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

Little Llangothlin Nature Reserve

Ramsar Site

Ecological Character Description

Citation: Cibilic, A. and White, L., 2011. Ecological Character Description for Little Llangothlin Nature Reserve, a Wetland of International Importance. Report prepared for the Department of Sustainability, Environment, Water, Population and Communities, Canberra, by WetlandCare Australia, Ballina, NSW.

Steering Committee
The authors would like to acknowledge the valuable input of the steering committee in the development and review of this document:
Ian Krebs - Department of Sustainability, Environment, Water, Population and Communities
Georgina Usher - Department of Sustainability, Environment, Water, Population and Communities
Brian Leahy - NSW Office of Environment and Heritage
Justin Kreis - NSW National Parks and Wildlife Service
Dorothy Bell - Scientific Representative, University of New England
John Clifton-Everest - Community Representative, Armidale, NSW

Acknowledgements
The authors wish to thank the following for assistance with the preparation of this document:
Robert Haworth, University of New England (Retired) – for assistance in providing information and in interpreting geological and geomorphological reports.
Peter Croft, NSW National Parks and Wildlife Service – local and historical knowledge of the site.

Craig Woodward, University of Queensland – for providing water quality data and information related to recent research (into sediments, chironomid larvae and current and historical ecosystem health) at the site.

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.

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.

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

Cover photo acknowledgements: Flying Cormorants (Alan Cibilic), Austral Toadflax (*Thesium austral*) (Alan Cibilic), Little Llangothlin Lagoon (Alan Cibilic) and Common reed (*Phragmites australis*) (Alan Cibilic).

Contents

Glossary

Benefits – see ecosystem services.

Biogeographic region - A scientifically rigorous determination of regions as established using biological and physical parameters such as climate, soil type, vegetation cover, etc (DEWHA 2008a).

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 (DEWHA 2008a).

Catchment - The area of land drained by a stream or stream system where a number of internal subcatchments contribute to the whole. (National Land and Water Resources Audit 2002).

Change in ecological character - The human-induced adverse alteration of any ecosystem component, process, and/or ecosystem benefit/service (Ramsar Convention Secretariat 2006).

Community - An assemblage of organisms characterised by a distinctive combination of species occupying a common environment and interacting with one another (DEWHA 2008a).

Community composition - All the types of taxa present in a community (DEWHA 2008a).

Community structure - All the types of taxa present in a community and their relative abundances (DEWHA 2008a).

Conceptual model - Wetland conceptual models express ideas about components and processes deemed important for wetland ecosystems (DEWHA 2008a).

Drainage division - broad regions of the Australian continent defined by aggregation of adjoining river basins with comparable climate or geography or shared discharge points (National Land and Water Resources Audit 2002).

Ecological character - The combination of the ecosystem components, processes and benefits/services that characterise the wetland at a given point in time (Ramsar Convention Secretariat 2006).

Ecological community - Any naturally occurring group of species interacting with each other especially through food relationships, and which inhabit a common environment and is relatively independent of other groups. Ecological communities may be of varying sizes, and larger ones may contain smaller ones (DEWHA 2008a).

Ecosystems - The complex of living communities (including human communities) and nonliving environment (ecosystem components) interacting (through ecological processes) as a functional unit, which provides, inter alia, a variety of benefits to people (ecosystem services) (DEWHA 2008a).

Ecosystem components - Include the physical, chemical and biological parts of a wetland (from large scale to very small scale, e.g. habitat, species and genes) (DEWHA 2008a).

Ecosystem processes - Dynamic forces within an ecosystem. They include all those processes that occur between organisms and within and between populations and communities, including interactions with the nonliving environment, that result in existing ecosystems and that bring about changes in ecosystems over time. They may be physical, chemical or biological (DEWHA 2008a).

Ecosystem services - Benefits that people receive or obtain from an ecosystem. The types of ecosystem services include:

- cultural services - the benefits people obtain through spiritual enrichment, recreation, education and aesthetics
- provisioning services - such as food, fuel and fresh water
- regulating services - the benefits obtained from the regulation of ecosystem processes such as climate regulation, water regulation and natural hazard regulation
- supporting services - the services necessary for the production of all other ecosystem services such as water cycling, nutrient cycling and habitat for biota. These services will generally have an indirect benefit to humans or a direct benefit in the long term. (DEWHA 2008a).

Essential element - a component or process that has an essential influence on the critical components, processes and services/benefits of the wetland. Should the essential element cease, reduce, or be lost, it would result in a detrimental impact on one or more critical component, process and service/benefit.

Evapotranspiration - the amount of water lost to the atmosphere at field sites, which is affected by factors influencing pan evaporation, and also surface area and the transpiration of vegetation - see pan evaporation (BoM 2010b).

Guanotrophy - enrichment with nutrients derived from bird droppings. Flocks of birds can cause guanotrophy in inland waters (www.studentsguide.in/environmetal-dictionary/gnathostomata-gyttya.html).

Limits of acceptable change - Variation that is considered acceptable in a particular component or process of the ecological character of the wetland without indicating change in ecological character that may lead to a reduction or loss of the criteria for which the site was Ramsar listed (DEWHA 2008a).

Monitoring - Collection of specific information for management purposes in response to hypotheses derived from assessment activities, and the use of these monitoring results for implementing management (DEWHA 2008a).

Pan evaporation - the amount of evaporation measured from an open Class A evaporation pan which includes the effects of solar radiation, cloudiness, temperature and wind - see evapotranspiration (BoM 2010b).

Population - A group of individuals of one species in an area, though the size and nature of the area is defined, often arbitrarily, for the purposes of study being undertaken (Begon et al. 1990)

Ramsar criteria - Criteria for Identifying Wetlands of International Importance, used by Contracting Parties and advisory bodies to identify wetlands that qualify for the Ramsar List on the basis of representativeness or uniqueness or of biodiversity values (Ramsar Convention Secretariat 2006).

Ramsar list - the List of Wetlands of International Importance; see Ramsar sites.

Ramsar sites - Wetlands 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 (Ramsar Convention Secretariat 2006).

River basin - Catchment areas of major rivers draining to the sea and named after these rivers. The 245 river basins as defined by the former Australian Water Resources Council. These form sub-basins of the drainage divisions (National Land and Water Resources Audit, 2002).

Significant impact - A ‘significant impact’ is an impact which is important, notable, or of consequence, having regard to its context or intensity. Whether or not an action is likely to have a significant impact depends upon the sensitivity, value, and quality of the environment which is impacted, and upon the intensity, duration, magnitude and geographic extent of the impacts (Department of Environment and Heritage 2006).

Wetlands - 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 6 metres (Ramsar Convention Secretariat 2006).

Abbreviations

AHD	Australian Height Datum
BBL	Billy Bung Lagoon
BoM	Bureau of Meteorology
CAMBA	China-Australia Migratory Bird Agreement
CEPA	Communication, Education, Participation and Awareness
CMA	Catchment Management Authority
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DECC	Department of Environment and Climate Change (NSW – prior to 2008)
DECCW	Department of Environment, Climate Change and Water (NSW – from 2008 to 2011)
DEWHA	Australian Government Department of Environment, Water, Heritage and the Arts (DSEWPaC from 2010)
DSEWPaC	Australian Government Department of Sustainability, Environment, Water, Population and Communities (DEWHA prior to 2010)
ECD	Ecological Character Description
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth)
IUCN	International Union for Conservation of Nature
JAMBA	Japan-Australia Migratory Bird Agreement
LAC	Limit of Acceptable Change
LLL	Little Llangothlin Lagoon
LLNR	Little Llangothlin Nature Reserve
NSW	New South Wales
NSW NPWS	New South Wales National Parks and Wildlife Service
OEH	Office of Environment and Heritage (NSW – from 2011)
ROKAMBA	Republic of Korea-Australia Migratory Bird Agreement
TEC	Threatened Ecological Community – listed as nationally threatened under the EPBC Act
UNE	University of New England

Executive summary

The Little Llangothlin Nature Reserve (LLNR) Ramsar site is located between Armidale and Glen Innes on the New England Tablelands in north-eastern New South Wales (NSW), Australia. The Ramsar site comprises all of the 257.6 hectare nature reserve which is managed by the NSW National Parks and Wildlife Service. The site has an elevation above 1 355 metres and contains all of Little Llangothlin Lagoon a permanent lake of approximately 105 hectares in size (Figure E1). The site also contains approximately 7.7 hectares of the intermittent 17 hectare Billy Bung Lagoon, as well as areas of non-forested peatland (fen) and small spring fed wetlands. The site supports threatened ecological communities and threatened flora and fauna species.

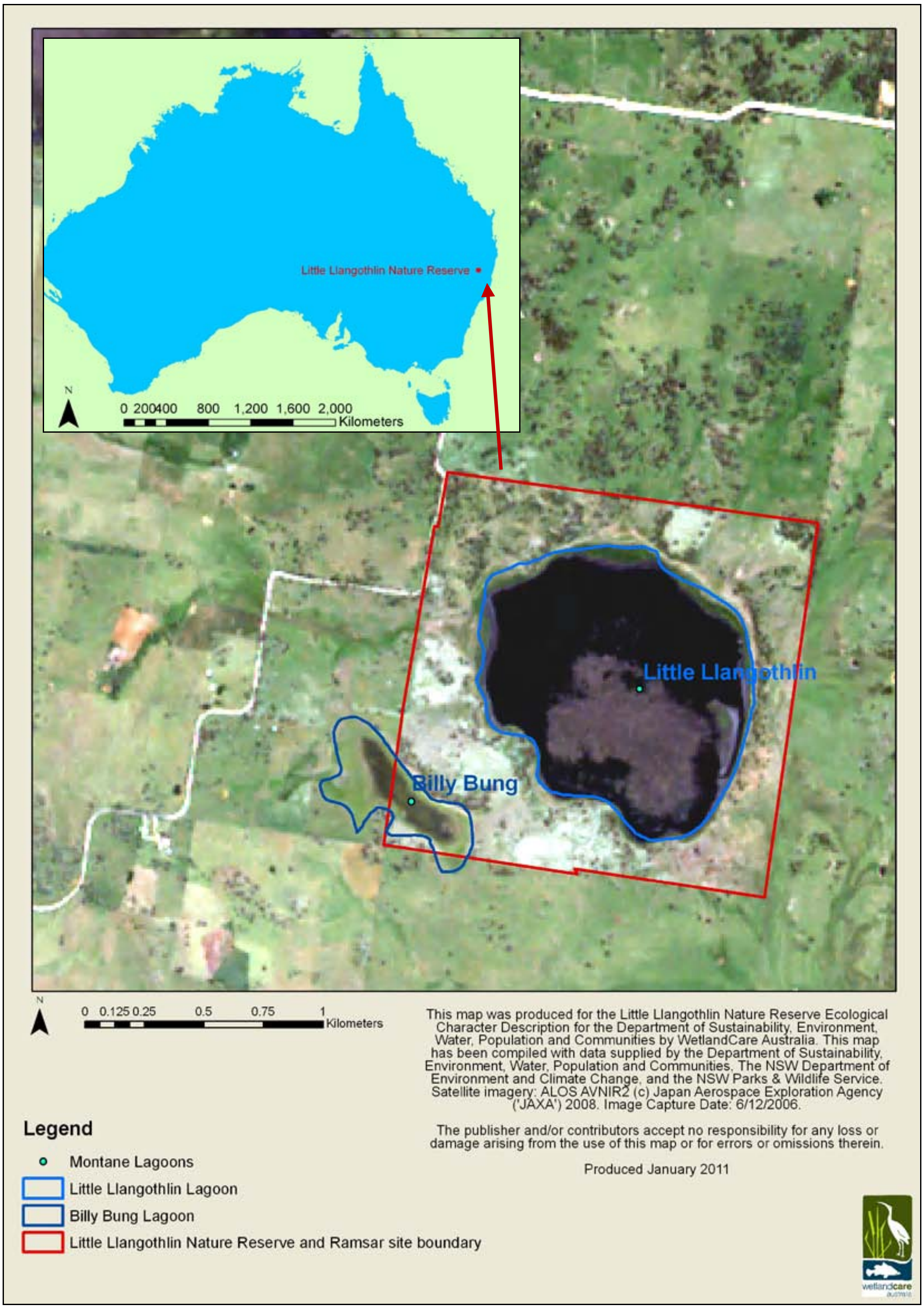


Figure E1: Location of LLNR and the major wetlands within the site.

The LLNR Ramsar site meets the following three Ramsar criteria:

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.
Little Llangothlin Lagoon and Billy Bung Lagoon are part of the larger New England Lagoons system which includes 57 lakes and swamp depressions extending along 100 kilometres of the Great Dividing Range. Only 39 of these lakes and swamp depressions occur within the South-East Coast Drainage Division (Haworth 1998). At 105 hectares, Little Llangothlin Lagoon is one of the largest examples of these high altitude lakes. It is also rare due to its near-natural condition, as the majority of the lakes have been degraded or destroyed through hydrological modification, grazing and cropping. LLNR Ramsar site is one of only two reserves in the New England Tablelands which contain examples of these lakes, and which are protected under the *National Parks and Wildlife Act 1974.*

Criterion 2: A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities.
The following are supported at the LLNR Ramsar site:

- The two lakes at the site constitute examples of the national threatened ecological community (TEC) 'upland wetlands of the New England Tablelands and the Monaro Plateau'.
- The site contains patches of 'New England peppermint (*Eucalyptus nova-anglica*) grassy woodlands', a national TEC.
- The nationally vulnerable plant species Austral toadflax (*Thesium australe*) occurs within the Ramsar site. This terrestrial species occurs in grassland or grassy woodlands, particularly in damp sites, and in association with kangaroo grass (*Themeda australis*) which it parasitizes.
- The nationally endangered Australasian bittern (*Botaurus poiciloptilus*) has been recorded at the site but the importance of the site for the conservation of this species is yet to be clarified.

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.
LLNR Ramsar site provides a habitat refuge for numerous species of waterbird which increase significantly in number at Little Llangothlin Lagoon during times of drought (White 1987). Particularly significant differences in numbers have been recorded for Pacific black duck (*Anas superciliosa*), grey teal (*Anas gracilis*), Australasian shoveler (*Anas rhyncotis*), Eurasian coot (*Fulica atra*) and white-faced heron (*Egretta novaehollandiae*). Protection of the site as a nature reserve increases its drought refuge significance as alternative habitat at relatively nearby coastal wetlands continues to be pressured by ongoing coastal development. The site also supports eight internationally listed migratory waterbird species.

This ecological character description (ECD), the first compiled for this site, describes the ecological character at the time of Ramsar designation in March 1996. A summary of the critical components and processes and benefits and services of the site is provided in Table E1. These are considered to be important determinants of the site's unique ecological character or otherwise underpin the Ramsar criteria for which the site is listed. The interactions between the critical components/processes and benefits/services are illustrated in Figure E2.

Table E1: Critical components/processes and benefits/services of the LLNR Ramsar site.

Critical element	Description
Components and Processes	
Hydrology	
Surface water	Little Llangothlin Lagoon contains water in all but times of extreme drought, and the much shallower Billy Bung Lagoon dries out every 20 years or so. The occurrence of permanent water contributes significantly to the site's ecology and function as a drought refuge.
Ground water	Lake water levels are supplemented by groundwater flows, both in the soil above the underlying basalt and granite, and also in basalt aquifers which may discharge at seepage areas in the local catchment.
Flora	
Threatened ecological communities	Lake vegetation underpins the wetlands' primary production and is protected as the national TEC 'upland wetlands of the New England Tablelands and the Monaro Plateau'. Remnant and recruiting patches of *Eucalyptus nova-anglica* represent the national TEC 'New England peppermint (*Eucalyptus nova-anglica*) grassy woodlands'.
Threatened species	At least one population of the nationally threatened Austral toadflax is supported by kangaroo grass within eucalypt woodland which occurs on the slopes adjoining Billy Bung Lagoon.
Fauna	
Waterbirds	At least 48 species of waterbirds utilise the site including eight migratory species. The site is used for breeding by at least 21 waterbirds including black swan.
Threatened species	The nationally threatened Australasian bittern has been recorded twice at the site in recent years and is suspected to breed there.
Services	
Supports representative near-natural wetlands	The four wetland types at the site are representative of the diverse upland wetlands of the region. Little Llangothlin Lagoon and Billy Bung Lagoon are two of only 39 upland lakes in the New England Tablelands within the South-East Coast Drainage Division. Eighty per cent of lakes in the New England Tablelands have been seriously degraded since European settlement. Compared with the other 37 upland lakes in the region, these two lakes are in near-natural condition as a result of their protection within the LLNR. (Brock et al. 1999)
Provides refuge during drought conditions	The number of waterbirds at Little Llangothlin Lagoon is known to double during times of drought. Also capable of providing refuge for migratory birds when droughts deplete wetlands in other regions of eastern Australia.

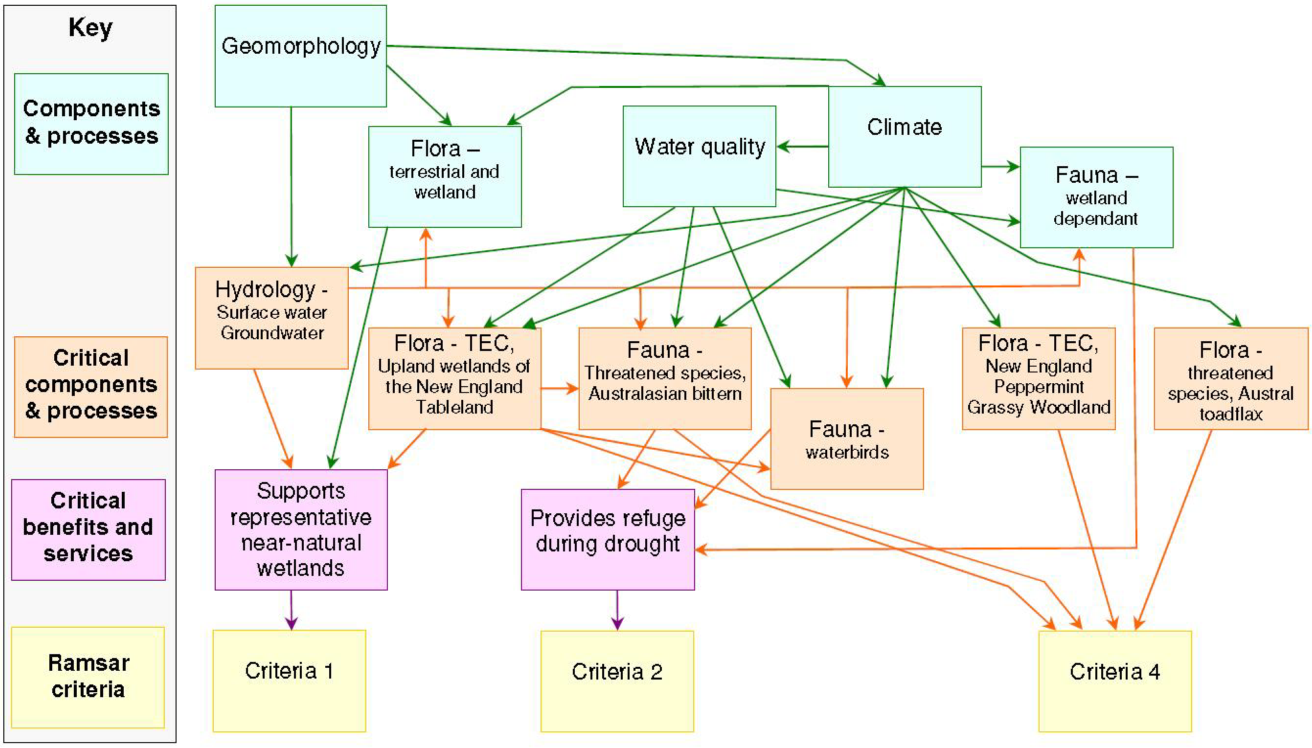


Figure E2: Relationships between components, processes, benefits and services and how they contribute to the Ramsar criteria

Limits of acceptable change (LACs) have been proposed for each of the critical components/processes and benefits/services. LACs are generally based on the natural variability of the critical elements and describe the extent these can vary without representing a change in the ecological character of the site. Proposed limits of acceptable change for the LLNR Ramsar site based on available data are summarized in Table E2.

Table E2: Limits of Acceptable Change in the ecological character of the LLNR Ramsar site.

Critical component, process or service	Baseline condition and range of natural variation	Limits of acceptable change	Confidence level
Critical components and processes			
Hydrology			
Surface water	1. The 105 ha Little Llangothlin Lagoon has a maximum water depth of about 2 m (Bell and Clarke 2004) and contains surface water most of the time under natural conditions while experiencing seasonal variation in water depth of 0.4-1.0 m (Haworth 1994, Briggs 1976, D. Bell, UNE, Pers. Comm. 2011), and while unlikely to dry completely (Gale et al. 2004), may prove to dry out in extreme droughts. If additional information becomes available, this LAC should be reviewed to include extent and depth.	1. Deepest pools in Little Llangothlin Lagoon contain water except in extreme droughts.	High
	2. The intermittent Billy Bung Lagoon has a maximum depth of about 0.8 m and experiences seasonal contraction of surface waters and periodic complete drying of the lake surface about once every 20 years (Brock et al. 2005), however long term datasets are unavailable. About 7.7 ha of its 17 ha area occurs within LLNR Ramsar site.	2. Insufficient data exists; baseline data (periodicity, extent, depth) must be developed.	Not applicable
Ground water	3. The contribution of groundwater flows to the waterbalance of wetlands at the site is unknown. Groundwater contributes to water levels in the lakes, including possibly at the basalt granite interface underneath Little Llangothlin Lagoon (Haworth 1994). The number, location and extent of groundwater springs are unknown.	3. Insufficient data exists; baseline data must be developed.	Not applicable
Flora			
Threatened ecological communities	1. Diverse wetland vegetation within Little Llangothlin and Billy Bung Lagoons is representative of the national TEC 'upland wetlands of the New England Tablelands and the Monaro Plateau'. About 113 ha of this community (Benson and Ashby 2000) usually occurs within the site but long-term data on the variation in the extent of the TEC has not been recorded. Native wetland species identified in permanent Little Llangothlin Lagoon numbered 29 in 1976 (Briggs 1976) and 34 in 1998 (D. Bell, UNE, Pers. Comm. 2011). The intermittent Billy Bung Lagoon contained slightly more native wetland species with 39 species recorded in 1998 (D. Bell, UNE, Pers. Comm. 2011). The distribution of minor species is unknown	1. One example of a permanent (Little Llangothlin Lagoon) and an intermittent (Billy Bung lagoon) lake representative of the TEC continues to occur within the site.	High

	and there is no data to demonstrate long-term variation in species composition of the communities at the site. If additional information becomes available, could consider a separate LAC for the condition and extent of the TEC, with extent potentially covered by an updated hydrology LAC.		
	2. Patches of mature and recruiting *Eucalyptus nova-anglica* occur within the site, representing the TEC 'New England peppermint (*Eucalyptus nova-anglica*) grassy woodlands' (Hunter 2011, DSEWPaC 2011a). The number of patches, their location, extent and condition are unknown; when obtained the LAC should be reviewed to include a condition and extent clause.	2. The TEC 'New England peppermint (*Eucalyptus nova-anglica*) grassy woodlands' continues to occur at the site.	Medium
Threatened species	3. A least one population of the nationally vulnerable herb Austral toadflax has been recorded (in 1996, 2006, and 2011) from the south-western corner of the site near Billy Bung Lagoon. The extent of this and other potential populations at the site has not been surveyed and the condition and population dynamics have not been studied. The species is cryptic and populations may be dynamic or transient, with population sizes fluctuating rapidly. (Bell et al. 2008, DECCW 2010b; D. Bell, UNE, Pers. Comm. 2011, Griffith 1991). If additional information becomes available should consider the inclusion of a condition and extent LAC.	3. At least one population of Austral toadflax continues to be recorded at the site.	Medium
Fauna			
Waterbirds	1. At least 48 waterbird species have been recorded within the LLNR. The following four species have been consistently recorded in surveys of the site since 1974, with counts > 100 at least once during each study in which waterbirds were counted: grey teal, Eurasian coot, Pacific black duck and black swan (Briggs 1976, White 1986a, Kingsford et al. 2011). The highest recorded counts for these species include 1800 grey teal, 722 Eurasian coot, 600 Pacific black duck, and 498 black swan (Briggs 1976, White 1986a, Kingsford et al. 2011).	1. Grey teal, Eurasian coot, Pacific black duck and black swan continue to be recorded at the site over a ten-year timeframe in counts >100.	Medium
Threatened species	2. In recent years the nationally endangered Australasian bittern has been observed twice and heard more often and is suspected to breed at the site; it is a highly cryptic species and the population ecology at the site is not known (J. Clifton-Everest, Pers. Comm. 2011).	2. Insufficient data exists; baseline data must be developed.	Not applicable

Critical benefits and services			
Supports representative near-natural wetlands	1. The four wetland types in the LLNR Ramsar site retain natural values: • The permanent Little Llangothlin Lagoon and the intermittent Billy Bung Lagoon - eighty percent of lakes in the New England Tablelands have been seriously degraded since European settlement, and as a result, compared with the other 39 upland lakes in the northern part of the bioregion, these lakes are in near-natural condition as a result of their protection within the LLNR under the NSW National Parks and Wildlife Act, 1974 (Brock et al. 1999). • 16.2 ha of Carex-dominated fens (non-forested peatlands) have been recorded on inflow and outflow watercourses and near the high water mark of both lakes (Hunter 2011), however insufficient data exists to determine any natural variation in extent over time. The community that occurs in the lower reaches of the main inflowing watercourse to Little Llangothlin Lagoon is described as one of seven remaining examples of high quality fens in the New England Tablelands (Hunter and Bell 2009). Many of the largest Carex fens in the New England Tablelands have been degraded or eradicated (Hunter 2011). • Very small spring-fed wetlands supported by groundwater soaks occur at the site, however these have not been surveyed or assessed to date. The authors note that the absence of livestock grazing at the site has allowed the natural values of the four wetland types to be retained.	1. The four wetland types continue to occur at the site. 2. The LAC for the natural condition and extent of Little Llangothlin Lagoon and Billy Bung Lagon would best be covered by the LACs for the upland wetlands of the New England Tablelands TEC and hydrology, above, when they are developed after sufficient baseline data is produced. 3. Insufficient data exists to determine the LAC for the natural condition and extent of *Carex*-dominated fens; baseline data must be developed. 4. Insufficient data exists to determine the LAC for the natural condition and extent of spring-fed wetlands; baseline data must be developed.	Medium Not applicable Not applicable Not applicable
Provides refuge during drought conditions	1. The presence of permanent water within the site provides a drought refuge for waterbirds in terms of resources such as food and breeding habitat. Recorded waterbird numbers range from a mean of 699 birds annually during a drought year to a mean of 334 birds annually after the drought ended (White 1987).	1. Statistically significant higher numbers of waterbirds occur at the site during times of drought.	Medium

Threats to the ecological character of the site are limited since the entire LLNR Ramsar site was gazetted as a nature reserve in 1979 under the *NSW National Parks and Wildlife Act 1974*, and there have been no changes in the ecological character of the site since the time of listing in 1996.

There are, however, some ongoing threats to the LLNR Ramsar site, in particular impacts of existing exotic species. Weeds such as introduced pasture grasses are present at the site, displacing native flora including TECs and nationally threatened Austral toadflax. Disturbance of soil and grazing by rabbits also threatens native flora. Introduced animals including European red fox and feral cats predate native fauna within the LLNR possibly including the nationally threatened Australasian bittern. The introduced fish *Gambusia holbrookii* suppresses native fish and frogs

Several knowledge gaps exist which are required to be filled in order to fully describe the ecological character and natural variability of the LLNR Ramsar site and set rigorous limits of acceptable change. The high priority knowledge gaps for the site are:

- Lake bed bathymetry of lagoons including area of deepest pools in Little Llangothlin Lagoon.
- Water balance and long term water level data for Billy Bung and Little Llangothlin Lagoons.
- Location and hydrological significance of groundwater aquifers and seepage areas.
- Recent and thorough composition and distribution data of wetland vegetation, especially at Billy Bung Lagoon.
- Comprehensive data on the extent and condition of eucalypt woodland at the site and assessment against New England peppermint grassy woodland TEC listing criteria.
- Number, size and location of populations of threatened Austral toadflax within the site.
- The extent and condition of freshwater spring wetlands and fens at the site.
- Comprehensive long-term waterbird data.
- The population dynamics of the Australasian bittern within LLNR.

Recommended monitoring to fill these knowledge gaps, as well as to assess the ongoing ecological character of the site against the LACs is summarised in Table E3.

Table E3: Monitoring recommendations for LLNR Ramsar site.

Component or process	Monitoring objective	Indicator	Frequency	Priority
Geomorphology	Track changes to the rate of sedimentation in the lake beds	Annual sedimentation rate (mm/yr), for example, at a series of sediment monitoring sites at each lake	Every 10 years	Medium
	Monitor any disturbance to the lunette at Little Llangothlin Lagoon and the outlet at Billy Bung Lagoon.	Assess disturbance to and change in elevation of the outlets	At least annually	Medium
Hydrology	Water level and depth at each lake	Water level (m AHD) and maximum water depth (e.g. mm)	At least weekly for 12 months, then monthly	High
Flora Wetland vegetation/TEC	Monitor the composition and distribution of wetland vegetation within the site (including introduced species). Establish the natural range of fluctuation in all wetland vegetation communities under the current hydrological and climate regime.	Species composition and distribution of aquatic and wetland vegetation communities and seasonal fluctuations in these.	Intensive survey, then regular monitoring at least every 5 to 10 years.	High
Eucalypt woodland/TEC	Document, map and monitor the composition, distribution and condition of eucalypt woodland within the site (especially *Eucalyptus nova-anglica*).	Composition, condition and extent of eucalypt woodland	Intensive survey, then regular monitoring at least every 5 to 10 years.	High
Threatened species	Map and monitor the abundance and distribution of the nationally endangered plant Austral toadflax.	Size and location of populations of Austral toadflax within the site.	Intensive survey, then regular monitoring at least every 3 years.	High
Fauna Waterbirds	Monitor waterbird numbers and breeding at the site under the current hydrological regime.	Long-term composition and abundance of waterbird population at the site. Numbers of waterbirds observed breeding	Biannual waterbird surveys at least every 5 years, but preferably each year.	High
Threatened species	Monitor populations and breeding of the nationally endangered Australasian bittern at the site.	Number, location, age and sex of individuals of this species found.	Intensive targeted survey (birdcalls at dawn and dusk) at least four times a year for at least two years, then biannual surveys at least every 3 years.	High
Surface water Water quality	Establish a baseline for water quality for water at different depths in both lakes and detect any change.	Salinity, pH, dissolved oxygen, turbidity, nutrients, organic carbon, chlorophyll.	In the wet and dry season at least once every 5-10 years	Medium
Ground water Water quality	Establish a baseline for water quality at any identified significant springs	Salinity, pH, bicarbonate, dissolved oxygen, nutrients.	At least once every 5-10 years	Medium

1. Introduction

1.1 Background

The *Convention on Wetlands of International Importance Especially for Waterbird Habitat,* to which Australia is a signatory, was initially adopted in Ramsar, Iran, in 1971. Commonly known as the Ramsar Convention, this was the first modern inter-governmental treaty between nations with the aim of conserving natural resources.

The original intent of the Ramsar Convention was to protect waterbird habitat, however the convention has broadened its scope to cover all aspects of wetland conservation and 'wise use'.

Australia signed the Ramsar Convention in 1974, becoming one of the first contracting parties and agreeing to a number of actions including to:

- designate sites that meet the Ramsar criteria for inclusion in the Ramsar List
- protect the ecological character of listed sites
- report on actions taken to implement the Ramsar Convention.

While management of Ramsar wetlands is the responsibility of each individual site manager, the Australian Government, through the Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) works closely with state governments, regional bodies and Ramsar site managers to implement Australia's Ramsar Convention obligations. In accordance with the Ramsar Convention, appropriate management of Ramsar wetlands includes describing and maintaining the ecological character of the wetland and implementing planning processes that promote conservation and wise use. These management principles are supported by national legislation under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The Ramsar Convention provides the following relevant definitions:

Ecological character is the combination of the ecosystem components, processes and benefits and services that characterise the wetland at a given point in time.

…change in ecological character is the human induced adverse alteration of any ecosystem component, process and or ecosystem benefit/service.

Within this context, ecosystem benefits and services are defined as the benefits that people receive from ecosystems.

1.2 Site details

This document describes the ecological character of the Little Llangothlin Nature Reserve (LLNR) Ramsar site. The site is 257.6 hectares in size and is located near Guyra on the New England Tablelands of northern New South Wales (NSW), Australia. It is managed by the NSW National Parks and Wildlife Service. Four wetland types are present at the site, including Little Llangothlin Lagoon a permanent freshwater lake of 105 hectares. The site supports threatened ecological communities and threatened flora and fauna species.

Table 1.1 Details of the Little Llangothlin Nature Reserve Ramsar site

Name	Little Llangothlin Nature Reserve Ramsar site, NSW
Location in Co-ordinates	Latitude: 30° 05' S Longitude: 151° 47' E.
General Location	LLNR Ramsar site is located approximately 60 km north of Armidale in north-east NSW, Australia. The site is approximately 18 km north-east of the small town of Guyra and 5 km east of the New England Highway.
Area	257.6 hectares
Date of Ramsar site designation	17th March 1996
Ramsar criteria met - current (2005)	1, 2 and 4
Management authority	NSW National Parks and Wildlife Service
Date the Ecological Character Description applies	Date of Listing: 17th March 1996
Status of description	This is the first Ecological Character Description compiled for the site.
Date of compilation	May, 2011
Name of compiler(s)	Alan Cibilic and Laura White, WetlandCare Australia
Reference for Ramsar Information Sheet	Compiled by Alan Cibilic and Laura White, WetlandCare Australia on behalf of the Department of Sustainability, Environment, Water, Population and Communities.
Reference for management plan	**NSW National Parks and Wildlife Service, 1998.** Little Llangothlin Nature Reserve Plan of Management. **NSW National Parks and Wildlife Service, Sydney. Website:** http://www.environment.nsw.gov.au/parkmanagement/ParkManagementPlans.htm

1.3 Statement of purpose

This assessment of ecological character is linked to the Ramsar criteria fulfilled by the site at the time of designation for the Ramsar list, following guidance of the Ramsar Convention (DEWHA 2008a).

Further, this ECD has several aims (McGrath 2006 as reported in DEWHA 2008a):

1) To 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*:
   a) to describe and maintain the ecological character of declared Ramsar wetlands in Australia
   b) to formulate and implement planning that promotes:
      i) conservation of the wetland
      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) To 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) To supplement the description of the ecological character contained in the Ramsar Information Sheet submitted under the Ramsar Convention for each listed wetland and, collectively, to form an official record of the ecological character of the site.
4) To assist the administration of the 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) To assist any person considering taking an action that may impact on a declared Ramsar wetland to determine whether to refer the action to the Minister under Part 7 of the EPBC Act for assessment and approval.
6) To inform members of the public who are interested generally in declared Ramsar wetlands to understand and value the wetlands.

In order to maintain the ecological character of a declared Ramsar wetland it is important to know the ecological conditions at the time of listing. As a result the ecological character is described at a particular point in time, and contracting parties are expected to notify the Ramsar Secretariat if the ecological character changes.

This ECD has been developed many years after the time of designation and the ecological character may have changed since that time. Every attempt has been made to document the ecological character of LLNR Ramsar site at its time of listing in 1996, in part by extrapolating from earlier or more recent data. However, identifying (with high confidence) the natural variability and defining limits of acceptable change for some of the Ramsar site's critical components, processes and benefits and services has not been possible. Dates have been used to identify where older or more recent data has been used to establish a baseline for specific components, processes and services.

Figure 1.1 places the ECD in the context of legislation, other planning and support documents, and various management and monitoring reports.

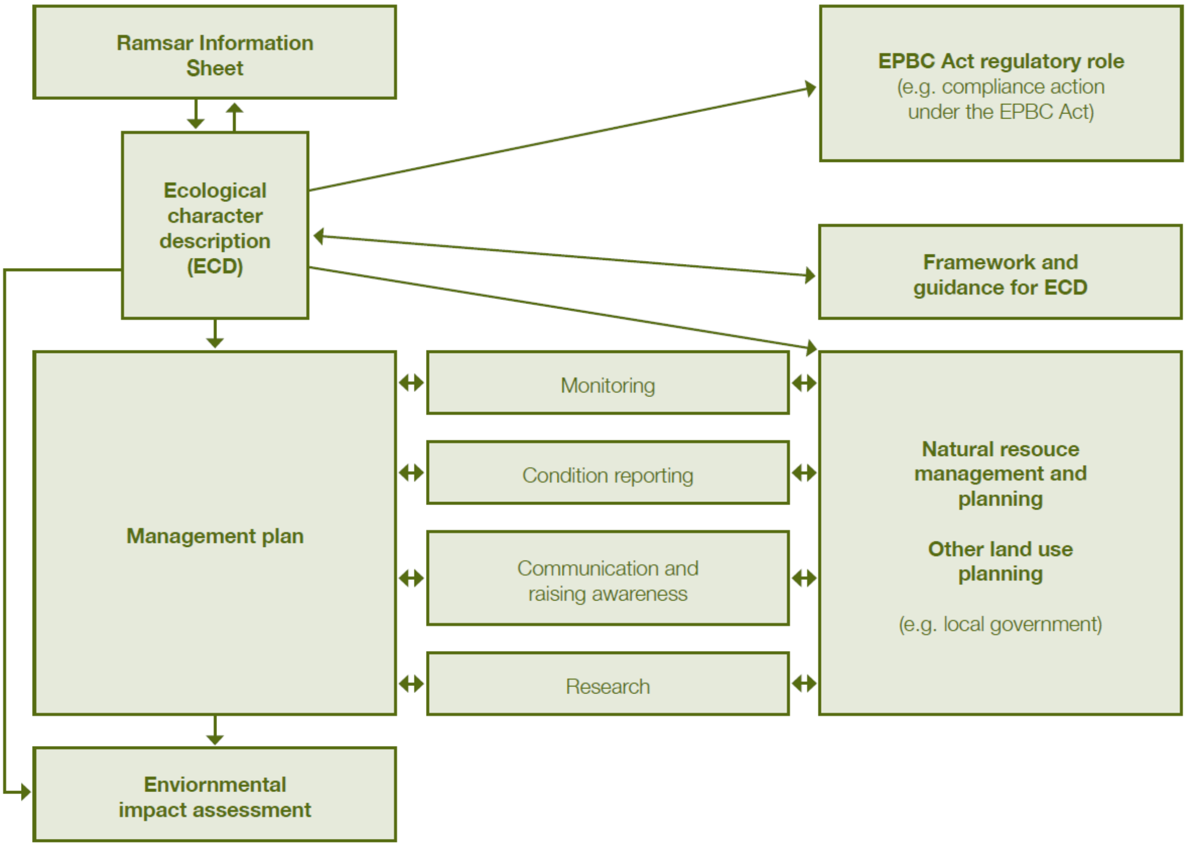


Figure 1.1 Relationship between the ECD and other documents (DEWHA 2008)

This Ecological Character Description has been compiled based on the methods outlined in the *National Framework and Guidance for describing the Ecological Character of Australian Ramsar wetlands* (DEWHA 2008a). Details of variations are provided in Appendix 1.

