cristatus*	Past wetlands/lakes	t (r)
Hoary-headed grebe	*Poliocephalus poliocephalus*	Recent lakes	
Musk duck	*Biziura lobata*	Recent Kemps Marsh	
White-faced heron	*Egretta novaehollandiae*	Recent wetlands	
Great egret	*Ardea alba*	Past wetlands	m (C)
Cattle egret	*Ardea ibis*	Past wetlands	m (J/C)
Australasian bittern	*Botaurus poiciloptilus*	Past wetlands	u (v)
Purple swamphen	*Porphyrio porphyrio*	Recent wetlands	

Tasmanian native hen	*Gallinula mortierii*	Recent wetlands	
Eurasian coot	*Fulica atra*	Past wetlands/lakes	m
Latham's snipe	*Gallinago hardwickii*	Recent wetlands	m (J/C)
Wedge-tailed eagle	*Aquila audax fleay*i	Recent wetlands/lakes	t (e)
White-bellied sea eagle	*Haliaeetus leucogaster*	Recent wetlands/lakes	m (C)
Swamp harrier	*Circus approximans*	Recent wetlands	
Brown goshawk	*Accipiter fascia*tus	Recent terrestrial	
Grey goshawk	*Accipiter novaeh*ollandiae	Past terrestrial	t (e)
Collared sparrowhawk	*Accipter cirrhocephalus*	Recent terrestrial	
Brown falcon	*Falco berigora*	Recent terrestrial	
Peregrine falcon	*Falco peregrinus*	Recent terrestrial	
Masked lapwing	*Vanellus miles*	Recent wetlands	
Red-capped plover	*Charadrius ruficapillus*	Recent wetlands	
Banded lapwing	*Vanellus tricolor*	Recent wetlands	
Silver gull	*Larus novaeholl*andiae	Recent wetlands/lakes	
Caspian tern	*Sterna caspia*	Recent Lake Sorell 1 sighting	m (C)
Common bronzewing	*Phaps chalcoptera*	Recent terrestrial	
Yellow-tailed black-cockatoo	*Calyptorhynchus funereus*	Recent terrestrial	
Musk lorikeet	*Glossopsitta concinna*	Past terrestrial	
Eastern rosella	*Platycercus eximius*	Recent terrestrial	
Swift parrot	*Lathamus discolor*	Past terrestrial	m(e)
Blue-winged parrot	*Neophema chrysostoma*	Recent terrestrial	m
Green rosella	*Platycercus caledonicus*	Recent terrestrial	
Sulphur-crested cockatoo	*Cacatua galerita*	Past terrestrial	
Pallid cuckoo	*Cuculus pallidus*	Recent terrestrial	m
Horsfield's bronze-cuckoo	*Chrysococcyx basalis*	Past terrestrial	m
Fan-tailed cuckoo	*Cacomantis flabelliformis*	Recent terrestrial	m
Shining bronze-cuckoo	*Chrysococcyx lucidus*	Recent terrestrial	
Southern boobook	*Ninox novaeseelandiae*	Recent terrestrial	
Masked owl	*Tyto novaehollandiae*	Past terrestrial	
Tawny frogmouth	*Podargus strigoides*	Recent terrestrial	
Australian owlet-nightjar	*Aegotheles cristatus*	Past terrestrial	

White-throated needletail	*Hirundapus caudacutus*	Past terrestrial	m
laughing kookaburra	*Dacelo novaeguineae*	Recent terrestrial	i
Flame robin	*Petroica phoenica*	Recent terrestrial	m
Superb fairy-wren	*Malurus cyaneus*	Recent terrestrial	
Spotted pardalote	*Pardalotus punctatus*	Recent terrestrial	
Striated pardalote	*Pardalotus striat*us	Recent terrestrial	m
Tasmanian scrubwren	*Sericornis humilis*	Recent terrestrial	
Scrubtit	*Acanthornis magnus*	Recent terrestrial	
Brown thornbill	*Acanthiza pusilla*	Recent terrestrial	
Tasmanian thornbill	*Acanthiza ewingi*	Recent terrestrial	
Yellow-rumped thornbill	*Acanthiza chrysorrhoa*	Past terrestrial	
Yellow wattlebird	*Anthochaera paradoxa*	Recent terrestrial	
Little wattlebird	*Anthochaera chrysoptera*	Recent terrestrial	
Noisy miner	*Manorina melanocephala*	Recent terrestrial	
Yellow-throated honeyeater	Recent terrestrial	*Lichenostomus flavicollis*	
Strong-billed honeyeater	*Melithreptus validirostris*	Recent terrestrial	
Black-headed honeyeater	*Melithreptus affinis*	Recent terrestrial	
Crescent honeyeater	*Phylidonyris pyrrhopterus*	Recent terrestrial	
New Holland honeyeater	*Phylidonyris novae-hollandiae*	Recent terrestrial	
Eastern spinebill	*Acanthorhynchus tenuirostris*	Recent terrestrial	
White-fronted chat	*Epthianura albifrons*	Recent terrestrial	
Scarlet robin	*Petroica multicolor*	Recent terrestrial	
Pink robin	*Petroica rodinogaster*	Past terrestrial	
Dusky robin	*Melanodryas vittata*	Past terrestrial	
Spotted quail-thrush	*Cinclosoma punctatum*	Past terrestrial	
Black currawong	*Strepera fuliginosa*	Recent terrestrial	
Grey currawong	*Strepera versicolor*	Recent terrestrial	
Forest raven	*Corvus tasmanicus*	Recent terrestrial	
Australian magpie	*Gymnorhina tibicen*	Recent terrestrial	
Richards pipit	*Anthus novaeseelandiae*	Recent terrestrial	
Skylark	*Alauda arvensis*	Recent terrestrial	

Olive whistler	*Pachycephala olivacea*	Past terrestrial	
Golden whistler	*Pachycephala pectoralis*	Recent terrestrial	
Satin flycatcher	*Myiagra cyanoleuca*	Recent terrestrial	m
Black-faced cuckoo-shrike	*Coracina novaehollandiae*	Recent terrestrial	m
Dusky woodswallow	*Artamus cyanopterus*	Recent terrestrial	m
Common starling	*Sturnus vulgaris*	Recent terrestrial	i
Bassian thrush	*Zoothera lunulata*	Past terrestrial	
Silvereye	*Zosterops lateralis*	Recent terrestrial	m
Little grassbird	*Megalurus gramineus*	Recent terrestrial	
Tree martin	*Hirundo nigricans*	Recent terrestrial	m
Welcome swallow	*Hirundo neoxena*	Recent terrestrial	m
European goldfinch	*Carduelis carduelis*	Recent terrestrial	i
European greenfinch	*Carduelis chloris*	Recent terrestrial	i
Beautiful firetail	*Stagonopleura bella*	Past terrestrial	
Grey fantail	*Rhipidura fuliginosa*	Recent terrestrial	m
Grey butcherbird	*Cracticus torquatus*	Recent terrestrial	
Grey shrike-thrush	*Colluricincla harmonica*	Recent terrestrial	

Appendix 2: Bird list from around Lake Crescent (Chilcott 1986)

2 February 1983

22	Great crested grebe (*Podiceps cristatus*)
12	Black swan (*Cygnus atratus*)
10	Purple swamphen (*Porphyrio porphyrio*)
8	Golden plover (*Pluvialis dominica*)
4	White-faced heron (*Ardea novaehollandiae*)
2	Hoary-headed grebe (*Poliocephalus poliocephalus*)
2	Marsh harrier (*Circus aeruginosus*)

14 June 1984

50	Chestnut teal (*Anas castanea*)
50	Masked lapwing (*Vanellus miles*)
30	Black swan (*Cygnus atratus*)
20	Black duck (*Anas superciliosa*)
10	Grey teal (*Anas gibberifrons*)
2	White-faced heron (*Ardea novaehollandiae*)
2	Silver gull (*Larus novaehollandiae*)
1	Hoary-headed grebe (*Poliocephalus poliocephalus*)

6-14 February 1986 (Survey areas shown in Fig. 10)

6 February 1986

Area 1

14	Great cormorant (*Phalacrocorax carbo*)
8	Black duck (*Anas superciliosa*)
6	Masked lapwing (*Vanellus miles*)
3	White-faced heron (*Ardea novaehollandiae*)
2	Native hen (*Gallinula mortierii*)

Area 2

37	Black swan (*Cygnus atratus*)
6	Silver gull (*Larus novaehollandiae*)

Area 3

many	Welcome swallow (*Hirundo neoxena*)
16	Coot (*Fulica atra*)
14	Black duck (*Anas superciliosa*)
3	Great crested grebe (*Podiceps cristatus*)

Area 4

300	Chestnut teal (*Anas castanea*) and Black duck (*Anas supercili*
100	Australasian grebe (*Tachybaptus novaehollandiae*)
70	Coot (*Fulica atra*)
10	Little pied cormorant (*Phalacrocorax melanoleucos*)

8 February 1986

Area 4

190	Black duck (*Anas superciliosa*)
190	Chestnut teal (*Anas castanea*)
100	Coot (*Fulica atra*)
30	Australasian grebe (*Tachybaptus novaehollandiae*)
20	Australasian shoveler (*Anas rhynchotis*)
18	Masked lapwing (*Vanellus miles*)
15	Black swan (*Cygnus atratus*)
14	Silver gull (*Larus novaehollandiae*)
3	White-faced heron (*Ardea novaehollandiae*)

Appendix 3: Phytoplankton in Lake Crescent

Phytoplankton species of Lake Crescent, summarizing results from three surveys about 15 year intervals.DO= Dominant; AB=Abundant; RA=Rare; VR=Very Rare; *=Recorded (from Uytendaal 2003a).