1.4 Relevant treaties, legislation, and regulations

The following have been identified as most relevant to the site, or to species and communities related to the site.

1.4.1 International

- The 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.
- The Agreement between the Australian Government and the Government of Japan for the Protection of Migratory Birds in Danger of Extinction and their Environment (JAMBA).
- The Agreement between the Australian Government and the Government of the People's Republic of China for the Protection of Migratory Birds and their Environment (CAMBA).
- The Agreement between the Australian Government and the Republic of Korea for the Protection of Migratory Birds and their Environment (ROKAMBA).
- The Convention on the Conservation of Migratory species of Wild Animals (the Bonn Convention).
- The Convention on Biological Diversity which was signed by 150 government leaders at the 1992 Rio Earth Summit and is dedicated to promoting sustainable development.

1.4.2 National

- *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, and ecological communities, including Ramsar sites.
- *Australia's Biodiversity Conservation Strategy 2010-2030* - a national policy document that will guide how governments, the community, industry and scientists manage and protect Australia's plants, animals and ecosystems over the next 20 years.
- *Australian Heritage Council Act 2003* - provides protection for places of National significance placed on the Register of the National Estate.

1.4.3 NSW legislation and policies

- *NSW National Parks and Wildlife Act 1974* – delineates responsibilities for the care, control and management of national parks, historic sites, nature reserves, Aboriginal areas and state conservation areas, including the development of management plans. This legislation also governs responsibilities for the protection and care of native flora and fauna and Aboriginal places and objects throughout NSW.
- *Threatened Species Conservation Act 1995* – provides for the conservation of threatened species, populations and ecological communities of plants and animals. It sets out processes of identification, classification and management through the preparation of recovery plans and abatement of key threatening processes.
- *Catchment Management Authorities Act 2003* – establishes Catchment Management Authorities and their natural resource management functions including natural resource planning and decision-making at a local and catchment-wide level in line with state concerns and standards.
- *NSW Wetlands Policy* - promotes sustainable conservation, management and wise use of wetlands in NSW by providing a set of guiding principles that government agencies will adopt and stakeholders can refer to when making decisions on wetland management and conservation.
- *Environmental Planning and Assessment Act 1979* – concerns the conservation and protection of natural areas through ecologically sustainable planning and development.
- *Noxious Weeds Act 1993* – provides for the identification, classification and control of noxious weeds. It defines the roles of government, councils, private landholders and public authorities in the management of noxious weeds. The Act sets up categorisation and control actions for the various noxious weeds, according to their potential to cause harm to the environment.

1.4.4 Regional plans and strategies

- LLNR Ramsar site Plan of Management, 1998, NSW National Parks and Wildlife Service.
- New England Weeds Authority Management Plans.
- Northern Rivers Regional Biodiversity Management Plan, National Recovery Plan for the Northern Rivers Region, 2010, DECCW NSW.
- Northern Rivers Catchment Action Plan, Northern Rivers Catchment Management Authority.

2. Site Description

2.1 Site location

The LLNR Ramsar site is located between Armidale and Glen Innes on the New England Tablelands in north-eastern NSW, Australia, and is situated approximately 18 kilometres north-east of the small town of Guyra and 5 kilometres east of the New England Highway (see Figure 2.1).

The Ramsar site boundary follows the boundary of the gazetted Little Llangothlin Nature Reserve. The gazetted area of the LLNR is 257.6 hectares (NSW Govt. 1979). It contains all of Little Llangothlin Lagoon and almost half of Billy Bung Lagoon as well as a large part of the catchments of both lakes (see Figure 2.2). LLNR Ramsar site is square in shape, positioned approximately 10 degrees clockwise from north. The boundary of the Ramsar site is situated about 200-300 metres from the outermost points of Little Llangothlin Lagoon on each side. The southern portion of the western boundary intersects Billy Bung Lagoon across the middle of the lake as shown in the map at Figure 2.2.

2.2 Little Llangothlin Nature Reserve Ramsar site

The Little LLNR Ramsar site was designated a Wetland of International Importance in 1996. The following criteria supported this listing: it contained a near-natural example of a lake within the New England Tablelands (namely Little Llangothlin Lagoon), its value as a drought refuge to waterbirds, and the provision of habitat for nationally threatened species such as the yellow-spotted bell frog (*Litoria castanea)*.

The New England Tablelands' of north-east New South Wales, in which LLNR Ramsar site is located, is the second highest land region of Australia (Haworth 1998), forming part of the Great Dividing Range of eastern Australia. The site has an elevation above 1 355 metres Australian Height Datum (AHD) (Haworth 1994) and probably extends to nearly 1 400 metres AHD at the highest point. The New England Tablelands geology is comprised primarily of granite, overlain by basalt flows which have been heavily eroded. The only extensive basalt areas that are found at the surface of the New England Tablelands occur around Guyra including in the vicinity of LLNR Ramsar site (DECCW 2010c). These basalt flows altered historical drainage patterns, resulting in the formation of small lakes and wetlands.

The two main wetlands which occur within the Ramsar site, Little Llangothlin Lagoon and Billy Bung Lagoon, are upland lakes on the plateau of the New England Tablelands. Although they are locally known as 'lagoons', they will be referred to as lakes throughout this document.

The New England Tablelands lake system extends over 100 kilometres along the Great Dividing Range and includes 57 lakes and swamp depressions (Bell et al. 2008). The majority of these have been highly modified through historical and recent land use and the lake wetlands of the New England Tablelands constitute a threatened ecological community (TEC). LLNR Ramsar site completely contains Little Llangothlin Lagoon, which is one of the few that remains relatively intact and protected by the *National Parks and Wildlife Act 1974*.

Little Llangothlin Lagoon is a permanent lake of approximately 105 hectares in size and 2 metres in depth, one of the largest and deepest lakes within the New England Tablelands lakes system which enables it to contain water in almost all years except during extreme droughts. Its size and depth and its consequent ability to provide a relatively permanent water source makes it a valuable drought refuge for waterbirds. It also provides habitat for the nationally endangered Australasian bittern (*Botaurus poiciloptilus)* and various species listed on international migratory bird agreements. Blue-billed duck (*Oxyura australis)*, and black swan (*Cygnus atratus)*, also occur in large numbers and breed in the reserve (J. Clifton-Everest, Pers. Comm. 2011).

LLNR Ramsar site also contains a portion, approximately 7.7 hectares, of the intermittent 17 hectare Billy Bung Lagoon (see Figure 2.2). Billy Bung Lagoon is situated approximately 300 metres south-west of Little Llangothlin Lagoon and its bed is approximately 8 metres higher. It is around 0.8 metres deep when full and drains north into the inflow channel to Little Llangothlin Lagoon.

Land near the lakes was previously partially cleared and used for agriculture, however since gazettal as a nature reserve and the removal of grazing, some of the native vegetation has re-established. The central portion of Little Llangothlin Lagoon is occupied by tall spikerush sedgeland, open water, and submerged and emergent aquatic plants. The edges are surrounded by herbfield and *Carex* fen communities. Billy Bung Lagoon seldom has open water but also supports sedgeland, herbfield and fen communities. Remnant eucalypt communities including the TEC 'New England peppermint (*Eucalyptus nova-anglica)* grassy woodlands' also occur on higher ground adjoining the lakes. The site contains a population of the nationally threatened terrestrial herb Austral toadflax (*Thesium australe*). Aquatic vegetation also provides habitat for various waterbirds, and potentially for the nationally threatened yellow-spotted bell frog which has not been recorded at the site since the 1970s and is probably now locally extinct.

Sedimentation of these lakes increased in response to European settlement during the 1800s which caused disturbance to the catchment through land clearing and cattle and sheep grazing. Although sedimentation has now slowed, it remains one of the key threats to the Ramsar site. Invasive plants and animals, climate change and altered hydrology are also current or potential threats to the ecological character of the site.

Little Llangothlin Lagoon (Photo: A. Cibilic)

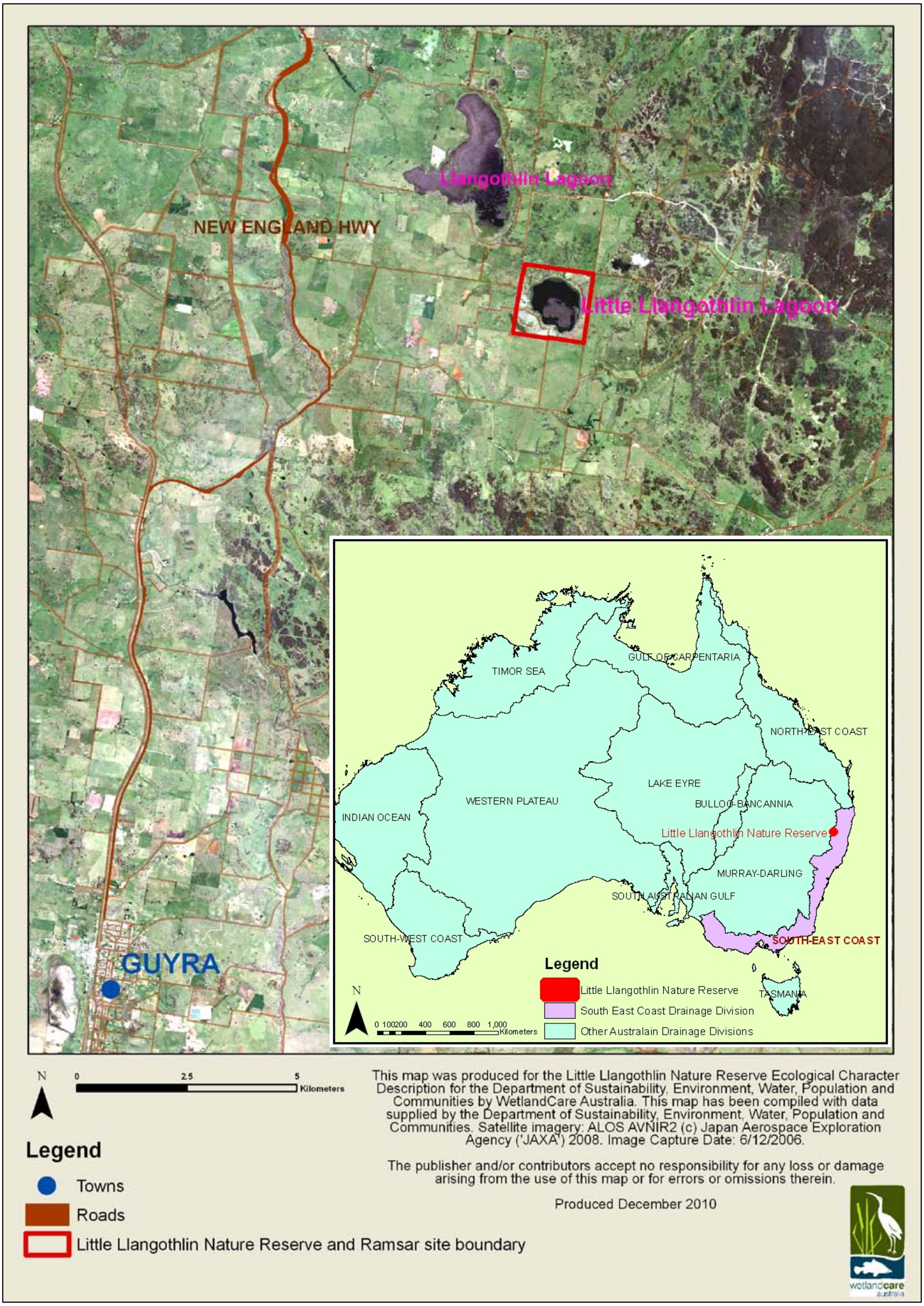


Figure 2.1 Location of Little Llangothlin Nature Reserve, in relation to local area and drainage division (inset)

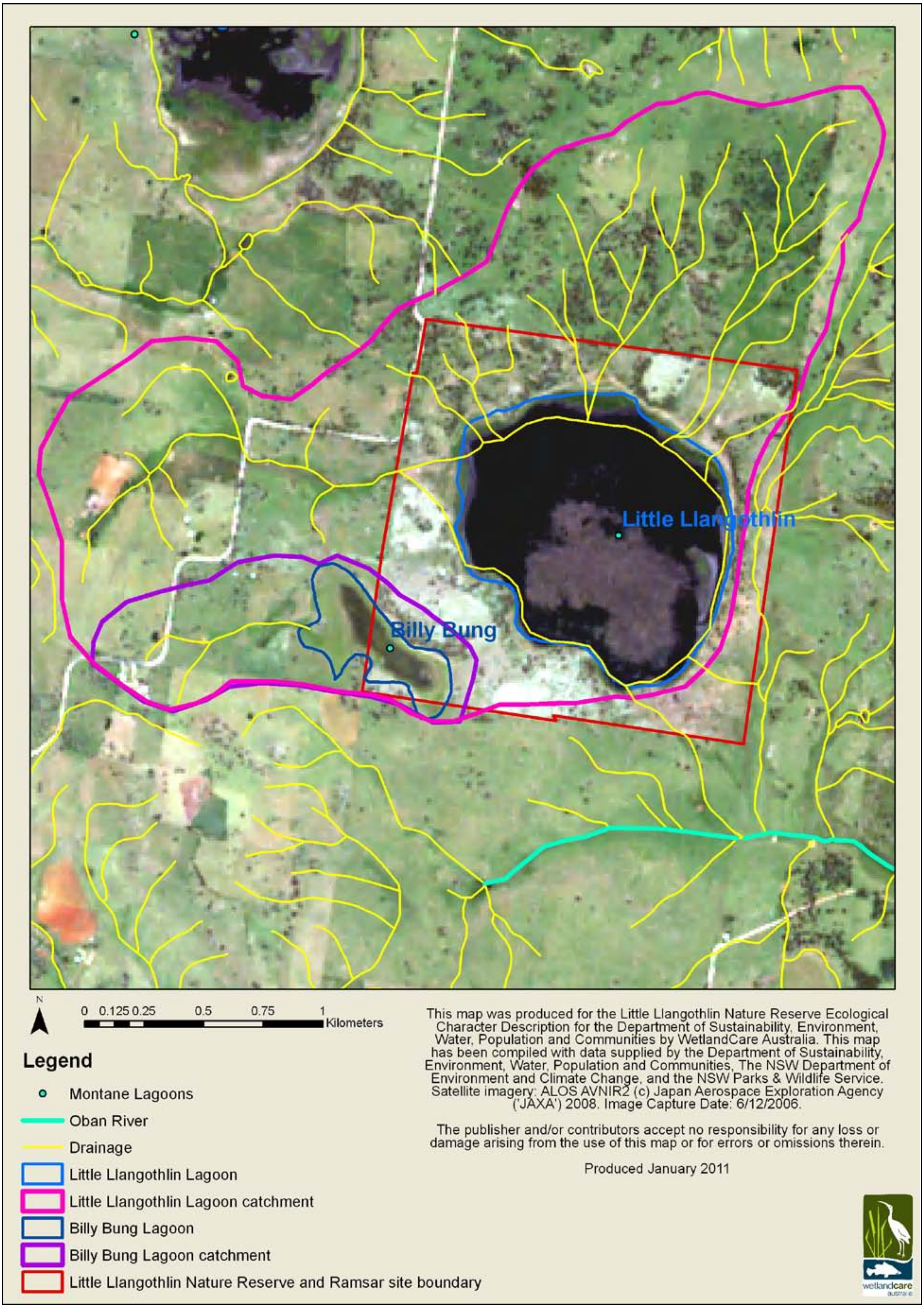


Figure 2.2 Little Llangothlin Nature Reserve showing lake basins, catchments and drainage

2.3 Drainage division

LLNR Ramsar site is located in the Clarence Basin within the South-East Coast Drainage Division according to the Australian Drainage Divisions System (Figure 2.1).

The South-East Coast Drainage Division occupies 264 003 square kilometres, incorporating the long narrow strip of coastal south-east Australia between the Great Dividing Range and the sea. While the southern, eastern and western boundaries are clearly defined by geography, the northern boundary is arbitrarily defined as the New South Wales - Queensland border. The drainage division extends south from the border and includes all of coastal New South Wales, all of coastal Victoria and a small part of south-eastern South Australia.

This South-East Coast Drainage Division comprises less than 4 per cent of the total area of Australia yet supports a human population of over 10 050 000, almost half that of the whole of Australia. Pasture is the primary land use within the drainage division with large areas of remaining forest and woodland.

2.4 Catchment

LLNR Ramsar site is situated about 14 kilometres east of the Great Divide within the Tubbamurra sub-catchment near the headwaters of the Oban River, a tributary of the Clarence River, in the south-west corner of the 22 300 square kilometre Clarence River catchment.

The local catchment of the two lakes in LLNR Ramsar site is essentially a 568 hectare closed basin located on the tableland, as no flows arrive from upstream and discharge into the Oban River occurs only periodically when Little Llangothlin Lagoon overflows (Figure 2.2).

Billy Bung Lagoon covers about 17 hectares and has a catchment of about 74 hectares. Little Llangothlin Lagoon covers about 105 hectares with a catchment of about 568 hectares (catchment areas include the lakes themselves). About 226 hectares (40 per cent) of the local catchment falls within the LLNR Ramsar site (see Figure 2.2).

During periods of high rainfall, Billy Bung Lagoon spills into Little Llangothlin Lagoon. When Little Llangothlin Lagoon overflows, it drains from the outflow in the south-eastern corner into the headwaters of the Oban River, which eventually discharges to the Pacific Ocean via the Clarence River.

2.5 Land tenure and management framework

The Little Llangothlin Nature Reserve was established in 1979 under the *NSW National Parks and Wildlife Act 1974*. The boundary of the nature reserve also forms the boundary of the LLNR Ramsar site (see Figure 2.2). The Office of Environment and Heritage, through the NSW National Parks and Wildlife Service, is responsible for the management of the LLNR and Ramsar site.

Under the *NSW National Parks and Wildlife Act 1974*, the LLNR is reserved for the purpose of protecting and conserving areas containing outstanding, unique or representative ecosystems, species, communities or natural phenomena. The NSW National Parks and Wildlife Service is required to manage the site in accordance with the following principles:

- the conservation of biodiversity, the maintenance of ecosystem function, the protection of geological and geomorphological features and natural phenomena
- the conservation of places, objects, features and landscapes of cultural value
- the promotion of public appreciation, enjoyment and understanding of the nature reserve's natural and cultural values
- the provision for appropriate research and monitoring.

As per the *NSW National Parks and Wildlife Act 1974*, a Plan of Management has been prepared for the site which outlines how the management principles will be met, including weed and feral animal control, revegetation and recreation facilities.

2.6 Wetland types

According to the Ramsar Classification System there are four wetland types within the LLNR Ramsar site. All of these fall within the inland wetlands' group.

Category O: Permanent freshwater lakes (over 8 hectares) - Little Llangothlin Lagoon. Although the water level at Little Llangothlin Lagoon fluctuates, it rarely dries out completely. It has retained water in the deepest pools even throughout major droughts in the past century (Haworth 1994). The surface area of this wetland varies seasonally with changing water levels from about 100 hectares during average conditions to a maximum of perhaps 120 hectares during extreme floods (See Figure 2.3 and 2.7).

Figure 2.3 Little Llangothlin Lagoon, a permanent lake over 8 hectares (Photo: A. Cibilic)

Category P: Seasonal/intermittent freshwater lakes (over 8 hectares) - Billy Bung Lagoon. Billy Bung Lagoon is much shallower than Little Llangothlin Lagoon (maximum depth 0.8 metres) and is a temporary lake which periodically dries out. The total size of Billy Bung Lagoon is approximately 17 hectares, however the boundary of the LLNR Ramsar site intersects the middle of the lake and only about 7.7 hectares occurs within the LLNR (See Figure 2.4 and 2.7).

Figure 2.4 Billy Bung Lagoon, an intermittent lake over 8 hectares (Photo: A. Cibilic)

Category U: Non-forested peatlands - fens.
A 7.9 hectare *Carex* fen has been identified in the drainage line of the inlet watercourse on the western side of Little Llangothlin Lagoon (Hunter and Bell 2009) (see Figure 2.5 and 2.7). The outflow, other drainage lines and lake margins also support additional *Carex* fen vegetation. Hunter (2011) reported that a total of about 16 hectares of this wetland type occurs within LLNR. *Carex* fen has recently been assessed as rare in NSW, and was recently listed as an endangered ecological community under the NSW *Threatened Species Conservation Act 1995*.

Figure 2.5 Non-forested peatland (*Carex* fen) in the watercourse to Little Llangothlin Lagoon (Photo: A. Cibilic)

Category Y: Freshwater springs.
There is evidence (e.g. Haworth 1994, Bell and Clarke 2004) of minor occurrences of freshwater springs (estimated total area < 0.1 hectare). These are found at seepage points to the south-west and north of Little Llangothlin Lagoon and on the slopes to the east of Billy Bung Lagoon, probably arising from local catchment groundwater (see Figure 2.6). The small springs, which have not been mapped, support a range of wetland plants. The existence of basalt aquifers regionally also has the potential to support small spring-fed wetlands at the site.

Figure 2.6 Groundwater dependent wetland above Billy Bung Lagoon (Photo: A. Cibilic)

Knowledge gap
- distribution, hydrology and ecology of freshwater spring wetlands

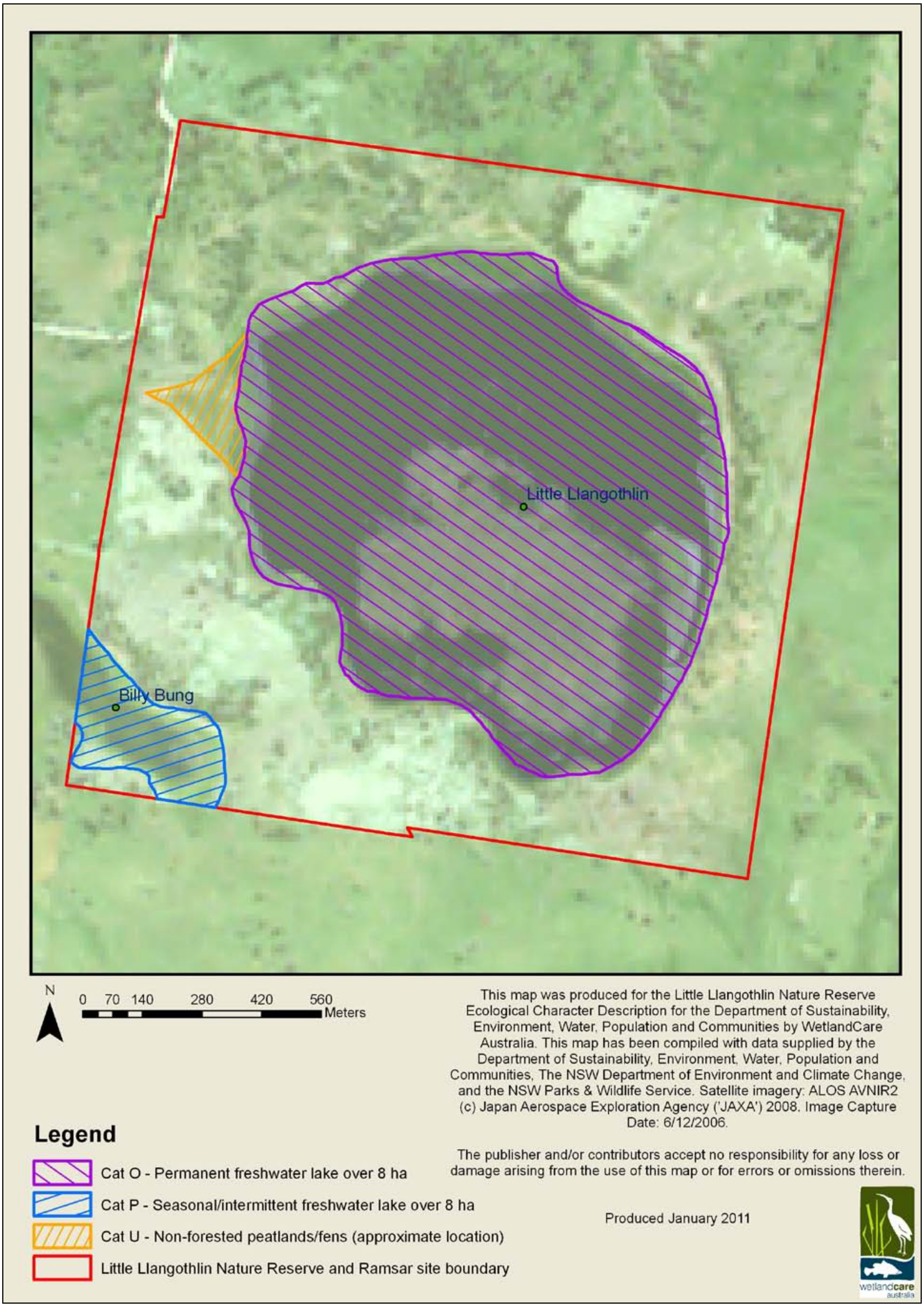


Figure 2.7 Wetland types at LLNR Ramsar site (Category Y Freshwater Springs have not been mapped)

2.7 Ramsar criteria

At the time of listing, in 1996, there were 13 criteria against which a wetland could qualify for Ramsar listing. The most recent revision of these criteria occurred in 2005.

2.7.1 Ramsar criteria met at the time of listing (pre-1999)

At the time of listing LLNR Ramsar site fulfilled former Ramsar criteria 1(a), 2(a) and 2(c). The RIS from the time of original listing does not give an explicit justification for listing, however the information provided within the body of the RIS (abridged below) gives an indication of the reasons for listing:

> 'The (LLNR) contains one of the few high altitude freshwater lagoons remaining on basalt soil on the New England Plateau of New South Wales … (and) is part of the larger New England Lagoons system which includes 29 lagoons and swamp depressions … (It) is a significant wetland providing a range of habitats for waterfowl and other fauna, and is particularly important as providing a drought refuge for waterbirds … The LLNR regularly supports large numbers of waterbirds and waders including ducks, swans, coots, moorhens, ibis, egrets, terns, stilts, and plovers ... some of these species breed in the LLNR along with the White-breasted Sea Eagle … (It) also provides habitats to support vulnerable and rare species such as … the Blue-billed Duck … LLNR provides habitats for many species of frogs including rare species. LLNR provides potential habitat for the rare New England (yellow spotted) Bell Frog … that is restricted to the New England Tablelands. Both lagoons contain the only known location of the genus *Rhabdocoel*, a planktonic flatworm, and the copepod crustacean *Ectocyclops rubescens* … (and contains) *Boeckella major* (at the northern limit of its range), *B. montana*, *Lynceus macleayana*, and ostracod species in either LLL and BBL or both. LLNR is one of the few areas containing wetland vegetation of the New England Tablelands, therefore, plant communities contained within the LLNR are regionally significant … The rare plant …*Thesium australe* occur(s) in LLNR …(and) is inadequately conserved in existing National Parks and Wildlife Service estate, especially on the Tablelands, increasing the significance of the LLL population …' (NSW NPWS 1996).

2.7.2 Ramsar criteria currently met (using post-2005 criteria)

The Ramsar criteria for identifying Wetlands of International Importance were revised in 2005 and additional information has become available since the site was designated as a Ramsar site in 1996. The following assessment of the Ramsar criteria fulfilled by the site at the time of writing takes into account the revised criteria and additional information.

Those criteria met by the LLNR Ramsar site at the time of listing equate to current criteria 1, 2 and 4. At the time of writing all three of these criteria continue to be met as detailed below. The site meets no further criteria than when initially listed.

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.

Little Llangothlin Lagoon and Billy Bung Lagoon are part of the larger New England Lagoons system which includes 57 lakes and swamp depressions extending along 100 kilometres of the Great Dividing Range. Only 39 of these lakes and swamp depressions occur within the South-East Coast Drainage Division (Haworth 1998). At 105 hectares, Little Llangothlin Lagoon is one of the largest examples of these high altitude lakes. It is also rare due to its near-natural condition, as the majority of the lakes have been severely degraded through hydrological modification, grazing and cropping. LLNR Ramsar site is one of only two reserves in the New England Tablelands which contain examples of these lakes, and which are protected under the *National Parks and Wildlife Act 1974.*

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

The following are supported at the LLNR Ramsar site:

- The two lakes at the site constitute examples of the national TEC 'upland wetlands of the New England Tablelands and the Monaro Plateau'.
- The site contains patches of 'New England peppermint (*Eucalyptus nova-anglica*) grassy woodlands', a national TEC.
- The nationally vulnerable plant species Austral toadflax (*Thesium australe*) occurs within the Ramsar site. This terrestrial species occurs in grassland or grassy woodlands, particularly in damp sites, and in association with kangaroo grass (*Themeda australis*) which it parasitizes.
- The nationally endangered Australasian bittern (*Botaurus poiciloptilus*) has been recorded at the site but the importance of the site for the conservation of this species is yet to be clarified.

At the time of Ramsar designation the nationally endangered yellow-spotted bell frog (*Litoria castanea*) was presumed to occur at the site, however no individuals have been recorded since the 1970s. As it is now considered to be locally extinct this species no longer provides evidence in support of Criterion 2.

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.

LLNR Ramsar site provides a habitat refuge for numerous species of waterbird which increase significantly in number at Little Llangothlin Lagoon during times of drought (White 1987). Particularly significant differences in numbers have been recorded for Pacific black duck (*Anas superciliosa*), grey teal (*Anas gracilis*), Australasian shoveler (*Anas rhyncotis*), Eurasian coot (*Fulica atra*) and white-faced heron (*Egretta novaehollandiae*). Protection of the site as a nature reserve increases its drought refuge significance as alternative habitat at relatively nearby coastal wetlands continues to be pressured by ongoing coastal development. The site also supports eight internationally listed migratory waterbird species.

Waterbird habitat at LLNR (Photo: A. Cibilic)

3. Ecosystem components and processes

Ecosystem components are the tangible physical, biological and chemical entities that comprise the wetland (including factors such as the physical size and shape of the wetland, wetland communities, species and genes, soil, water quality, and chemical compounds), whereas the ecosystem processes are the dynamic forces which contribute to the functioning of the wetland (including physical, chemical and biological actions such as reproduction, predation, decomposition, erosion, nutrient and carbon cycling, evaporation, and hydrology) (DEWHA 2008a). Ecosystem components and processes are two important aspects that contribute to a site's ecological character.

This ECD aims to describe the ecological character of the site at the time it was designated as a Ramsar site in 1996. Limited or no data exists for some components or processes at that time, and in those instances older or more recent data which assists in describing or understanding the ecological character of the site has been included.

3.1 Geomorphology

Geomorphology is concerned with understanding landforms and landscapes over the macro-timescale of millions of years to the micro-timescale of seasons and years (Short and Blair 1986, Ch. 1).

The New England Tablelands of north-east New South Wales, in which LLNR Ramsar site is located, is the second highest land region of Australia (Haworth 1998, 1) forming part of the Great Dividing Range of eastern Australia. The Guyra-Glen Innes area is the highest part of this tableland, with elevations generally between 700 and 1 500 metres (NSW NPWS 2003, 162), while Little Llangothlin Lagoon has an elevation of 1 355 metres (Haworth 1994, 29).

3.1.1 Geology

The tableland geology is largely based on marine sedimentation interspersed with periods of volcanism and terrestrial sedimentation, extending from around 444 to 251 million years ago (Packham 1969, p3), while the main period of orogeny or uplift which formed the Great Dividing Range occurred from around 90 million years ago (NSW Department of Primary Industries 2010).

This New England Fold Belt or orogen includes a major plutonic province where magma cooled slowly beneath the surface to form large-grained rocks (mainly granite), and extrusive volcanic rocks such as basalt (which cooled quickly and has small mineral crystals) of similar age and composition also formed. More recent basalt flows dating from the Tertiary period or 43 to 17 million years ago also formed in the region (Anon 1999, pp 4, 11).

The New England granites, exposed after kilometres of surface sediments were removed, represent one of the most significant granitic outcrops in Australia (Hunter and Clarke 1998). The granite immediately to the east of LLNR Ramsar site was identified as Wards Mistake Adamellite with a radiometric age, estimated in 1967, of 244 million years (Binns et al. 1967), and is considered one of several similar granites in the Uralla Supersuite (Bryant et al. 2004, p 30, 45).

The granites and folded strata (meta-sediments), the most common rocks on the New England Tablelands, are overlain by a series of more recent basalt flows which have been heavily eroded. The only extensive basalt areas that are found at the surface occur around Guyra including in the vicinity of LLNR Ramsar site (DECCW 2010c). These basalt flows altered historical drainage patterns, resulting in the formation of small lakes and wetlands, particularly around Guyra (DECCW 2010c).

LLNR Ramsar site is located on the eastern boundary of basalt flows from Ben Lomond with adamellite granite suspected to underlie the lunette and eastern margin of Little Llangothlin Lagoon, whereas Billy Bung Lagoon and the majority of the local catchment of both lakes is basalt-derived, as shown in Figure 3.1 (Haworth 1994).

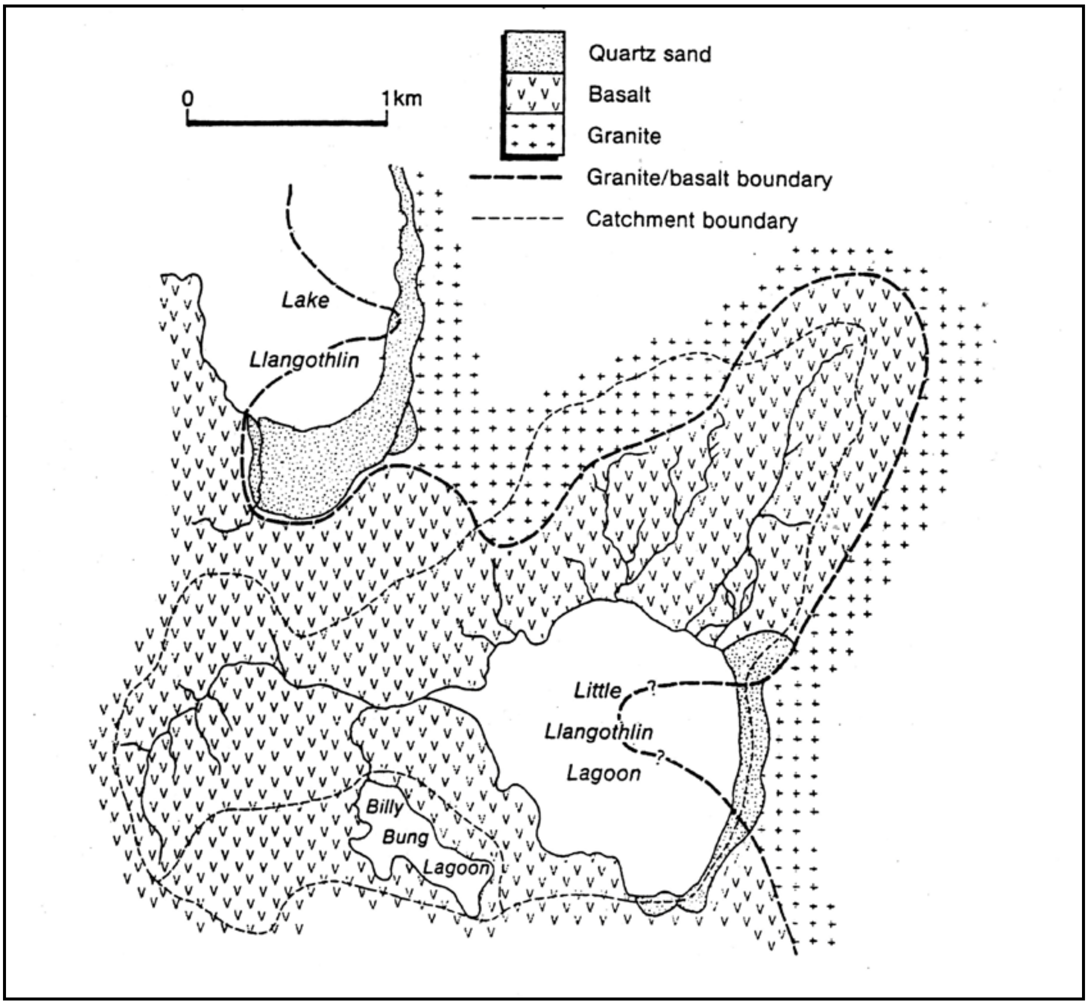


Figure 3.1 Underlying catchment geology of Little Llangothlin Lagoon catchment (Haworth 1994)

3.1.2 Lake morphology

Little Llangothlin Lagoon and Billy Bung Lagoon are upland lakes on the plateau of the New England Tablelands, however they are locally and erroneously known as lagoons.

These two lakes form part of a series of eight lakes in the near vicinity which are sometimes referred to as the Llangothlin Lagoons (Haworth 1994). These and most other upland lakes on the New England Tablelands were probably formed by the conjunction of several factors (Walker 1977):

- The development of drainage lines that intersected resistant laterite or silcrete bodies exhumed from beneath a younger basalt cover. As the basalt weathered away, the erosion-resistant laterite and silcrete formed barriers to drainage and allowed unconsolidated sediments to accumulate against them.
- The persistence of these structures as a result of their occurrence close to the topographic divide and resulting small catchments with correspondingly small runoff.
- The drainage lines becoming outlet sills for lake depressions which developed under Pleistocene conditions (over the last 2 million years) which favoured lake-bed deflation and aelioan lunette formation. The lunettes blocked the drainage lines and raised the outlet sill of each lake.
- Restricted rates of run-off and sediment yield that contributed to long-term lake survival.

Little Llangothlin Lagoon is ovoid in shape, and the eastern and south-eastern boundaries are constrained by a crescent-shaped lunette approximately 1 kilometre long, with a smaller, older, mainly clay lunette at its southern end (Haworth 1994, 155). The large lunette is comprised of sand (41 per cent by weight), clay (51 per cent), and silt (eight per cent) (Walker 1977) and it is likely that granite has contributed the quartz sand in the lunette (Haworth 1994).

Haworth (1994, 155) determined the pre-1800 bathymetry of Little Llangothlin Lagoon and sedimentation rates (p 76) which together indicate that the deepest section was around 1.2 metres at the time of research (also Haworth 1994, 66), however Bell and Clarke (2004, 120) note that Little Llangothlin Lagoon has a maximum depth of about 2 metres, and this latter figure is likely to be more accurate.

In 1975 Briggs (1976, 90) completed vegetation mapping of this lake and noted the usual water depth associated with the different vegetation communities (see section 3.5). This research was undertaken prior to the decommissioning of the discharge drain in 1989 (see section 3.2 for further detail on the drain), and therefore depths shown at Figure 3.6 have been adjusted to account for the 1 metre increase in water depth that occurred after the outlet drain was filled in. As a result of the drain in-filling the area of the lake increased by around 20 or more hectares, however this additional area (mainly across the northern half) is not shown in the figure.

Billy Bung Lagoon is located approximately 300 metres south-west of Little Llangothlin Lagoon and its bed is about 8 metres higher than Little Llangothlin Lagoon (Bell et al. 2008, 478). Its formation is likely to be similar to that of Little Llangothlin Lagoon as it lies wholly on basalt (Walker 1977).

Billy Bung Lagoon is 0.8 metres deep at its deepest (Bell and Clarke 2004, 120; Figure 3.8) and when full it covers about 17 hectares of which around 7.7 hectares occurs in the LLNR Ramsar site. Billy Bung Lagoon does not have a lunette and this lake drains to the north, into the main inflow watercourse into Little Llangothlin Lagoon – see Figure 2.2. Billy Bung Lagoon dries infrequently, about once every 20 years (Brock et al. 2005, 1379) and can best be described as intermittent. According to Bell et al. (2008, 478), it has never been drained. Brock et al. (2005, 1379) report that the water level was lowered in the early 1900s and restored by 0.6 metres in 1990, however this is unlikely to be the case and most likely refers to Little Llangothlin Lagoon (see Brock et al. 1999, 42).

3.1.3 Soils

Soils at the site have not been comprehensively described, however those at Dangars Lagoon near Uralla (71 kilometres from LLNR) have been described in detail including 3 type profiles, and these are probably representative of other lacustrine soils on the New England Tablelands (D. King, DECCW, Pers. Comm. 2010). The soils include deep to very deep (> 1 metre), poorly drained Sodic and Eutrophic Sodosolic and Dermosolic Oxyaquic Hydrosols (Grey Clays) in lake centres and margins, and Haplic Eutrophic Brown Kandosols (affinity with Brown Earths) in some lake margins (King 2009, 135).

The dominant factor influencing soil formation on the New England Tablelands is parent rock type, although topography and rainfall have important secondary effects. The basalt rocks develop fertile, shallow (< 1.5 metres), brown soils, with high clay content but good permeability as a result of the generally strong soil structure, whereas the granites and sedimentary rocks develop more strongly leached duplex podsolic and solodic soils of lower fertility with a sandy surface layer overlying a hard, clayey subsoil (Banens 1987).

Rock pile at LLNR (Photo: A. Cibilic)

Basalt soils occur on the plateaus and gentle slopes of the Little Llangothlin Lagoon catchment, and have generally been cleared and used for agriculture. Granite soils are not usually cultivated, are often skeletal except on the flat granite upland at the north of the catchment, and tend to be relatively shallow. Since European settlement the most fertile basalt soils have been used for cropping (Haworth 1994). Some basalt soils contain basalt floaters or stones (Banens 1987), and these are evidenced in the rock piles adjoining many agricultural paddocks, including in and adjoining LLNR Ramsar site.

Haworth (1994, 67-68) describes three topographic zones in the catchment:

1. Sedge-covered (i.e. regularly waterlogged) hollows and valleys with gleyed soils sometimes overlain with alluvium containing a high proportion of organic matter
2. Flat uplands usually developed on residual basalt flows (excluding the granite upland in the north-west)
3. Stony basalt rises, including the lake banks, that separate the hollows from the uplands.

Peat also accumulates in some areas, such as in hollows at the basalt-granite interface. The lowest elevation areas demonstrate complicated stratigraphies with interfingering of sand in the gleyed soils, possibly representing alternating episodes of aeolian deposition and pedogenesis, and with secondary precipitation of mobile elements such as iron and magnesium (Haworth 1994, p 68). Silcrete and ferricrete are present at the granite-basalt interface at Little Llangothlin Lagoon and both have been considered as principal agents of upland lake formation, due to their ability to form barriers that can block drainage (Haworth 1994).

Land use has an influence on soil properties, with the upper 20 to 30 centimetres of basaltic woodland soils in the region showing higher pH, carbon and nitrogen and lower bulk density with better porosity than soils under natural or improved pasture. Improved pasture soils also demonstrate significantly more acidity in the surface layers than soils for all other land uses (Wilson et al. 2010).

Soils from different vegetation communities in and adjoining Little Llangothlin Lagoon sampled at depths of 5-15 centimetres and 15-25 centimetres showed that the percentage of organic carbon (oven dry weight) varied from 2.7 per cent to 7.2 per cent (average of 5.24 per cent), with higher figures generally related to the biomass of the vegetation communities (Briggs 1976, 72). Organic matter contains about 57 per cent organic carbon (Briggs 1976, 73), and accumulation of organic matter is one of the indicators of wetland soils (Department of Environment and Resource Management 2010).

Haworth estimated organic matter content of sediments in Little Llangothlin Lagoon by loss of weight on ignition, and found results of 40-60 per cent organic matter within the top 20 centimetres and as high as 74 per cent prior to European occupation (Haworth 1994, 90). The organic matter accumulation was sufficient to allow a peat fire to develop in 1928 at one site near the lake (Haworth 1994, 95).

Soil results are shown at Table 3.1. These are within the expected ranges (Briggs 1976, 74), and contribute to baseline soil data for Little Llangothlin Lagoon soils.

Table 3.1 Soil test results for a grass-sedge swamp soil (adapted from Briggs 1976, 69-70)

Factor		Grass-sedge swamp soil 5-15 cm	Grass-sedge swamp soil 15-25 cm
Water depth		4 cm	4 cm
Organic carbon g/100g oven dry soil		3.0	2.5
Available $PO4^-$ P mg/g oven dry soil		8.9	4.8
$NO3^-$ N ppm		1	1
Exchangeable cations ppm oven dry soil	Na	36.8	34.5
	K	105.3	58.5
	Mg	850.8	1 094.4
	Ca	1 964	2 338
pH		5.4	6.4

3.1.4 Lake bed sediment

Haworth (1998, 4) reports that radiocarbon dating of the peat in lake sediment from the New England Tablelands indicates that the present cycle of sedimentation commenced about 15 000 years ago at the close of the last Ice Age, with lake basin deposition and deflation (from wind erosion) cycles likely to occur over tens of thousands of years. Tertiary period coal deposits have been found approximately 30 metres below the surface in the same locality as some lakes suggesting that similar lakes may have existed for at least 20 million years.

The geochemical conditions at Little Llangothlin Lagoon have been described as stable for millennia prior to the arrival of Europeans (Gale et al. 2004, 155). This is demonstrated by the absence of deltaic deposition at the main western inflow watercourse prior to about 1800 which is indicative of a low rate of sedimentation prior to European settlement. However, over a 25 year period following settlement and the associated land clearing and sheep and cattle grazing, rapid sediment deposition occurred producing a lake-wide sedimentation unit 0.15 to 1.00 metres deep (Haworth 1994, 293).

Sediment was deposited 1 metre deep near the western and northern inflow watercourses, with sediment 0.80 metres deep deposited near another smaller inflow watercourse in the north-east; overall more sediment was deposited in the north and west than in the south and south-east of the lake where the sediment was only 0.4 metres deep as shown in Figure 3.2. As a result, the maximum water depth of Little Llangohtlin Lagoon was reduced by around 0.5 metres.

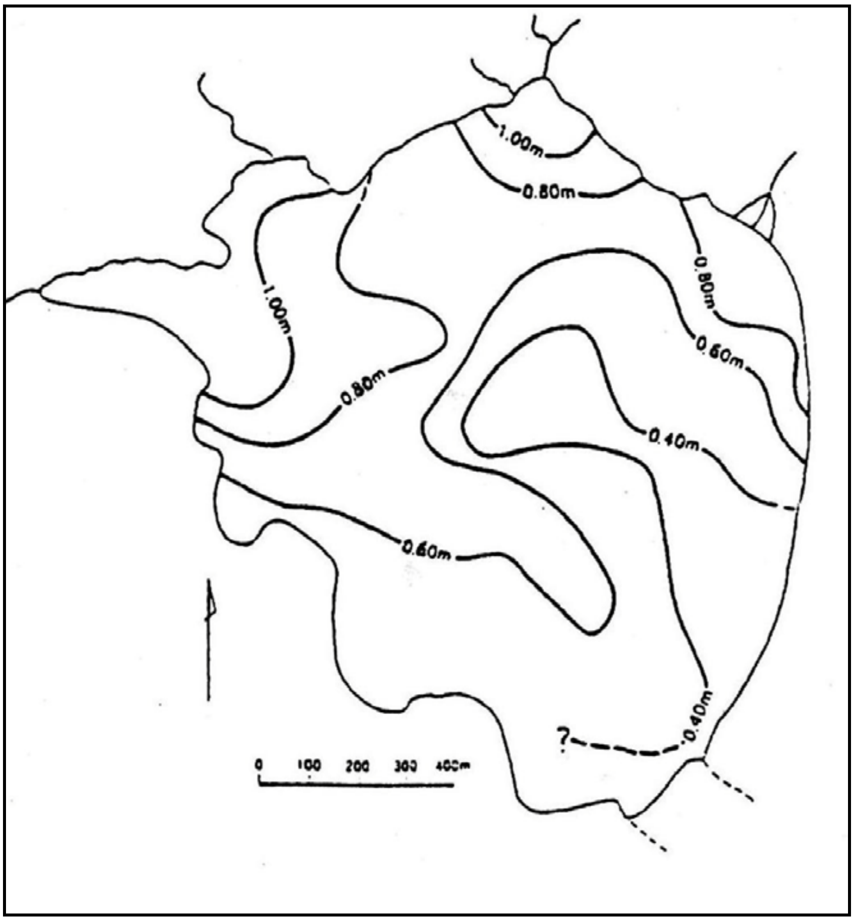


Figure 3.2 Vertical sediment accumulation from 1836 to 1989 (Haworth 1994, 76)

The catchment-wide loss of sediment from 1836 to 1861 was 1.40 kg/m^2/yr however in the subsequent period to 1989 this was reduced to 0.05 kg/m^2/yr (Haworth 1994, 108-109).

Comparisons of lakebed vertical sediment deposition rates are complicated by factors including compaction, environmental changes through time, and differences in organic content and deposition patterns, however the background average deposition rate through the late Pleistocene-early Holocene period was estimated to be 0.084 millimetres per year (Gale and Haworth 2002, 129). The results from one core at Little Llangothlin Lagoon (C 2.0 located adjoining the western inlet watercourse in the deltaic sedimentation plug) show that sediment accumulated on the lake bed at an average rate of around 4 millimetres per year from the late 1800s, compared with a rate of around 10 millimetres per year in the early to mid 1880s, with a maximum rate between 1836 to 1861 of around 24 millimetres per year (Haworth 1994, 83, 93). In more recent times, the sedimentation rate from 1945 to 1960 was found to be 2.7 millimetres per year, and from 1960 to 1989 it had increased to 9.7 millimetres per year (Haworth 1994, 83, 93).

These and other rates in Haworth (1994) and Gale and Haworth (2002) could serve as baseline for any future assessments or monitoring of sediment rates and indicate that sediment deposition rates prior to the time of Ramsar designation were up to 100 times the long-term background rate.

Knowledge gaps

- lakebed bathymetry for both lakes
- current sedimentation rate

3.2 Hydrology

Hydrology plays a significant role in the ecology of the LLNR Ramsar site, both in relation to the two lakes and other wetlands, and also in supporting terrestrial flora and fauna that contribute to the ecological character. Site hydrology is driven by climate, topography, land forms, and geology and is also influenced by human activities.

3.2.1 Surface water

The site is located in the upper catchment of the eastern flowing Clarence River (via the Oban River) about 14 kilometres east of the topographic divide (near Ben Lomond). The local subcatchment of LLNR Ramsar site is essentially a small closed basin, as no inflows originate from upstream, and it also exhibits some of the characteristics of a sub-terminal lake system, as flows in the local catchment generally terminate in the two lakes with only occasional overflow into the Oban River.

Figure 2.2 shows the local catchment of the two lakes which have a combined catchment area of 568 hectares (including the area of the two lakes). The lakes are relatively large by Australian upland wetland standards and the ratio of catchment (excluding the lakes) to lake area is low at 4.4 for Little Llangothlin Lagoon and 3.4 for Billy Bung Lagoon.

The area of Little Llangothlin Lagoon has varied with seasonal and climatic conditions and the existence or absence of an outlet drain. Since decommissioning the discharge drain in 1989 the lake has varied between 100 and about 120 hectares except in extreme droughts.

The catchment of the intermittent Billy Bung Lagoon is 57 hectares, excluding the 17 hectare lake, with around 9.2 hectares of the catchment and 7.7 hectares of the lake within the LLNR Ramsar site.

In addition to a probable single natural outlet channel, the lunette at Little Llangothlin Lagoon was breached by a narrow agricultural drain of unknown depth around 1916 - 1920 (Haworth 1994, 125). This drain was deepened by a further 0.5 metres in 1945 (Briggs 1976, p 33). NSW NPWS dammed the drain in July 1989 which probably reinstated the historical water level, with the maximum water level rising approximately 1 metre (Brock et al. 1999).

There is no accurate long-term data on water level or depth in the two lakes to identify fine details of the water regime, however it is known that prior to in-filling the outlet drain the water level in Little Llangothlin Lagoon varied by around 1 metre between 1973 and 1975 (Briggs 1977, 305) and by around 0.4 metres from 1984 to 1989 (Haworth 1994). After the natural water level was reinstated the water level varied by 1 metre between 1994 and 1998 (D. Bell, UNE, Pers. Comm. 2011). Overall, lakes in the Guyra area tend to exhibit positive water balances under present climatic conditions, compared with many Australian water bodies (Haworth 1994, 35).

High intensity rainfall events that result in above average surface run-off from the small local catchments probably contribute the major inflows to the lakes. Low winter rainfall does not appear to result in a significant reduction in lake water levels, at least in part due to the low winter evaporation rates. Catchment soil moisture is also higher in winter for the same reason (Haworth 1994, 39).

Little Llangothlin Lagoon only dries out in extreme drought (Brock et al. 1999, 41). For example, in the dry of 1911, although the area of the lake was less, the lake retained an average depth of 0.6 metres and was 1.2 metres in the deepest pool in the south (Haworth 1994, 124). An assessment of the available information by Gale et al. (2004, 153) confirmed that Little Llangothlin Lagoon did dry out around 1980 to 1981 (although the bed remained moist), and that after the outlet drain was decommissioned in 1989 and lake levels returned to normal it retained water through the early years of the 1997-2010 drought, leading to the conclusion that the natural lake retained water even under severe drought.

No accurate flood records have been located, however Little Llangothlin Lagoon is known to have overflowed in 1974 (Briggs 1976, 40), 1990 (Haworth 1994, 125), and 2010-2011 (Figure 3.3) when it overflowed both at the natural outlet and also at the site of the in-filled drain. The authors also observed evident seepage through the sandy lunette.

Figure 3.3 Overflow at natural outlet, southern Little Llangothlin Lagoon, 2011 (Photo: A. Cibilic)

According to some reports, the constructed drain lowered the outlet sill by about 1 metre (Bell et al. 2008, 478, Hunter and Bell 2009, 60, Brock et al. 1999, 41) while Haworth (1994, 125) reported two reductions, one between 1916 and 1920 of unknown depth, and one in 1945 of 0.5 metres. The amount the maximum water level was increased with the decommissioning of the outlet drain in 1989 is also unclear, with one report of 0.6 metres (Brock et al. 1999, 42), however it is more likely to be closer to 1 metre (Brock et al. 1999, 41; Haworth 1994).

As a result of the large amount of sediment that accumulated after the 1830s, maximum water depth in Little Llangothlin Lagoon is still around 0.5 metres less than the depth prior to European settlement, even after the outlet level was raised by 1 metre to the natural level in 1989 (Haworth 1994, 125). The maximum depth of the lake is now around 2 metres (Bell and Clarke 2004, 120), although Haworth (1994, 66) reports a maximum depth post-1989 of 1.4m.

No water level records of Billy Bung Lagoon have been located, however it is reported to dry about every 20 years (Brock et al. 2005), and to overflow occasionally into Little Llangothlin Lagoon. The authors observed in January 2011 that the outflow appeared to result from seepage through the sill rather than over it. In 1898 Billy Bung Lagoon was reported to be a shallow lake, whereas by 1994 it was described as largely silted and weed-choked (Haworth 1994, 123) and in 1998 it was described as providing seasonal, ephemeral (wetland) habitat (Brock et al. 1998, 41, 42, 44). The current maximum depth is around 0.8 metres and it is reasonable to assume that this depth was greater prior to the sediment deposition that occurred after land clearing and grazing commenced in the 1830s.

3.2.2 Groundwater

No studies have focused on groundwater interactions at the site, however the underlying basalts of Tertiary origin in the New England Fold Belt are known from other locations to be fractured and therefore quite permeable (e.g. Mackney 1996, 35, Rančić 2009, 15).

Driller's logs from 11 bores greater than 10 metres depth within a 10 kilometre radius west and north of the site show that at every location basalt layers described as water-bearing, fractured, decomposed, broken, or porous, occur within 10m of the ground surface, and many sites have multiple basalt layers with similar description down to a depth of at least 93 metres (NSW Government website - http://nratlas.nsw.gov.au/wmc/custom/homepage/home.html).

Numerous soaks and springs can occur at the perimeter of remnant basalt outcrops (Mackeny 1996, 40), and seepage as a source of moisture has been noted for those lakes whose catchments include basalt slopes or lunettes (Bell et al. 2008, 483, 485). Seepages have been identified at the foot of the steep, basaltic, bluffs at the south-west of Little Llangothlin Lagoon which separates the two lakes (Haworth 1994, 66), however any subsurface connectivity from Billy Bung Lagoon to the lower elevation Little Llangothlin Lagoon, for example through fractures in the underlying basalt, is unknown. These soaks could result from local groundwater seepage or from an aquifer not connected with Billy Bung Lagoon. Wetland vegetation communities at the margins of the lakes are fed by seepage (Bell et al. 2008, 483).

In 2011 the authors observed a small, apparently groundwater-fed, wetland pool about 15m above the eastern side of Billy Bung lagoon (Figure 2.6) but which has been known to dry out (J. Kreis, NSW NPWS, Pers. Comm. 2011).

Groundwater flows are also evident along the northern shore of Little Llangothlin Lagoon, flowing over exposed granite rock on the hillslope, infiltrating the clayey basalt soils and reappearing as side bogs near the lake margin (R. Haworth, UNE (Retired), Pers. Comm. 2010.). The authors identified soaks in 2011 near the headwaters of two intermittent watercourses approximately 20 metres above the northern lake boundary with moist soils supporting wetland flora. Haworth (1994, 126) explained the positive water balance at Little Llangothlin Lagoon as at least partly due to the slow discharge of groundwater to the lake through the basalt.

3.2.3 Hydrology and land use

Historically, the sub-catchment hydrology has been affected by land-clearing and subsequent agricultural land use such as livestock grazing, cropping, and the introduction of improved pastures, all of which have altered the rainfall run-off and infiltration patterns (Haworth 1994, 124). From the 1960s improved pastures became widespread in the region and reportedly halved the runoff rate compared with native pasture on similar soil (Patterson and Perrens 1985). Hard-hoofed cattle and sheep, for example, are credited with causing soil compaction and increased rates of runoff (Haworth 1994, 123) with large herds of sheep and cattle evident by the mid 1800s (Haworth 1994, Gale and Pisanu 2001, 486). The periodic bulldozing of the western inlet watercourse, presumably to maintain agricultural drainage, has been reported (Haworth 1994, 153).

Little Llangothlin was declared a nature reserve in 1979 and cropping is presumed to have ceased at that time, while cattle were removed from the site in 1989 (Brock et al. 1999, 41, 42, 44, P. Croft, NSW NPWS, Pers. Comm. 2011)

Land clearing by ringbarking trees began in earnest in the 1870s, and this practice is credited with raising the groundwater level in the region and increasing the number of springs, even on previously waterless ridges (Haworth 1994, 124). The vast majority of the local catchment has been cleared for agriculture, with only a few stands of woodland and forest remaining, mainly on steep slopes and the granite ridge.

The more recent phenomena of Eucalypt dieback, prevalent in many areas of the New England Tablelands since the 1970s, is also likely to have contributed to a rise in the water table in badly affected areas. Dieback itself has been attributed, at least in part, to increased soil moisture resulting from agricultural and fire management practices (Jurskis and Turner 2002, 90, 95). Extensive dieback in the Little Llangothlin catchment since the 1960s may have contributed to increased groundwater discharge resulting from a raised water table (Haworth 1994, 126). However, given the small extent of forest in the local catchment (the majority was cleared for grazing), dieback is not expected to have contributed significantly to raising the water table.

Knowledge gaps

- long-term and seasonal patterns in area and depth of water in Billy Bung Lagoon and Little Llangothlin Lagoon
- groundwater significance including for lake recharge
- amount of direct aquifer discharge to and recharge from the lakes
- number and extent of groundwater springs including those that feed the lakes
- water balance for each lake

3.3 Climate

The climate of the New England Tablelands is cool temperate with more rain falling through the summer months to autumn. Thunderstorms often produce heavy falls of rain and occasionally hail, while snowfalls can occur from June until November, with heavy falls every three to five years. Annual rainfall is typically 700 to 900 millimetres, increasing with proximity to the eastern escarpment (DECCW 2010a, Appendix 9, 17).

LLNR Ramsar site, located about 30 kilometres west of the escarpment of the Great Dividing Range within the boundary of the eastern seaboard and about 14 kilometres east of the topographic divide and the boundary to the Murray Darling Basin, is affected by atmospheric patterns that drive the climate of both the eastern seaboard and inland south-eastern Australia. Climate at the site is affected by large-scale features of atmospheric circulation that influence weather patterns over both, such as the El Niño Southern Oscillation, the Indian Ocean Dipole, and East coast lows (which can cause heavy rainfall events along the east coast) (e.g. Nicholls 1997, Ummenhofer et al. 2009, CSIRO 2010, Wiles et al. 2009, Timbal 2010). Timbal (2010, 6) has noted the unique features of the climate of the eastern Australian seaboard including its difference from the climate of south-east Australia (including the Murray Darling Basin), and unlike for south-east Australia, the difficulty in relating its climate variability to large-scale atmospheric patterns such as the El Niño Southern Oscillation and the Indian Ocean Dipole.

The weather stations closest to the site are the post office at Guyra, about 18 kilometres south-west of the site at an elevation of 1 275 metres, and Glen Innes, about 40 kilometres north-north-west of the site at an elevation of 1 060 metres. Local weather is quite variable due to topography including proximity to the escarpment and neither of these sites accurately depict climatic features of LLNR Ramsar site which has an elevation above 1 355 metres, however together they provide the best available approximation.

The climate at LLNR Ramsar site is likely to differ from that at nearby weather stations as a result of:

- higher elevation which is likely to result in slightly lower winter minimum temperatures and increased frosts as a result of the adiabatic lapse rate, which varies between 0.98 degrees Celsius for dry air and 1.5 degrees Celsius for saturated air for every 100 metres of increased elevation (BoM 2010b)
- cold air drainage and potential temperature inversions as a result of local topography - Guyra is situated on the exposed top of a plateau with little surrounding higher land unlike LLNR Ramsar site which varies in height by around 50 metres, the lakes being the lowest locations in the immediate area and potentially subject to cold air drainage which may lower the minimum winter temperature resulting in more frequent frosts, especially in drainage lines and on the alluvial flats adjoining the lakes.

3.3.1 Rainfall

Large scale rainfall patterns in the New England Tableland are dominated by the tropical easterly winds of summer, and the temperate westerly winds of late autumn, winter and early spring (Sumner 1983, 125). Local topography also influences rainfall patterns, especially in the high elevation country of the Great Dividing Range in close proximity to the escarpment, with orographic effects and localised convection both inducing rainfall and producing more intense rainfall cells within a more general rain area (Sumner 1983, 121).

LLNR Ramsar site is about 30 kilometres west of the escarpment, but 10 kilometres closer to the escarpment than Guyra, and the orographic uplift effects are likely to be greater, with south-easterly winds bringing slightly more rainfall than to Guyra. This situation is likely to be reversed, but probably not by as much, for rain coming from the west.

Average annual rainfall at Guyra for the period 1886 to 2008 is 881 millimetres. The highest average monthly rainfall occurs in summer months with lower averages in autumn and winter. There is one report that the long-term average annual rainfall at nearby Llangothlin Lagoon (about 1-3 kilometres north-east of LLNR Ramsar site) is 980 millimetres (White 1993, 117), which is significantly higher than the rainfall at both Guyra and Glen Innes. Mean monthly rainfall at Guyra is highest in January (113 millimetres) and lowest in April (48 millimetres) (BoM, 2010a).

Intense rainfall events likely to result in a high percentage of runoff are relatively common. At Guyra, the highest recorded daily rainfall in any month exceeds the average monthly rainfall in all months except January, October, November and December. The highest recorded daily rainfall of 108 millimetres occurred in January 1946 while two months (November and December) have experienced a daily rainfall event in excess of 100 millimetres (BoM 2010a). It is likely that similar intense rainfall events occur at LLNR Ramsar site located only 18 kilometres from Guyra, and 10 kilometres closer to both the escarpment and Ben Lomond (highest local point on the plateau at 1 500 metres AHD) than Guyra.

No flood records have been located for LLNR Ramsar site, however overflows into the Oban River from Little Llangothlin Lagoon have been reported in 1974 before the outlet drain was filled in (Briggs 1976, 40), in August 1990 after the drain was decommissioned (in 1989) (Haworth 1994, 125), and again in 2011 (see section 3.2). It is presumed that overflow under natural conditions would occur possibly every decade or two, although it may be less frequent.

3.3.2 Temperature

Maximum mean monthly temperatures range from 24.5 (January) to 10.2 (July) degrees Celsius. Minimum mean monthly temperatures are also lowest in July dropping to -0.6 degrees Celsius and are highest in February (10.9 degrees Celsius). Table 3.2 shows additional climate data for Guyra.

In the New England region a clear warming trend has occurred since the 1950s, and this trend has been more pronounced since the 2000s (DECCW 2010a, 19). This is discussed in more detail in section 7.5.

Table 3.2 Selected temperature and rainfall data for Guyra Post Office (BoM 2010a)

GUYRA POST OFFICE - BoM Site number: 056016; records from 1886 to 2008														
Parameter	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**	**No of Years**
Mean maximum temperature °C	24.5	23.5	21.7	18.3	14.1	11.1	10.2	11.9	15.4	18.8	21.5	23.8	17.9	49
Mean minimum temperature °C	10.8	10.9	9.2	5.6	2.4	0.3	-0.6	0.1	2.4	5.4	7.6	9.9	5.3	49
Mean rainfall (mm)	112.9	93.9	71.7	48	50.9	61.3	59.2	54.6	57.6	81.2	87.4	101.3	880.6	118
Highest monthly rainfall (mm)	300.9	261.4	282.9	176.1	203	269.3	173.5	194.7	211.2	210.8	256.5	248.9	1 408.4	118
Year of highest monthly rainfall	1996	1956	1931	1990	1921	1950	1921	1886	1970	1949	1917	1921	1890	N/A
Lowest monthly rainfall (mm)	0	8.6	1.5	1.6	2	5.2	0	0	5.1	9.4	8.9	3.8	553.9	118
Year of lowest monthly rainfall	1909	1923	1965	1980	1975	1986	1977	1946	1925	1951	1926	1950	1919	N/A
Highest daily rainfall (mm)	108	101.6	96.5	72.9	74.9	86.4	72.9	67.3	61.2	74.9	75.2	78.2	108.0	115
Date of Highest daily rainfall	22 Jan 1946	11 Feb 1976	25 Mar 1946	1 Apr 1904	8 May 1963	24 Jun 1950	11 Jul 1962	24 Aug 1944	17 Sep 1932	11 Oct 1952	11 Nov 1959	21 Dec 1973	22 Jan 1946	N/A

3.3.3 Evaporation

Evaporation data is not available for the site but pan evaporation significantly exceeds rainfall at nearby Glen Innes Agricultural Research Station (BoM site number: 056013). Records show that between 1971 and 2010 average rainfall exceeds average pan evaporation in only the two winter months of June and July, and that on average over the year, evaporation exceeds rainfall by 493 millimetres, or over half of the annual rainfall figure (BoM 2010a).

Evapotranspiration from reed beds is commonly up to twice that of pan evaporation (Patterson 2006, 2) which suggests that evapotranspiration at vegetated wetlands in LLNR Ramsar site is also likely to be similarly high. These data indicate that surface and groundwater inflows to the lakes are required to maintain a positive water balance, with groundwater flows being potentially significant in drought years.

3.3.4 Droughts

Records show that there have been 5 major droughts in the New England area since 1900 - around 1902, 1939, 1966, 1982 (Patterson and Perrens 1985), and around 2004. These dates approximate the largest NSW droughts on record which occurred around 1900 (Federation drought), 1940 (World War 2 drought), and 1997-2010 (the Big Dry), with less pervasive droughts around 1913, 1927, and 1970 (Ummenhofer et al. 2009). CSIRO (2010, 6) analysis indicates that throughout the Big Dry (1997-2010) the New England Tablelands received average rainfall.

3.3.5 Frosts and snowfall

Frosts occur at LLNR Ramsar site, especially in low elevation areas adjoining the lakes and watercourses that are likely to act as cold air sinks. Glen Innes experiences 46 days per year on average when the minimum air temperature is equal to or less than 0 °C, and an average of 107 days per year when ground temperature is equal to or less than -1 °C. The lowest recorded ground temperature at Glen Innes of -16 °C has occurred on several occasions.

Guyra experiences an average of around five snowfalls per year, including light falls (Burr 2010) and LLNR Ramsar site also experiences snowfall events, recorded as late as November (P. Croft, NSW NPWS, Pers. Comm. 2011).

Knowledge gap

- baseline temperature and rainfall data for the site and comparison to nearby weather stations

3.4 Water Quality

Little Llangothlin and Billy Bung Lagoons are both freshwater lakes in catchments that have generally been cleared for grazing and which experience some periodic cropping and use of fertilizers on pastures (Briggs 1976, Haworth 1994). Agricultural land and roads comprise about 311 hectares or 53 per cent of the local catchment, while the remainder is nature reserve (aerial photographic interpretation).

With no inflow from upstream catchments and in the absence of other industries, local agricultural practices provide the major anthropomorphic influences on water quality. It could be expected that nutrients from fertilizers and livestock wastes and some sediment as a result of livestock access to watercourses (and in the case of Billy Bung Lagoon, to the lake itself) would find their way into the lakes, if filtration and biological processing in the watercourses and adjoining the lagoons was insufficient to remove them. Guanotrophy could also be expected to supply nutrients to the lakes when nomadic waterbird and local wetland avifauna numbers are high (Briggs 1976, 62).

Land use, vegetation and soil degradation as a result of livestock have changed significantly in the vicinity of Little Llangothlin Lagoon and part of Billy Bung Lagoon since the nature reserve was gazetted in 1979. Livestock have been excluded from the site since 1989 and cropping ceased in 1979 (Brock et al. 1999, 41, 42), vehicle access has been reduced, and native vegetation has been encouraged to regenerate. Since the constructed outlet drain was decommissioned in 1989, the maximum water depth in Little Llangothlin Lagoon has increased by around 1 metre (see section 3.2), allowing wetland vegetation on the lake flats to regenerate, and also potentially increasing the dilution of dissolved nutrients.

Agricultural practices continue in the small local catchment outside of the LLNR Ramsar site, particularly grazing by sheep and cattle, fertilizer applications, some cropping, and use of improved pastures for grazing, however, overall, the nutrient and mineral inputs to the lakes could reasonably be expected to have declined since the 1980s and certainly would not have increased.

Cattle in Billy Bung Lagoon near the LLNR boundary (Photo: A. Cibilic)

Water quality parameters in Little Llangothlin Lagoon were measured from February 1974 to April 1975, part of a study of four New England Lagoons completed prior to gazettal of the nature reserve, and the results are shown at Table 3.3 and Figure 3.4 (Briggs 1976). Opportunistic samples were collected from the inflow and outflow when conditions were suitable, and two samples monthly from the edge of the lakes and these were generally combined when the results were identical.

Table 3.3 Mean values of water quality factors, with mean standard errors in brackets (Briggs 1976, 49-50)

Parameter	Little Llangothlin Lagoon	Little Llangothlin Lagoon outflow	Little Llangothlin Lagoon inflow (3 samples)	Little Llangothlin Lagoon marsh (1 sample)
Calcium (µg/ml*)	21.27 (10.70)	19.00 (7.55)	12.33 (4.61)	23.0
Magnesium (µg/ml)	17.53 (7.68)	15.07 (4.20)	12.83 (6.01)	10.6
Potassium (µg/ml)	5.15 (2.56)	4.97 ()2.76)	1.77 (1.10)	9.0
Sodium (µg/ml)	32.47 (20.10)	31.87 (17.91)	20.67 (12.26)	24.0
Nitrate - N (µg/ml)	0.32 (0.15)	0.35 (0.17)	0.22 (0.18)	1.0
Phosphate - P (µg/ml)	0.05 (0.03)	0.02 (0.03)	0.07 (0.042)	0.07
Conductivity (µmho/cm or µS/cm	278.00 (89.38)	235.33 (88.31)	140.00 (26.46)	-
Alkalinity (µg/ml $CaCO_3$)	132.33 (45.19)	113.00 (21.45)	75.13 (24.77)	56.0
pH	7.6 (0.6)	7.5 (0.3)	-	-

* µg/ml = g/l

Brigg's study also collected water samples from Little Lagoon, Llangothlin Lagoon and Mother of Ducks Lagoon. The results indicate that seasonal, general site, and land use factors, which were similar for all lakes studied, except Mother of Ducks Lagoon, dominated the results rather than any single site-specific factor or impact.

The order of dominant cations in the lake water was Na > Ca > Mg > K, and the alkalinity values indicate that bicarbonate was the most common anion measured (Briggs 1976, 48). For Little Llangothlin Lagoon with a pH of around 7.5, the alkalinity of 132 g/l was considered equivalent to bicarbonate (Briggs 1980, 731). Bicarbonate levels of between 50 and 300 g/l (µg/ml) buffer swings in acidity that are caused by changes in flora and fauna respiration (Primary Industries and Resources SA 2001, 7) and photosynthesis. The source of bicarbonate is generally taken to be the substrates and rocks that the water flows through (Apps 2006, 68).

Briggs (1976, 48) reports that Timms (1970) found a chloride concentration of 50 µg/ml in Little Llangothlin Lagoon. This conforms in part with the observation that Australian rivers, streams and standing waters are often dominated by sodium and chloride, rather than magnesium, calcium and bicarbonate (ANZECC, 2000, A2-4), although the indicative bicarbonate ion levels are higher at Little Llangothlin Lagoon. In fact bicarbonate was considered to be the dominant anion, rather than chloride, unlike most Australian water bodies (Briggs 1980, 734).

Mean conductivity of the lake water, at 278 µS/cm, is within the range of default trigger values for upland rivers in NSW that have slightly disturbed ecosystems, however it is around 10 times the default trigger value for lakes (ANZECC, 2000, 3.3-11). The elevated conductivity may be related to reduced outflows and the resulting containment of salts which are then concentrated over time which is typical of many subterminal lake systems.