			Lake Crescent		
Division	**Family**	**Genus**	**1973**	**1987**	**2001**
Bacillariophyta (Diatoms)	Fragilariaceae	Fragilaria			**VR**
		Asterionella	*		**VR**
	Coscinodiscaceae	Cyclotella	*		**RA**
	Cymbellaceae	Cymbella			**AB**
	Naviculaceae	Navicula 'a'			**DO**
		Navicula 'b'			**AB**
		Navicula 'c'			**AB**
		Pinularia			**RA**
	Surirellaceae	Surirella			
	Rhizosoleniaceae	Rhizosolena	*	*	**VR**
	Aulacoseiraceae	Aulacoseira 'a'			**AB**
		Aulacoseira 'b'			**DO**
		Melosira	*		**AB**
		Diatoma elongatum	*		**DO**
Chlorophyta (Green algae)	Dictyosphaeriaceae	Botryococcus	*	*	
		Dictytosphaerium	*		**RA**
	Oocystaceae	Ankistrodesmus		*	**RA**
		Kirchneriella	*		**RA**
		Oocystis	*		**AB**
	Hydrodictyaceae	Pediastrum 'a'	*		**AB**
		Pediastrum 'b'	*		**AB**
		Pediastrum 'c'	*		**AB**
	Scenedesmaceae	Scenedesmus 'a'	*		**AB**
		Scenedesmus 'b'			**RA**
		Dicellula			**RA**
	Chlorococcaceae	Tetrahedron			**RA**
	Volvoccaceae	Gonium	*		**RA**
		Various Volvocaceae			**RA**
	Oedogoniaceae	Oedogonium			
	Palmellaceae	Pseudophaeocystis			**VR**
	Mesotaenuaceae	Genicularia			**AB**

			Lake Crescent		
Division	**Family**	**Genus**	**1973**	**1987**	**2001**
Chlorophyta (Desmids)	Desmidiaceae	Closterium 'a'	*	*	**AB**
		Closterium 'b'	*	*	**AB**
		Cosmarium	*	*	**AB**
		Desmidium			**RA**
		Staurastrum 'a'	*		**AB**
		Staurastrum 'b'	*		**VR**
		Staurastrum 'c'	*		**RA**
		Staurodesmus	*		**RA**
Chlorophyta (Green Filaments)	Zygnemataceae	Geminella	*		**AB**
		Mougeotia	*	*	**DO**
		Spirogyra			**VR**
	Ulotrichaceae	Ulotherix			**VR**
		'Minute Green Filament'	*		**DO**
Chrysophyta	Synuraceae	Mallomonas			
	Dinobryaceae	Dinobryon	*		**VR**
Cyanobacteria (Blue-green algae)	Oscillatoriaceae	Arthrospira			**AB**
		Oscillatoria	*		**VR**
	Microcystaceae	Microcystis	*		**AB**
		Gomphosphaeria	*	*	**VR**
Dinophyceae		Peridinium	*		**VR**

Appendix 4: Plant species (and codes) recorded at ILR

Plant species recorded at ILR in 1981 (Kirkpatrick and Harwood 1981), 1986 (Chilcott 1986) and 2003 (Heffer 2003a).

*introduced species; r- listed under the *Threatened Species Protection Act 1995* (Tas); shaded cells- native wetland species.

Species	Plant Code	Common Name	ILR		
			'81	'86	'03
CHARECEAE					
Chara spp.	Char_spp.	stonewort		√	
Nitella sp.	Nite_sp				
DICOTYLEDONAE					
APIACEAE					
Hydrocotyle hirta	Hydr_hirt	hairy pennywort			√
Hydrocotyle javanica	Hydr_java			√	
Hydrocotyle muscosa	Hydr_musc	mossy pennywort			√
Lilaeopsis polyantha	Lila_poly	Australian lilaeopisis		√	√
ASTERACEAE					
Brachyscome angustifolia	Brac-angu				√
Euchiton collinus	Euch_coll				√
Leptinella reptans	Lept_rept				√
*Onopordum acanthium**	Onop_acan	scotch thistle			√
Psuedo-gnaphalium luteo-album	Psue_lute				√
*Senecio vulgaris**	Sene_vulg	groundsel			√
*Taraxacum officinale**	Tara-offi	common dandelion		√	√
BORAGINACEAE					
Myosotis australis	Myos-aust				√
BRASSICACEAE					
Rorippa dictyosperma	Rori_dict				√
CAMPANULACEAE					
Pratia surrepens	Prat_surr	pratia			√
CARYOPHYLLACEAE					
*Cerastium fontanum**	Cera_font	mouse-eared chickweed			

CLUSIACEAE					
Hypericum japonicum	Hype-japo	matted St. Johns wort			√
CRASSULACEAE					
Crassula helmsii	Cras-helm	swamp crassula			√
FABACEAE					
*Trifolium dubium**	Trif_dubi	yellow suckling			√
ELATINACEAE					
Elatine gratioloides	Elat-grat	waterwort		√	
HALORAGACEAE					
Myriophyllum simulans	Myri_simu	common milfoil	√	√	√
MENYANTHACEAE					
Villarsia reniformis	Vill_reni	running marshflower	√	√	√
ONAGRACEAE					
Epilobium tasmanicum	Epil_tasm				√
PORTULACEAE					
Montia fontana	Mont_font	blinks			√
Neopaxia australasica	Neop_aust	white purslane		√	√
RANUNCULACEAE					
Ranunculus amphitrichus	Ranu-amph	river buttercup	√	√	√
ROSACEAE					
Acaena novae-zelandiae	Acae_nova	buzzy			√
RUBIACEAE					
Galium gaudichaudii	Gali-gaud				√
SCROPHULARIACEAE					
Limosella australis	Limo_aust	mudwort	√		√
VIOLACEAE					
Viola hederacea	Viol_hede	ivy-leaf violet			√
MONOCOTYLEDONAE					
CYPERACEAE					
Baumea arthrophylla	Baum_arth	soft twig-rush	√		√
Carex gaudichaudiana	Care_gaud				√
Chorizandra australis	Chor_aust	bristlerush		√	√
Eleocharis acuta	Eleo_acut	common spike-rush		√	√
Eleocharis sphacelata	Eleo_spha	tall spike-rush		√	√

Isolepis fluitans	Isol_flui	floating clubrush	√	√	√
Isolepis montivaga	Isol_mont	mountain isolepis	√		√
Schoenus tesquorum	Scho_tesq	soft bog-rush			√
JUNCACEAE					
*Juncus bufonius**	Junc_bufo	toad rush			√
Juncus holoschoenus	Junc_holo	joint-leaf rush			√
Juncus spp.	Junc_spp.				√
JUNCAGINACEAE					
Triglochin procerum	Trig_proc	water ribbon	√	√	√
POACEAE					
Agrostis aemula	Agro_aemu				√
Agrostis avenacea	Agro_aven	common blown-grass			√
*Agrostis stolonifera**	Agro_stol	creeping bent			√
*Aira praecox**	Aira_prae	early hairgrass			√
Amphibromus recurvatus	Amph_recu	dark swamp wallaby – grass			√
Amphibromus sinuatus	Amph_sinu				√
Amphibromus neesii (r)	Amph_nees	Southern swampgrass	√		
*Anthoxanthum odoratum**	Anth_odor	sweet vernal grass			√
Festuca sp.*	Fest_sp.				√
*Holcus lanatus**	Holc_lana	Yorkshire fog			√
*Poa bulbosa**	Poa_bulb				√
Poa labillardierei	Poa_labi	silver tussock			√
*Vulpia bromoides**	Vulp_brom	squirrel-tail fescue			√
*Vulpia myuros**	Vulp_myur	rat's tail fescue			√
POTAMOGETONACEAE					
Potamogeton australiensis	Pota_aust	thin pondweed		√	
Potamogeton tricarinatus	Pota_tric	floating pond weed	√	√	√
UNKNOWN					
Aust aust	Aust_aust		√		
YAA YAA	YAA_YAA		√		
YAF YAF	YAF_YAF		√		
YYA YYA	YYA_YYA		√		
Total Number of Species	93		14	16	52

Appendix 5: Comparative invertebrate species lists for lakes Crescent and Sorell

Results from past and present studies are presented on the following pages, '?' means unconfirmed identification (Source: Hardie 2003b).

Species	Lake Sorell					Lake Crescent				
	Burrows (1968)[1]	Leonard & Timms (1974)[2]	Timms (1978)[3]	Fulton (1983)[4]	Hardie (2003)[5]	Burrows (1968)[1]	Leonard & Timms (1974)[2]	Timms (1978)[3]	Chilcott (1986)[6]	Hardie (2003)[5]
PORIFERA										
Family Spongillidae									X	
CNIDARIA										
Hydra sp.					X					XX
PLATYHELMINTHES										
Turbellaria										
Spathula sp.				XX						
Planarian A			XX					X		
Planarian B			X							
Triclad A		XX			XX		XXXX			XX
Triclad B		X			X		X			X
Triclad C		XX					XX			
Triclad D		XX			X		X			XXX
Un/ID sp.									X	
NEMERTEA										
Potamonemertes sp.				X						
Prostoma sp.										X
NEMATODA										
Un/ID sp. A									XXX	
Un/ID sp. B									XX	
Un/ID sp. C									X	
Un/ID sp. D									X	
Un/ID sp. E									X	
Un/ID spp.			XX		XXXX			XXX		XXXX
ANNELIDA										
Oligochaeta										
Haplotaxis ornamentus				X						
Haplotaxis sp.			X					X		
Phreodrilus magnaseta				XXX						
Phreodrilus plumaseta				XX						
Phreodrilus palustris				X						
Phreodrilus branchiatus				X						
Phreodrilus proboscidea				X					X	
Phreodrilus sp.			X					X		
Antipodrilus plectilus				XX					XXX	
Antipodrilus multiseta				X						
Telmatodrilus papillatus				X					XX	
Telmatodrilus multiprostatus			X	XX				X	X	
Limnodrilus hoffmeisteri			X	XX				X	X	
Diporochaeta lacustris				XX						
Rhyacodrilus fultoni									X	
Rhyacodrilus sp.				XXX						
Stylodrilus heringianus (?)				XX						
Fridericia sp. (?)			X							
Family Tubificidae									X	