Potassium, calcium, phosphate-P and nitrate-N were higher in the single marsh sample from the shallow northern end of Little Llangothlin Lagoon (Briggs 1976, 51), which may reflect accelerated organic matter decomposition as a result of alternate wetting and drying cycles at this location which increased the trophic status of the water (Briggs 1976, 62).

Analysis of the results by Briggs (1976, 60, 22) concluded that Little Llangothlin Lagoon was at least slightly eutrophic based on suggested trigger values (that were developed for European conditions) of around 0.020 µg/ml of phosphate-P, 0.30 µg/ml of nitrate-N, and 200 µmho/cm or µS/cm for conductivity. The catchment had been fertilized during the study (Briggs 1976, 58) and the main fertiliser used in the region was superphosphate but this was not considered to influence changes in water chemistry (Briggs 1980, 732), despite slightly elevated phosphate-P in the three inflow samples.

Further analyses by Briggs (1976, 61) based on the hardness ratio [(Ca + Mg) / (Na + K) x conductivity] for British lakes concluded that Little Llangothlin Lagoon was mesotrophic, and based on the hardness of the water (hard being > 50 µg/ml $CaCO_3$) concluded that Little Llangothlin Lagoon was moderately rich to rich (taken to mean that it tended towards eutrophy).

Compared with guidelines for aquaculture ponds which rely on a degree of eutrophy to facilitate growth of algae and zooplankton, magnesium, sodium, potassium, chloride, phosphate, and nitrate concentrations all fall in the lower half of recommended levels, while bicarbonate was in the upper range (Primary Industries and Resources SA 2001, 9). This supports the conclusion that at the time of the study, Little Llangothlin Lagoon was indeed at least slightly eutrophic, and this is further supported by reports of algal growth in the water column at the time (Briggs 1976).

The results also indicate phosphorus take-up by plants as water moved through the lake, with the concentration decreasing by the time water flowed from the system. Phosphate-P is also likely to be released into the lake water during plant decomposition. A number of species of plants which occur in the wetlands and intermittent watercourses which drain into the lakes may die back over winter as a result of cold temperatures and frosts. The dead material decays as temperatures rise through spring and summer and this is likely to contribute to the slight summer increase in phosphorus levels (Briggs 1976, 55).

No turbidity records are known, however the accelerated sediment deposition at least until the late 1980s (see section 3.1.4) probably also resulted in elevated turbidity levels in both lakes. Billy Bung Lagoon is likely to periodically have elevated turbidity as a result of cattle disturbing the lake bed to the boundary of the LLNR Ramsar site.

A single recent summer (1 December 2010) water quality site at Little Llangothlin Lagoon (C. Woodward, University of Queensland, Pers. Comm. 2011) indicated eutrophic conditions in both surface and bottom waters 1.29 metres deep, based on total nitrogen, total phosphorus and chlorophyll a, as shown in Table 3.4. The site in the north-west, about 300 metres from the western margin, also demonstrated oxygenated waters suitable for animal respiration near the surface and at the bottom, possibly because the water is shallow and well-mixed. It is also possible that the abundant macrophytes have prevented turbid and algal-dominated waters from developing in this shallow and nutrient-rich lake (C. Woodward, University of Queensland, Pers. Comm. 2011). Conductivity and pH values are similar to those recorded in the 1970s.

Table 3.4 Water quality in Little Llangothlin Lagoon at a single site in December 2010 (C. Woodward, University of Queensland, Pers. Comm. 2011).

	Surface[A]	Bottom[B]	units	measurement	Default Trigger Value[C]	units
Water Temperature	17.6	17.4	°C	Field		
Dissolved Oxygen Concentration	11.31	11.1	mg/L	Field		
Dissolved Oxygen Saturation	118.6	116.4	%	Field	Low = 90, High = 110	%
Conductivity	282	281	µS/cm	Field		
pH	7.7	7.8		Field	Low = 6.5, high = 8.0	
Total Dissolved Solids	0.183	0.183	g/L	Field		
Chlorophyll a	15		µg/L	Laboratory[D]	5	µg/L
Total Nitrogen	1600		µg/L	Laboratory[D]	350	µg/L
Total Phosphorus	62		µg/L	Laboratory[D]	10	µg/L
Total Dissolved Nitrogen	1500		µg/L	Laboratory[D]		
Total Dissolved Phosphorus	31		µg/L	Laboratory[D]		

A 20cm below water surface
B Water depth of 1.29m
C Australian and New Zealand Environment and Conservation Council (2000) default trigger values for freshwater lakes
D All water samples were analysed at Forensic and Scientific Services Environmental Waters Laboratory Brisbane

No other relevant water quality results were found for the LLNR Ramsar site, and there is no relevant data for the groundwater soaks or from Billy Bung Lagoon other than a mention that the conductivity in Billy Bung Lagoon is less than 300 µS/cm.

Macrophytes at Little Llangothlin Lagoon (Photo: A. Cibilic)

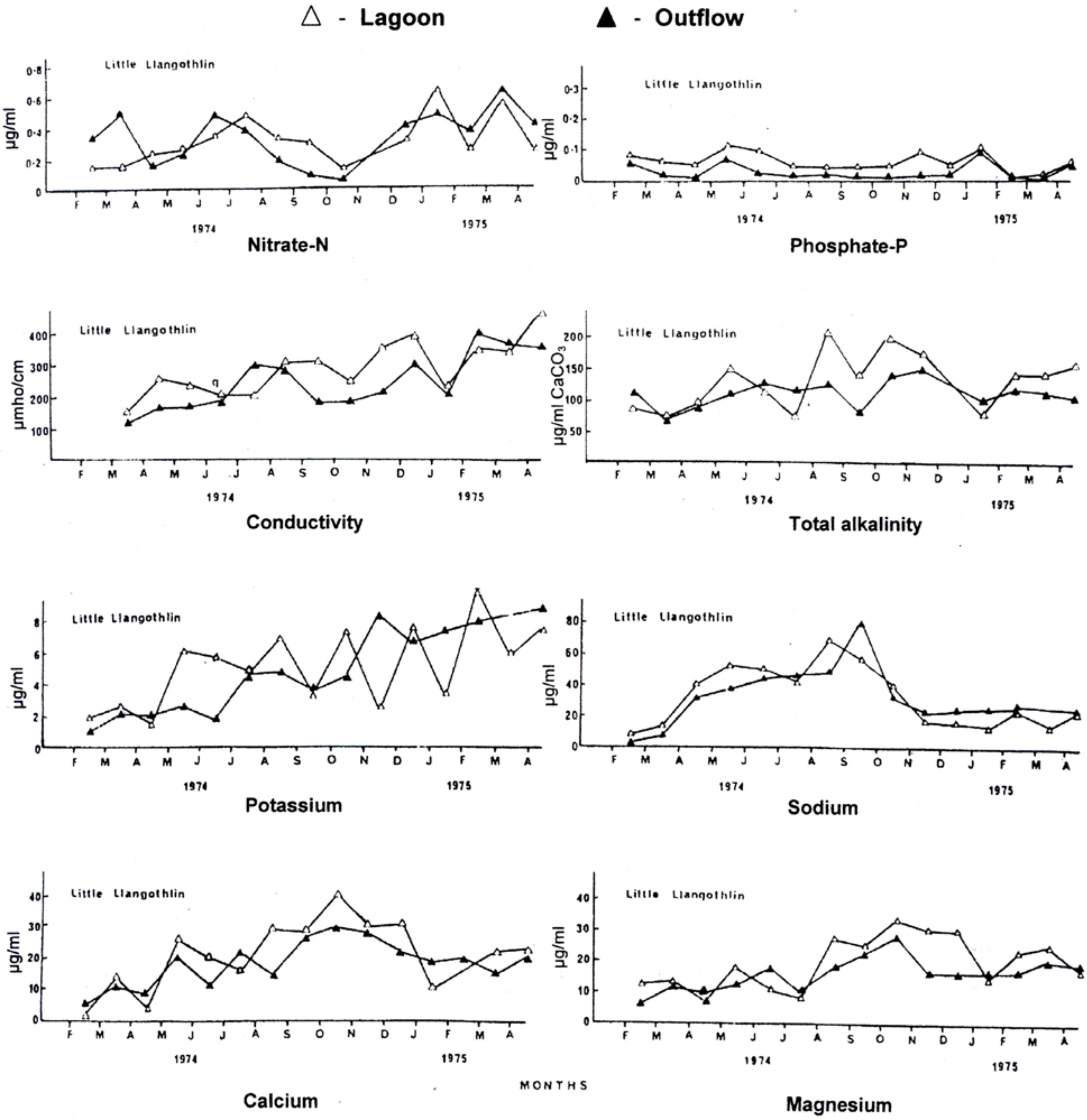


Figure 3.4 Little Llangothlin Lagoon water quality parameters 1974-1975 (Briggs 1976, 44-47)

> Knowledge gaps
> - updated baseline water quality data

3.5 Flora

Native vegetation communities are a key component of the LLNR Ramsar site, including aquatic and semi-aquatic communities within the inundated areas of the lakes, as well as eucalypt woodlands on the adjoining slopes. Over 175 native vegetation species have been identified within the site and these are listed in Appendix 2.

Benson and Ashby (2000) described the broad vegetation of the Guyra area and identified three distinct native vegetation communities present at LLNR although a large proportion (approx 97 hectares) was classified as ‘cleared’ and contained native as well as introduced grasses although some woodland regeneration is continuing. According to Benson and Ashby (2000), the basalt plateau lagoon communities at Little Llangothlin Lagoon and Billy Bung Lagoon occupy 113 hectares (although Hunter (2000) reports a figure of 118 hectares). Several areas of black sallee (*Eucalyptus stellulata*) / snow gum (*E. pauciflora*) low open forest or woodland (27 hectares in total) occur on the slopes, and patches of ribbon gum (*E. viminalis*) / mountain gum (*E. Dalrympleana*) / snow gum tall open forest (about 17 hectares) occur in the north-west corner of the site. Broad vegetation of the site is shown in Figure 3.5.

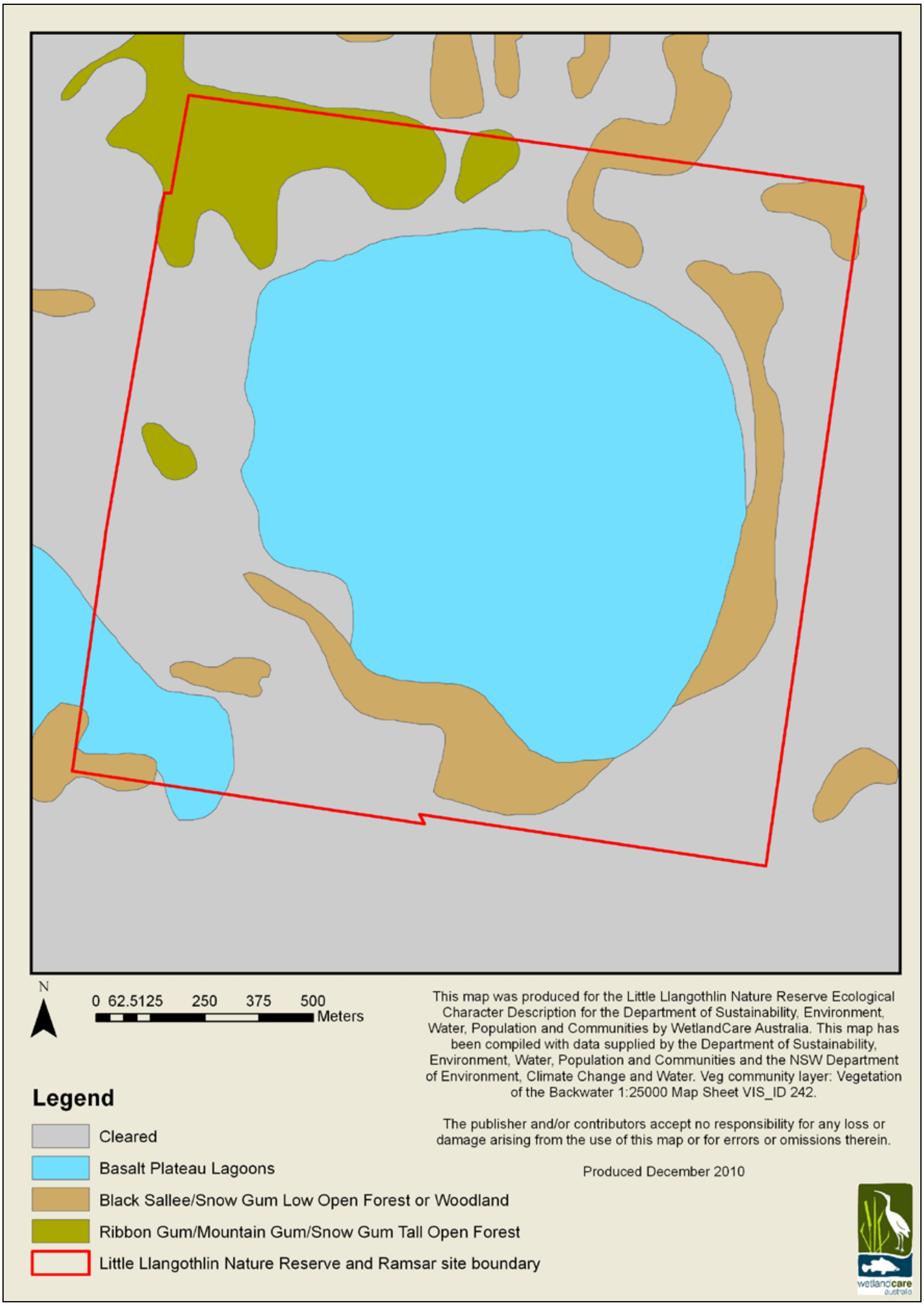


Figure 3.5 Broad vegetation communities within LLNR Ramsar site (adapted from Benson and Ashby 2000)

3.5.1 Little Llangothlin Lagoon wetland vegetation

The broad vegetation communities described by Benson and Ashby (2000) classify the aquatic and semi-aquatic vegetation occurring within Little Llangothlin Lagoon and Billy Bung Lagoon as a single community (basalt plateau lagoons). More detailed assessments reveal that there is a succession and zonation of plant communities from the submerged aquatic vegetation in the deeper water in the centre of the lake to the more terrestrial vegetation on the outer lake edges.

Briggs (1976) described the zonation in aquatic vegetation at Little Llangothlin Lagoon as it existed in March/April 1975 when the maximum water depth was about 1 metre lower than after the 1989 in-filling of the outlet drain. Aquatic vegetation zonation was most pronounced in the gently sloping northern section of the lake, where wide distinct zones were present as shown in Figure 3.6.

The deepest water at the southern end of the lake (up to 1 metre deep at that time) was occupied by a community of submerged aquatic plants. In slightly shallower water (up to 0.8 metres deep) in the centre of the lake was a large community of reed swamp (now called tall spikerush sedgeland). A zone of herb-dominated wet meadow swamp occurred in water that ranged from about 0.6 metres on the reed swamp edge to about 0.2 metres on the landward edge. The wet meadow swamp community also occurred in the lake outflow channel growing in up to 0.2 metres of water. Sedge swamp occurred in water up to 0.25 metres deep. Wet grass swamp occurred on waterlogged soil which was occasionally inundated up to 0.2 metres deep. A zone of dry grass swamp surrounded the entire lake, occurring on wet soils above the area usually inundated. A community of grass meadow (now called *Carex* fen) also encircled the lake on soils furthest from the lake edges which were moist but rarely waterlogged. A grass sedge swamp grew within the inflow channel of the lake in water 0.05 to 0.2 metres deep. On the steeper banks in the southern section of the lake the aquatic submerged community adjoined the dry grass swamp abruptly, with only narrow strips of moist meadow swamp (in water to about 0.1 metres deep) and herb meadow (in waterlogged soils that were not usually inundated) occurring in several small shallow bays. Vegetation communities at that time are described in Table 3.5.

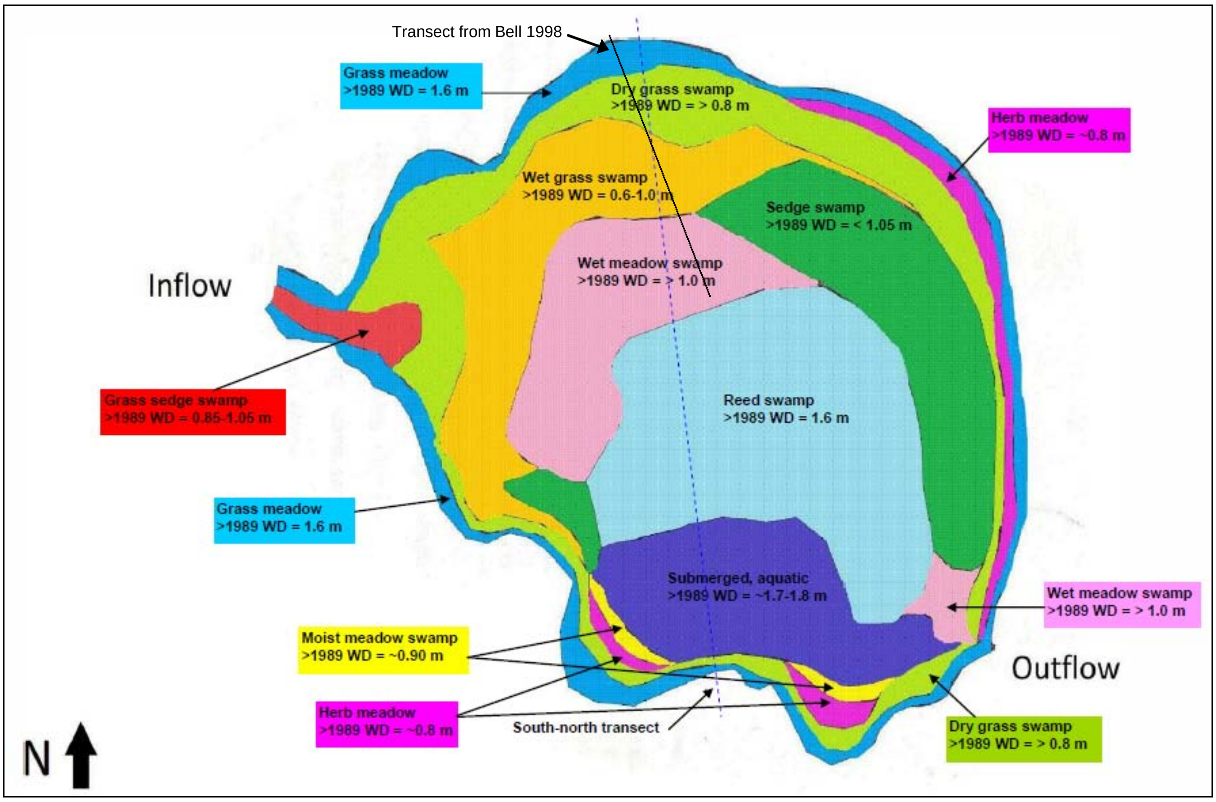


Figure 3.6 March 1975 plant communities in Little Llangothlin Lagoon with water depth adjusted to post-1989 level (adapted from Briggs 1976).

Table 3.5 Typical composition of vegetation associations within Little Llangothlin Lagoon in the early 1970s (Briggs 1976)

Association	Dominant spp	Subordinate spp
Submerged	*Potamogeton ochreatus* *Chara sp.*	*Utricularia biloba (*now known as *U. australis)* *Myriophyllum propinquum (*now known as *M. variifolium*)
Reed Swamp	*Eleocharis sphacelata*	n/a
Wet Grass Swamp	*Glyceria australis*	**Juncus articulatus* *Myriophyllum propinquum* *Potamogeton tricarinatus*
Dry Grass Swamp	*Glyceria australis*	*Agrostis avenacea* (now known as *Lachnagrostis filiformis)* *Eleocharis acuta* *Myriophyllum propinquum* *Brachychome radicans* *Stellaria palustris (*now known as *S. angustifolia)* *Cyperus gracilis* (probably misidentified) *Hydrocotyle peduncularis (*probably *H. tripartita)* *Hypericum japonicum* *Juncus usitatus* *Carex inversa*
Sedge Swamp	*Juncus articulatus**	*Myriophyllum propinquum*
Grass Sedge Swamp	*Glyceria australis* *Juncus articulatus**	n/a
Wet Meadow Swamp	*Myriophyllum propinquum*	*Potamogeton tricarinatus* *Juncus articulatus**
Moist Meadow Swamp	*Nymphoides* geminata (now known as *N. montana)* *Myriophyllum propinquum*	*Eleocharis acuta*
Herb Meadow	*Hydrocotyle peduncularis (*probably *H. tripartita)*	*Glyceria australis* *Stellaria palustris* *Brachychome radicans*
Grass Meadow	*Carex gaudichaudiana* *Holcus lanatus*	*Epilobium billardieranum* *Pennisetum alopecuroides* *Trifolium repens* *Eleocharis dietrichiana* *Gnaphalium japonicum* (now known as *Euchiton involucratus)* *Eragrostis brownii* *Stellaria palustris* *Cyperus brevifolius* (probably misidentified, most likely *Lipocarpha microcephala)* *Juncus usitatus* *Ranunculus inundatus*

* = introduced species

Briggs (1976) found that the distribution of aquatic and semi-aquatic vegetation at Little Llangothlin Lagoon was primarily determined by water depth and the vegetation communities occurred in zones that changed as water depth changed. The width of each community depended upon the slope of the lake bed. In areas of the lake with shallow, gently sloping edges, such as the northern portion of the lake, communities extend over a wide area, whereas the steeper southern banks of the lake had narrower vegetation community zones with fewer communities overall. Water depth also influenced the species richness of vegetation communities with species diversity gradually increasing as water depth decreased. Those communities occurring in submerged and inundated communities usually consisted of less than

three species, while communities on the moist soil on the lakes landward edges contained more than 12 species.
Water chemistry was also suspected to influence aquatic vegetation, with the large amount of *Chara sp* in Little Llangothlin Lagoon thought to be a function of the alkalinity and high calcium in the lake waters. Many other species associated with nutrient rich and alkaline waters were also present including species of *Potamogeton* and *Myriophyllum* (Briggs 1976).

The relationship between vegetation communities and water depth results in a change in vegetation communities over time as water levels in the lake rise or fall. It is apparent that the vegetation communities described by Briggs (1976) have changed somewhat since the outflow was restored to its natural condition in 1989 (Brock et al. 1999).

Rutherford (1999) used satellite imagery from 1972 to 1998 to examine changes in the emergent aquatic vegetation of Little Llangothlin Lagoon and found that aquatic vegetation was evident only in the northern extents of the lake in the 1970's while by February 1981 the lake was almost entirely vegetated. By September 1981 the distribution of vegetation had returned to that of the 1970's, however imagery from 1985 and 1987 showed the lake to be almost entirely vegetated again. Imagery acquired during the 1990's revealed a distinct dense aquatic vegetation community in the central and southern sections of the lake, which contracted slightly between 1994 and 1998.

The variation in the distribution of aquatic vegetation apparent from satellite imagery of Little Llangothlin Lagoon was attributed to fluctuating water levels. An extensive tall spikerush sedgeland community (reed swamp in Briggs 1976) has dominated the central and southern sections of the lake since the outlet was restored in 1989.

Recent field data also indicates that there has been a contraction of some of the vegetation assemblages identified by Briggs (1976) since the outlet was restored in 1989, whilst others remain essentially unchanged (D. Bell, UNE, Pers. Comm. 2011). Following observations of the vegetation from 1994-1998, three belt transects were placed at random in the NNW edge of the lake along the direction of a delta fed by an area of inflow.

The vegetation communities along a typical transect 356 m long are shown in Figure 3.7. Table 3.6 describes the species composition of the communities and also contains records of species encountered during nine surveys in Little Llangothlin Lagoon from 1994 to 1998 (Bell et al. 2008).

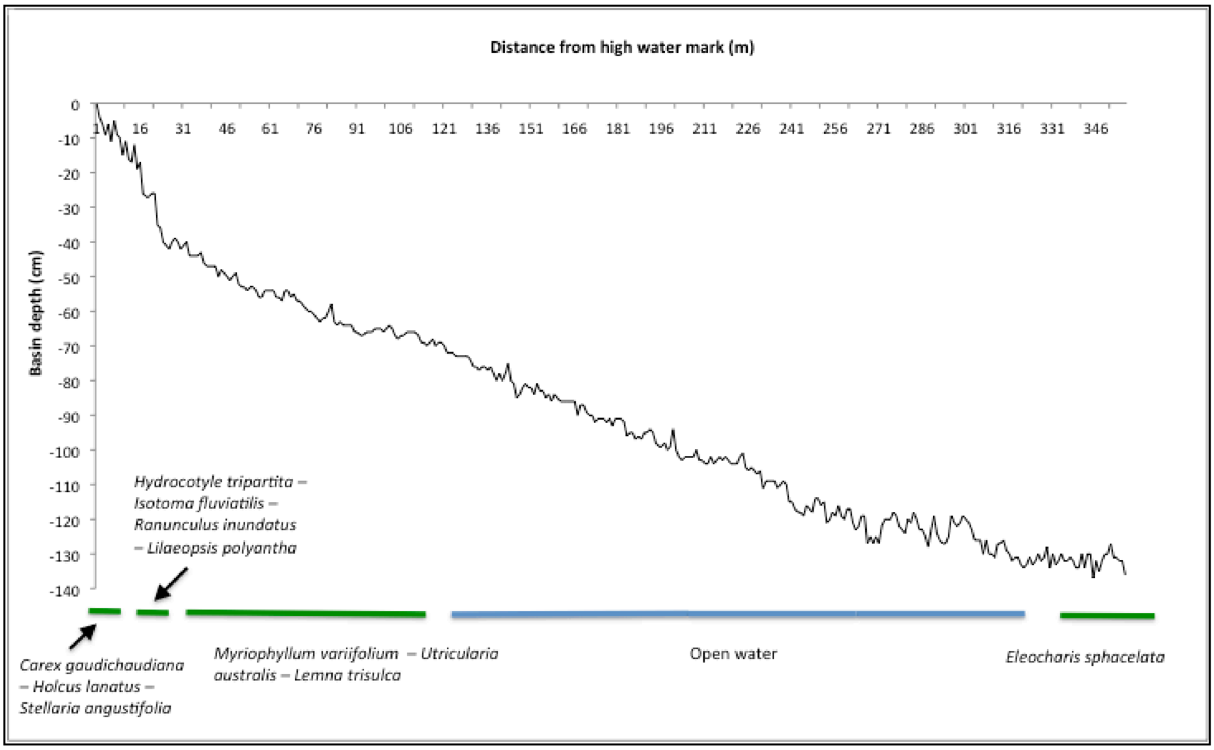


Figure 3.7 Changes in vegetation communities with depth along a transect in Little Llangothlin Lagoon in January 1998 (provided by D. Bell, UNE, 2011).

Table 3.6 Composition of vegetation communities in Little Llangothlin Lagoon along a January 1998 transect with additions from 1994-1998 surveys and observations (D. Bell, UNE, Pers. Comm. 2011).

Community	Dominant Species	Other species
Carex fen (Community 6 of Bell et al. 2008; grass meadow in Briggs 1976))	*Carex gaudichaudiana, Holcus lanatus, Stellaria angustifolia*	*Eleocharis acuta, Hydrocotyle tripartita, Epilobium billardierianum subsp. hydrophyllum, Asperula charophyton, Carex inversa*
∗Herbfield (Community 1 of Bell et al. 2008)	*Hydrocotyle tripartita, Eleocharis pusilla, Eleocharis acuta, Isotoma fluviatilis, Stellaria angustifolia, Eleocharis dietrichiana, Myriophyllum variifolium, Glyceria australis, Ranunculus inundatus, Epilobium billardierianum subsp. hydrophyllum*	*Crassula helmsii, Rorippa palustris, Isolepis fluitans, Lachnagrostis filiformis, Potamogeton crispus, Limosella australis, Elatine gratioloides, Utricularia australis, Holcus lanatus, Brachyscome radicans, Schoenus apogon*
Sparse emergent/floating community	*Myriophyllum variifolium, Utricularia australis, Lemna trisulca*	*Glyceria australis*
Open water	No records	No records
Tall spikerush sedgeland (Community 2 of Bell et al. 2008; reed swamp of Briggs (1976))	*Eleocharis sphacelata*	
∗Note: The plots in this herbfield are included in Community 1 in the larger analysis of Bell et al. (2008), in which *Lilaeopsis polyantha* is a characteristic species. However this species has never been encountered at Little Llangothlin Lagoon and so does not appear in the species list.		

Anecdotal evidence suggests that the area occupied by tall spikerush sedgeland (reed swamp in Briggs 1976) has extended marginally towards the shore (D. Bell, UNE, Pers. Comm. 2011). In the driest years, the submerged plant *Potamogeton crispus* and the alga *Spirogyra* may be present in that part of the 1998 open water zone closest to the shore. Thus the major part of the areas mapped by Briggs (1976) as wet meadow swamp and sedge swamp are now open water with occasional development of submerged plants in very dry years. During wet years the open water extends shoreward into the area Briggs (1976) mapped as moist meadow swamp; on drawdown this area close to the shore becomes bare mud and is later colonised by weedy species such as *Cirsium vulgare, Juncus articulatus, Rorippa palustris, Rorippa nasturtium-aquaticum* and *Trifolium repens* and by the native species *Persicaria lapathifolium, P. hydropiper*, *Myriophyllum variifolium, Carex inversa, Limosella australis, Lachnagrostis filiformis* and *Elatine gratioloides.* Prolonged low water levels in this zone may result in the sparse emergent/floating vegetation dominated by *Myriophyllum variifolium* seen in January 1998. The *Carex* fen and the tall spikerush sedgeland change little from season to season and year to year. The herbfield above the lip on the shoreline is usually dominated by a variety of species depending on water level and time of year.

Historical lowering and subsequent restoration of the lake's outlet impacted on water levels, however the surface area and water level, and distribution of aquatic vegetation, of Little Llangothlin Lagoon also varies naturally in response to rainfall conditions. The successive proliferation and submergence of aquatic vegetation plays an important role in nutrient cycling, ensuring the availability of resources for aquatic plants and animals, including waterbirds.

In a severe drought plant species survive as a persistent soil seed bank; in 1995 seeds and other diaspores of 31 species were found in the soil seed bank of Little Llangothlin Lagoon (Bell 2000). In cores from the present open water zone, seeds of ten species such as *Schoenus apogon, Hydrocotyle tripartita* and *Eleocharis pusilla*, were found that now only occur in the herbfield above the lip of the shoreline. Seeds of these species were probably deposited in the soil before the outlet was raised to its present level in 1989.

3.5.2 Billy Bung Lagoon wetland vegetation

A comprehensive vegetation description of Billy Bung Lagoon is not available within published literature. General descriptions indicate that the main communities in this intermittent wetland are wet swamps, sedge swamps and wet grass swamps (NSW NPWS 1998) dominated by spike-rush (*Eleocharis dietrichiana*), a daisy (*Brachycome radicans*), pennywort (*Hydrocotyle tripartita*), swamp starwort (*Stellaria angustifolia*), ladies tresses (*Spiranthes sinensis ssp. australis*), prostrate blue devil (*Eryngium sp. nov.*), and *Baloskion stenocoleum* (Bacon 1995). The edge of Billy Bung Lagoon is reported to contain a population of the rare *Plantago sp nov* (Bell et al. 2008).

During a January 1998 vegetation survey of six of the New England Tablelands lagoons (Bell et al. 2008) three belt transects were placed at random in Billy Bung Lagoon within the LLNR Ramsar site from the high water mark to the deepest areas of the Lagoon (a typical transect is shown in Figure 3.8). Maximum water depth at that time was 0.7 metres. Three of the communities described in the larger six lagoon survey occurred in this lagoon: a *Carex* fen community at or near the high water mark, a tall spikerush (*Eleocharis sphacelata*) sedgeland in the deepest parts, and between the two a herbfield dominated by *Hydrocotyle tripartita*, *Isotoma fluviatilis*, *Ranunculus inundatus* and *Lilaeopsis polyantha (*Table 3.7*)*. The *Carex* fen is similar to Briggs (1976) grass meadow of Little Llangothlin Lagoon. The tall spikerush sedgeland shares the same dominant species (*Eleocharis sphacelata*) as the deep water reed swamp of Briggs (1976) but unlike this community in Little Llangothlin Lagoon, in Billy Bung Lagoon it co-occurs with two other species. The intervening herbfield does not fit exactly with any of Briggs' (1976) Little Llangothlin Lagoon descriptions. Table 3.7 contains records of species encountered during nine surveys in Billy Bung from 1994 to 1998 as well as the 1998 transects survey (Bell 2000).

The following information has been provided by D. Bell (UNE, Pers. Comm. 2011) based on regular site visits. Billy Bung Lagoon never has permanent zones of open water; on occasions free water is visible but this soon disappears under species growing up through the water column. There is very little seasonal or annual variation in the composition of the *Carex* fen at the lagoon margin. The dominant species of tall spikerush sedgeland remain much the same even in a drought, apart from *Utricularia australis* which dies back in winter. However the dominants of the intervening herbfield vary depending on season and water level. Sometimes *Myriophyllum variifolium* is dominant; on damp mud *Lachnagrosis filiformis* is often initially dominant, but mostly a mixture of co-dominant species occurs. Occasionally there is free water for some weeks and wind action blows plant fragments disturbed by bird activities onto the shoreline where they lodge and become established. In a drought most species survive as small short tufts or rosettes (*Myriophyllum, Ranunculus*) or as underground tubers (*Potamogeton*) or rhizomes (*Eleocharis*). In a severe drought species survive as a soil seed bank; in 1995 seeds and other diaspores of 30 species were found in the soil seed bank of Billy Bung Lagoon.

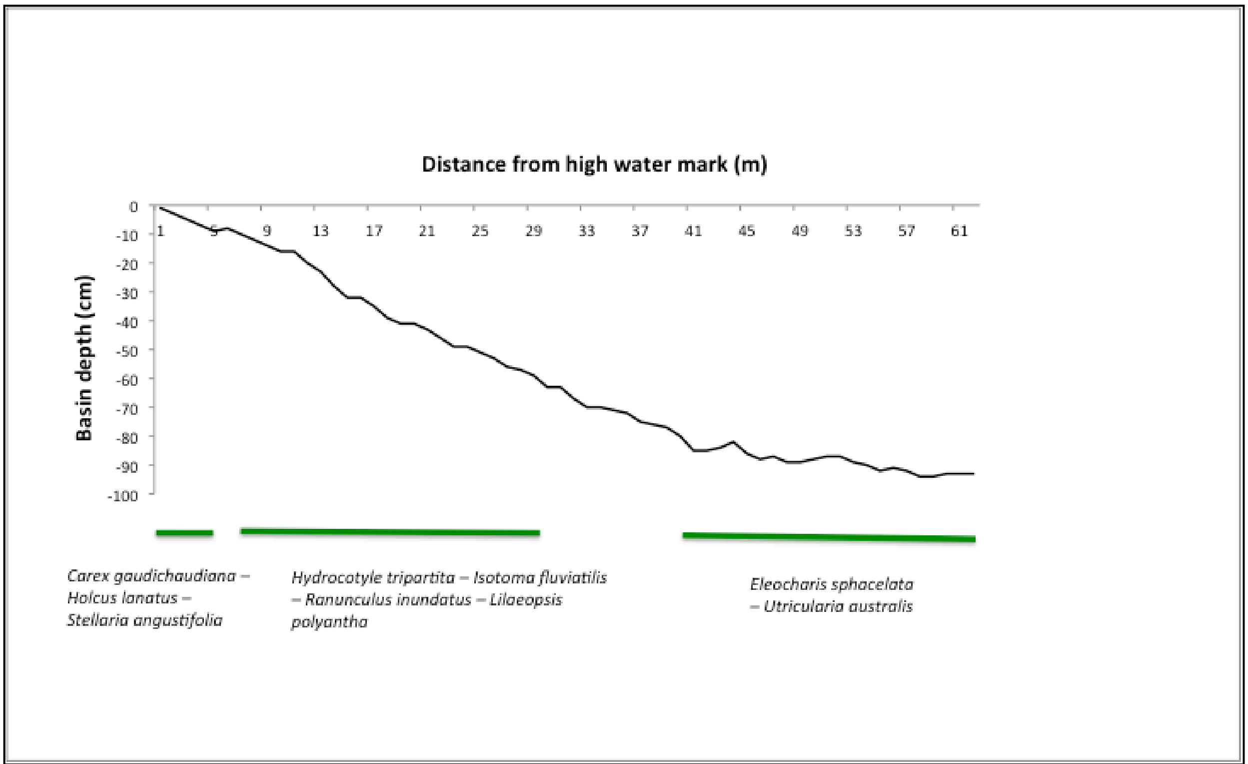


Figure 3.8 Changes in vegetation communities with depth along a transect in Billy Bung Lagoon in January 1998 (provided by D. Bell, UNE, 2011).

Table 3.7 Composition of vegetation communities in Billy Bung Lagoon along a January 1998 transect and from surveys and observations from 1994–1998 (D. Bell, UNE, Pers. Comm. 2011).