Species	Lake Sorell					Lake Crescent				
	Burrows (1968)[1]	Leonard & Timms (1974)[2]	Timms (1978)[3]	Fulton (1983)[4]	Hardie (2003)[5]	Burrows (1968)[1]	Leonard & Timms (1974)[2]	Timms (1978)[3]	Chilcott (1986)[6]	Hardie (2003)[5]
Oligochaeta										
Un/ID sp. A									X	
Un/ID sp. B									X	
Un/ID spp.		XX			XXXX		X			XXXX
Hirundinae										
Un/ID sp.							X			XX
MOLLUSCA										
Gastropoda										
Gyraulus scottianus		X							XXX	
Gyraulus meridionalis				X						
Gyraulus sp.					XX					X
Potamopyrgus niger		XXX					XX	XX		
Potamopyrgus sp.			XX				XX	XX		
Physastra gibbosa				XX					XX	
Bulinus hainesii		X					X	X		
Angrobia sp.				XXX					X	
Austropyrgus sp.					XXXX					XXX
Glyptophysa sp.					XX					X
Glacidorbis sp.				X					X	
Bivalva										
Pisidium fultoni				XXX					X	
Pisidium cf casertanum		X					X	XXX		
Pisidium sp.					XX					XX
Sphaerium tasmanicum			XXX							
ARTHROPODA										
Acarina										
Oxus sp.				XX						
Lycosa sp.									X	
Family Hydryphantidae				X						
CRUSTACEA										
Cladocera										
Daphnia carinata	X				XXX	X				XXX
Ceriodaphnia quadrangular (?)	X				X	X				XXX
Bosmina meridionalis					X					XX
Bosmina hagmanni	X					X				
Un/ID sp.									XX	
Ostracoda										
Un/ID sp.					XX				X	XXXX
Copepoda										
Boeckella rubra	X					X				
Macrocyclops albidus	X					X				
Microcyclops leuckarti	X					X				
Harpactacoida sp.	X					X				X
Calanoid sp.					XXX					XX
Cyclopoid sp.					XX					X
Amphipoda										
Austrachiltonia australis		XX	XX	XXX	XXXX				XXX	XX
Austrachiltonia subtenuis							XXXX	X		
Antipodeus mortoni (?)					XXXX					X
Neoniphargus cf exiguus							X			
Family Gammaridae	X									

Species	Lake Sorell					Lake Crescent				
	Burrows (1968)[1]	Leonard & Timms (1974)[2]	Timms (1978)[3]	Fulton (1983)[4]	Hardie (2003)[5]	Burrows (1968)[1]	Leonard & Timms (1974)[2]	Timms (1978)[3]	Chilcott (1986)[6]	Hardie (2003)[5]
Isopoda										
Uramphisopis relictus				XX					X	
Uramphisopis australis								X		
Heterias petrensis					XXXX				X	XXX
Heterias sp.				X						
Colubotelson joyneri (?)					XXXX					
Colubotelson thomsoni (?)		X					XX			
Pseudasellus sp.		X					XX			
Decapoda										
Paratya australiensis				X	XXX				X	XX
Paratya tasmaniensis		XX								
Family Atyidae	X									
INSECTA										
Odonata										
Austrolestes analis									X	
Ephemeroptera										
Atalophlebia albiterminata				X						XX
Atalophlebia sp.									X	
Tillyardophlebia AV2					X					XXX
Atalonella delicatula		XX								
Atalonella sp.							X			
Plecoptera										
Eusthenia spectabilis/lacaustris					XX					XXX
Eusthenia sp.		X					XX			
Leptoperla varia					XX			X		XXX
Leptoperla tasmanica			X					X		
Leptoperla beroe				X						
Leptoperla sp.		X					X			
Dinotoperla bassae									X	
Dinotoperla sp.					X					X
Cardioperla sp.		XX								
Hemiptera										
Family Chrysomelidae									X	
Un/ID sp.									X	
Coleoptera										
Sternopriscus tarsalis oscillator										X
Sternopriscus clavatus									X	
Sclerocyphon lacaustris					XX					X
Sclerocyphon aquaticus		X								
Kingolus auratus					XXX					
Platynectes decempunctatus							X			
Berosus sp.									X	
Simsonia sp.		X								
Family Corixidae									X	
Family Hydrophilidae									X	
Family Curculionoidae									X	
Family Ditiscidae		X								
Diptera										
Coelopynia pruinosa			XX	XXX				XX	X	XXX
Procladius villosimanus			XX	XX				X	X	
Cryptochironomus griseidorsum				XX					X	
Chironomus oppositus				X					XX	
Polypedilum tonnoiri									X	
Polypedilum nr oresitrophus				X						