Community	Dominant species	Other species
Carex fen (Community 6 of Bell et al. 2008; grass meadow in Briggs 1976)	*Carex gaudichaudiana, Holcus lanatus, Stellaria angustifolia, Hydrocotyle tripartita*	*Epilobium billardierianum subsp. hydrophyllum, Anthoxanthum odoratum, Eleocharis acuta, Eleocharis gracilis, Eleocharis dietrichiana, Eleocharis pusilla, Glyceria australis, Neopaxia australasica, Viola betonicifolia, Asperula charophyton*
Herbfield (Community 1 of Bell et al. 2008)	*Hydrocotyle tripartita, Isotoma fluviatilis, Ranunculus inundatus, Lilaeopsis polyantha, Myriophyllum variifolium, Nymphoides montana, Eleocharis pusilla, Eleocharis dietrichiana, Utricularia australis*	*Brachyscome radicans, Eleocharis acuta, Isolepis fluitans, Potamogeton tricarinatus, Utricularia dichotoma, Aldrovanda vesiculosa, Amphibromus sinuatus, Lachnagrostis filiformis, Stellaria angustifolia, Glyceria australis, Juncus fockei*
Tall spikerush sedgeland (Community 2 of Bell et al. 2008)	*Eleocharis sphacelata, Myriophyllum variifolium, Utricularia australis*	*Potamogeton tricarinatus, Nymphoides montana*

3.5.3 Wetland vegetation ecology

The shallow, gently sloping edges adjoining parts of the lakes result in areas that become wet or dry under the prevailing water regime, resulting in nutrient pulses. Little Llangothlin Lagoon rarely dries out, however the water level varies seasonally, by around 0.4-1.0 metres, which causes changes to the northern lake boundary estimated to be around 20-40 metres or more. The shallow Billy Bung Lagoon periodically dries out and substantially reduces in size seasonally. As emergent vegetation in the shallows of these lakes becomes inundated it dies and decomposes, releasing nutrients into the water. Vegetation is also killed by winter frosts and this, too, breaks down. Livestock, which have direct access to more than half the area of Billy Bung Lagoon and the majority of its catchment, also contribute nutrients.

Elevated nutrients support the growth of aquatic vegetation. For example, *Potamogeton spp*, *Myriophyllum spp* and *Lemna spp* are usually associated with nutrient rich waters and were often present in Little Llangothlin Lagoon (Briggs 1980). As water levels recede, vegetation again colonises the drying edges of the lakes, taking up nutrients, only to be released when the cycle begins again. Even when water levels are relatively stable wetland vegetation may cause fluctuations in nutrients seasonally as they take up phosphorus, nitrogen, calcium and potassium in the growing season (spring and summer) and release them when plants die back in winter (Briggs 1980, 1976). This cycle maintains elevated lake water nutrient content (see Section 3.4) and promotes aquatic vegetation and abundant invertebrates, which in turn support high numbers of waterbirds.

3.5.4 Other wetland vegetation

3.5.4.1 *Carex* fen

Carex fen vegetation occurs not only around the lake margins but in other areas which are poorly drained but not inundated permanently (Hunter 2011). This community is also evident in the bed of watercourses flowing into and out of Little Llangothlin Lagoon and the 7.9 hectare *Carex* fen (Bell et al. 2008) at the main inflow probably helps to filter sediment and nutrients flowing into the lake. A *Carex* fen community is also evident at the outflow watercourse south of the lunette (Hunter 2011) and may also be supported by seepage. Some areas of *Carex* fen may be located within the mapped area of the upland wetlands of the New England Tablelands TEC. Hunter (2011) estimated that this community comprises about 16 hectares of LLNR. He documented a total of 27 native groundcover species within this sedgeland community, dominated by *Carex gaudichaudiana*, *Stellaria angustifolia*, *Neopaxia australasica* and *Glyceria australis*. He reported that 30 per cent of all species in this community were introduced.

3.5.4.2 Freshwater springs

The LLNR Ramsar site also contains other wetland communities, which play a role in supporting the ecological character of the site. Observers have noted a number of groundwater seepage areas that contain wetland vegetation, probably similar to meadow swamps, with vegetation suited to moist but not waterlogged soils in addition to some semi-permanent or seasonal pools (see Section 2.6 and figure 2.6). These have not been studied and there is no data available, but they are likely to serve as a source of propagules during any periods when the lakes are dry and also as alternative habitat for fauna species such as frogs and aquatic invertebrates. The *Carex* fen in the western inlet watercourse may also be supported by seepage, as could the wetland community at the high water mark of Billy Bung Lagoon (Bell et al. 2008).

3.5.5 Eucalypt woodland

As mapped by Benson and Ashby (2000), several areas of eucalypt woodland occur within the LLNR Ramsar site, providing roosting and nesting habitat for waterbirds and a grassy understorey supporting Austral toadflax.

Black sallee (*Eucalyptus stellulata*)/snow gum (*Eucalyptus pauciflora*) low open forest or woodland community occurs in several patches (27 hectares in total), primarily adjacent to the southern and eastern edges of Little Llangothlin Lagoon and Billy Bung Lagoon. This community has a low canopy less than 12 metres high with a moderately dense to open canopy cover of 10-50 per cent. This community is dominated by black sallee with snow gum also common in the canopy. Common shrub species include *Acacia dealbata*, *Pultenaea microphylla* and *Pimelea linifolia.* Ground cover in this community is usually comprised of the following species: *Geranium solanderi* var. *solanderi*, *Hydrocotyle laxiflora*, *Glycine clandestina*, *Rubus parvifolius*, *Asperula conferta*, *Poa sieberiana*, *Acaena novae-zelandiae*, *Dichondra repens*, *Hypericum gramineum*, *Scleranthus biflorus*, *Wahlenbergia stricta* subsp. *stricta* and *Ammobium alatum*.

Small patches (17 hectares in total) of ribbon gum (*E. viminalis*)/mountain gum (*E. Dalrympleana*)/snow gum tall open forest occur in the north-western portion of the site. Trees in this community are generally between 20 and 30 metres tall with a moderately dense canopy cover of 30-50 per cent. The canopy is dominated by *Eucalyptus viminalis*, *Eucalyptus dalrympleana* subsp. *heptantha*, *Eucalyptus pauciflora* and occasionally *Eucalyptus stellulata*. There is a sparse shrub layer of 10 per cent cover dominated by *Acacia dealbata*, *Pultenaea microphylla* and *Pimelea linifolia*. Ground cover in this community is dense to very dense (50-100 per cent) and is dominated by grass species. Common groundcover species include: *Geranium solanderi* var. *solanderi*, *Hydrocotyle laxiflora*, *Glycine clandestina*, *Rubus parvifolius*, *Asperula conferta*, *Themeda australis*, *Poa sieberiana*, *Poa labillardieri*, *Acaena novae-zelandiae*, *Acaena ovina*, *Viola betonicifolia*, *Dichondra repens*, *Wahlenbergia stricta* subsp. *stricta*, *Bracteantha bracteata, Desmodium varians*, *Scleranthus biflorus*, *Diuris abbreviata*, *Galium ciliare*, *Hypericum gramineum*, *Ranunculus lappaceus* and *Ammobium alatum*.

Note that the listed species apply to the wider area and may not all occur at the LLNR Ramsar site.

3.5.6 Threatened Ecological Communities

3.5.6.1 Upland wetlands of the New England Tablelands and the Monaro Plateau

The basalt plateau lagoon community (Benson and Ashby 2000) which includes aquatic and semi-aquatic vegetation within and surrounding Little Llangothlin and Billy Bung Lagoons is representative of the TEC ‘upland wetlands of the New England Tablelands and the Monaro Plateau’.

This community was listed as endangered under the EPBC Act in 2005 and is comprised of moderately dense to closed sedgeland and grassland occurring on the shores of open water or extending across shallow or intermittent wetlands. This community is characterised by native ground cover species including water plants, sedges, forbs and grasses, such as those that occur around the lakes in LLNR. Trees and shrubs are usually not found within this community.

On near-permanent upland wetlands (including degraded wetlands) about 15 native vegetation species generally occur, however, around 24 native species generally occur on intermittent wetlands as they are usually shallower and vegetation can grow throughout most of the wetland (DEWHA, 2005). D. Bell (UNE, Pers. Comm. 2011) identified 34 native species in Little Llangothlin Lagoon (permanent) and 39 native species in Billy Bung Lagoon (intermittent). Dominant native species are emergent or submerged water plants adapted to these conditions creating a range of micro-habitats for native fauna, including water birds and frogs (DEWHA 2005).

Due to the underlying geology most of the wetlands in this community are smaller than 10 hectares in size, and only five are between 100 and 450 hectares. The total area of this community is 3 195 hectares, and 57 wetlands (1 666 hectares) occur on the New England Tablelands (Bell et al. 2008), with 39 of these within the South-East Coast Drainage Division (Haworth 1998). About 113 hectares of this TEC occurs within the LLNR, comprised of the 105 hectare permanent Little Llangothlin Lagoon and 7.7 hectares of the 17 hectare intermittent Billy Bung Lagoon.

The rich soil and flat topography of this community means it has an extensive agricultural history of over 100 years. Only a small component of this community in the New England area is reserved with over 75 per cent occurring on freehold land which is primarily used for grazing cattle and sheep. Grazing changes the floristic composition and structure and causes erosion, with the resultant sediment altering the depth of these wetlands. Agricultural practices also increase nutrient loads in these wetlands, changing the vegetation composition and encouraging the growth of introduced species (DEWHA 2005).

It is estimated that 80 per cent of the wetlands in this community have been severely degraded since European settlement through draining or damming for agriculture or other land use. The change in water regime leads to a change in the vegetation which is dependent on the wetlands (DEWHA 2005).

The conservation advice for this community identifies numerous priority actions to support recovery and address threats such as the establishment of buffer zones and the management of hydrology, weeds, pests and grazing (DEWHA 2008b).

LLNR Ramsar site provides conservation for this otherwise poorly reserved TEC. The near-permanent Little Llangothlin Lagoon is one of the most intact remaining examples of this community and is also one of the largest.

3.5.6.2 New England peppermint (*Eucalyptus nova-anglica*) grassy woodlands

LLNR Ramsar site contains examples of New England peppermint (*Eucalyptus nova-anglica*) grassy woodlands. This community was listed in 2011 as critically endangered under the EPBC Act.

This community is a temperate grassy eucalypt woodland or open forest in which the tree canopy is dominated or co-dominated by *Eucalyptus nova-anglica* (DSEWPaC, 2011a). The understorey is usually made up of a dense, species rich ground layer comprised of a wide variety of grasses and herbs often including *Poa sieberiana* and *Themeda australis*. This community usually lacks a substantial shrub layer.

This community usually occurs on flat fertile soils and has been extensively cleared or degraded for agricultural purposes. The majority of the remaining patches of this TEC are small and scattered and continue to be threatened by further clearing and fragmentation, grazing, altered hydrology, dieback and weed invasion.

The conservation advice for this community identifies numerous priority actions to support recovery and address threats. Identified actions include formal and informal conservation of remaining patches and the management of weeds, pests, fire and grazing (DSEWPaC, 2011a).

Hunter (2011) recently reported that the majority of the non-inundated area of LLNR is comprised of existing or regenerating New England peppermint woodland which ‘falls within’ the national TEC (a total of almost 120 hectares). He noted that many areas are currently in relatively poor condition, but predicted that condition will continue to improve under the current management regime. It is unclear whether Hunter (2011) considered the key diagnostic characteristics for the TEC within his assessment. These are included within the listing advice for the community (DSEWPaC 2011a) and include condition thresholds such as patch size, species richness and tree density.

The listing advice for this community (DSEWPaC 2011a) refers to the mapping by Benson and Ashby (2000), which indicates that this TEC does not occur within LLNR. The listing advice specifically differentiates Benson and Ashby’s (2000) New England peppermint grassy woodland communities from the ribbon gum / mountain gum / snow gum community which occurs at LLNR. It states that while the latter community may contain occurrences of New England peppermint, it is usually dominated by other tree species and is not representative of the TEC.

However, the listing advice for this TEC also notes that minor areas of New England peppermint woodland or woodland containing New England peppermint exist within the LLNR but it has largely been cleared and is affected with moderate to severe dieback (DSEWPaC, 2011a).

Haworth (1994, 69) reported the last major grove of New England peppermint in the local catchment to be located on the lunette at the south of Little Llangothlin Lagoon, the remainder having succumbed to dieback, and also reported an undescribed hybrid growing on the lagoon edge and dry ridges.

Additional research is required to thoroughly assess and map the areas of eucalypt woodland within LLNR which currently represent this TEC. This TEC is inadequately reserved so any examples of the community that exist within the LLNR Ramsar site are significant.

New England peppermint (*Eucalyptus nova-anglica*) woodland at Little Llangothlin Nature Reserve (Photo: A. Cibilic)

3.5.7 Threatened flora

One nationally threatened species of flora is known to occur within the LLNR Ramsar site boundary. *Thesium australe,* commonly called Austral toadflax, is listed as vulnerable under the EPBC Act and occurs within the Ramsar site in association with grassy woodland or grassland communities.

Austral toadflax is the only Australian representative of the worldwide genus *Thesuim* (Griffith 1992). It is a straggling annual, biennial or short-lived perennial herb with wiry stems up to 40 centimetres long, narrow succulent leaves and tiny white flowers from spring to autumn (Griffith 1991, 1992). It is a parasitic plant, taking water and nutrients from the roots of grasses, especially kangaroo grass (*Themeda australis*) (DECCW 2010e). The plant is found in kangaroo grass grassland or grassy eucalypt woodlands with a kangaroo grass understorey, particularly in damp sites. Individuals are often concealed, growing among grasses and herbs.

The often damp grassland, containing kangaroo grass, surrounding Little Llangothlin Lagoon and Billy Bung Lagoon provides suitable habitat for the species and several populations occur within the site (Benson and Ashby 2000). Details on the size and location of populations of this species within the site are lacking, as no targeted survey has been done (J. Kreis, NSW NPWS, Pers. Comm. 2010). There is a record at Lat 30.0921, Long 151.7736 from December 2006 (DECCW 2010b), as well as several records from points nearby from the 1990’s (Bell 1996).

In 2011 a significant population of at least 50 plants, identified by D. Bell, was observed by the authors among the eucalypt woodland community on the slope to the north of Billy Bung Lagoon. All known occurrences of the species are from the south-west corner of the site on the slope above Billy Bung Lagoon. Given the distribution of grassy woodland in the north and eastern portions of the site, it is possible that there may be other populations in these areas.

This species once occurred across south eastern Australia, from south-eastern Queensland, through eastern New South Wales and into Victoria and eastern Tasmania. Although it was quite widespread and displays a relatively broad ecological tolerance, it was thought to have always been generally rare and found in small populations. It is thought to be a dynamic or transient species, with population sizes fluctuating rapidly. Overall, its abundance has been reduced through habitat destruction and fragmentation, particularly due to intensive grazing and cultivation (Griffith 1991, 1992, Benson and Ashby 2000). Kangaroo grass grassland is susceptible to modification by grazing and pasture improvement (Griffith 1991). Austral toadflax is now thought to be extinct in Tasmania, and far less widespread in mainland Australia occurring only in small populations which are mainly restricted to highly specific and localised habitats (Griffith 1992).

The majority of populations of this species are not in conservation areas and the species habitat of *Themeda* grassland is currently inadequately reserved, particularly within the New England Tablelands (Griffith 1991, Benson and Ashby 2000). Australia-wide, less than 1 000 plants are known to occur within conservation areas (Griffith 1992). The protected habitat and known population occurring within the LLNR Ramsar site is therefore very significant.

Austral toadflax near Billy Bung Lagoon within the LLNR Ramsar site (Photo: A. Cibilic)

Knowledge gaps
- comprehensive flora distribution and composition
- distribution and population dynamics of Austral toadflax
- condition and distribution of *Eucalyptus nova-anglica* and assessment against TEC diagnostic characteristics

3.6 Fauna

The Ramsar site provides important habitat for various waterbirds, many of which live and breed at the site. Numerous other fauna species also use the site as habitat and all available non-waterbird fauna records are listed in Appendix 2. These species include frogs and small reptiles such as lizards, snakes and turtles which provide food for waterbirds such as the white-bellied sea eagle. Numerous terrestrial bird species including rosellas, cockatoos, wrens and flycatchers also utilise the site, primarily inhabiting the remnant fringing woodland vegetation. Aquatic invertebrates are an important part of the fauna within the site as they play a vital role in productivity and nutrient cycling and provide a significant food source for the waterbirds which rely on the site.

3.6.1 Aquatic invertebrates

Comprehensive data on the wetland–dependent invertebrate fauna at Little Llangothlin and Billy Bung lagoons is not available in published literature, however some invertebrates occurring at the site have been identified as being regionally rare or unique. An undescribed species of the order *Rhabdocoel* has been found at Little Llangothlin Lagoon, its only known location (Bayly 1995 Unpub). This little known order includes flatworms that exhibit behaviour similar to a plankton, in that they have a floating, free swimming life. The calanoid copepod *Boekella montana*, which is common in highland areas of southern Australia, occurs at Little Llangothlin Lagoon at the most northern limit of its presently known range and *Boekella major*, previously only known from isolated localities in Tasmania, Victoria and the southern Highlands of NSW, was also found at Little Llangothlin Lagoon (Timms 1970).

In addition, Haworth (1994, 143) noted that freshwater crayfish were used as supplementary foods by early settlers, and the authors found crayfish shells that remained after being consumed, possibly by a water rat. The authors also noted a variety of water-dependent insects such as dragonflies, damselflies and water beetles, however no other invertebrate species records for this site have been found.

White (1986a) sampled the invertebrate fauna at nearby Llangothlin Lagoon, approximately 1 kilometre north-west of Little Llangothlin Lagoon, during refilling after a drought in August 1981. A diverse insect fauna had established after several months. Initially species typical of both temporary ponds and permanent water bodies were found. These early colonising temporary invertebrate species were found to be important for the initial productivity of the lake during refilling, however their numbers tapered off after two months. After a period, permanent water invertebrate species dominated and productivity and biomass were found to fluctuate with water level and season. The aquatic invertebrate assemblage at Llangothlin Lagoon was found to be rich and abundant compared with many Australian water bodies, with at least 57 species recorded. It is likely that the invertebrate composition at Little Llangothlin Lagoon Nature Reserve would be similar due to the close proximity of these two large upland lakes.

Unlike Llangothlin Lagoon which dries out every 15-20 years (possibly similar to Billy Bung Lagoon), Little Llangothlin Lagoon is considered permanent, so it is likely that the invertebrate assemblage at Little Llangothlin Lagoon is similar to that of the later stages at Llangothlin Lagoon. Aquatic invertebrate populations are most abundant during initial filling or, as is more often the case at Little Llangothlin Lagoon, during high water levels when wetland vegetation becomes inundated and breaks down, releasing nutrients. It is likely that an abundance of diverse aquatic invertebrates occurs at Little Llangothlin Lagoon, fluctuating with water level and temperature, and providing a generally reliable food source for the many waterbirds that inhabit the area.

Due to the intermittent hydrology at Billy Bung Lagoon, it is likely to support transient populations of aquatic invertebrates that are adapted to temporary water bodies and to be more often in the highly productive initial inundation stage. This is likely to provide an occasional but important opportunistic food source for waterbirds to supplement that available in Little Llangothlin Lagoon.

3.6.2 Waterbirds

3.6.2.1 Waterbirds at LLNR

LLNR Ramsar site is an important habitat, breeding site and drought refuge for a range of waterbirds. It also supports the nationally threatened Australasian bittern (*Botaurus poiciloptilus)* and eight internationally important migratory waterbird species.

A small number of systematic ornithological studies have been conducted within LLNR Ramsar site in the 1970s and 1980s, prior to its listing as a Ramsar site (Briggs 1976, White 1986a). Since the time of listing in 1996 no similar scientific studies have been conducted, however local bird watchers visit the reserve regularly, providing additional and more recent records of waterbirds within the site and a single aerial survey of the site was conducted in 2008

(Kingsford et al. 2011). As the earlier studies yield comprehensive data, they provide the best available indication of the types and numbers of waterbirds which likely occurred at the site at the time of listing.

At least 48 species of waterbird have been recorded within the LLNR Ramsar site (see Table 3.8). Grey teal (*Anas gracilis*), chestnut teal (*Anas castanea*), Eurasian coot (*Fulica atra*) and Pacific black duck (*Anas superciliosa*) are the most abundant waterbirds recorded at the site with recorded maximum counts of 600 or above, for a density of at least 5 individuals of each of these species per hectare of wetland. Black swan (*Cygnus atratus*) and purple swamphen (*Porphyrio porphyrio*) have also occurred at the site with maximum recorded numbers above 400 for each species. At least 21 species of waterbird breed at the site (see Table 3.8).

The blue-billed duck (*Oxyura australis*), while not nationally threatened, is nevertheless uncommon over its relatively restricted range in south-eastern Australia. It is listed as threatened in NSW. A recent count (2009) indicated a maximum of c.180 birds present at LLNR Ramsar site, and it is believed that there in recent times there are usually more than 100 birds present (J. Clifton-Everest, Pers. Comm. 2011). The significance of the site for this species is not known as it was not recorded in high numbers in the 1970s and 1980s but it is likely that it represents, at least periodically, a significant breeding-stronghold for the species near the northern limit of its range.

The freckled duck (*Stictonetta naevosa*), while not nationally listed as threatened, is widely considered to be Australia’s rarest species of duck. It is nomadic in habit and often found on ephemeral wetlands. It appears quite regularly at LLNR, though in small numbers, underscoring the role of the site as a drought-refuge for such species generally (J. Clifton-Everest, Pers. Comm. 2011).

Eight waterbird species known to occur at the site are listed on various international migratory bird agreements (see Table 3.8).

Regular black swan breeding has been recorded at LLNR Ramsar site. Briggs (1976) found that black swans bred consistently in relatively high numbers at the site, with at least 50 pairs breeding at the site each year between 1973 and 1975. Another study (White 1986b) found 43 black swan pairs nesting at the site in 1982, representing a density of greater than 1 pair per hectare of suitable habitat. Of the 43 nests, 20 broods fledged, giving a nest success rate of 47 per cent, with a mean clutch size of three.

Black swans at Little Llangothlin Lagoon nested in swamp vegetation dominated by *Glyceria sp* in inundated areas, and constructed nests of *Glyceri*a sp (White 1986b). Black swans require areas of inundated vegetation for nesting and White (1986b) found that breeding usually occurs after a period of rising water level and nests are abandoned if water level drops significantly, suggesting that breeding is not seasonal, but rather opportunistic and dependent on regional rainfall (White 1986b). Black swan nesting has not been studied since the time of listing but as the habitat has not been significantly modified it is expected that it continues to regularly occur. In January 2011 the authors identified numerous juvenile black swans from recent hatchlings to almost adult size.

Successful breeding of the white-bellied sea eagle (*Haliaeetus leucogaster*) was recorded in 2007 and there is also evidence of older nests present at the site, indicating historical breeding of this species (Debus 2008).

Table 3.8 Waterbirds recorded at LLNR Ramsar site (DECCW 2010b, White 1986a, Briggs 1976, J. Clifton-Everest, Pers. Comm. 2011, Kingsford et al. 2011)

Common name	Scientific name	Max count	International treaty	Breeds at site
Grey teal[1]	*Anas gracilis*	1800		Yes
Chestnut teal	*Anas castanea*	722		
Eurasian coot[1]	*Fulica atra*	722		Yes
Pacific black duck[1]	*Anas superciliosa*	600		Yes
Black swan[1]	*Cygnus atratus*	498		Yes
Purple swamphen	*Porphyrio porphyrio*	436		Yes
Black-winged stilt	*Himantopus himantopus*	195		Yes
Australasian shoveler	*Anas rhynchotis*	184		Yes
Blue-billed duck	*Oxyura australis*	180		Yes
Straw-necked ibis	*Threskiornis spinicollis*	141		
Whiskered tern	*Chlidonias hybridus*	136		
Hardhead	*Aythya australis*	126		Yes
Australian wood duck	*Chenonetta jubata*	80		Yes
Masked lapwing	*Vanellus miles*	80		Yes
Dusky moorhen	*Gallinula tenebrosa*	60		Yes
Australasian grebe	*Tachybaptus novaehollandiae*	60		Yes
White-necked heron	*Ardea pacifica*	54		
White egret	*Ardea modesta*	45	CJ	
White-faced heron	*Egretta novaehollandiae*	25		
Australian white ibis	*Threskiornis molucca*	24		
Glossy ibis	*Plegadis falcinellus*	23	C	
Black-fronted plover	*Elseyornis melanops*	17		Yes
Marsh sandpiper	*Tringa stagnatilis*	14	CJR	
Intermediate egret	*Ardea intermedia*	12		
Cattle egret	*Bubulcus ibis*	8	J	
Yellow-billed spoonbill	*Platalea flavipes*	8		
Wandering whistling duck	*Dendrocygna arcuata*	5		
Lathams snipe	*Gallinago hardwickii*	4	CJR	
Musk duck	*Biziura lobata*	2		Yes
Red-necked stint	*Calidris ruficollis*	2	CJR	
Pacific marsh harrier	*Circus approximans*	2		Yes
White-bellied sea eagle[2]	*Haliaeetus leucogaster*	2		Yes
Comb-crested jacana	*Irediparra gallinacea*	2		
Little pied cormorant	*Microcarbo melanoleucos*	2		
Australasian darter	*Anhinga novaehollandiae*	Unknown		
Australasian bittern	*Botaurus poiciloptilus*	Unknown		Yes
Sharp-tailed sandpiper	*Calidris acuminata*	Unknown	CJR	
Australian hobby	*Falco longipennis*	Unknown		Yes
Plumed whistling-duck	*Dendrocygna eytoni*	Unknown		
Pink-eared duck	*Malacorhynchus membranaceus*	Unknown		
Australian pelican	*Pelecanus conspicillatus*	Unknown		
Little black cormorant	*Phalacrocorax sulcirostris*	Unknown		
Pied cormorant	*Phalacrocorax varius*	Unknown		
Royal spoonbill	*Platalea regia*	Unknown		
Great crested grebe	*Podiceps cristatus*	Unknown		Yes
Hoary-headed grebe	*Poliocephalus poliocephalus*	Unknown		Yes
Freckled duck	*Stictonetta naevosa*	Unknown		
Common greenshank	*Tringa nebularia*	Unknown	CJR	

Legend: C = CAMBA, J = JAMBA, R = ROKAMBA

Notes:

1: These species have been recorded at the site with counts >100 at least once in 1981-84, 1974-75, and 2008.

2: DSEWPaC recognises that the white-bellied sea eagle is incorrectly listed on the annex to the CAMBA agreement and has recommended to China that it be removed from the annex; there is no scientific evidence to support the fact that the white-bellied sea eagle migrates between Australia and China (G. Usher, DSEWPaC, Pers. Comm. 2011).

3.6.2.2 Threatened species

The Australasian bittern (*Botaurus poiciloptilus*) is listed as endangered both nationally, under the EPBC Act, and at the global level (IUCN Red List).

This heron-like bird occurs from south-east Queensland to south-east South Australia, in south-west Western Australia, as well as in New Zealand and New Caledonia. The total Australian population in 2010 was estimated to be between 250 and 800 birds (DSEWPaC, 2011b). The Australasian bittern preferred habitat comprises wetlands with tall dense vegetation and still, shallow freshwater. The species is threatened by habitat loss, reduced water quality, overgrazing and predation by introduced carnivores.

It is a highly cryptic species, which is rarely sighted even at locations where, by its calls, it is known to be present. The species has been sighted at least twice and its calls heard frequently at LLNR in recent years. The first of the sightings (2002) was of a juvenile bird, the second (2009) of an adult, and on these grounds Birds Australia believes that a small breeding population persists at the location (J. Clifton-Everest, Pers. Comm. 2011). The permanent freshwater and intact vegetation at LLNR which is protected from grazing and clearing provide valuable habitat for this species.

3.6.2.3 Waterbird ecology at LLNR

Waterbird numbers vary with season, regional and local water availability, habitat and food availability, water quality, and disturbance. For example, high water levels were correlated with high numbers of some waterbirds in studies by both Briggs (1976) and White (1996a). Invertebrates increase during times of flooding due to the high nutrient conditions of recently inundated land and the improved food availability probably explains why numbers of some waterbirds, such as Eurasian coot, were correlated with water level at Little Llangothlin Lagoon. White (1996a) also found that numbers of Pacific black duck, grey teal, Eurasian coot, purple swamphen, Australian grebe, Australasian shoveler, hardhead, Australian wood duck and musk duck were all positively correlated with water depth at Little Llangothlin Lagoon at certain times of the year, depending on regional flooding conditions. This preference for deep water may also be due to the diving feeding habits of some of these species.

Grey teal have a high capacity for rapid and extensive movement in response to water conditions and in early 1975 their numbers increased rapidly at the site, probably due to prevailing dry conditions elsewhere in the wider area (Briggs 1976). White (1996a) found that grey teal numbers decreased at Little Llangothlin Lagoon in response to flooding elsewhere in the region.

Studies in the 1980s showed Pacific black duck were common at Little Llangothlin Lagoon and their numbers were relatively stable, probably because this species does not move as rapidly or extensively in response to changing water conditions. To avoid predation, black swans moved away after breeding when cygnets began to fly, accounting for lower numbers during summer. Purple swamphen left Little Llangothlin Lagoon during spring and summer, presumably to breed elsewhere, and returned in autumn (White 1996a).

Water chemistry and temperature have a major influence on the distribution of aquatic plants and invertebrates. As these are the main waterbird food resources, water chemistry also has an indirect effect on waterbird distribution and abundance. The water regime, lake morphology, water chemistry, and aquatic vegetation and invertebrates all interact to provide waterbird habitat. The shallow, gently sloping edges of the lakes mean that the wetland vegetation and soils in these shallow areas are wetting and drying under the prevailing water regime. This maintains high water nutrient content, which in turn enables higher densities of aquatic invertebrates and aquatic vegetation to provide food for waterbirds.

Briggs (1976) examined habitat use by waterbirds at Little Llangothlin Lagoon and found that black swans were most often found in meadow swamp and open water habitat (section 3.5.1). Grey teal and Pacific black duck both showed strong preferences for open water, while purple swamphen preferred meadow swamp and reed swamp habitats. All species showed a negative preference for herb meadow and grass swamp, with very few waterbirds occurring in these areas. Waterbird densities initially increased with the size of the habitat patch, however, after a size limit was reached densities then began to decrease with patch size. This suggests that waterbirds prefer interspersed areas of various habitats rather than a single large patch of one habitat.

Associations of particular waterbird species with particular habitats is likely a consequence of the feeding ecology of the species (Table 3.9). Aquatic plant eaters including swans and swamp hens favoured highly vegetated habitats, while aquatic invertebrate feeders such as grey teal favoured open water where invertebrates are more accessible (Briggs 1976). Herons, egrets, ibis and spoonbills feed on aquatic animals and plants found in mud along the edge of swamps, and although not counted in this study, are likely to favour herb meadow and exposed mud habitats.

Plants and seeds form a large part of the diet of many Australian waterbirds. Aquatic plants in and around Little Llangothlin Lagoon and Billy Bung Lagoon include species of the genus *Glyceria, Myriophyllum, Cyperus, Eleocharis* and *Isotoma,* which are favoured waterfowl food plants (Brigss 1976).

Briggs (1976) also demonstrated that the habitat preferences of waterbirds at Little Llangothlin Lagoon varied temporally over the year. This may be due to seasonal behavioural changes such as breeding or due to the wetland productivity changing temporally and spatially as a result of the changing water regime.

Table 3.9 Feeding ecology of waterbirds with high counts >100) recorded at LLNR Ramsar site (Birds Australia 2010, Briggs 1979)

Species	Feeding ecology
Grey teal	Dabble or dive for insects and crustaceans, or graze on terrestrial and aquatic plants and seeds
Chestnut teal	Dabbles or dives for insects, molluscs and crustaceans
Eurasian coot	Dive for vegetative material from submerged or emergent plants
Pacific black duck	Mainly dabbles for aquatic plants and seeds in the water or damp grassy areas. Occasionally eats small invertebrates.
Black swan	Feed by grazing and uprooting submerged vegetation
Purple swamp hen	Graze terrestrial and emergent vegetation
Black-winged stilt	Usually feed in shallow water seizing aquatic insects near the surface.
Australasian shoveler	Filters invertebrates and plants from the water or soft mud with its specialised grooved bill.
Blue-billed duck	Dives at the water surface, taking aquatic insects. They may also eat the seeds, buds, stems, leaves and fruit of a wide variety of plants. Feeding occurs in permanent areas of clear fresh water.
Straw-necked ibis	Hunt for terrestrial and aquatic insects, molluscs and small reptiles and amphibians
Whiskered tern	Hover or fly low over the water and plunge or dip into the water to take small fish, amphibians, crustaceans and insects.
Hardhead	Dive for aquatic invertebrates and submerged vegetation

3.6.3 Frogs

3.6.3.1 Frogs at LLNR

A recent survey of LLNR (Dudley 2011) found nine native frog species occurring at the site. The most common of these was the brown-striped frog (*Limnodynastes peronii*) with over 200 specimens found. Other species recorded included common eastern froglet (*Crinia signifera*), eastern sign-bearing froglet (*Crinia parinsignifera*) and spotted marsh frog (*Limnodynastes tasmaniensis*). A complete species list can be found in Appendix 2.

3.6.3.2 Threatened species

The yellow-spotted bell frog (*Litoria castanea*) previously had a highly restricted distribution in the New England Tablelands and Southern Highlands of NSW and is listed as critically endangered under the EPBC Act. The New England Tablelands population was confined to an area of approximately 50 by 25 kilometres centred around the Guyra township, between altitudes of 1 000 and 1 500 metres (Campbell 1999, NSW NPWS 2001). The species was relatively common in dams, lakes and streams in the area in the early 1970s (Campbell 1999) and was previously relatively common within LLNR Ramsar site, with over 40 individuals collected from Little Llangothlin Lagoon in 1971 (Campbell 1999).

The species has declined dramatically throughout all of its range and there are no verified records of the New England Tablelands population of yellow-spotted bell frog since 1975. The decline of this population was very rapid and various surveys of its known range between 1992 and 1995 found no sign of the frog. The South East Highland population has also suffered rapid decline and the species was not found for several decades after 1980 (Campbell 1999). The exact cause of the rapid decline of this species is not known, however possible factors include disease, drought, introduced fish, chemical use or habitat modification (Hero and Morrison 2004, NSW NPWS 2001).

Concerns were held for the survival of the species, however, in 2009 a small population of approximately 100 individuals was found in an isolated stream on private land on the South East Highlands of NSW and several of the frogs have been placed into a captive breeding program at Taronga Zoo (Platt 2010). Surviving individuals of the New England Tablelands population have not been found, however, sufficient surveys have not been undertaken to determine with certainty if this population is extinct or if small populations may still persist as is the case with the southern population.

This species inhabits still or slow moving high altitude wetlands with abundant fringing vegetation. They breed in still or slow moving water bodies, laying masses of eggs on the water surface usually attached to emergent vegetation. If the species is found to persist in northern NSW, the LLNR Ramsar site may still be valuable as a future distribution or captive breeding release site that could re-establish a wild population. However this is not currently planned and is further complicated by the presence of the introduced pest fish *Gambusia holbrookii*.

3.6.4 Other wetland-dependent vertebrates

Data on other wetland dependent fauna at LLNR Ramsar site is very limited. There are records of eastern snake-necked turtle (*Chelodina longicollis*) at the site, and the authors observed numerous egg clutches within about 100 metres of Little Llangothlin Lagoon which had been disturbed by predators, possibly foxes (J. Kreis, NSW NPWS, Pers. Comm. 2011). The water-rat (*Hydromys chysogaster*) was recently recorded at the site.

No data exists on the composition or abundance of the fish population within the site, however the presence of piscivorous waterbirds (such as the white-bellied sea eagle) indicate that fish are present and are likely to be an important part of the food-web ecology of the site. Eels have been reported as a food source of early settlers (Haworth, 1994, 143).

Knowledge gaps

- comprehensive information on water-dependent vertebrates, invertebrates and microbes
- long-term seasonal and annual patterns of waterbird numbers and breeding events
- the significance of LLNR for the blue-billed duck, including population size and breeding events

4. Benefits and services

Benefits and services are defined as the benefits that people receive from ecosystems, including items such as food, water, hazard regulation, recreation opportunities, economic resources and cultural values (DEWHA 2008a). It is important to note, however, that the underlying components and processes within the system are crucial for ecological functioning and for the production of all ecosystem services.

This section outlines the benefits and services provided by the LLNR Ramsar site. Where benefits and services have come to light since the time of listing, these have been included.

4.1 Supports representative near-natural wetlands

Approximately 80 per cent of the wetlands on the New England Tablelands have been severely degraded since European settlement, mainly by drainage and agriculture (Brock et al. 1999, 38). Some of these, the lakes, have been protected under the EPBC Act as the TEC 'upland wetlands of the New England Tablelands and the Monaro Plateau'.

Of these protected wetlands:

- 81 per cent are smaller than 10 hectares
- 17 per cent are between 11 and 100 hectares (e.g. Billy Bung Lagoon)
- 2 per cent are between 100 - 450 hectares in size (e.g. Little Llangothlin Lagoon)

(DEWHA 2005).

Only 55 wetlands protected as the TEC occur in the New England Tablelands with an average size of around 30 hectares, while Little Llangothlin Lagoon is the third largest of the three wetlands over 100 hectares in size (DEWHA 2005). Others have identified 57 wetlands in the New England Tablelands that meet or potentially meet the criteria of TEC (Bell et al. 2008, 484), however only around 39 are located within the northern NSW section of the South-East Coast Drainage Division (Haworth, 1998, 5-7) which includes within its boundary only the eastern part of the New England Tablelands.

The wetlands in the LLNR Ramsar site are varied and include the permanent Little Llangothlin Lagoon, the intermittent Billy Bung Lagoon, very small wetlands supported by groundwater soaks, and *Carex*-dominated fen which occurs in seepage depressions in watercourses and at the lake margins.

This variety of wetland types in near-natural condition increases the site's significance as representative of high altitude wetlands in the South-East Coast Drainage Division. The condition of the wetlands as near-natural results largely from their location in the LLNR, protected under the *National Parks and Wildlife Act 1974*.

4.2 Provides refuge during drought conditions

Studies indicate that LLNR Ramsar site provides a valuable refuge for waterbirds during times of drought within the wider area with a doubling of numbers during drought times as shown in Table 4.1. White (1987) studied waterbird numbers at Little Llangothlin Lagoon during a 42 month period from June 1981. The first half of this period was the latter part of a prolonged widespread drought, followed by above average rainfall for the remainder of the period.

At Little Llangothlin Lagoon the mean number of all waterbirds present was significantly greater during the drought than after it ended and the difference was particularly significant for Pacific black duck *(Anas superciliosa)*, grey teal (*Anas gracilis*), Australasian shoveler (*Anas rhunchotic*), Eurasian coot (*Fulica atra*) and white-faced heron (*Egretta novaehollandiae*) (White 1987). Many Australian waterbirds, particularly ducks, do not have strict seasonal migration paths, but move around nomadically influenced by food supply and as this is often governed by rainfall, movements may sometimes follow seasonal rainfall patterns (White 1996a, Briggs 1976). For example, they may move towards permanent water in coastal regions when inland swamps dry up and leave permanent coastal wetland during times of inland flooding (White 1996a).

Data suggests that Little Llangothlin Lagoon is one such destination for waterbirds in south-east Australia when surrounding areas are dry, as it contains permanent water and is situated within a nature reserve (White 1987). Intact high altitude drought refuges are likely to be increasingly important as alternative nearby coastal wetlands decline in area due to increasing human population (White 1987).

Table 4.1 Mean waterbird numbers at Little Llangothlin Lagoon during and after a period of drought between 1981 and 1983 (White 1987)

Common name	Scientific name	Drought	Post-drought
Australasian shoveler	*Anas rhynchotis*	*39*	*6*
Eurasian coot	*Fulica atra*	*181*	*46*
Grey teal	*Anas gracilis*	*209*	*23*
Pacific black duck	*Anas superciliosa*	*144*	*66*
White-faced heron	*Egretta novaehollandiae*	*8*	*2*
All recorded waterbirds		*699*	*334*

The migratory whiskered tern (*Chlidonias hybridus*) is believed not to have bred in NSW for some years as a result of the widespread 1997-2010 drought. Its quite regular summer occurrence at the LLNR through this period, during which the New England Tablelands experienced average rainfall (see section 3.3.4), while yielding no conclusive evidence of breeding, confirms the importance of the site for this drought-sensitive species (J. Clifton-Everest, Pers. Comm. 2011)

4.3 Supports TECs and nationally threatened species

4.3.1 Threatened ecological communities

The LLNR Ramsar site contains two relatively large examples of the national TEC ‘upland wetlands of the New England Tablelands and the Monaro Plateau’. These high altitude wetlands only exist in isolated depressions within a very restricted geographic range.

Most examples of this community are small and seasonal wetlands and the vast majority have been modified for agricultural purposes. The morphology and hydrology of the LLNR Ramsar site supports approximately 105 hectares of this community within Little Llangothlin Lagoon and approximately 7.7 hectares of the 17 hectare Billy Bung Lagoon. These wetlands represent some of the largest and most intact areas of this TEC due to their conservation status and associated management regime.

Numerous small stands of *Eucalyptus nova-anglica* occur within the site including areas of healthy recruitment, representing the national TEC ‘New England peppermint (*Eucalyptus nova-anglica*) grassy woodlands’ (Hunter 2011, DSEWPaC 2011a).

4.3.2 Threatened flora

The grassland and grassy eucalypt woodland to the east of Billy Bung Lagoon support the nationally vulnerable plant Austral toadflax (*Thesium australe*). Populations of this species are naturally dynamic and can fluctuate between seasons and years, however populations have been noted within the site on several occasions. There is a lack of information on the location, size, ecology and dynamics of populations within the site, however there are records of the plant from the south-west corner of the site from the 1990s, 2006 and 2011. This short-lived herb parasitises the native kangaroo grass (*Themeda australis)* which occurs within the emergent vegetation surrounding the lakes as well as in the understorey of eucalypt woodlands at the site. Austral toadflax is highly susceptible to disturbance such as grazing and vehicle traffic, and is currently under-reserved, so the protected grassland communities within LLNR Ramsar site are a valuable habitat for this threatened species.

4.3.3 Threatened fauna

The Australasian bittern (*Botaurus poiciloptilus)* is listed as endangered under the EPBC Act and the IUCN Red List of Threatened Species and has been recorded on two occasions at LLNR. This species is highly cryptic and the exact size of the population at the site is unknown, however it is suspected to breed at the site (J. Clifton-Everest, Pers. Comm. 2011).

There are historical records (as late as 1971) of the nationally endangered yellow-spotted bell frog at the site, however it is no longer considered to occur at this site or elsewhere in northern NSW.

4.4 Supports significant biodiversity

LLNR Ramsar site is located on the eastern margin of the sub-region Glenn Innes-Guyra basalts which has been identified as a high conservation value mainland island on the basis of the number of threatened species and ecological communities, overall species richness, level of endemism and other factors (Ecological, 2009, 14). Mainland islands are defined as those areas that are isolated and/or do not currently have invasive species (Ecological, 2009, 11).

Eight waterbird species known to occur at the site are internationally significant migratory species. The marsh sandpiper (*Tringa stagnatilis*), glossy ibis (*Plegadis facinellus*), white egret (*Ardea alba*), cattle egret (*Bubulcus ibis*), Latham's snipe (*Gallinago hardwickii*), red-necked stint (*Calidris ruficollis*), sharp-tailed sandpiper (*Calidris acuminata*) and common greenshank (*Tringa nebularia*) have been recorded at the site and are listed on various international migratory bird agreements. All eight are listed on the CAMBA list of significant migratory birds. Seven of these species are also on the JAMBA list and a further five of these are also ROKAMBA listed species. The white-bellied sea eagle also occurs and breeds at the site (Debus 2008), and this species is erroneously listed as a CAMBA species on the Australian Government migratory species list (G. Usher, DSEWPaC, Pers. Comm. 2011).

The site also supports a small breeding population of the internationally endangered Australasian bittern and a relatively large breeding population of the uncommon and restricted blue-billed duck (*Oxyura australis*). The nomadic freckled duck (*Stictonetta naevosa*) is also found at the site quite regularly. The site also represents a significant breeding refuge for black swan (*Cygnus atratus*) within the New England Tableland region.

LLNR Ramsar site is located in an area that has been extensively cleared and the remnant woodland and wetland vegetation provides important habitat and refuge areas for birds, mammals, amphibians and reptiles including some species at the limit of their climatic or geographical range, such as those associated with fens in the New England Tablelands (Hunter and Bell 2009, 60), and invertebrates as discussed in Section 3.6.1.

Most of the flora and fauna surveys of the site have focused on vascular plants and vertebrate animals, and little information exists on the occurrence and species richness of invertebrates, microbes, and non-vascular plants. However, there is evidence that some of the invertebrates in the lakes are also at the limit of their range (NSW NPWS 1998, 15).

Knowledge gap

- comprehensive species list including non-vascular plants, fish, invertebrates

4.5 Aboriginal cultural heritage

Evidence of relatively intensive Aboriginal occupation in the New England Tablelands dates back to at least 5 000 years before present in the mid-Holocene period (Bowdler 1981, 106), and has been linked to a period of rapid climatic change that continued after the last stage of significant sea level rise was completed (Hiscock 1994). Some other regional archaeological sites are older, for example a site on the lowlands at Seelands near Grafton, about 120 kilometres east-north-east of LLNR Ramsar site, has been dated at around 6 400 years before present. Another site at Stuarts Point on the coast about 140 kilometres south-east of LLNR Ramsar site was dated at about 9 300 years before present (Lea et al. 1977, 128). A number of archaeological sites are located within 120 kilometres of the LLNR including art sites in rock shelters, quarry sites where stone industry was carried out, ceremonial sites such as bora rings and stone arrangements, and open living sites (Lea et al. 1977, Godwin 1983).

The LLNR Ramsar site is within the boundary of the Anaiwan tribe which lies approximately between the towns of Glen Innes, Uralla, and Tingha (Bowdler 1981, 105). Language group boundaries are not entirely clear and it is reported that the coastal Gumbaynggirr people may have extended as far west as Ben Lomond (Grant 2003), or as far from the coast as the eastern escarpment and possibly Guyra (Muurrbay Aboriginal Language and Culture Cooperative 2010).

Aboriginal food resources on the tablelands included animals caught in standing kurrajong bark nets, crayfish from swamps, panic grass seeds, grass tree blossoms, and yams, possibly the *Microseris scapigera* (Bowdler 1981, 106). Godwin (1983, 45) reports tableland food from three zones, the open woodlands (macropods often caught in communal nets, figs and other fruit including the native grape (*Cissus hypoglauca*)), swamps and marshes (crayfish, two types of yam, waterfowl, eels, roots and stems of reeds), and grassy clearings (attractive to eastern grey kangaroo and red-necked wallaby). Many other plants and animals are also likely to have been used for food, including reptiles such as snakes, lizards and turtles, non-wetland birds, and the seeds and flowers of a large number of plants.

According to Hunt (2010), Banbai people (an Anaiwan sub-group centred around Guyra) emphasise that they had a complex society, which lived well on the natural resources available; they had good nutrition, they ground flour and baked bread, they knew the plant medicines and were doctors and meteorologists, and had developed the technology of the boomerang.

Davidson (1982, 51) found evidence in 1978 of two open (or living) sites at LLNR Ramsar site, shown in Figure 4.1, demonstrating moderate density in an area where important resources of food and water were available, and where later agricultural and other activities allowed artefacts to be discovered.

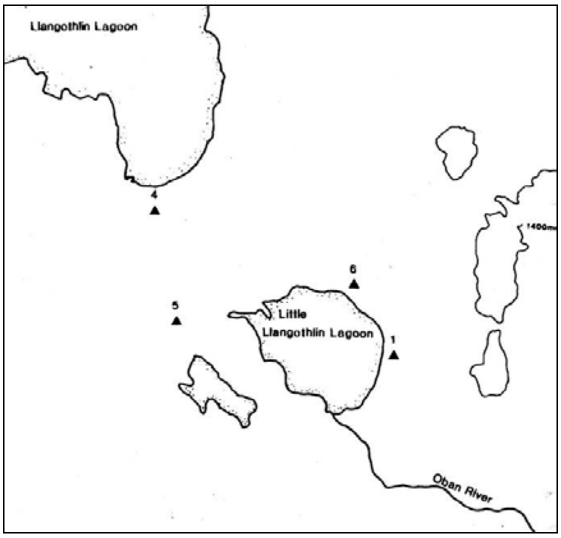
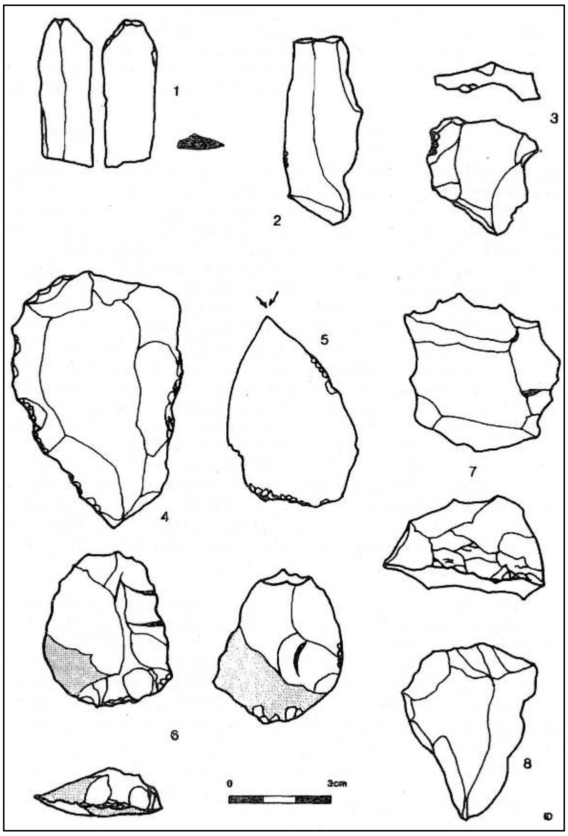


Figure 4.1 Archaeological find sites around the Llangothlin lagoons (adapted from Davidson 1982)

Five separate find spots were identified in the vicinity of the Llangothlin lagoons, and although the absolute quantity of flaked artefacts was not great, an additional find of six edge-ground hatchets and four grinders by a landowner west of Little Llangothlin Lagoon, indicates that past Aboriginal activity in the area was more than an isolated incident (Davidson 1982, 52).

Some of the flaked artefacts from the sites are shown in Figure 4.2, including a flaked piece of glass (artefact 5) from site 4 near Llangothlin Lagoon within 1 kilometre north-east of the LLNR which shows that such activity continued into the historic era (Davidson 1982, 52).



1, 2:	from Enmore, approx. 70 km south of Little Llangothlin Lagoon
3	site 5, immediately west of Little Llangothlin Lagoon
4, 5	site 4, immediately south of Llangothlin Lagoon
6	site 1, the lunette east of Little Llangothlin Lagoon
7, 9	from about 4 km north-west of Little Llangothlin Lagoon, near Llangothlin Lagoon

Figure 4.2 Flaked stone artefacts from the New England Tablelands (Davidson 1982)

In 1995 an Aboriginal site survey of LLNR was completed by the Banbai Cultural Resource Officers for Guyra Local Aboriginal Land Council. This indicates recent interest in the cultural sites at LLNR, however present Anaiwan connection to the land has probably been directed more towards Wattleridge and Tarriwa Kurrukun which were declared Indigenous Protected Areas in 2008 and 2009 respectively, and have been the focus of intensive cultural and environmental assessment and management actions.

In addition to the stone artefacts, five scarred trees have been identified at the site (J. Kreis, NSW NPWS, Pers. Comm. 2010). Scarred trees can be destroyed by bush fires, termites, vandalism and decay, and their preservation requires positive action, while stone artefacts can be disturbed or taken by fossickers (Lea et al. 1977, 129).

The occurrence of these sites and artefacts in the LLNR is particularly significant as many nearby sites occur on private property, and even though all Aboriginal occupation sites and artefacts are protected by legislation in New South Wales, their endurance is not ensured.

It has been noted that some of the sites, such as the sites on the lunette, may be datable however damage by rabbit burrows may have disturbed the sediments sufficiently to prevent accurate dating.

4.6 Provides recreation and tourism opportunities

LLNR Ramsar site is advertised regionally as a tourist attraction and nationally as a nature reserve including for the high altitude wetland TEC and as a wetland of international importance. The nature reserve provides limited infrastructure in the form of toilet and picnic facilities, interpretive information, and mostly unformed walking trail, but no other facilities, while activities such as camping, canoeing and boating are not permitted (DECCW 2010c). As a result, LLNR Ramsar site attracts day visitors interested in nature appreciation, bushwalking and bird watching including from regional clubs and organisations.

The NSW NPWS has recorded vehicles visiting the site since around 2002 and records show that annual visitor numbers, using a conversion of 2.5 visitors/car, increased from around 400 in 2005 to over 1 000 in 2010 (J. Kreis, NSW NPWS, Pers. Comm. 2011).

4.7 Scientific and educational significance

LLNR Ramsar site is of scientific interest as evidenced by the number of papers and theses which have investigated aspects of the site. Most of the 57 upland lakes in the New England Tablelands have been impacted by drainage and agriculture, and those that remain near-natural are important control sites for investigations. Some components and processes relevant to the site have not been studied or are inadequately understood, and could potentially serve as future research subjects.

In addition, the site provides suitable habitat for the nationally endangered yellow-spotted bell frog. The protected LLNR Ramsar site with its near-natural lakes may provide a suitable future site for such reintroduction of the frog to the region, especially if the introduced fish *Gambusia holbrookii* can be successfully controlled.

The NSW NPWS provides interpretive and educational material to the community via its website, and to visitors at the site in the form of signage. Brochures and other publications also provide information relevant to LLNR Ramsar site. NSW NPWS conducts up to five “Discovery” tours per year at the site, during which Rangers interpret aspects of the site for the benefit of community members (J. Kreis, NSW NPWS, Pers. Comm. 2011).

School and university groups visit the site, use the interpretive materials, and participate in educational activities, however the number of visitors and frequency of visits are unknown.

5. Critical components, processes and services

Critical ecosystem components, processes and services are those that, if altered, will result in a significant change in ecological character of the site.

General guidance has been developed to assist with the identification of critical components, processes and services (DEWHA 2008a):

- They are important determinants of the site's unique character.
- They are important for supporting the Ramsar criteria under which the site was listed.
- Change to which is reasonably likely to occur over short or medium time scales (less than 100 years).
- They will cause significant negative consequences if change occurs.

Table 5.1 Summary of the critical components, processes and services

Critical element	Description
Components and Processes	
Hydrology	
Surface water	Little Llangothlin Lagoon contains water in all but times of extreme drought, and the much shallower Billy Bung Lagoon dries out every 20 years or so. The occurrence of permanent water contributes significantly to the site's ecology and function as a drought refuge.
Ground water	Lake water levels are supplemented by groundwater flows, both in the soil above the underlying basalt and granite, and also in basalt aquifers which may discharge at seepage areas in the local catchment.
Flora	
Threatened ecological communities	Lake vegetation underpins the wetlands' primary production and is protected as the national TEC 'upland wetlands of the New England Tablelands and the Monaro Plateau'. Remnant and recruiting patches of *Eucalyptus nova-anglica* represent the national TEC 'New England peppermint (*Eucalyptus nova-anglica*) grassy woodlands'.
Threatened species	At least one population of the nationally threatened Austral toadflax is supported by kangaroo grass within eucalypt woodland which occurs on the slopes adjoining Billy Bung Lagoon.
Fauna	
Waterbirds	At least 48 species of waterbirds utilise the site including eight migratory species. The site is used for breeding by at least 21 waterbirds including black swan.
Threatened species	The nationally threatened Australasian bittern has been recorded twice at the site in recent years and is suspected to breed there.
Services	
Supports representative near-natural wetlands	The four wetland types at the site are representative of the diverse upland wetlands of the region. Little Llangothlin Lagoon and Billy Bung Lagoon are two of only 39 upland lakes in the New England Tablelands within the South-East Coast Drainage Division. Eighty per cent of lakes in the New England Tablelands have been seriously degraded since European settlement. Compared with the other 37 upland lakes in the region, these two lakes are in near-natural condition as a result of their protection within the LLNR (Brock et al. 1999).
Provides refuge during drought conditions	The number of waterbirds at Little Llangothlin Lagoon is known to double during times of drought. Also capable of providing refuge for migratory birds when droughts deplete wetlands in other regions of eastern Australia.

The relationship between the components and processes, critical benefits and services for the LLNR Ramsar site are illustrated in Figure 5.1.

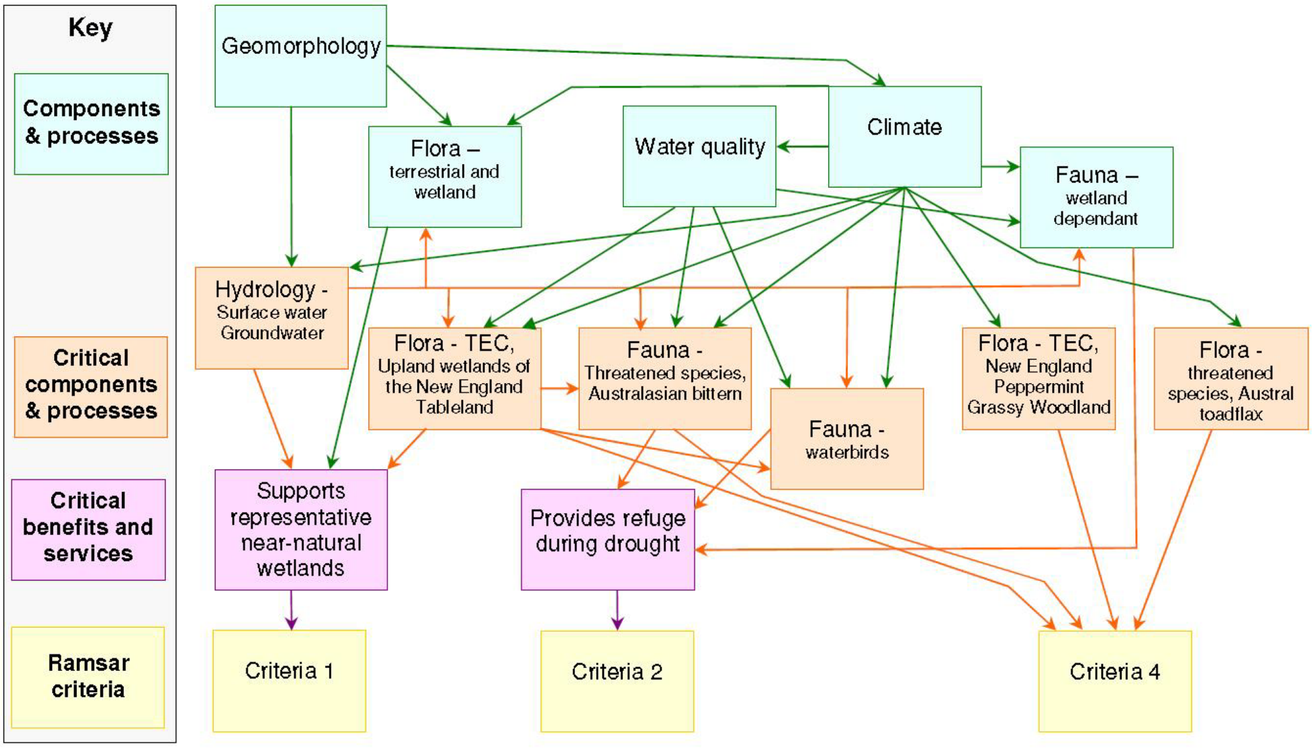
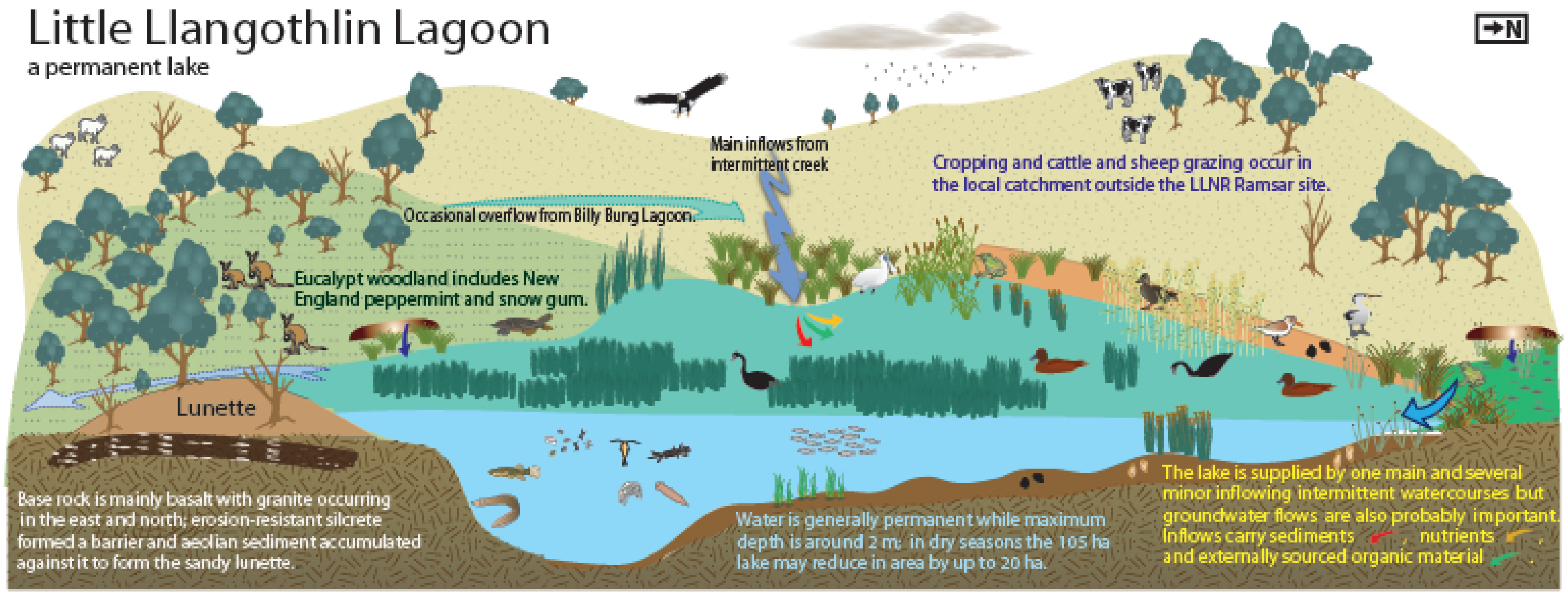


Figure 5.1 Flow chart showing the relationships between components, processes, benefits and services and how they contribute to the Ramsar criteria.

Conceptual models of ecological character of Little Llangothlin Lagoon and Billy Bung Lagoon, showing the interactions between critical components, processes and services are shown in Figures 5.2 and 5.3.



Components and processes

Fauna

Aquatic invertebrates: Likely to be diverse and abundant; depend on inundation phase, water quality and food and habitat availability. Invertebrates convert primary production into animal biomass, a major food resource for fish and birds. Freshwater crayfish, insects, and snails are common and unusual *Rhabdocoel* flatworms and copepods occur.

Fish abundance depends on factors including inundation phase, water quality and food and habitat availability. Pest species such as *Gambusia* are a threat. Eels were once common but no recent surveys have been undertaken.

Frogs and eastern snake-necked turtles are common. Kangaroos, wallabies, and reptiles such as snakes and lizards inhabit the hills and lake margins. Other terrestrial birds and mammals also inhabit the site and contribute to wetland ecology.

Waterbirds vary with regional conditions, water depth and vegetation. Reeds and rushes in and adjoining the lake provide important breeding sites. Trees also provide roosting and nesting sites.

Large wading birds — Shorebirds — Ducks and grebes — Piscivores — Herbivores

Hydrology

Groundwater seepage which may also arise from basalt aquifers.

Additional inflows from minor intermittent watercourses, mainly in north.

Episodic overflow discharge at lunette, into the Clarence River (via the Oban R.).

Flora

Emergent macrophytes: Growth depends mainly on water depth which varies seasonally. No emergent vegetation occurs in the deepest areas which reach 2 m depth, however extensive areas of tall spikerush (*Eleocharis sphacelata*) growing in water of around 0.6-1.0 m depth are common.

Submerged macrophytes are common during the wet phase, including *Myriophyllum variifolium* and *Chara* (plant-like algae). Subordinate species include species of *Potomogeton* (pondweed) and *Utricularia australis*.

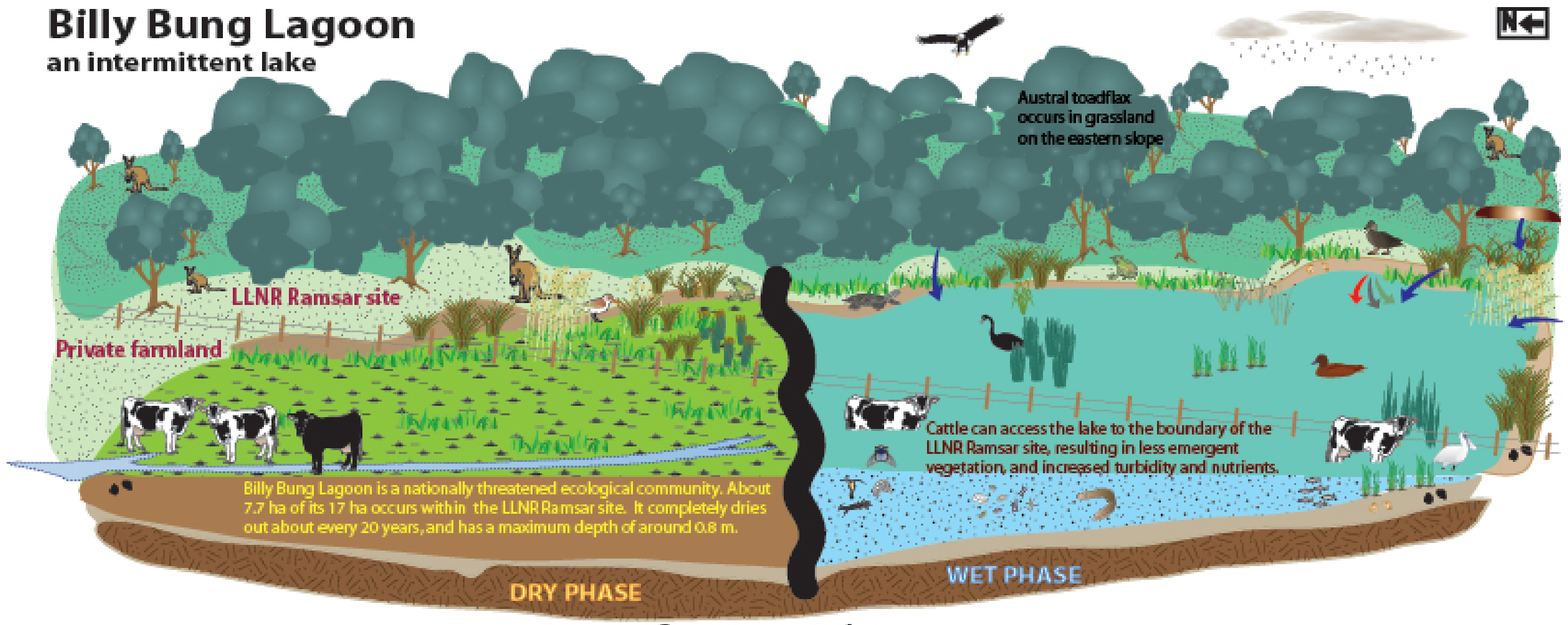
Carex fen: The moist soils of the inlet watercourses are dominated by the swamp grass *Glyceria australis* and the sedge *Carex gaudichaudiana*. These filter sediment inputs and provide substrate for algae and microbes which absorb nutrients. The high productivity is probably peat-producing.

Algae: Macro- and microscopic species occupy all habitats; macroscopic algae include filamentous algae and species which are attached to sediments whereas microscopic algae includes phytoplankton which predominates in open water and periphyton that grow attached to sediment, plants and other surfaces. Algal production can be significant.

Eucalypt woodland (including snow gum and New England peppermint): Occurs on the lunette and slopes. Much of the woodland was previously cleared for agriculture, but regrowth is occurring while some trees are affected by dieback. Understory includes the threatened species Austral toadflax which parasitises kangaroo grass roots.

Seed and egg banks in lake sediment sustain communities through droughts. In 1995, seeds and diaspores of 31 species were identified.

Figure 5.2 Ecological character model for Little Llangothlin Lagoon (A. Cibilic)



Components and processes

Hydrology

Inflows mainly arise from local surface flows in the small catchment, especially as a result of high rainfall events, and carry sediment, nutrients, and organic matter.

Episodic overflow north towards Little Llangothlin Lagoon.

Groundwater seepage may be seasonally important, possibly also from basalt aquifers.

Fauna

Aquatic invertebrates are likely to be diverse and abundant depending on inundation phase, water quality and food and habitat availability. Invertebrates convert primary production into animal biomass food resources for birds, reptiles, and fish.

Fish and eel abundance is unknown as no surveys have been undertaken.

Frogs and Eastern snake-necked turtles are common. Kangaroos, reptiles, foxes, and other terrestrial birds and mammals inhabit the hills and lake margins and contribute to wetland ecology.

Waterbird species and numbers vary with regional conditions, water depth and vegetation, however more birds frequent the nearby much larger Little Llangothlin Lagoon which is about 300m east.

Large wading birds | Shorebirds | Ducks and grebes | Piscivores | Herbivores

Flora

Emergent macrophytes such as tall spike rush (*Eleocharis sphacelata*) are relatively common during the wet phase within the LLNR Ramsar site, however cattle grazing reduces their density outside the boundary.

Submerged macrophytes are common during the wet phase, including *Myriophyllum variifolium* and *Chara* (plant-like algae). Subordinate species include species of *Potamogeton* (pondweed) and *Utricularia australis*.

Carex fen community occurs near the high water mark, and wet meadow community colonises the edges of the lake and the lake bed during the dry phase, including species such as pennywort, swamp starwort, ladies tresses, and *Plantago* spp.

Algae: Macro- and microscopic species occupy all habitats and they are likely to be important contributors to primary production during the wet phase.

Eucalypt woodland (including snow gum and New England peppermint) occurs on the adjoining and nearby slopes. Understory includes the threatened species Austral toadflax (*Thesium australe*) which parasitises kangaroo grass (*Themeda australis*) roots.

Seed and egg banks in lake sediment sustain communities through droughts. Seeds and diaspores of 30 species were found in 1995.

Figure 5.3 Ecological character model for Billy Bung Lagoon (A. Cibilic)

6. Limits of acceptable change

Change in ecological character occurs when the critical parameters of the wetland ecosystem fall outside their normal range (Ramsar Convention 1996), and as a signatory to the Ramsar Convention, Australia is obliged to maintain the ecological character of the site. Phillips (2006) as cited in DEWHA (2008a) has defined limits of acceptable change (LAC) as the variation that is considered acceptable in a particular measure or feature of the ecological character of the wetland, inferring that if a parameter moves beyond the LAC this may indicate a change in ecological character. Exceeding or not meeting a single limit of acceptable change does not necessarily indicate that there has been a change in ecological character.

The LAC may equal the natural variability or may be set, with justification, at some other value (DEWHA 2008a, 26). Many Australian wetlands have a high degree of variability which has not been accurately recorded and as a result it is sometimes difficult or even impossible to establish the natural variation in a particular parameter. The limits of acceptable change in Table 6.1 do not necessarily represent the natural variability of LLNR at the time the site was listed as a Ramsar wetland, 1996.

While the best available information has been used to prepare this Ecological Character Description and define limits of acceptable change for the site, in many cases only limited information and data is available for these purposes. The natural range in condition of a critical parameter (identified in section 3), where it can be defined or inferred with confidence, has provided the basis for the LAC for the LLNR Ramsar site. Where it has not been possible to define the natural variability with confidence, the LAC either has not been described due to insufficient data, or has been estimated with a lower level of confidence.

Resilience has been described as the capacity of a system to absorb disturbance, established by the amount of change a system can undergo while essentially retaining the same function, structure and feedbacks (Walker and Salt 2006). In the absence of the necessary research it has not been possible to incorporate resilience analysis into this document. However in the event that new information on ecosystem resilience for LLNR Ramsar site should become available, then the LACs should be reviewed.

Confidence levels for LACs have been determined based on a subjective assessment of the reliability of the data used to determine the LAC (i.e. duration of data collection, number of measurements, consistency of methodology) and the known or expected variability of a measure. That assessment has been used to determine a confidence level of high, medium or low as follows:

- High – reliable or long-term data set for baseline condition; LAC derived from other reputable studies or guidelines; variability of measure well understood; LAC is objectively measurable.
- Medium – less long-term data for baseline condition, or data available but some uncertainty about direct applicability of LAC to measure; variability of measure understood to certain extent.
- Low – little long-term data or insufficient data collected using consistent methodology; LAC largely based on expert opinion; variability of measure not well understood.

(Adapted from DECCW 2010d and Hale 2010).

The LACs for the LLNR Ramsar site are described in Table 6.1.

Limits of Acceptable Change explanatory notes

1. 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.
2. 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.
3. 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.
4. 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.
5. 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.