Species	Lake Sorell					Lake Crescent				
	Burrows (1968)[1]	Leonard & Timms (1974)[2]	Timms (1978)[3]	Fulton (1983)[4]	Hardie (2003)[5]	Burrows (1968)[1]	Leonard & Timms (1974)[2]	Timms (1978)[3]	Chilcott (1986)[6]	Hardie (2003)[5]
Diptera										
Ablabesmyia notabilis			XX	X				X	X	
Riethia sp.			XXX	XXX					XXXX	
Cryptocladopelma sp.								X		
Paramerina sp.				X					X	
Tanytarsus sp. (?)				XX						
Orthoclad A		X	XXX	X	XXX		X		X	XXX
Orthoclad B			XXX							
Orthoclad C			XXX							
Ceratopogonid A		X	X	XX	X			X	X	
Ceratopogonid B				X						
Family Muscidae									X	
Family Chironominae			XX		XXX					XXX
Family Tanypodinae					XXX					XX
Family Tipulidae					X					X
Family Dolichopodidae										X
Family Athericidae					X					
Family Limoniinidae		X								
Family Tabanidae		X								
Un/ID sp.				X					X	
Trichoptera										
Atriplectides dubius				XX	X					X
Ecnomus tillyardi				X	XX					XX
Helicopsyche murrumba				X	XX					
Helicopsyche sp.		XXX								
Aphilorheithrus AV6					X					
Aphilorheithrus sp.				X						
Philorheithrus AV2					X					
Notalina parkeri				XX					X	
Notalina AV9					X					X
Notalina sp.					X					X
Family Leptoceridae		X	X				X	X	X	
Family Conoesucidae				X						
Family Rhyacophilidae			X							
Family Hydroptilidae			X							
Total No. of Species	**9**	**26**	**24**	**48**	**40**	**7**	**20**	**20**	**52**	**40**

Presence/absence and relative abundance of invertebrates is illustrated by:

[1] X indicates presence of species

[2] X infrequent, XX present, XXX abundant and XXXX very abundant

[3] X 1-10 individuals, XX 11-100, XXX 101-500, XXXX >500

[4] X 1-10 individuals, XX 11-100, XXX >100

[5] X <10 individulas, XX 10-100, XXX 100-1000 and XXXX >1000

[6] X 1-5 individuals, XX 6-20, XXX 21-100, XXXX >100

Appendix 6: Methods used to compile the Ecological Character Description (ECD)

The draft Ecological Character Description (ECD) for the Interlaken Lakeside Reserve Ramsar site was compiled by Dr Helen Dunn. Entura (ENTURA) was subsequently commissioned to address comments on the draft ECD from the Department of Sustainability, Environment, Water, Population and Communities (SEWPaC); and finalise the document.

ENTURA has compiled this ECD in accordance with the *National Framework and Guidance for Describing the Ecological Character of Australia's Ramsar Wetlands* Module 2, (DEWHA 2008a). This document refers to the character and condition of the wetland at the time of listing (1982), although much of the data are drawn from more recent research and documentation. The process for the development of this ECD is outlined below:

1. The draft ECD for Interlaken Lakeside Reserve Ramsar site was compiled by Dr Helen Dunn, based on literature review and consultation with stakeholders.

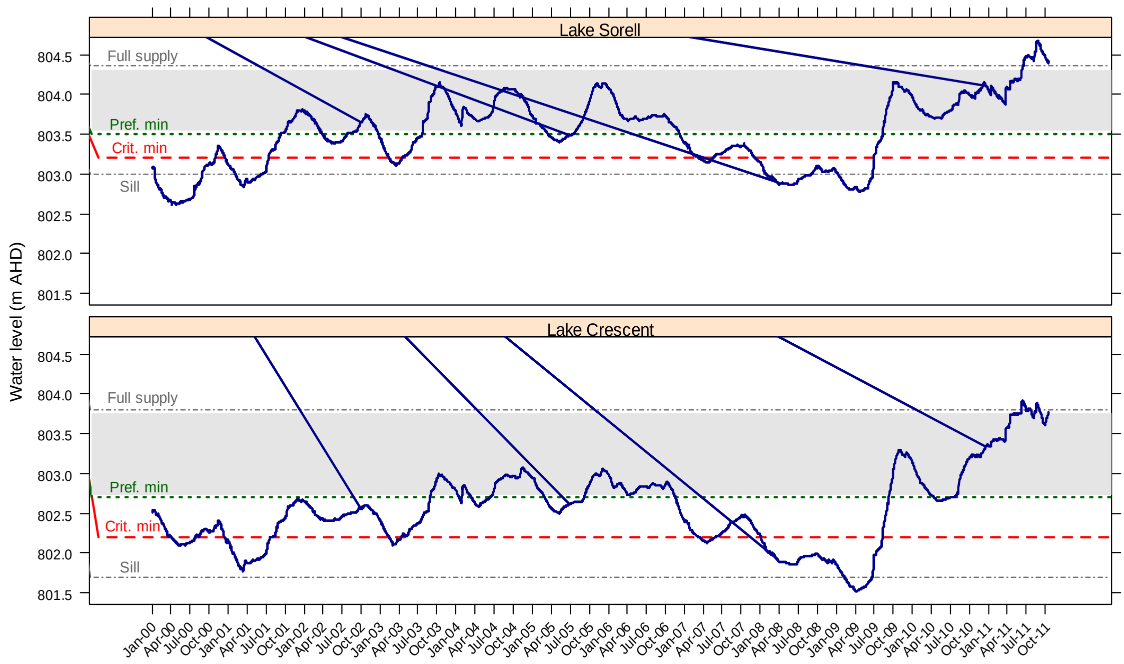
2. ENTURA addressed SEWPaC's comments on the draft ECD. Additional literature review and stakeholder consultation was completed as part of this process. Key literature sources included the current and superseded Ramsar Information Sheet (RIS) for the site; the Rehabilitation of Lakes Sorell and Crescent Report Series (including the site management plan); reports and journal papers pertinent to the site; consultation with key stakeholders, research institutions and government agencies; experience and knowledge of the project team; and various state and national biodiversity databases (refer References).

3. The ECD was submitted to SEWPaC for final comment.

4. ENTURA addressed SEWPaC's final comments on the ECD, and finalised the report.

5. Following submission of the final ENTURA report submitted at 4. above, DSEWPaC and DPIPWE reviewed the ECD and made several minor editorial revisions to it.

Appendix 7: Lakes Sorell and Crescent water levels January 2000 to October 2011. (DPIPWE 2011).



Appendix 8: Curricula vitae

Short curricula vitae for the authors of this version of the ECD are provided below.

Stephen Casey

Stephen Casey is a Senior Consultant with Entura with expertise in the areas of environment impact assessments and ecological surveys and assessments. This role requires Stephen to provide advice on environmental impact assessments for major projects, undertake flora and fauna habitat surveys, and develop mitigation strategies for clients. This involves engaging with stakeholders and liaising and negotiating with regulatory authorities.

Stephen has an excellent knowledge of Tasmania's conservation values, including threatened species and vegetation communities and is involved in ecological assessment surveys for wind farm development in Australia.

Eleni Taylor-Wood

Dr Eleni Taylor-Wood is a Principal Consultant with Entura and has over ten years experience in project management and terrestrial and aquatic ecology. Eleni specialises in aquatic plants having studied seagrasses, marine and estuarine macroalgae, aquatic freshwater macrophytes and phytoplankton (freshwater and marine) both as a research scientist and environmental consultant. While working as an environmental consultant, Eleni has been involved in a diverse range of studies including: terrestrial flora and fauna assessments; aquatic surveys and impact assessment; environmental flow studies; design and implementation of monitoring programs; instream, riparian and wetland management; and investigations into the transportation pests (aquatic and terrestrial).

Eleni was a member of the Independent Expert Panel assisting the Hawkesbury-Nepean Management Forum from 2001 - 2005. Eleni's role on this panel was to provide advice on matters relating to vegetation (aquatic and riparian) especially in regards to environmental flow regimes, monitoring programs and management of the riverine environment. Eleni has considerable experience with successfully project managing large-scale, complex projects that run over several years. Eleni also has experience in providing expert advice and critically reviewing reports.

Raymond Brereton

Raymond Brereton is a Senior Ecologist for Entura. His role requires Raymond to be a technical specialist and project manager being responsible for conducting and managing environmental impact assessments and development approvals for wind farm developments, and other energy and water infrastructure projects. Raymond also has a technical specialist and project management role in natural resource planning and management projects for government agencies.

Raymond has expertise in performing environmental assessments and approvals and assessing the impacts of developments on fauna, flora and their habitats, providing advice on policy and prescriptions for fauna and flora conservation and providing guidance and training on fauna and flora conservation and management.

Raymond has had over twenty years previous experience working for natural resource management agencies in the field of fauna and flora conservation, addressing the impacts of developments on fauna, flora and their habitats; providing advice on policy and prescriptions for fauna and flora conservation; providing guidance and training on fauna and flora conservation and management; monitoring implementation of management prescriptions; and supervising fauna research projects. Raymond has continuing research interests in bird utilisation at wind farm sites and monitoring butterfly populations and is a Member of Forest Practices Tribunal (Fauna Specialist).

David Ikedife

David Ikedife is a Specialist Environmental Scientist with Entura and is responsible for aquatic ecology, fish ecology, native and threatened species management and pest fish management. This role requires David to undertake project management for single and multidisciplinary projects, provide scientific specialist advice, manage subcontractors and undertake community stakeholder engagement and consultation.

David has over thirteen years of professional expertise and has managed the Inland Fisheries Service Biological Consultancy providing a sound understanding of aquatic ecological issues in Australia, particularly within Tasmania.

David has worked on a variety of projects including aquatic ecological compliance monitoring, threatened and pest fish management, fish passage design and construction, aquatic environmental impact assessments and water quality monitoring programs. David has designed and constructed a novel internal elver ladder within the Trevallyn Dam.

Anita Wild

Anita Wild is a Senior Ecologist with Entura and is responsible for ecology and management of natural and managed ecosystems. This role requires Anita to undertake ecological assessments of aquatic and terrestrial systems.

Anita has over fifteen years experience in performing quantitative ecology and flora surveys, wind farm environmental approvals, performing impact assessments and provide scientific experimental designs and reports. Anita liaises with key stakeholders including government agencies, proponents, land owners and local governments to develop mitigation strategies for ecological impacts.

Anita is the lead vegetation specialist for the Basslink Scientific Reference Committee investigating potential impacts of altered flow regimes on the riparian vegetation of the Gordon River. Anita continues to further her research interests in the restoration of ecosystems including alpine vegetation and continuing publication preparation.

Dax Noble

Dax Noble is an Environmental Scientist with Entura and is responsible for carrying out environmental impact assessments, preparing environmental management plans and seeking environmental approvals for infrastructure development. This role requires Dax to carry out contaminated site assessments and field investigations including site selection and analysis.