Table 6.1 Limits of acceptable change in the ecological character of LLNR Ramsar site

Critical component, process or service	Baseline condition and range of natural variation	Limits of acceptable change	Confidence level
Critical components and processes			
Hydrology			
Surface water	1. The 105 ha Little Llangothlin Lagoon has a maximum water depth of about 2 m (Bell and Clarke 2004) and contains surface water most of the time under natural conditions while experiencing seasonal variation in water depth of 0.4-1.0 m (Haworth 1994, Briggs 1976, D. Bell, UNE, Pers. Comm. 2011), and while unlikely to dry completely (Gale et al. 2004), may prove to dry out in extreme droughts. If additional information becomes available, this LAC should be reviewed to include extent and depth.	1. Deepest pools in Little Llangothlin Lagoon contain water except in extreme droughts.	High
	2. The intermittent Billy Bung Lagoon has a maximum depth of about 0.8 m and experiences seasonal contraction of surface waters and periodic complete drying of the lake surface about once every 20 years (Brock et al. 2005), however long term datasets are unavailable. About 7.7 ha of its 17 ha area occurs within LLNR Ramsar site.	2. Insufficient data exists; baseline data (periodicity, extent, depth) must be developed.	Not applicable
Ground water	3. The contribution of groundwater flows to the waterbalance of wetlands at the site is unknown. Groundwater contributes to water levels in the lakes, including possibly at the basalt granite interface underneath Little Llangothlin Lagoon (Haworth 1994). The number, location and extent of groundwater springs are unknown.	3. Insufficient data exists; baseline data must be developed.	Not applicable
Flora			
Threatened ecological communities	1. Diverse wetland vegetation within Little Llangothlin and Billy Bung Lagoons is representative of the national TEC 'upland wetlands of the New England Tablelands and the Monaro Plateau'. About 113 ha of this community (Benson and Ashby 2000) usually occurs within the site but long-term data on the variation in the extent of the TEC has not been recorded. Native wetland species identified in permanent Little Llangothlin Lagoon numbered 29 in 1976 (Briggs 1976) and 34 in 1998 (D. Bell, UNE, Pers. Comm. 2011). The intermittent Billy Bung Lagoon contained slightly more native wetland species with 39 species recorded in 1998 (D. Bell, UNE, Pers. Comm. 2011). The distribution of minor species is unknown	1. One example of a permanent (Little Llangothlin Lagoon) and an intermittent (Billy Bung lagoon) lake representative of the TEC continues to occur within the site.	High

	and there is no data to demonstrate long-term variation in species composition of the communities at the site. If additional information becomes available, could consider a separate LAC for the condition and extent of the TEC, with extent potentially covered by an updated hydrology LAC.		
	2. Patches of mature and recruiting *Eucalyptus nova-anglica* occur within the site, representing the TEC 'New England peppermint (*Eucalyptus nova-anglica*) grassy woodlands' (Hunter 2011, DSEWPaC 2011a). The number of patches, their location, extent and condition are unknown; when obtained the LAC should be reviewed to include a condition and extent clause.	2. The TEC 'New England peppermint (*Eucalyptus nova-anglica*) grassy woodlands' continues to occur at the site.	Medium
Threatened species	3. A least one population of the nationally vulnerable herb Austral toadflax has been recorded (in 1996, 2006, and 2011) from the south-western corner of the site near Billy Bung Lagoon. The extent of this and other potential populations at the site has not been surveyed and the condition and population dynamics have not been studied. The species is cryptic and populations may be dynamic or transient, with population sizes fluctuating rapidly. (Bell et al. 2008, DECCW 2010b; D. Bell, UNE, Pers. Comm. 2011, Griffith 1991). If additional information becomes available should consider the inclusion of a condition and extent LAC.	3. At least one population of Austral toadflax continues to be recorded at the site.	Medium
Fauna			
Waterbirds	1. At least 48 waterbird species have been recorded within the LLNR. The following four species have been consistently recorded in surveys of the site since 1974, with counts > 100 at least once during each study in which waterbirds were counted: grey teal, Eurasian coot, Pacific black duck and black swan (Briggs 1976, White 1986a, Kingsford et al. 2011). The highest recorded counts for these species include 1800 grey teal, 722 Eurasian coot, 600 Pacific black duck, and 498 black swan (Briggs 1976, White 1986a, Kingsford et al. 2011).	1. Grey teal, Eurasian coot, Pacific black duck and black swan continue to be recorded at the site over a ten-year timeframe in counts >100.	Medium
Threatened species	2. In recent years the nationally endangered Australasian bittern has been observed twice and heard more often and is suspected to breed at the site; it is a highly cryptic species and the population ecology at the site is not known (J. Clifton-Everest, Pers. Comm. 2011).	2. Insufficient data exists; baseline data must be developed.	Not applicable

Critical benefits and services			
Supports representative near-natural wetlands	1. The four wetland types in the LLNR Ramsar site retain natural values: • The permanent Little Llangothlin Lagoon and the intermittent Billy Bung Lagoon - eighty percent of lakes in the New England Tablelands have been seriously degraded since European settlement, and as a result, compared with the other 39 upland lakes in the northern part of the bioregion, these lakes are in near-natural condition as a result of their protection within the LLNR under the NSW *National Parks and Wildlife Act, 1974* (Brock et al. 1999). • 16.2 ha of *Carex*-dominated fens (non-forested peatlands) have been recorded on inflow and outflow watercourses and near the high water mark of both lakes (Hunter 2011), however insufficient data exists to determine any natural variation in extent over time. The community that occurs in the lower reaches of the main inflowing watercourse to Little Llangothlin Lagoon is described as one of seven remaining examples of high quality fens in the New England Tablelands (Hunter and Bell 2009). Many of the largest Carex fens in the New England Tablelands have been degraded or eradicated (Hunter 2011). • Very small spring-fed wetlands supported by groundwater soaks occur at the site, however these have not been surveyed or assessed to date. The authors note that the absence of livestock grazing at the site has allowed the natural values of the four wetland types to be retained.	1. The four wetland types continue to occur at the site. 2. The LAC for the natural condition and extent of Little Llangothlin Lagoon and Billy Bung Lagon would best be covered by the LACs for the upland wetlands of the New England Tablelands TEC and hydrology, above, when they are developed after sufficient baseline data is produced. 3. Insufficient data exists to determine the LAC for the natural condition and extent of *Carex*-dominated fens; baseline data must be developed. 4. Insufficient data exists to determine the LAC for the natural condition and extent of spring-fed wetlands; baseline data must be developed.	Medium Not applicable Not applicable Not applicable
Provides refuge during drought conditions	1. The presence of permanent water within the site provides a drought refuge for waterbirds in terms of resources such as food and breeding habitat. Recorded waterbird numbers range from a mean of 699 birds annually during a drought year to a mean of 334 birds annually after the drought ended (White 1987).	1. Statistically significant higher numbers of waterbirds occur at the site during times of drought.	Medium

7. Threats

Identifying actual and likely threats to ecological character serves an important function in framing future management planning and action. They may also provide initial guidance in assessing likely impacts of potential development proposals under the EPBC Act (DEWHA 2008a).

This chapter is not a comprehensive threat assessment. Rather, only those factors that pose a significant threat to the critical components, processes, benefits, and services, are discussed.

Table 7.1 Summary of key threats to the ecological character of LLNR Ramsar site

Threat	Potential impacts	Likelihood of occurrence	Timing
Weeds	Introduced pasture grasses out-compete:		
	Themeda grassland reducing habitat quality for nationally threatened Austral toadflax.	Medium – High*	Short term
	Components of the nationally endangered New England peppermint grassy woodland community	Medium – High*	Short term
	Other weeds displace native terrestrial and wetland flora	Medium – High*	Short term
Feral animals	European red fox and feral cat predate fauna including waterbirds, frogs, reptiles, and invertebrates, possibly reducing populations of these species.	Medium – High*	Short term
	Grazing and soil disturbance by rabbits can displace the sensitive herb Austral toadflax which is nationally endangered.	Medium – High*	Short term
	Gambusia holbrookii can displace native fish and frog species through aggression and predation.	High*	Short term
Soil disturbance and erosion	Disturbance by vehicles can:		
	Damage individuals of the sensitive herb Austral toadflax which is nationally endangered.	Medium	Short term
	Reduce water quality and disturb vegetation in watercourses and wetlands.	Medium – High	Immediate
Hydrological interference	Groundwater change as a result of groundwater extraction or exploration or extraction of minerals and other resources.	Low	Medium to long term
	Disturbance of outflow level of both lakes	Low	Medium to long term
	Modification to surface flows	Medium	Medium to long term
	Ongoing catchment erosion and lake bed sedimentation above background levels is likely to accelerate the reduction in water depth that would occur naturally.	High	Long term
Climate change	Average temperature will rise	High (virtually certain)	Medium term
	Rainfall will increase in all seasons except winter	Medium (likely)	Medium term
	Structure, composition, and function of ecosystems will change	Medium (likely)	Medium term
	Drier soil conditions will occur in spring and winter	Medium (likely)	Medium term

*depending on success of management programs
Note: immediate = occurring now, short term = 0-25 years, medium term = 25-50 years, long term = >50 years.

7.1 Weeds

At least 59 exotic plant species have been recorded within LLNR Ramsar site (see Appendix 2). Hunter (2011) reported that weeds are widespread in many areas of the site. He notes that introduced species comprise up to 50 per cent of the total species richness in eucalypt woodlands, up to 30 per cent in *Carex* fen and 15 per cent in upland wetland vegetation. This indicates that weeds are currently a threat to the TECs at the site.

Introduced jointed rush (*Juncus articulatus)* occurs at the site and in the early 1970s was found to occupy large areas, dominating the sedge swamp community in Little Llangothlin Lagoon (Briggs 1976, 1980). Surveys or control activities for this weed have not recently been carried out (J. Kreis, NSW NPWS, Pers. Comm. 2010), however this species no longer appears to be common. As it has a persistent seed bank, it could potentially become a problem for the upland wetland vegetation community if drought exposes mud flats for extended periods of time (D. Bell, UNE, Pers. Comm. 2011).

Introduced pasture grasses are abundant due to the land use history of clearing and grazing and they are particularly dominant within the north-west portion of the site. These species can threaten woodland recruitment (including New England peppermint) and outcompete native grasses including kangaroo grass (*Themeda australis)* which provides habitat for the nationally threatened Austral toadflax.

Blackberry (*Rubus ulmifolius*) and, to a lesser extent, nodding thistle (*Carduus nutans*) are also present within the terrestrial vegetation surrounding the lakes in the LLNR. These weeds can outcompete native flora, reducing habitat quality for native fauna including waterbirds and frogs.

The weed *Ranunculus sceleratus* has recently appeared at Little Llangothlin Lagoon (Bell et al. 2008, 487). Dispersed by waterbirds, it is a coloniser of bare mud and is therefore of concern due to the wetting and drying cycle of Billy Bung Lagoon and the margins of Little Llangothlin Lagoon. It potentially reduces habitat for native wetland plants and waterbirds.

Successive years of weed control programs have been undertaken since the designation of the site as a nature reserve (NSW NPWS 1998) focusing on terrestrial weeds using manual removal and limited herbicide application. Trial hazard reduction burns were undertaken in 2009 to reduce pasture grass dominance and facilitate native regeneration, however the trial was unsuccessful due to the rapid regrowth of introduced grasses and so control methods using herbicide to promote native vegetation are currently being explored (J. Kreis, NSW NPWS, Pers. Comm. 2010).

7.2 Feral animals

Several introduced animals have been recorded at LLNR Ramsar site including European red fox, feral cat and rabbit. These three pest species have been identified as one of the key threats to the ‘upland wetlands of the New England Tablelands and the Monaro Plateau’ TEC (DEWHA 2008b). Foxes and cats pose a threat through predation of waterbirds and other native species including those using the reserve as a drought refuge.

Rabbits compete with native species for food, their burrows potentially increase erosion, and grazing by rabbits may be destructive to native wetland vegetation. Their burrows also threaten the cultural values of the site by disturbing historical soil profiles and Aboriginal heritage sites; such disturbance inhibits accurate carbon dating of soil layers containing artefacts. The lunette at Little Llangothlin Lagoon which contains cultural artefacts has previously been riddled with rabbit burrows (Banbai Cultural Resource Officers 1995). Rabbits pose a significant threat to the nationally vulnerable herb Austral toadflax. This plant is palatable and has been found to be highly susceptible to grazing as well as erosion and soil disturbance (Griffith 1991).

The introduced fish *Gambusia holbrookii* also poses a threat as it is an aggressive predator which has documented impacts on native fish and frog species (Rowe et al. 2008). It is thought to be a contributor to the decline of the yellow-spotted bell frog and its presence may be a reason why the threatened species is no longer found at LLNR (J. Kreis, NSW NPWS, Pers. Comm. 2011).

Pest control, especially of rabbits and European red fox, is part of the current management strategy at the site which is designed to prevent pest numbers increasing to levels which could damage the ecology.

7.3 Soil disturbance and erosion

The nationally threatened herb Austral toadflax is a very fragile plant which is highly susceptible to direct disturbance. It may be damaged or displaced by trampling (by livestock or pedestrians), motor vehicles, or by erosion caused by these disturbances. There is currently a NSW NPWS vehicle track within the area of the known population within the site.

A vehicle track also occurs around Little Llangothlin Lagoon, crossing most inlet and outlet channels as well as the outlet channel to Billy Bung Lagoon which adjoins the site. Soil compaction and disturbance at the outlet channels of the lakes as a result of vehicles has the potential to impact on lake hydrology, while disturbance of inlet channels may impact on water quality and wetland vegetation. Disturbance by recreational walkers is currently at a low level.

Vehicle tracks in LLNR (Photo: A. Cibilic)

7.4 Hydrological interference and modification

Human-induced changes to the timing or volume of hydrological events has the potential to alter the fine balances of wetland community boundaries, species composition, trophic relationships, and wetland resilience.

Threatening actions that have the potential to impact on surface and sub-surface flows and shallow aquifers in the catchment of LLNR Ramsar site include:

- accelerated lake bed sedimentation
- altering flows e.g. damming or diverting watercourses, or changing the elevation of the outlets from the lakes
- groundwater drilling and extraction
- mineral and resource exploration and extraction.

7.4.1 Accelerated lake bed sedimentation

Long-term background sedimentation rates are low at around 0.084 millimetres per year (Gale and Haworth, 2002, 129) however from 1960 to 1989 it had increased to 9.7 millimetres per year, 115 times the background level (Haworth, 1994, 83, 93). Such an accelerated sedimentation rate of almost 10 millimetres per year has the potential to reduce the maximum water depth in Little Llangothlin Lagoon by 50 per cent or 1 metre over a century and also have a significant impact on Billy Bung Lagoon.

7.4.2 Altering surface and groundwater flows

Surface flows in the catchment can potentially be affected by agricultural activities, earthworks and infrastructure such as farm dams, bunds, channels, roads, farm tracks, and culverts, while groundwater flows that reach the catchment can potentially be affected by public and private infrastructure within and external to the local subcatchment (e.g. agricultural dams, public and private roads). Impacts on groundwater can potentially occur outside the surface water catchment as groundwater flows in basalt aquifers may originate some distance from LLNR (most likely north-west of the site, towards Ben Lomond).

The probability of future mining-related infrastructure impacting negatively on the hydrology and/ or ecology of LLNR Ramsar site is considered to be low due to the legislative requirements on such development. The EPBC Act regulates actions that will have or are likely to have a significant impact on any matter of national environmental significance, which includes the ecological character of a Ramsar wetland (EPBC Act s16(1)). An action that will have or is likely to have a significant impact on a Ramsar wetland will require an environmental assessment and approval under the EPBC Act. An 'action' includes a project, a development, an undertaking or an activity or series of activities (DSEWPaC, 2011 - http://www.environment.gov.au/epbc/index.html).

The water regimes of the lakes depend in part on the level of the outlet sills which are currently natural or near-natural. The outlet at Little Llangothlin Lagoon is within the LLNR Ramsar site and could potentially be lowered as a result of erosion (e.g. resulting from direct or indirect human interference such as from vehicular or pedestrian access or (less likely) as a result of the activity of an introduced pest species such as rabbits), or by any planned activity to change the water regime of the lake, such as drying it out temporarily to improve the ecology or to remove a pest species. Both of these are considered to be unlikely, however only the former constitutes a threat as the latter is designed to restore or improve the ecology of the lake.

The outlet sill at Billy Bung Lagoon is largely located on private property (one section crosses a public road reserve), and could potentially be lowered as a result of erosion from human interference (such as from cattle or vehicle access) or as a planned activity to alter water flows such as diverting some flow to a storage dam. Both of these are considered to be unlikely however they are noted as potential threats.

7.4.3 Groundwater drilling and extraction

It is unlikely that groundwater extraction currently poses a threat to the ecological character of LLNR Ramsar site. At the time of writing, licences for eleven groundwater bores and three relatively shallow wells or bores (5 metres or less) within an approximate 10 kilometre radius of Little Llangothlin Lagoon had been approved. None of these are located in the immediate surface-flow catchment of LLNR Ramsar site, however all are to the north and west of the Reserve on the basalt landforms, and none occur west in the granite area (NSW Natural Resource Atlas 2010).

Numerous basalt flows originating from Ben Lomond, approximately 14 kilometres west-north-west of LLNR Ramsar site, transmit groundwater (Banens 1987, 1293) as evidenced by drillers' logs from bores. The water-bearing basalt layers are generally described in drillers' logs as porous or fractured, vary from 1 metre to over 10 metres in thickness, and occur both near the surface and at depth (NSW Natural Resource Atlas 2010).

The likelihood of significant future groundwater interference occurring as a result of extraction is considered low, as an action that will have or is likely to have a significant impact on the ecological character of a Ramsar wetland requires approval under the EPBC Act. In addition, all groundwater bores must be approved and have a current state licence and the NSW Government assesses applications in relation to potential impacts. Drillers and installers of groundwater bores are also licensed by the state government, and so the potential for a bore to fail and an aquifer to leak as a result is also considered to be low.

7.4.4 Mineral and resource exploration and extraction

The area is highly prospective for gems, minerals, and geothermal energy, with around 13 mineral exploration licences within a 35 kilometre radius current in 2010 (NSW Government website, 2011 - http://digsopen.minerals.nsw.gov.au/). Two metals exploration licences (EL 7477 and EL 7478) adjoin the LLNR, however no reports are available relating to these which signifies that the licences have recently been approved and that no reporting had occurred at the time of writing.

Current resource exploration effort within about 20 kilometres is focused on: bauxite; gems such as diamonds, zircon and garnet in surface alluvium including in streambeds and relict waterways; copper-gold deposits in porphyry intrusions beneath basalt; and confidential geothermal exploration which may involve drilling through basalt into the granite batholith. No petroleum exploration or interest has occurred in the region, however widespread exploration interest exists in regional coal and coal seam gas.

Potential impacts from exploration or mining, if not properly managed, may include:

- Changes in groundwater flows to wetlands (including lakes, soaks and watercourses) in the LLNR Ramsar site.
- Changes in surface water flows which could occur if groundwater is extracted from an aquifer discharging into a watercourse upstream of the LLNR Ramsar site, or if infrastructure (e.g. access road) interferes with surface water flow in the local catchment.
- Groundwater and surface water pollution or sedimentation if control or containment methods fail.

As indicated above, actions that will have or are likely to have a significant impact on any matter of national environmental significance, including wetlands of international importance, listed threatened species and ecological communities, and migratory species protected under international agreements require environmental assessment and approval under the EPBC Act. In addition, resource exploration and mining in NSW is subject to approval by the NSW Government and consequently all associated actions with the potential to have a negative impact on the ecology of LLNR Ramsar site are likely to be thoroughly assessed.

7.5 Climate change

Records show that the climate of Australia and the Northern Rivers region of NSW in which LLNR Ramsar site is located is changing, however it is difficult to distinguish the relative contribution of natural variability and human intervention (CSIRO 2007, DECCW 2010a).

Predictions of future climate for the area may be unreliable as the global climate models on which they are based do not accurately represent the eastern seaboard or have sufficient resolution to provide a realistic physical representation of the eastern Australian coastline; in addition eastern seaboard rainfall does not have the same strong relationship with the El Niño Southern Oscillation and the Indian Ocean Dipole as the rest of Australia (Timbal 2010, 6).

Despite these shortcomings, the best current assessments of NSW climate patterns and how these will change by 2050 as a result of human-induced climate change (DECCW 2010a, 82-89) indicate that the eastern New England Tableland is likely to experience:

- additional flooding from local streams as a result of increases in flood-producing rainfall intensities particularly during short storms
- an increase in average summer maximum temperature of between 1 °C and 2 °C and an increase in average winter minimum temperature of between 2 °C and 3 °C with less frosts
- an overall increase in average annual precipitation of between 19 millimetres to 75 millimetres and a decrease in winter precipitation of between 18 millimetres and 33 millimetres
- an increase in annual evaporation and drier soil conditions especially in spring and winter
- more severe short-duration droughts and potentially slightly less severe medium and long-term droughts
- an increase in plant cover on an overall warmer tableland
- less plant growth on the hills and ridges as a result of drier soil conditions in spring, autumn and winter, except in moist areas fed by shallow aquifers and soaks
- an increase in summer runoff, with moderate reductions in spring and winter runoff resulting in a slight overall annual increase in runoff by 2030
- a potential decrease in the overall Australian populations of wetland dependent waterbirds, resulting in less opportunistic visits by these birds
- an increase in fire frequency but with generally less intense fires
- an impact on fauna as a result of long hot spells, habitat loss and reduction in key habitat resources such as hollow-bearing trees and nectar
- additional pressures on biological communities that are already stressed by fragmentation
- increased damage to scarred trees and other Aboriginal cultural artefacts and sites as a result of rainfall and temperature changes.

In addition:

- Some ecosystems such as montane and tablelands bogs and fens which are locally restricted to drainage depressions with specific soil chemistry, are at risk of substantial alteration and decline, due to inundation changes and altered soil chemistry (DECCW 2010a, 38, 88). There is likely to be less impact where such wetlands benefit from shallow groundwater aquifers, for example in fractured or porous basalts.
- In and adjoining the lakes and soaks where water and nutrients are not limiting, an increase in plant growth is likely as a result of warmer conditions, and over time this will affect sediment and soil organic loads and soil chemistry.

In summary, climate change is likely to result in changes to the ecology of LLNR Ramsar site, however the specific nature of those changes is far from certain. The site will be warmer in all seasons, and the soils will generally be drier despite increased annual rainfall. Short duration droughts and high-intensity rainfall events will probably increase. Conditions for plant growth are likely to be reduced in exposed sites, for example on the lunette, hills and ridges, however sites in and adjoining the lakes and soaks where water is not limiting are likely to experience increased plant growth and potentially, over time, also increased soil or sediment organic matter. Uncertainty regarding the presence and significance of shallow aquifers adds to uncertainty regarding impacts on flora and fauna.

DECCW (2010a) has estimated, by 2050, the probability of occurrence of some key changes as follows:

- Temperature will rise – virtually certain.
- Rainfall will increase in all seasons except winter – likely.
- Structure, composition, and function of ecosystems will change – likely.
- Drier soil conditions will occur in spring and winter – likely.

The probability terminology used in the NSW Government reporting is consistent with that used by the Intergovernmental Panel on Climate Change with reference to the following terms (DECCW 2010a, 32):

- Virtually certain >99 per cent probability.
- Likely >66 per cent probability.

Use of other terms related to probability in this section, such as ‘may’ and ‘probably’, are not linked to independent assessment and represent the judgement of the authors after a review of the literature.

7.6 Summary of key threats

The most immediate threats to the ecological character of the LLNR Ramsar site are the ongoing impacts of existing exotic species. Weeds such as introduced pasture grasses are present on the site, displacing native flora including TECs and nationally threatened Austral toadflax. Disturbance of soil and grazing by rabbits also threatens native flora. Feral animals including foxes and cats predate native fauna within the LLNR including the nationally threatened Australasian bittern. The introduced fish *Gambusia holbrookii* suppresses native fish and frogs.

8. Changes in ecological character since designation

LLNR Ramsar site was first listed under the Ramsar convention as a wetland of international importance in March 1996. Unfortunately there are limited data available on the ecological condition of the site in 1996 or at the time of writing, with much of the available data occurring prior to or since listing. Notably, there are little repeat data on any single element to enable a comprehensive assessment of changes in the ecological character of the site since the time of listing.

This section summarises some of the issues that may indicate the presence or absence of changes to the critical components and processes (and therefore ecological character) of the site in the past 15 years since it was listed.

The available evidence relating to the ecological character supports the contention that it has not changed since designation in 1996 and that the LLNR Ramsar site still fulfils the Ramsar criteria identified in section 2.7.

8.1 Hydrology

Within the last century the following significant changes to hydrology have occurred:

- Reduction of the maximum water depth in Little Llangothlin Lagoon by agricultural drainage in the early and mid 1900s, from around 2 metres to around 1 metre, however the near-natural level was reinstated in 1989 and no changes have occurred since 1996.
- Reduction, by sediment accumulation, of the water depth in Little Llangothlin Lagoon by up to 1 metre near the inlet watercourses and by around 0.4 metres in the deeper areas, resulting in an overall reduced depth and volume of maximum water storage and possible increased dry lakebed return period. Present sediment accumulation rates are unknown but are presumed to continue at levels above natural background rates. However, since 1996 no significant change to the depth of water in Little Llangothlin Lagoon has occurred as a result.

In addition to the above, an access road with culvert has been constructed (date unknown) to the west of the LLNR Ramsar site across the main inlet watercourse to Little Llangothlin Lagoon, however this is not expected to have significantly altered the hydrology. It may have reduced the natural maximum surface flow rates and extended the period of discharge and may have contributed to a slight increase in sub-surface flows, but this is probably not altered since 1996.

Some minor channelling on private land near the outlet to Billy Bung Lagoon is evident at the present time (Figure 8.1), however does not appear to have affected maximum water level at this lake but acts to divert small outlet flows, including seepage, to a farm storage dam. It is not known when this modification occurred, however its impact is considered to be insignificant.

The climate is changing (see Section 7.5) and there is evidence that the annual rainfall has reduced by around 15 millimetres in the period since 1996 (CSIRO 2007) however this is not considered sufficient to result in any significant change in hydrology. The evaporation rate and volume of local catchment runoff have probably also changed however no data are available and again, the amounts, if any, are considered insignificant.

In summary, no significant changes to the hydrology of the site have occurred since 1996.

Figure 8.1 Channel near outlet at Billy Bung Lagoon which diverts water north-west to a farm dam (Photo: A. Cibilic)

8.2 Flora

The three broad vegetation types and their boundaries within LLNR Ramsar site were described and mapped in 2000 (Benson and Ashby 2000), four years after the site was listed, and are unlikely to have changed since listing.

The only published comprehensive description of the wetland vegetation within the reserve was undertaken in 1976 approximately 20 years prior to the date of listing. Vegetation was also studied within the reserve in the late 1990s as part of a wider study of wetlands in the area. Vegetation communities within and surrounding Little Llangothlin Lagoon and Billy Bung Lagoon occur in zones, the extent and location of which vary with water level. Water levels of these lakes vary naturally as a result in changes in rainfall and runoff. It is apparent that wetland vegetation underwent a change around 1989 when natural lake hydrology was restored, however there is no evidence of any change in the wetland vegetation within the site since the date of listing in 1996.

Little information is available on changes to the condition and extent of terrestrial vegetation communities at the site over time, and this is identified as a knowledge gap. Eucalypt dieback has been evident at the site, but it is not clear if this has contributed to any changes in the Eucalypt woodland since the time of listing.

Grazing of the site by sheep and cattle ceased in 1989. The absence of grazing and management of the site for conservation purposes is likely to have enhanced the native vegetation, including increased recruitment of shrubs and trees and their expansion into previously cleared areas. No information exists on changes to the mix of exotic pasture species and native groundcover, however more palatable species may have increased to some extent. It is likely that the condition and extent of native vegetation within the LLNR has improved slightly since the time of listing and will continue to do so into the future.

8.2.1 Threatened ecological communities

The national TEC ‘upland wetlands of the New England Tablelands and the Monaro Plateau’ was listed under the EPBC Act in 2005. ‘New England peppermint (*Eucalyptus nova-anglica*) grassy woodlands’ was listed as a national TEC in 2011. Although these communities have always occurred within the LLNR Ramsar site, at the time of listing the conservation status of the communities themselves did not exist and so their status was not considered a critical part of the ecological character of the site. The presence and condition of these TECs is generally defined by the characteristic plant species of the representative communities. As a result, any changes in species composition could impact on the TECs. An improvement in the condition of these communities since the time of listing is likely, reflective of the restoration of the natural hydrology, absence of grazing and the conservation management actions.

8.2.2 Threatened flora

Populations of Austral toadflax are highly variable and naturally fluctuate from year to year, however are ultimately dependent on the availability of suitable habitat. Comprehensive data does not exist for the size and distribution of populations of Austral toadflax within the LLNR Ramsar site so it is impossible to definitively pinpoint any changes in the extent or condition of this species at the site. There are records of the species occurring within the south-western corner of the site in the 1990s and a single record from a similar area in 2006. The authors observed a population of at least 50 plants at the site in January 2011.

Suitable habitat for this species is grassland or eucalypt woodland with a grassy understorey including kangaroo grass, of which significant areas occur within the site. Since the time of listing it is possible that the extent and condition of this habitat has increased due to conservation based management actions and the absence of grazing.

8.3 Fauna

The presence of high waterbird numbers during periods of drought demonstrates the site's significance as a drought refuge. Most of the records of increased waterbird numbers at the LLNR Ramsar site relate to Little Llangothlin Lagoon only and were recorded between 1974 and 1984, well before the time of listing. Therefore, most of these records occurred during the period of altered hydrology prior to the restoration of the natural water level in 1989, and in the case of earlier records prior to gazettal of the LLNR in1979.

Comprehensive waterbird surveys have not been undertaken since 1989 but it is expected that the increased water level in Little Llangothlin Lagoon after 1989 has contributed to the site becoming more valuable as a drought refuge. These changes occurred prior to the time of listing of LLNR as a Ramsar site in 1996 and since then there has been little change in the site as a significant habitat and drought refuge for waterbirds, aside from a slight increase in habitat quality resulting from ongoing improvement in the condition of aquatic and fringing vegetation at the site.

The nationally endangered Australasian bittern is a highly cryptic species and only two records exist for this species at LLNR. Therefore, it is impossible to determine changes in the population of this species since the time of listing.

There is likely to have been little change in the predation of waterbirds by European red fox since 1996, as fox control measures have been in place since the LLNR was gazetted.

8.4 Summary of ecological character past to present

There is no evidence of any significant adverse human induced changes in the ecological character of the site since the time of listing. However, there is a lack of comprehensive data for most elements which makes it difficult for changes in the condition of the critical components, processes and ecological character of the site to be identified.

At the time of designation as a Ramsar site in 1996, the ecological condition of LLNR Ramsar site was probably still improving as a result of the cessation of agriculture, reinstatement of natural hydrology, weed control activities, regrowth of native vegetation, and the improved habitat available to fauna at the site. This trend has probably continued to the present time, however cannot be quantified.

9. Knowledge gaps

Throughout the ECD information has been identified that is required to fully quantify and describe components and processes of the system and to understand the interactions between them. Comprehensive data over reasonable timeframes are also essential for determining natural variability and establishing limits of acceptable change. There are many elements of the LLNR Ramsar site for which only limited data are available or which are yet to be thoroughly described or investigated. The most vital knowledge gaps to be addressed are those which will assist in describing the ecological character or determining if it has changed. These are identified as high priority in Table 9.1.

Table 9.1 Knowledge gaps for the LLNR Ramsar site

Component or process	Identified knowledge gaps	Recommended monitoring or action to address gap	Priority
Geomorphology			
Morphology	Lake bed bathymetry of Billy Bung Lagoon and Little Llangothlin Lagoon	Undertake bathymetric survey of both lakes	High
	Sedimentation rate at both lakes	Assess sediment accumulation rate and compare with historical data	High
	Area of the deepest pools in Little Llangothlin Lagoon	Complete calculations from bathymetric data	High
	Elevation of the natural level of the Little Llangothlin Lagoon lunette and complete outlet sill at Billy Bung Lagoon	Complete elevation survey (using a suitable permanent benchmark) across the complete natural outlets at both lakes	Medium
Hydrology			
Hydrological regime	Water balance of Billy Bung Lagoon and Little Llangothlin Lagoon	Quantify relative significance of the various hydrological inputs to and outputs from the two lakes	High
	Long-term water level and drying and overflow frequency of the lakes	Measure and record, at least seasonally (and preferably daily or weekly), the water level (depth), overflow and area of both lakes	High
Groundwater	Occurrence, location, and significance of basalt aquifers and groundwater seepage areas	Assess basalt aquifers and groundwater seepage areas: locations, volume or flow, seasonality, significance to lake water level and any groundwater-dependent ecosystems and aquifer recharge from lakes	High
	Hydrological sub-surface connectivity between Billy Bung Lagoon and Little Llangothlin Lagoon	Assess if the seepage from the basalt cliffs at the south-west margin of Little Llangothlin Lagoon originates from Billy Bung Lagoon	Low
Water quality	Recent water quality data	Undertake comprehensive water quality analysis of the surface waters of Billy Bung Lagoon and Little Llangothlin Lagoon (at least seasonally), and the groundwater aquifers	Medium
Climate	Baseline climate data (especially rainfall and temperature) relevant to the site for the period 1961-1990 (or other suitable baseline period)	Develop a daily baseline data series for rainfall and temperature from existing available data or appropriate models	Medium
	Actual rainfall and temperature data at LLNR Ramsar site	Establish an automated weather station at the site to obtain data, and determine the extent of site variability from nearby weather stations	Medium

Flora Aquatic vegetation / threatened ecological community	The current composition and distribution of aquatic vegetation (which represents the 'upland wetlands of the New England Tablelands and the Monaro Plateau' TEC) has never been thoroughly documented and mapped at Billy Bung Lagoon and has not been documented and mapped at Little Llangothlin Lagoon since the natural water level was restored.	Seasonal vegetation surveys over a number of years to document and map the species assemblages and natural range of fluctuation for the TEC at both lakes. Include non-vascular plants and exotic flora (include area and coverage).	High
Eucalypt woodland/threatened ecological community	Baseline data on the extent, composition and condition of eucalypt woodland within the site, in particular an assessment against the diagnostic characteristics of the 'New England peppermint (*Eucalyptus nova-anglica*) grassy woodlands' TEC.	A site wide study to assess and map areas currently meeting the diagnostic characteristics of the TEC. Thorough seasonal vegetation surveys over a number of years to document and map species assemblages and condition i.e. recruitment, dieback etc.	High
Threatened Species	Size, number and location of populations of the nationally vulnerable herb Austral toadflax (*Thesium australe*).	Ongoing annual surveys of the site during flowering to map, document and monitor the distribution of this cryptic and transient species.	High
Wetland (non-TEC) vegetation	The occurrence of freshwater spring wetlands	Identify, map and undertake flora surveys of freshwater spring wetlands at the site	High
	Occurrence, species assemblages including non-vascular plants), area, and variation in non-forested peatlands (fens) and other Ramsar wetland types.	Identify, map and undertake flora surveys of any non-forested peatlands and other wetland types at the site	High
Fauna Waterbirds	Comprehensive studies of waterbird species and numbers have not been undertaken since the 1980s, before the natural water level was restored in Little Llangothlin Lagoon.	Ongoing seasonal (at least biannual) waterbird surveys within the site to establish and monitor current waterbird numbers and species present, and assessment of the results to determine any changes in adverse times (e.g. droughts).	High
	Long-term waterbird breeding data.	Ongoing seasonal surveys to document waterbird breeding within the site.	Medium
	Significance of LLNR for the bue-billed duck	Ongoing targeted surveys of blue-billed duck numbers and breeding at the site and analysis in a regional context.	Low
Threatened species	The population dynamics and breeding behaviour of the Australasian bittern at the site are unknown	Seasonal targeted surveys (including bird call surveys) to determine the population size and behaviour of this species at the site.	High
	Potential for natural reoccurrance of the nationally endangered yellow-spotted bell frog, while low, is still uncertain.	Periodic targeted surveys to identify any presence of this species	Low
Other fauna	Significance as a refuge from adverse conditions for non-waterbird fauna	Complete desktop assessment, and targeted surveys if required.	Low
	Comprehensive fauna data	Targeted fauna surveys to identify water-dependent vertebrates, invertebrates and microbes.	Low

10. Key monitoring needs

As a signatory to the Ramsar Convention, Australia has made a commitment to maintain the ecological character of its Ramsar sites. Whilst there is no explicit requirement for monitoring the site, a monitoring program would provide data to assist in assessing changes to the site, and thereby to determine if the site's ecological character is being maintained. The ECD identifies the monitoring needs for critical components and processes and for assessing against the LACs.

The purpose of the monitoring recommended in this ECD is to:

- Identify objectives for monitoring critical components, processes, services or threats;
- Recommend indicators or measures to be used and the frequency of monitoring;
- Provide priorities for monitoring; and
- Address key knowledge gaps identified for the site.

Table 10.1 Monitoring recommendations for LLNR Ramsar site

Component or process	Monitoring objective	Indicator	Frequency	Priority
Geomorphology	Track changes to the rate of sedimentation in the lake beds	Annual sedimentation rate (mm/yr), for example at a series of sediment monitoring sites at each lake	Every 10 years	Medium
	Monitor any disturbance to the lunette at Little Llangothlin Lagoon and the outlet at Billy Bung Lagoon.	Assess disturbance to and change in elevation of the outlets	At least annually	Medium
Hydrology	Water level and depth at each lake	Water level (m AHD) and maximum water depth (e.g. mm)	At least weekly for 12 months, then monthly	High
Flora				
Wetland vegetation/TEC	Monitor the composition and distribution of wetland vegetation within the site (including introduced species). Establish the natural range of fluctuation in all wetland vegetation communities under the current hydrological and climate regime.	Species composition and distribution of aquatic and wetland vegetation communities and seasonal fluctuations in these.	Intensive survey, then regular monitoring at least every 5 to 10 years.	High
Eucalypt woodland/TEC	Document, map and monitor the composition, distribution and condition of eucalypt woodland within the site (especially *Eucalyptus nova-anglica*).	Composition, condition and extent of eucalypt woodland	Intensive survey, then regular monitoring at least every 5 to 10 years.	High
Threatened species	Map and monitor the abundance and distribution of the nationally endangered plant Austral toadflax.	Size and location of populations of Austral toadflax within the site.	Intensive survey, then regular monitoring at least every 3 years.	High
Fauna				
Waterbirds	Monitor waterbird numbers and breeding at the site under the current hydrological regime.	Long-term composition and abundance of waterbird population at the site. Numbers of waterbirds observed breeding	Biannual waterbird surveys at least every 5 years, but preferably each year.	High
Threatened	Monitor populations and	Number, location, age and	Intensive targeted	High

species	breeding of the nationally endangered Australasian bittern at the site.	sex of individuals of this species found.	survey (birdcalls at dawn and dusk) at least four times a year for at least two years, then biannual surveys at least every 3 years.	
Surface water Water quality	Establish a baseline for water quality for water at different depths in both lakes and detect any change.	Salinity, pH, dissolved oxygen, turbidity, nutrients, organic carbon, chlorophyll.	In the wet and dry season at least once every 5-10 years	Medium
Ground water Water quality	Establish a baseline for water quality at any identified significant springs	Salinity, pH, bicarbonate, dissolved oxygen, nutrients.	At least once every 5-10 years	Medium

11. Communication, education and public awareness messages

The Ramsar Convention's Program on Communication, Education, Participation and Awareness (CEPA) was established to help raise awareness of wetland values and functions and it has the vision “People taking action for the wise use of wetlands”. The CEPA Program is underpinned by three guiding principles which were developed in Resolution X.8 in 2008:

a. The CEPA Program offers tools to help people understand the values of wetlands so that they are motivated to become advocates for wetland conservation and wise use and may act to become involved in relevant policy formulation, planning and management.
b. The CEPA Program fosters the production of effective CEPA tools and expertise to engage major stakeholders’ participation in the wise use of wetlands and to convey appropriate messages in order to promote the wise use principle throughout society.
c. The Ramsar Convention believes that CEPA should form a central part of implementing the Convention by each Contracting Party. Investment in CEPA will increase the number of informed advocates, actors and networks involved in wetland issues and build an informed decision-making and public constituency (Ramsar 2008).

Governments lead the delivery of CEPA activities at local, state (NSW Government), national and international scales (Australian Government). Various non-government organisations such as universities, Southern New England Landcare, WetlandCare Australia and Birds Australia partner the delivery of local CEPA activities at LLNR by contributing to monitoring, research, and community field days.

The 1998 Plan of Management for the LLNR identifies CEPA-related use of the nature reserve including the promotion of natural and cultural heritage conservation, environmental and cultural education, and scientific research (NSW NPWS 1998).

Key CEPA messages that arise from the specific ecological character of and threats to LLNR, and which should be promoted include:

- Promotion of the values underpinning the Ramsar criteria for the site; that LLNR Ramsar site has significant biodiversity, contains threatened ecological communities, and threatened plants and animals.
- The importance of LLNR Ramsar site as a result of the near-natural representative wetlands, permanent water, and waterbird habitat.
- That past land use in the region has caused massive sedimentation which threatened the water regime of the lakes and continues to pose a threat.
- That weeds and feral animals require controlling to avoid threats to the ecology of the site.
- That negative ecological impacts resulting from visitors and recreational use of LLNR Ramsar site can be minimised by wise use of the lake.

References

Anon, 1999. Assessment of Mineral Resources in the Upper North East CRA Study Area. Geological Survey of NSW, Department Of Mineral Resources and Australian Geological Survey Organisation.

Anon, 2009. Geoserve, *Geoscience Information newsletter vol 35, September 2009*. Geological Survey of Queensland, Queensland Mines and Energy.

Anon, 2010. White Rock Resources prospectus.

Apps, G.J.T., 2006. 'Model based diagnosis of acid-base disturbances in natural waters'. Doctoral thesis, Faculty of Education Monash University, Melbourne.

Australian and New Zealand Environment and Conservation Council, 2000. 'Australian and New Zealand Guidelines for Fresh and Marine Water Quality: Volume 2 - Aquatic Ecosystems - Rationale and Background Information'. Agriculture and Resource Management Council of Australia and New Zealand.

Bacon, P., 1995, (revised Laity, T. 1998). Directory of Important Wetlands in Australia - Information Sheet - Llittle Llangothlin Lagoon. NSW NPWS, Glenn Innes.

Banens, R.J., 1987. The geochemical character of upland waters of northeast New South Wales, *Limnol. Oceanogr.,* 32(6), 1987, 1291-1306. American Society of Limnology and Oceanography, Inc.

Bayly, I., 1995. Unpublished. Notes provided by DECC summarising a conversation with Dr Ian Bayly in February 1995.

Begon, M., Harper, J.L., Townsend, C.R., 1990. 'Ecology: individuals, populations and communities', second edition. Blackwell Scientific Publications, Massachusetts, USA.

Bell, D., 1996. LLNR Ramsar site - Species List. Unpublished.

Bell, D.M., 2000. The ecology of co-existing *Eleocharis* species. PhD Thesis, University of New England, Armidale.

Bell, D.M. and Clarke, P.J., 2004. Seed-bank dynamics of *Eleocharis*: can spatial and temporal variability explain habitat segregation? *Australian Journal of Botany* 52: 119–131.

Bell, Dorothy M., Hunter, John T. and Haworth, Robert J., 2008. Montane lakes (lagoons) of the New England Tablelands Bioregion. *Cunninghamia* **10** (3) 475–492.

Benson, J.S. and Ashby, E.M., 2000. Vegetation of the Guyra 1:100 000 map sheet New England Bioregion, New South Wales. *Cunninghamia* **6** (3)

Binns, R.A., 1967. Geological Map of New England, New England Tableland, Southern Part. University of New England, Armidale.

Birds Australia, 2010. Birds in Backyards. www.birdsinbackyards.net

Bowdler, S., 1981. Hunters in the Highlands: Aboriginal Adaptations in the Eastern Australian Highlands. *Archaeol. Oceania* 15 (1981) 99-111.

Briggs, S.V., 1976. Comparative ecology of four New England wetlands. M. Nat. Res. Thesis, University of New England, Armidale.

Briggs, S.V., 1977. Variation in waterbird numbers at four swamps on the Northern Tablelands of New South Wales. Australian Wildlife Research **4** (3) 301-309.

Briggs, S.V., 1979. Daytime habitats of waterbirds at four swamps on the Northern Tablelands of New South Wales. *Emu* **79** (4) 211-214.

Briggs, S.V., 1980. Chemical studies of four swamps on the northern tablelands New South Wales. *Australian Journal of Marine and Freshwater Research* **31** (6) 729-736

Brock, M.A., Smith, R.G.B., and Jarman, P.J., 1999. Drain it, dam it: alteration of water regime in shallow wetlands on the New England Tablelands of New South Wales, Australia. *Wetlands Ecology and Management* **7** (1-2) 37-46.

Brock, M. A., Nielson D. L., and Crosslé K., 2005. Changes in biotic communities developing from freshwater sediments under experimental salinity and water regimes. *Freshwater Biology* ***50**,* 1376-1390.

Bryant, C.J., Chappell, B.W., and Blevin P.L., 2004. Granites Of The Southern New England Orogen in *The Ishihara Symposium: Granites and Associated Metallogenesis*. Geoscience Australia.

Bureau of Meteorology (BoM), 2010a. Climate statistics for Australian locations. http://www.bom.gov.au/climate/data/index.shtml

Bureau of Meteorology (BoM), 2010b. Glossary. http://www.bom.gov.au/lam/glossary/lpagegl.shtml. Australian Bureau of Meteorology.

Burr, P., 2010. The weather at Guyra NSW. http://wwwpersonal.une.edu.au/~pburr/weather/guyra.html

Campbell, A., 1999. Declines and Disappearances of Australian frogs. Environment Australia.

CSIRO, 2007. Climate Change in the Northern Rivers Catchment. Commonwealth Scientific and Industrial Research Organisation, Australia.

CSIRO, 2010. Climate variability and change in south-eastern Australia: A synthesis of findings from Phase 1 of the South Eastern Australian Climate Initiative (SEACI). Commonwealth Scientific and Industrial Research Organisation, Australia.

Davidson, I., 1982. Archaeology on the New England Tablelands, a preliminary report. *Armidale and District Historical Society Journal* 25, 43-56.

Debus, S.J.S., 2008. Biology and Diet of the White-bellied Sea-Eagle *Haliaeetus leucogaster* Breeding in Northern Inland New South Wales. Australian Field Ornithology **25** 165–193.

DECCW, 2010a. NSW Climate Impact Profile - The impacts of climate change on the biophysical environment of New South Wales. Department of Environment, Climate Change and Water, NSW.

DECCW, 2010b. Flora and Fauna database extract. Department of Environment, Climate Change and Water, NSW.

DECCW, 2010c. Little Llangothlin Nature Reserve Ramsar site. See website - http://www.environment.nsw.gov.au/NationalParks/parkHome.aspx?id=N0531

DECCW, 2010d, Myall Lakes Ramsar site Ecological Character Description (Draft). Department of Environment, Climate Change and Water, NSW.

DECCW, 2010e. Threatened Species Profile – Austral Toadflax. See: http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/profile.aspx?id=10802

Department of Climate Change, 2009. Climate Change Risks to Australia's Coasts. Department of Climate Change, Canberra.

Department of Environment and Heritage, 2006. EPBC Act Policy Statement 1.1 Significant Impact Guidelines. Commonwealth of Australia.

Department of Environment and Resource Management, 2010. Queensland Wetland Definition and Delineation Guideline, DRAFT Queensland Government, Brisbane.

Department of Primary Industries, NSW, 2010. Statewide Tectonics. NSW Government website - http://www.dpi.nsw.gov.au/minerals/geological/overview/statewide

DEWHA, 2005. Upland Wetlands of the New England Tablelands (New England Tablelands Bioregion) and the Monaro Plateau (South Eastern Highlands Bioregion) - Advice to the Minister for the Environment and Heritage from the Threatened Species Scientific Committee (TSSC) on amendments to the List of Ecological Communities under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).
http://www.environment.gov.au/biodiversity/threatened/communities/upland-wetlands.html

DEWHA, 2008a. National Framework and Guidance for Describing the Ecological Character of Australian Ramsar Wetlands. Australian Government, Canberra.

DEWHA, 2008b. Approved Conservation Advice for Upland Wetlands of New England Tablelands and Monaro Plateau. Australian Government, Canberra.

DSEWPaC, 2011a. Threatened Ecological Community Listing Advice for New England peppermint (*Eucalyptus nova-anglica*) Grassy Woodlands, Australian Government, Canberra.

DSEWPaC, 2011b. Approved Conservation Advice for *Botaurus poiciloptilus* (Australasian Bittern), Australian Government, Canberra.

Dudley, A. 2011. The Frogs of Little Llangothlin Nature Reserve, NSW.

Ecological Australia, 2009. Prioritisation of high conservation status mainland islands, a report for the Department of Environment, Water, Heritage and the Arts.

Gale, S.J. and Pisanu, P.C., 2001. The late-Holocene decline of Casuarinaceae in southeast Australia, *The Holocene 11, 4*: 484-490.

Gale, S.J. and Haworth, R.J., 2002. Beyond the limits of location: human environmental disturbance prior to official European contact in early colonial Australia, *Archaeology in Oceania 37 (2002):* 123-136.

Gale, S. J., Haworth, R. J., Cook, D. E., and Williams, D. J., 2004. Human impact on the natural environment in early colonial Australia, *Archaeology in Oceania 39, 3*, Oceania Publications.

Godwin, L., 1983. Archaeological site surveys on the eastern margin of the New England Tablelands, *Australian Archaeology,* No 17 (1983). Archaeological Association.

Grant, A.P., 2003. Book Review: A Gumbaynggir Language Dictionary, *Journal of the Royal Anthropological Institute*, Vol. 9, 2003.

Griffith, S.J., 1991. The biology and management of Austral Toad-flax (*Thesium australe*) in New South Wales. NSW National Parks and Wildlife Service, Hurstville.

Griffith, S.J., 1992. Draft Species Recovery Plan: *Thesium australe*. NSW National Parks and Wildlife Service.

Haworth, R.J., 1994. European impact on lake sedimentation in upland eastern Australia: case studies from the New England Tablelands of NSW. PhD Thesis, University of New England, Armidale.

Haworth, R.J., 1998. Preliminary report on An Inventory of Wetlands in the New England Region and an Assessment of their Environmental Health, Past History and Present Status. Report to Severn Shire Council, Glen Innes, NSW.

Hero, J. and Morrison, C., 2004. Frog declines in Australia - Global implications. *Herpetological Journal* **14** 175-186.

Hiscock, P., 1994. Technological responses to risk in Holocene Australia. *Journal of World Prehistory* 8(3):267-292.

Hudson, S., 1996. Salisbury Axe Quarry: the acquisition, distribution and cross-exchange patterns from a local distribution site. Unpublished honours thesis, University of New England, Armidale.

Hunt, J., 2010. Looking After Country in New South Wales: Two Case Studies of Socioeconomic Benefits for Aboriginal People. Centre for Aboriginal Economic Policy Research working paper No. 75/2010, Australian National University, Canberra.

Hunter, J. T., 2011. Vegetation and Floristics of Little Llangothlin Nature Reserve. A report to the Parks and Wildlife (DRAFT), NSW.

Hunter, J.T. and Clarke, P.J., 1998. The vegetation of granitic outcrop communities on the New England Batholith of eastern Australia. *Cunninghamia Vol. 5(3)*.

Hunter, John T. and Bell, Dorothy, 2009. The *Carex* Fen vegetation of northern New South Wales. *Cunninghamia* **11** (1).

Jurskis, V. and Turner, T., 2002. Eucalypt dieback in eastern Australia: a simple model, *Australian Forestry* Vol. 65, No. 2 pp. 87–98.

King, D.P., 2009. Soil Landscapes of the Armidale 1:100 000 sheet. Report, Department of Environment and Climate Change, Sydney.

Kingsford, R.T., Porter, J.L. and Halse, S.A., 2011. National waterbird survey: a tool for water resource assessment and management. National Water Commission, 95 Northbourne Avenue, Canberra ACT 2600

Lea, D.A., Pigram, J.J. and Greenwood, L.M. (eds), 1977. An Atlas of New England, Volume 2 – The Commentaries. Department of Geography, University of New England, Armidale.

Mackney, B.J., 1996. Preliminary Regional Landfill Siting Study, a report for Armidale City, Uralla, and Dumaresq Shire Councils.

McCarthy, J.J., Canziani, O.F., Leary, N.A., Dokken, D.J. and White, K.S. (Eds), 2001. Climate Change 2001: Impacts, Adaptation, and Vulnerability. Intergovernmental Panel on Climate Change

Muurrbay Aboriginal Language and Culture Cooperative, 2010. Gumbaynggirr Language Revitalisation. Website: http://www.muurrbay.org.au/gumbaynggirr.html

National Land and Water Resources Audit, 2002. Australian Catchment, River and Estuary Assessment, Canberra, ACT.

Nicholls, N., 1997. El Nino - of droughts and flooding rains. ABC. http://www.abc.net.au/science/slab/elnino/story.htm

NSW Department of Natural Resources, NSW Natural Resource Atlas, 2010. NSW Government website - http://nratlas.nsw.gov.au/wmc/custom/homepage/home.html

NSW Govt., 1979. Gazettal notice for the LLNR, 14 Dec 1979.

NSW National Parks and Wildlife Service, 1996. Information Sheet on Little Llangothlin Nature Reserve Ramsar site NPWS.

NSW National Parks and Wildlife Service, 1998. Little Llangothlin Nature Reserve Plan of Management. NSW National Parks and Wildlife Service, Sydney. Website: http://www.environment.nsw.gov.au/parkmanagement/ParkManagementPlans.htm

NSW National Parks and Wildlife Service, 2001. Yellow-spotted Bell Frog (*Litoria castanea*) and Peppered Tree Frog (*Litoria piperata*) Recovery Plan. NPWS, Hurstville, NSW.

NSW National Parks and Wildlife Service, 2003. The Bioregions of New South Wales: their biodiversity, conservation and history. New South Wales National Parks and Wildlife Service, Hurstville.

Packham, G.H., (ed), 1969. The Geology of New South Wales, *Journal of the Geological Society of Australia, Vol 16, Part 1.* Geological Society of Australia.

Patterson, R.A., 2006. Evapotranspiration bed design for inland areas, *Septic Safe Technical Reference Sheet 05/15*. Department of Local Government and Lanfax Laboratories.

Patterson, R.A. and Perrens, S.J., 1985. Drought Resistant Farm Dams for New England Tablelands. Hydrology and Water Resources Symposium, 14-16 May, 1985, Sydney.

Platt, J., 2010. ‘Extinct’ Australian frog reappears 30 years after last sighting. *Scientific American* March 2010.

Primary Industries and Resources SA, 2001. ‘Water quality in freshwater aquaculture ponds’. Fact Sheet 60/01. Department of Primary Industries and Resources South Australia. www.pir.sa.gov.au/factsheets

Ramsar Convention Secretariat, 2006. The Ramsar Convention Manual: a guide to the Convention on Wetlands. 4th ed. Ramsar Convention Secretariat, Gland, Switzerland.

Ramsar Convention Secretariat, 2007. Inventory, assessment, and monitoring: An Integrated Framework for wetland inventory, assessment, and monitoring. Ramsar handbooks for the wise use of wetlands, 3rd edition, vol. 11. Ramsar Convention Secretariat, Gland, Switzerland.

Rancic A., Salas G., Kathuria A., Acworth I., Johnston W., Smithson A., and Beale G., 2009. Climatic influence on shallow fractured rock groundwater systems in the Murray-Darling Basin, NSW. NSW Department of Environment and Climate Change, Sydney available at http://www.environment.nsw.gov.au/resources/salinity/09108GroundwaterMDB.pdf

Rowe, D.K., Moore, A., Giorgetti, A., Maclean, C., Grace, P., Wadhwa, S. Cooke, J., 2008. Review of the impacts of gambusia, redfin perch, tench, roach, yellowfin goby and streaked goby in Australia. Prepared for the Australian Government Department of the Environment, Water, Heritage and the Arts.

Rutherford, H., 1999. The use of Remote Sensing and GIS in a Temporal Analysis of the Llangothlin Lagoons in North-eastern NSW. Thesis, University of New England.

Short, N.M., and Blair, W.R. (Jr), (eds), 1986. Geomorphology from Space, National Aeronautics and Space Administration.

Stonestreet, P.G., Ashley, P.M., Brown, R.E., Sivell, W.J., 2006. The Fox Tor Diorite, a newly recognised intrusion within the New England Batholith, northern New South Wales, *Quarterly Notes No 122.* Geological Survey of NSW.

Sumner, G.N., 1983. Seasonal changes in the distribution of rainfall over the Great Dividing Range: general trends, *Australian Meteorological Magazine 31: 121 - 130*.

Timbal, B., 2010. The climate of the Eastern Seaboard of Australia: a challenging entity now and for future projections. Proceedings, 17th National Conference of the Australian Meteorological and Oceanographic Society. Australian Meteorological and Oceanographic Society.

Timms, B.V., 1970. Chemical and zooplankton studies of lentic habitats in north-eastern New South Wales. *Australian Journal of Marine and Freshwater Research* **21** 11-33.

Ummenhofer, C.C., England, M.H., McIntosh, P.C., Meyers, G.A., Pook, M.J., Risbey, J.S., Gupta, A. (Sen), Taschetto, A.S., 2009. What causes southeast Australia's worst droughts? *Geophysical Research Letters, Vol. 36*. American Geophysical Union.

Virotec, 2006. Case study: Mt Carrington tailings dam. Virotec Pty Ltd.

Walker, G.T., 1977. Origin of the New England Lagoons*.* unpublished Department of Geography, University of New England.

Walker, B. and Salt, D., 2006, 'Resilience thinking: Sustaining ecosystems and people in a changing world'. Island Press, Washington, DC.

White, J.M., 1993. Changes in the numbers of waterbirds on Llangothlin Lagoon, NSW, in relation to the water level and distant flooding, 1981–1984. *Corella* **17** 117–121.

White, J.M., 1986a. The management of the New England Lagoons for Waterbirds. Masters Natural Resources Thesis, University of New England.

White, J.M., 1986b. Breeding of Black Swans on two New England lagoons. *Corella* **10** 17-20.

White, J.M., 1987. The New England Lagoons as Drought Refuges for Waterbirds, *Emu* **87** (4) 253-255.

Wiles. P., Pepler A., Speer, M., 2009. Inter-Annual Variability In Australian East Coast Lows And Its Relation With Key Climatic Indices. Proceedings 9th International Conference on Southern Hemisphere Meteorology and Oceanography. Australian Meteorological and Oceanographic Society and American Meteorological Society.

Wilson, B., Barnes, P., Ghosh, S., Koen, T. and King, D., 2010. Measurement of land-use effects on soil carbon and related properties for soil monitoring: a study on two soil landscapes of northern New South Wales, Australia, 19th World Congress of Soil Science, Soil Solutions for a Changing World

Appendices

Appendix 1 – Methods

1. A – Approach

A nationally agreed framework for describing the ecological character of Australia's Ramsar-listed wetlands has been developed which outlines the minimum set of information required and provides a preferred process in the form of a step-by-step guide (DEWHA 2008a). Additional activities were completed to ensure that the process was technically robust for this particular Ramsar site, to comply with the requirements of DSEWPaC, and to ensure that a comprehensive description of the ecological character resulted.

A project inception meeting between DSEWPaC, DECCW, and WetlandCare Australia project manager and principal author Alan Cibilic, confirmed the milestones and timeframes and identified preliminary nominees for vacant project Steering Committee positions. The preferred candidates for community and scientific expert members were approached by DECCW, and the Steering Committee membership was finalised:

- DSEWPac representative
- DECCW representative
- Park Ranger responsible for LLNR, NSW NPWS, DECCW
- Community representative with knowledge of the site
- Scientific expert with knowledge of the site
- WetlandCare Australia project team

The Steering Committee met by teleconference in late 2010 and mid 2011 and face-to-face in early 2011, to discuss the ECD structure, components, processes and benefits, including natural variability and limits of acceptable change. Written review comment on two drafts of the ECD and RIS was invited from members and provided as relevant. The authors also discussed aspects of the ecology with additional experts knowledgeable of the site, as listed in the acknowledgements.

The following site visits were conducted to assist in understanding the ecological character:

- August 2010 - Alan Cibilic met with the Parks Ranger responsible for managing the site who guided a comprehensive trip around the access tracks and provided relevant site and management information.
- August 2010 - Community and Scientific representatives of the Steering Committee met with Alan Cibilic at the site to discuss ecological issues and highlight challenges.
- January 2011 - Alan Cibilic and Laura White visited the site to investigate various aspects including the catchment hydrology, lunette, threatened species and the TEC, groundwater-dependent wetlands, site threats, waterbird occurrence, and terrestrial vegetation.
- January 2011 - the Steering Committee conducted a site visit prior to meeting in order to share knowledge and gain a better understanding of the site, its ecology, and threats.

The draft ECD was developed consistent with the national framework and guidance (DEWHA 2008a) but with some minor variation including some re-arrangement of content which was completed in consultation with the Steering Committee:

1. Introduction - Site details, purpose of the description and relevant legislation
2. Site description - Site location, climate, maps and images, tenure, wetland criteria and types
3. the critical components, processes and services were identified and described:
    - Identify and describe all possible components, processes and benefits (minor components and processes were not identified)
    - Of these, identify the critical components, processes and benefits responsible for determining the ecological character of the site

4. Develop a conceptual model for the wetland – one ecological character model was developed for each of the two significant wetlands at the site identifying the critical components and processes, and some threats and other aspects of the ecology
5. Set limits of acceptable change - limits of acceptable change for critical components, processes and services of the site were determined where sufficient data was identified to determine natural variation
6. Identify threats to the ecological character of the site - information from Steps 3–5 and other information was used to identify the actual or likely threats to the site
7. Describe changes to ecological character - changes to the ecological character of the site since the time of listing were described, including information on the current condition of the site
8. Summarise the knowledge gaps - information from Steps 3–7 was used to identify knowledge gaps
9. Identify site monitoring needs - information from steps 3–8 was used to identify monitoring needs
10. Identify communication and education messages - communication and education messages highlighted during the development of the description were identified
11. The description of ecological character was compiled in three steps involving two drafts of the ECD (and RIS) which were provided to the Steering Committee and written comments received, prior to development of the final ECD
12. Update the Ramsar Information Sheet – this was completed as a companion document to the ecological character description following the standard format provided by the Ramsar Secretariat.

1. B – Project team

Alan Cibilic

Training in agricultural science and education has provided a platform for a varied career in education, community development, floodplain mangement, acid sulfate soils, and wetland management. Field expertise in wetland assessment, saltmarsh, coastal wetlands, drainage system management, wetland connectivity, on-site wastewater treatment, and acid sulfate soils assessment and remediation complements management experience in decision support systems, project design and delivery, partnership development, and resource analysis. Alan worked with WetlandCare Australia (2004-2010) in a variety of capacities and has developed numerous wetland management and restoration plans, environmental impact assessments, and the ECD for the Lake Albacutya Ramsar site for the Australian Government.

Laura White

A Bachelor of Tropical Environmental Science and First Class Honours in Aquatic Food Web Ecology supports specialist skills in trophic ecology, ecological data analysis and reporting, wetland assessment, research, environmental weed management, riparian management, and GIS mapping and analysis. Laura has worked with WetlandCare Australia since 2008 and has delivered numerous wetland management and communications projects, and the ECD for the Lake Albacutya Ramsar site for the Australian Government.

Appendix 2 – Species lists for the LLNR Ramsar site

Non-waterbird fauna recorded at LLNR Ramsar site (DECCW 2010b, Dudley 2011)

Common name	Scientific name
Australian magpie	*Cracticus tibicen*
Black-faced cuckoo-shrike	*Coracina novaehollandiae*
Brown thornbill	*Acanthiza pusilla*
Brown-striped frog	*Limnodynastes peronii*
Common brushtail possum	*Trichosurus vulpecula*
Common eastern froglet	*Crinia signifera*
Common ringtail possum	*Pseudocheirus peregrinus*
Common Wallaroo	*Macropus robustus*
Copper-tailed skink	*Ctenotus taeniolatus*
Crimson rosella	*Platycercus elegans*
Cunningham's skink	*Egernia cunninghami*
Dark-flecked garden sunskink	*Lampropholis delicata*
Dusky moorhen	*Gallinula tenebrosa*
Eastern banjo frog	*Limnodynastes dumerilii*
Eastern dwarf tree frog	*Litoria fallax*
Eastern grey kangaroo	*Macropus giganteus*
Eastern rosella	*Platycercus eximius*
Eastern sign-bearing froglet	*Crinia parinsignifera*
Eastern snake-necked turtle	*Chelodina longicollis*
Eastern water-skink	*Eulamprus quoyii*
Echidna	*Tachyglossus aculeatus*
Glossy black-cockatoo	*Calyptorhynchus lathami*
Grey fantail	*Rhipidura albiscapa*
Highland copperhead	*Austrelaps ramsayi*
Little friarbird	*Philemon citreogularis*
Pale-flecked garden sunskink	*Lamprpholis guichenoti*
Peron's tree frog	*Litoria peronii*
Red-bellied black snake	*Pseudechis porphyriacus*
Red-necked wallaby	*Macropus rufogriseus*
Red-rumped parrot	*Psephotus haematonotus*
Red-throated skink	*Acritoscincus platynota*
Restless flycatcher	*Myiagra inquieta*
Rufous whistler	*Pachycephala rufiventris*
Scarlet robin	*Petroica boodang*
Short-beaked echidna	*Tachyglossus aculeatus*
Smooth toadlet	*Uperoleia laevigata*
Spotted marsh frog	*Limnodynastes tasmaniensis*
Striated thornbill	*Acanthiza lineata*
Superb fairy-wren	*Malurus cyaneus*
Swamp wallaby	*Wallabia bicolor*
Three-toed skink	*Saiphos equalis*
Tussock skink	*Pseudemoia pagenstecheri*
Verreaux's frog	*Litoria verreauxii*
Water-rat	*Hydromys chysogaster*
Weasel skink	*Saproscincus mustelinus*
White-breasted woodswallow	*Artamus leucorynchus*
White-lipped snake	*Drysdalia coronoides*
White's skink	*Liopholis whitii*
Yellow-faced honeyeater	*Lichenostomus chrysops*

Flora within the LLNR Ramsar site (DECCW 2010b, D. Bell, UNE, Pers. Comm. 2011, Hunter 2011)

Scientific name	Common name
Acacia dealbata	Silver wattle
Acacia melanoxylon	Blackwood
Acaena novae-zelandiae	Bidgee-widgee
Acaena ovina	Bidgee-widgee
Ajuga australis	Austral bugle
Aldrovanda vesiculosa	Waterwheel plant
Ammobium alatum	Winged everlasting

Amphibromus sinuatus	Wavy swamp wallaby-grass
Amyema pendulum	Drooping mistletoe
Angophora floribunda	Rough-barked apple
Aristida sp.	Wiregrass
Arthropodium milleflorum	Pale vanilla-lily
Arthropodium minus	Vamilla -lily
Asperula charophyton	Strapleaf woodruff
Asperula conferta	Common woodruff
Asplenium flavellifolium	Necklace fern
Austrodanthonia racemosa var. *racemosa*	Slender wallaby grass
Azolla filiculoides	Azolla
Baloskion stenocoleum	Cordrush
Billardiera scandens	Hairy apple berry
Bothriochloa macra	Red-leg grass
Brachyscome radicans	Marsh daisy
Bulbine bulbosa	Bulbiine lily
Bulbine sp. aff. *bulbosa*	Bulbine lily
Calotis cuneifolia	Purple burr-daisy
Carex appressa	Tall Sedge
Carex chlorantha	Green-top sedge
Carex fascicularis	Sedge
Carex gaudichaudiana	Fen sedge
Carex incomitata	Hillside sedge
Carex inversa	Knob sedge
Carex sp. Bendemeer (D. M. Bell 296)	A sedge
Chara australis	A charophyte
Chara fibrosa	A charophyte
Chrysocephalum apiculatum	Common everlasting
Coronidium scorpioides	Button everlasting
Craspedia variabilis	Billy buttons
Crassula helmsii	Swamp stonecrop
Cullen tenax	Emu-foot
Cynoglossum australe	Australian hound's tongue
Cyperus sanguinolentus	Flat-sedge
Cyperus sphaeroideus	Scented sedge
Desmodium varians	Slender tick trefoil

Dianella revoluta	Spreading flax-lily
Dichelachne micrantha	Short-haired plumegrass
Dichondra repens	Kidney weed
Dichopogon fimbriatus	Nodding chocolate lily
Dichopogon sp.	Chocolate lily
Discaria pubescens	Australian anchor plant
Echinopogon ovatus	Forest hedgehog grass
Elatine gratioloides	Waterwort
Eleocharis acuta	Common spikerush
Eleocharis dietrichiana	
Eleocharis pusilla	Small spikeursh
Eleocharis sphacelata	Tall spikerush
Elymus scaber	Common wheatgrass
Epilobium billardierianum subsp. cinereum	Smooth willow-herb
Epilobium billardierianum subsp. hydrophilum	A willow-herb
Epilobium gunnianum	Gunn's willow-herb
Eryngium sp. Little Llangothlin NR (D. M. Bell 56)	A blue devil
Eryngium sp. nov.	A blue devil
Eryngium vesiculosum	Prostrate blue devil
Eucalyptus acaciiformis	Wattle-leaved peppermint
Eucalyptus dalrympleana	Mountain gum
Eucalyptus nova-anglica	New England peppermint
Eucalyptus pauciflora	White sally, snow gum
Eucalyptus stellulata	Black sally
Eucalyptus viminalis	Manna gum
Euchiton gymnocephalus	Creeping cudweed
Euchiton involucratus	Star cudweed
Euchiton sphaericus	Cudweed
Galium binifolium	Bedstraw
Galium ciliare	Bedstraw
Galium propinquum	Maori bedstraw
Geranium neglectum	Crane's bill
Geranium potentilloides	Cinquefoil geranium
Geranium solanderi var. grande	Native geranium
Geranium solanderi var. solanderi	Native geranium

Glyceria australis	Australian sweetgrass
Glycine clandestina	Glycine
Gonocarpus tetragynus	Poverty raspwort
Haloragis heterophylla	Rough raspwort
Hemarthria uncinata var. *uncinata*	Matgrass
Hovea linearis	Common hovea
Hybanthus monopetalus	Slender violet-bush
Hydrocotyle laxiflora	Stinking pennywort
Hydrocotyle tripartita	Pennywort
Hypericum gramineum	Small St. John's wort
Hypericum japonicum	Matted St. John's wort
Hypoxis hygrometrica	Golden weather-grass
Isolepis fluitans	Floating club-rush
Isolepis gaudichaudiana	Benambra club-sedge
Isotoma fluviatilis subsp. *borealis*	Swamp Isotome
Juncus bufonius	Toadrush
Juncus falcatus	Rush
Juncus filicaulis	Thread rush
Juncus fockei	Slender joint-leaf rush
Juncus homalocaulis	Wiry rush
Juncus pauciflorus	Rush
Juncus prismatocarpus	Branching rush
Juncus subsecundus	Finger rush
Juncus usitatus	Common rush
Juncus vaginatus	Clustered rush
Lachnagrostis filiformis	Blowngrass
Lagenifera stipitata	Blue bottle-daisy
Leiocarpa sp. Uralla (D. M. Bell NE 54142)	Yellow buttons
Lemna trisulca	Ivy leaf duckweed
Leptorhynchos squamatus	Scaly buttons
Leucopogon fraseri	Beard heath
Lilaeopsis polyantha	Australian lilaeopsis
Limosella australis	Australian mudwort
Lomandra longifolia	Spiny-headed mat-rush
Lotus australis	Australian trefoil
Luzula flaccid	Grass rush

Luzula sp.	Woodrush
Lycopus australis	Australian gypsywort
Melichrus urceolatus	Urn-heath
Mentha satureioides	Native pennyroyal
Microlaena stipoides var. *stipoides*	Weeping grass
Microtis unifolia	Common onion orchid
Myosotis australis	Australian forget-me-not
Myriophyllum alpinum	Water-milfoil
Myriophyllum simulans	Water-milfoil
Myriophyllum variifolium	Water-milfoil
Myriophyllum verrucosum	Red water-milfoil
Neopaxia australasica	White purslane
Nitella cristata	A charophyte
Nitella tasmanica	A charophyte
Nymphoides montana	Marshwort
Oxalis exilis	Shady wood-sorrel
Panicum decompositum	Native millet
Panicum effusum	Panic
Pennisetum alopecuroides	Swamp foxtail
Persicaria hydropiper	Water pepper
Persicaria lapathifolia	Pale knotweed
Persicaria orientalis	Princes feathers
Phragmites australis	Common reed
Pimelea linifolia	Slender rice-flower
Plantago sp. Little Llangothlin NR (L.M.Copeland 342)	A plantago
Poa labillarieri	Tussock
Poa sieberiana var. *sieberiana*	Snowgrass
Podolepis jaceoides	Showy copperwire-daisy
Polygala japonica	Dwarf milkwort
Poranthera microphylla	Small poranthera
Potamogeton crispus	Curly pondweed
Potamogeton tricarinatus	Floating pondweed
Prasophyllum dossenum	Leek orchid
Pteridium esculentum	Common bracken
Pultenaea microphylla	Bush-pea

Ranunculus inundatus	River buttercup
Ranunculus lappaceus	Common buttercup
Rubus parvifolius	Native raspberry
Rumex brownii	Swamp dock
Scaevola hookeri	Alpine fan flower
Schoenus apogon	Common bogrush
Scleranthus biflorus	Knawel
Senecio interpositus	A groundsel
Solanum opacum	Green-berry nightshade
Sorghum leiocladum	Wild sorghum
Spiranthes australis	Ladies' tresses
Stellaria angustifolia	Swamp starwort
Stylidium graminifolium	Grass trigger-plant
Themeda australis	Kangaroo grass
Thesium australe	Austral toadflax
Thysanotis tuberosus subsp. *tuberosus*	Common fringe-lily
Trachymene incisa subsp. *incisa*	Wild parsnip
Typha orientalis	Narrow-leaved cumbungi
Utricularia australis	Yellow bladderwort
Utricularia dichotoma	Fairy aprons
Velleia paradoxa	Spur velleia
Veronica calycina	Hairy speedwell
Viola betonicifolia	Native violet
Vittadinia cuneata	Fuzzweed
Wahlenbergia ceracea	Waxy bluebell
Wahlenbergia communis	Tufted bluebell
Wahlenbergia gracilis	Sprawling bluebell
Wahlenbergia luteola	Bluebell
Xerochrysum bracteatum	Golden everlasting
Xerochrysum sp. Glencoe	An everlasting

Introduced flora at LLNR Ramsar site (DECCW 2010b, D. Bell, UNE, Pers. Comm. 2011, Hunter 2011)

Scientific name	**Common name**
Acetosella vulgaris	Sheep sorrel
Anthemis arvensis	Corn chamomile
Anthoxanthum odoratum	Sweet vernal grass
Briza minor	Shivery grass
Centaurium erythraea	Common centaury
Cerastium glomeratum	Mouse-ear chickweed
Chenopodium album	Fat hen
Cirsium vulgare	Spear thistle
Conyza bonariensis	Flaxleaf fleabane
Conyza sumatrensis	Tall fleabane
Crepis capillaris	Smooth hawsbeard
Dactylis glomerata	Cocksfoot
Dianthus armeria	Deptford pink
Eleusine tristachya	Goosegrass
Fallopia convolvulus	Black bindweed
Festuca arundinacea	Tall fescue
Hedera helix	English ivy
Holcus lanatus	Yorkshire fog
Hupochaeris micrcephala	White flatweed
Hypochaeris radicata	Catsear
Juncus articulatus	Jointed rush
Juncus bufonius	Toad rush
Lactuca serriola	Prickly lettuce
Leucanthemum vulgare	Ox-eye daisy
Lolium perenne	Perennial ryegrass
Malus pumila	Apple
Medicago polymorpha	Burr medic
Onopordum acanthium	Scotch thistle
Panicum gilvum	Sweet panic
Paronychia brasiliana	Brazilian whitlow
Paspalum dilatatum	Paspalum
Pastinaca sativa	Parsnip

Persicaria orientalis	Princes feathers
Phalaris aquatica	Phalaris
Phleum pratense	Timothy
Plantago lanceolata	Lamb's tongues
Poa pratensis	Kentucky bluegrass
Prunella vulgaris	Self-heal
Ranunculus sceleratus	Celery buttercup
Rorippa nasturtium-aquaticum	Watercress
Rorippa palustris	Yellow cress
Rubus ulmifolius	Blackberry
Rumex crispus	Curled dock
Senecio madagascariensis	Fireweed
Setaria sp.	Pigeon grass
Solanum nigrum	Black-berry nightshade
Sonchus asper subsp. *glaucescens*	Prickly sowthistle
Sonchus oleraceus	Common sowthistle
Taraxacum officionale	Dandelion
Tragopogon dubius	Goatsbeard
Trifolium campestre	Hop clover
Trifolium dubium	Yellow suckling clover
Trifolium pratense	Red clover
Trifolium repens	White clover
Trifolium striatum	Knotted clover
Verbascum virgatum	Green mullein
Verbena bonariensis	Purpletop
Veronica anagallis-aquatica	Blue water speedwell
Vulpia bromoides	Squirrel tail fescue