Dax has over three years experience in coastal and fluvial geomorphology, environmental/land and water management. Dax has worked both overseas and within Australia on varying projects including participating in an exchange program in the Netherlands undertaking field work on fen meadows focusing on water quality, ground water, ecohydrology and disturbed area restoration.

Dax has presented the 'Transition from Study to Work - Over three years of Reflection' to the 'Industry Connect Seminar Series' in New Zealand at the Environment Institute of Australia and New Zealand.

Brad Smith

Brad Smith is an Environmental Scientist and is responsible for Aquatic Ecology including aquatic macroinvertebrate taxonomy and ecology, low lake level management and assessing the impacts of development on the aquatic environment. This role requires Brad to undertake scientific investigations into impact assessments and conduct surveys and monitoring of the aquatic environment. Brad also provides advise on the mtigation and monitoring of the aquatic environment as a result of past and recent developments. Brad has over five years professional experience in water management, field logistics, stakeholder liaison and lab processing. Brad currently participates and manages various projects within Hydro Tasmania's Aquatic Environment Program and has published a paper on the 'Changes in benthic macroinvertebrate communities in upper catchment streams in Tasmania across a gradient of catchment forest operation history' in a respected, peer reviewed journal.

Ruth Painter

Ruth Painter is a Senior Environmental Consultant with Entura and is responsible for managing the Aboriginal Heritage Stream of the Cultural Heritage Program and perform environmental heritage assessments.

This role requires Ruth to provide technical advice on Aboriginal heritage issues, undertake archaeological investigations, develop and implement Aboriginal heritage policy and procedures and provide Aboriginal heritage awareness training.

Ruth has over sixteen years professional experience in providing technical experience in field archaeology and specialises in Aboriginal heritage in Tasmania. Ruth has worked on a number of projects including development applications for proposed wind farms, pre-feasibility assessments, planning applications and legislative reviews. Ruth has also developed an employment program for Aboriginal trainees within Hydro Tasmania.

Dave Graddon

Dave Graddon is a Senior Environmental Consultant. He is mainly responsible for providing advice for environmental impact assessments and planning approvals for infrastructure developments and environmental management of infrastructure maintenance and upgrade works, including land rehabilitation, catchment management and materials management.

This role requires Dave to identify environmental values, assess the potential impacts on these values and provide specifications for avoiding or minimising these impacts. Dave also has a major role in providing advice on assessment of natural conservation values and data management to support the provision of these services.

Dave has over twelve years experience in environmental impact assessment and environmental management planning for large infrastructure developments including wind farms, transmission lines, pipelines and dams. He has a wealth of knowledge in assessment of land management and conservation values including natural values, soil management, disease and pest management, with a strong background in remote sensing and GIS techniques and data management. Dave has worked on projects in Australia and overseas.

Malcolm McCausland

Malcolm McClausland is a Senior Environmental Scientist with Entura and is responsible for water resource management. This role requires Malcolm to undertake field data collection and data analysis.

Malcolm has significant experience and knowledge in algal culture experimentation and bloom management. This experience has been gained from experimental ecophysiology work examining preferences for light, mixing and nutrients in freshwater cyanobacteria and diatoms and brackish/estuarine phytoplankton. Malcolm has experience in determining and coordinating monitoring programmes for the detection observation and identification of underlying influences on cyanobacterial blooms in water storages.

With over thirteen years of professional expertise Malcolm's quality of scientific work is indicated by the publication of a significant number of papers in internationally referred journals and the presentation of results at national and international scientific meetings.

Malcolm has worked on a variety of projects undertaking bloom sampling design, shallow lake ecology and limnology.

Carolyn Maxwell

Carolyn Maxwell is an Aquatic Scientist with Entura and is responsible for the management and delivery of aquatic ecology projects. This role requires Carolyn to specialise in aquatic ecology, physical chemistry, inorganic chemistry, experimental design, limnology, data interpretation, water quality and water management. Carolyn has over ten years of professional expertise.

Johanna Slijkerman

Johanna Slijkerman is a Senior Environmental Scientist with Entura. Johanna is responsible for the delivery of flora and fauna surveys, stream condition assessments, environmental management plans, strategies and environmental investigations. Her role also involves the preparation of submissions and project management of large multi-disciplinary projects.

Johanna has over seven years experience as a consultant environmental scientist, specialising in vegetation and stream condition assessments, riparian ecology, monitoring and catchment planning. She has worked extensively in urban and regional Victoria, southern New South Wales and Tasmania. Johanna has qualifications in Botany and Physical Geography.

Catherine Walsh

Catherine Walsh is an Environmental Scientist with Entura and assists with flora and fauna habitat assessments, surveys and preliminary investigations for the development of environmental impact assessments and management plans. This role requires Catherine to provide advice on environmental impact assessments for major projects, undertaking flora and fauna habitat surveys and develop mitigation strategies for clients.

Catherine has an excellent understanding of river assessment methods and in-stream physical and biological processes in arid and semi-arid river and coastal systems in sub tropical and tropical Australia. She has excellent knowledge of tropical marine systems, seagrass communities and water quality.